The Iowa Chemistry Education Alliance, ICEA: Process and product

by

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A dissertation submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Education (Curriculum and Instructional Technology)

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2005

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Prologue

This work is a documentation of the process and product called the Iowa Chemistry Education Alliance. Four central Iowa high school teachers had a vision of what could be an exciting addition to the secondary school chemistry curriculum for them and for their students. They jumped into the task of making their vision a reality, drafted an outline, assumed their creative roles, and never looked back.

Through the marvels of technology, they spent hours together, whether virtually (via electronic mail) or in face-to-face real time interactive audio-video exchanges. By sheer tenacity and determination, the outline became a draft, the draft was implemented, modifications were made, and the final product was finely crafted. At the end of eighteen months, the creative process yielded a worthy outcome—eight supplemental instruction modules with three supporting videotapes for the high school chemistry curriculum.

The product was so good that other high school chemistry teachers wanted to use it, not one or two locally, but twenty-five teachers across the state of Iowa. Not a few hundred students, but 1600 of them! Not one year, but three succeeding years under federal funding and another three without funding! The original four teachers in Phase I shared their enthusiasm with eight new teachers in Phase II. Those twelve recruited fourteen more in Phases III and IV. Each veteran group mentored the novices. And all communicated the "right chemistry" to their students.

Words cannot convey the good will, collegiality, and professionalism that have sprung from their Project. For each successive new group of students, however, the wellspring of the "right chemistry" was tapped and the excitement of statewide collaboration began again. This is their story...

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ABSTRACT

The Iowa Chemistry Education Alliance, ICEA, supported by Department of Education Star Schools funding (R203F5000198), was both a Process and a Product.

The Process included:

a. Design and support of high school teacher training sessions that incorporated distance learning techniques, cooperative learning and guided inquiry strategies, and a constructivist, student-centered classroom focus;

b. Design and incorporation of eight supplemental learning modules, corresponding assessment rubrics, and supporting videotapes into the existing Iowa high school chemistry curriculum;

c. Adaptation of the learning modules throughout the course of the academic year *while* the units were being integrated into the existing curriculum;

d. Modification and final editing of the curriculum modules and videotapes.

The Product consisted of eight supplemental ICEA learning modules with corresponding assessment rubrics, and three supporting videotapes.

To integrate ICEA materials into the existing curriculum, students at high schools around the state of Iowa conducted cooperative, guided-inquiry laboratory exercises. Via electronic mail and Iowa's two-way interactive audio-video system, the Iowa Communications Network (ICN), they discussed strategies for experimentation and shared results obtained. Invited guest experts also visited student groups via the ICN. Teachers conducted regular biannual on-site face-to-face planning meetings. These were augmented and supported by weekly or biweekly "staff" meetings conducted via the ICN.

From the original three hundred students in four central Iowa high schools (rural,

urban, and suburban), by its third and fourth year, the Project evolved to include over 1500 students in twenty-five high schools statewide.

IOWA CHEMISTRY EDUCATION ALLIANCE MISSION STATEMENT

The mission of the Iowa Chemistry Education Alliance is to provide Iowa high school chemistry students and their teachers with supplemental hands-on activities with which to network, collaborate, and share results via the Iowa Communications Network, the Internet, electronic mail, FAX, and CUSeeMe.

I. CHAPTER 1. INTRODUCTORY OVERVIEW DESCRIPTION OF THE ICEA PROJECT

A. The Problem

Iowa chemistry faculty teaching at the secondary and post-secondary levels are geographically too far apart and too committed to their own schedules to be able to drive the distances required to meet with one another on a regular basis. They are generally recognized as practicing a state-of-the-art high school curriculum (Cary, 1984). In an attempt to ameliorate the problem of distance, two statewide interactive collaborative projects utilized the Iowa Communications Network (ICN), Iowa's two-way interactive fiber optic communication technology. The ICN system allowed real-time video and voice exchange among users. It provided participating members with the opportunity to network with one another and to communicate on a regular basis without having to travel any farther than their local high school, community college, or college/university ICN classroom (Greenbowe and Burke, 1995: Burke and Greenbowe, 1998; Burke and Greenbowe, 1999).

B. The Iowa General Chemistry Network

College chemistry faculty members of the Iowa General Chemistry Network (IGCN) (Greenbowe and Burke, 1995; Burke, Greenbowe, and Partin, 1998; Burke, Greenbowe, Partin, and Woo, 1998) took advantage of the availability of the ICN technology to convene every two months during the academic year from 1994-1998 (supported first by the Funds for the Improvement of Post-Secondary Education, FIPSE, and then by the National Science Foundation) to discuss project-associated issues, topics of curricular modification and/or change, and simple matters of importance to their project (planning, dissemination, etc.). These meetings were coordinated with annual or semiannual face-to-face gatherings (1993-2002).

C. The Iowa Chemistry Education Alliance, ICEA

The Iowa Chemistry Education Alliance Project (ICEA), funded in Spring Semester 1996 by a United States Department of Education Star Schools Grant R203F50001-95, included a group of four master high school chemistry teachers, and advisory faculty and staff at Iowa State University. The Project incorporated distance education as a form of curriculum enhancement.

The Iowa Chemistry Education Alliance was a 51-month opportunity (June 1996-September 2000) to study the dynamic nature of student-student, student-teacher, and teacher-teacher interaction via the Iowa Communications Network. Master high school chemistry teachers at four locations in central Iowa developed and implemented eight supplemental modular units to complement the existing high school chemistry curriculum. Lessons were simultaneously shared among the four high schools using the two-way interactive capabilities of the ICN as curriculum enrichment. Collaborative exercises included use of electronic mail, CUSeeMe cameras, and Internet capabilities. In addition to sharing the results of classroom or laboratory activities, students used the ICN to discuss experimental strategies or to interview guest speakers. Teacher-prepared materials developed for the Project were modified through the course of the academic year and during the following summer. Changes were made and the finalized version of the modular materials (including implementation rubrics), was made available to all of Iowa's high school chemistry teachers the following fall semester.

The Iowa Chemistry Education Alliance Project focused on cooperative strategies in local and distant learning groups and a collaborative exchange between these classrooms. When planned and orchestrated correctly, the distance-learning classroom allows for student-centered and cooperative group work with the same ease as any locally-based classroom (Cyrs, 1997; Paterson, 1999; Gosmire and Vondrette, 2001; Schopp and Rothernel, 2001; Simonson and Sparks, 2001). These multi-site interactive exchanges among students or their teachers are the fundamental cohesive force that continues to make the ICEA a dynamic and evolving entity.

No two inter-school exchanges were identical. Similarities may have existed, but each exchange had its own lively brand of uniqueness. Students at one school may have tried to talk directly to their distant peers, while students at another school may have incorporated more skits to convey their message. It is part of what characterizes the use of the ICN in Iowa—the ability to maintain local control while participating in a statewide networking (Simonson, personal communication, June, 1998). School district borders are opened to expand dialogue between students of diverse backgrounds (Paterson, 1999).

As a part of the Iowa Chemistry Education Alliance (ICEA) (Burke and Greenbowe, 1998 and Burke and Greenbowe, 1999), Iowa high school chemistry teachers held bi-monthly ICN "staff" meetings to undertake the planning of collaborative interactive ICN sessions that were held concurrently among several Iowa high school chemistry classes around the state. Communication among teachers via the ICN was critical to the successful planning and execution of the Project. Faculty shared information via electronic mail and CUSeeMe technology, small cameras integrated with a computer that allowed real-time visual communication at 10 frames per second (for reference, videotapes run at 30 frames per second), in addition to using "live" ICN sessions. Three times each year, ICEA teachers gathered at Iowa State University for face-to-face discussions (in August to prepare for the Fall semester of the upcoming academic year, in December to debrief from the Fall semester and to prepare for the upcoming Spring semester, and in early June to debrief from the Spring semester and prepare a working draft of a strategy for the next academic year). Project Managers Charlie Schlosser (1996-1997) and Kathy Burke (1997-2000) organized and facilitated these meetings. Drs. Mike Simonson (distance education) (1996-1998), Gary Downs (curriculum and instruction) (1996-2000), Tom Greenbowe (chemistry) ((1996-2000), and Gary Phye (curriculum and instruction) (1998-2000) contributed guidance and content area expertise.

1. The use of interactive technology

It is the purpose of this document to show the networking background and dynamic evolution of the Iowa Chemistry Education Alliance. Student and teacher participants resided in a rural state, but utilized cutting edge communication technologies. Use of two-way interactive audio-video ICN technology provided participants with the opportunity to reach outside the confines of their individual classrooms to collaborate with distant peers. Critical thinking skills were fostered by using real-world hands-on laboratory experiences to investigate problem-solving techniques. The result was the advancement of social communication skills as well as the promotion of a student-centered chemistry curriculum that reached statewide. Students found the ICEA curriculum to be highly motivating.

It was impossible for those who conceived the idea of the ICEA to believe that students and their teachers could actively use technology (electronic mail, Internet "surfing", video games, computer simulations, etc.) outside of their school environment (i.e., at home or at gaming arcades), but would fail to take advantage of its use inside the classroom. Herring (1997) noted that a transition from home to school use was not likely to be difficult. Miller (1996) concurred: "Due to the interactive character of distance learning technologies, students and instructors alike have access to tools that are adaptable, investigative, and open to a myriad of uses, both academic and nonacademic in nature. Their availability for use in life contexts can change the way students and teachers operate, think, perform, and acquire information. Students hone their communication and presentation skills as they learn about chemistry", p. 57.

The ICEA Project overcame the geographical isolation of the individual teachers and their classes, bringing groups together to collaborate. Teachers were enthusiastic about using the ICN and its potential for both teacher networking and student interactions. Paterson (1999) favors using the term *interactive technology*, placing the emphasis on interaction *facilitated* by technology rather than using the term distance learning as many do when referring to classroom studies involving the ICN. Use of the ICN by its nature changed the methods by which students and teachers interacted. The more teachers successfully encouraged interactivity, the more equivalent the learning environment became for students at a distance compared to those who were on-site learners (Simonson, Smaldino, Albright, and Zvacek, 2000).

2. Communication

The design of interactive technology/distance education should be focused on fostering social interaction and communication. The purpose of the interactive technology/distance education environment is supporting the social, distributed, and situated construction of new knowledge (Herring, 1997). Participants in the ICEA Project acquired the ability to communicate in a variety of different ways. Students honed their communication and presentation skills as they learned and talked about chemistry by being immersed in the problem-solving skills required by their interactive lessons.

3. Interactive learning environment

A learning environment must reflect student needs and encourage investigation (Moore, 2003). Willis (1994) emphasized that teachers needed to design learning experiences that necessitated student involvement and participation. A learning environment designed to reproduce authentic and legitimate work, i.e., "real world" experiences or activities, provides students with opportunities to learn within environments attached to the world outside the high school classroom (Herring, 1997) or in disciplines other than the one students are studying (Moore). The relevance of these settings seemed to provide motivation because students interpreted them as real life experiences related to their own experiences or goals (Moore), instead of the rote memorizing of meaningless tidbits of information. Learning modules created for the ICEA Project provided this environment to the students involved. They were especially motivated by the charge of solving a crime in the Forensics Unit, Module 4.

Teachers adapted their traditional teaching style to enhance the ICN teaching/learning experience for the best results for their students. It was important to develop effective methods in interactive classrooms that encouraged active student involvement with their own learning (Schoenfelder, 1997). It was crucial to create an interactive environment appropriate for the technology to keep students attentive and engaged, helping them to learn better, and retain the information longer (Gosmire and Vondrette, 2001; Schopp and Rothernel, 2001; Simonson and Sparks, 2001; Anderson and Kent, 2002). The goal of the ICEA Project was and continues to be to *enhance* the traditional curriculum, not simply add the bells and whistles of the ICN, electronic mail, the Internet, or CUSeeMe technologies.

Teachers needed to be trained to incorporate the use of technology where appropriate in knowledge construction. Instructors needed to learn to incorporate interactive distance learning technologies in such a way that they became seamless and that their students were encouraged to *actively* construct their *own* knowledge (Lochte, 1993; Herring, 1997). Students became proficient at integrating use of the ICN system into their collaborative work and network presentations. As participants in the ICEA Project, they were enthusiastic, especially about the Forensics learning module, because they learned a great deal in the process of analysis, sharing their results, and conversing with guest experts via the ICN.

The tools used to investigate these "real world" experiences are important. Today's technologies have an increasing ability to support and facilitate learning. Use of the Internet and electronic mail, because they have become a regular part of daily life, are recognized as legitimate learning tools (Cyrs, 1997; Frizler, 1999; Simonson et al., 2000).

4. Product and process

The ICEA was both a *product* and a *process*. A Department of Education Star Schools Grant was drafted to create a more active and motivating learning environment among high school chemistry students while at the same time utilizing cutting-edge interactive communication technologies. Four high school chemistry teachers, recognized as innovators and leaders in Iowa high school chemistry education, were invited to undertake the challenge of drafting a series of interactive learning modules that could be incorporated into an existing high school chemistry curriculum The charge was simple—produce activities that would motivate students to construct creative problem-solving strategies in the laboratory and communicate their results with distant classmates via interactive communication technologies—two-way interactive television, electronic mail, and real-time computer video interaction using CUSeeMe cameras.

The *process* of the ICEA was the development, implementation, and modification of a set of learning modules. The process also included the effective training and teacher preparation necessary to facilitate student interactive communication sessions. Once the teachers were comfortable with the system, they were able to train their students to use the equipment as well.

The *product* was a set of eight learning modules and three accompanying videotapes capable of being integrated into any existing high school chemistry curriculum. Although modules were designed to be used at the secondary level, materials could be adapted to middle school science (and perhaps elementary school if appropriately modified) as well as to post-secondary chemistry classrooms.

5. The ICEA Project—Phase I

The ICEA Project is dynamic and on-going. Conceived in the Fall of 1995, Phase I of the Project began in the summer of 1996. Four teachers and a dedicated support staff at Iowa State University (Charlie Schlosser, Project Manager; Gary Downs, Curriculum Development; Mike Simonson, Distance Education; Tom Greenbowe, Chemistry) worked three weeks to draft a skeletal outline of the product modules. The team worked feverishly to create a working model of the first four modules before the actual beginning of the academic year 1996-1997. Teachers were trained in the use of interactive communication technologies including the two-way interactive audio-video capabilities of the Iowa Communications Network, CUSeeMe video cameras, and electronic mail/the Internet. (At the beginning of the Project, none of the four master teachers had used the ICN and one had used CUSeeMe. At least two of the four teachers did not have access to electronic mail/the Internet in their classrooms the first year of the Project.)

Teachers trained their students in the use of interactive communication technologies, supervised student laboratory experiences, facilitated interactive communication sessions, and conducted interactive weekly "staff meetings" to keep the Project on course. As the Fall semester progressed, teachers implemented the first four modules while they created the next four that would be used during the Spring semester, 1997. This was challenging, rigorous work. But, student reaction was strongly favorable, providing teachers with the motivation to work through their exhaustion and implement the second set of four learning modules. At the end of the academic year, student focus groups enthusiastically commended the teachers and the Project and recommended the continued use of the ICEA "curriculum". The four teachers worked together that ensuing summer to modify the eight units to increase their flexibility and adaptability to any existing curriculum After 18 months of unceasing devotion to the Project, the four teachers and the Iowa State support staff (Charlie Schlosser, Gary Downs, Mike Simonson, Tom Greenbowe, and Kathy Burke) had created a commendable product.

Whatever the success of any given study has been, it cannot be exactly replicated with different students—the results will inevitably be different because different classes have different compositions, therefore different personalities, responses, approaches to interaction, etc. (Felder, Felder, and Dietz, 1998). Phase I instructors were enthusiastically supportive of implementing the ICEA learning modules again, this time incorporating what they had learned during Phase I.

What was learned from Phase I of the ICEA Project? The idea of integrating interactive supplemental curricular materials into Iowa's high school chemistry curriculum was a good one. Teachers and students reflected a revitalized enthusiasm. But, the frenetic pace of implementing all eight modules in one year was too taxing. Phase I teachers recommended that only four of the eight modules be implemented in any one academic year.

6. The ICEA Project—Phase II

Officials of the United States Department of Education, impressed with the success of Phase I of the ICEA Project, promised refunding for the academic year 1997-1998. The main stipulation required of Phase II of the ICEA Project was an expansion to include another eight high schools. The four original teachers, aided by Iowa State University support staff, invited a new group of energetic and enthusiastic teachers to participate. There was a minor problem: funding for Phase II was not procured until November, 1997. By that time, the Fall semester was well under way.

The new group of eight Phase II teachers joined the original four to learn about the process of the ICEA. Phase I teachers served as mentors to the eight new teachers. They explained the module packet and its use, they modeled the use of interactive communications technologies and worked with the new teachers to practice, and they encouraged their new colleagues through the challenging scheduling process of when and how twelve schools could work simultaneously on the same learning units as well as utilize the statewide interactive telecommunications network. The result? Another success!

However, student focus groups revealed that the success was not without its struggles. Due to the late start, some students perceived the learning modules as "add-ons", taking valuable classroom time and attention away from the traditional curriculum, which they perceived to be more "valid". Some students feared this supplemental curriculum would be detrimental to their preparations for college. Also, beginning to integrate the four ICEA learning units into the curriculum as of January of 1998 (rather than the planned August 1997) was akin to implementing four modules in a semester, something that had been deemed too demanding during Phase I. Due to the delay in funding, this was unavoidable, but caused problems. What was learned? To be recognized as valid in the eyes of the <u>students</u>, the ICEA Project

(a) Must be integrated into the existing curriculum;

(b) From the first day of the fall semester; and,

(c) There should be, at most, two modules implemented during any one semester.

7. The ICEA Project—Phase III

Teachers from both Phase I and Phase II were enthusiastic about seeking Star Schools funding to expand the ICEA group to include more Iowa high school chemistry classrooms. The group extended a statewide invitation to double the number of schools. Phase III of the ICEA included twenty-five schools and impacted over 1500 students. Officials at Iowa State University arranged to avoid the previous year's delays in program funding. The desire was to make the ICEA Project viable from the outset of the 1998-1999 academic year.

New Phase III teachers met in August 1998 to explore the ICEA learning modules and to practice using interactive communication technologies. From the first day of classes during the Fall of 1998, students were introduced to the ICEA Project. By now the Project had a good reputation in the original four schools. Students in those schools looked forward to becoming a part of it just as older siblings or peers had been. At other Phase II and Phase III schools where the idea was newer, students considered it just another aspect of their "regular" chemistry class.

The Phase III academic year went smoothly with students experiencing the benefits of interacting with peers at distant schools more effectively and efficiently than had previous groups in the ICEA Project. The ICEA, product and process, was an acclaimed success, both in the eyes of students and teachers (Burke and Greenbowe, 1998).

8. The ICEA Project—Phase IV

The emphasis of the fourth and final year of official Department of Education Star Schools funding (1999-2000), evolved away from dissemination of the ICEA materials and philosophy, to look instead at several different aspects of the Project. What was the process that made the Project "work"? What was the impact of the Project on student learning? Efforts were made to capture the essence of the organization, training, mentoring, and implementation aspects of the ICEA Project. In addition, ICEA teachers and support staff drafted and administered a diagnostic instrument to students statewide at the start and finish to the academic year. Statistically significant improvements in student learning were documented.

9. The ICEA Project after funding

What was it about the ICEA Project that so energized participating teachers that they took it upon themselves to secure appropriations at their individual schools to continue the ICEA Project into Phases V, VI and VII, without funding from the Department of Education? With the offer from Iowa State support personnel to be of whatever help they could be without a source of federal monetary assistance, the ICEA Project successfully continued through academic years 2000-2001, 2001-2002, and 2002-2003. (In the years that have followed, teachers have incorporated modules in their local curriculum, but have not collaborated between schools.) Fewer schools participated as time went on, but there was still an enthusiasm for the concept that could not be dampened by lack of outside subsidizing. Committed teachers petitioned administrators to provide the necessary ICN time to permit students with the continued opportunity to interact with distant peers across the state.

D. Dissertation Goal

It is the goal of this dissertation to document the detailed history of the Project from its inception to the present to try to convey the dynamic evolutionary spirit that characterized the Iowa Chemistry Education Alliance. In addition, it will examine the role of the Iowa Communications Network (ICN) as a communication tool for faculty in the ICEA, particularly during critical developmental stages. All work was conducted with the approval and support of the Iowa State University Human Subjects Review Committee. A yearly review and revision was conducted for each period the grant was renewed.

E. Author's Role in the ICEA Project as a Whole

The author of this document was invited to participate during the initial discussion and drafting of the grant that was submitted for Star Schools funding of the ICEA Project (late Fall

Semester, 1995). At this time, her role was minimal—simply someone interested in the Project's proposed scope and concept, who might be able to offer some ideas or suggestions. She was not assigned to become a member of the ICEA Project's Iowa State University personnel staff until after the beginning of the academic term, Fall Semester 1996. For the next fifteen months, she served as a research assistant for the Project, gradually becoming more involved in answering questions about subject matter content, advising other ISU ICEA staff members about ordering scientific equipment (e.g., water test kits) requested by the four Phase I teachers, and similar duties related to her usefulness as a subject matter resource person. She attended and documented all ICEA Project "staff" meetings, either via the ICN or on campus at Iowa State University. She traveled with Charles Schlosser, the Project Manager during Phase I and Fall Semester of Phase II, to make observations in multiple classrooms of student groups as they conducted work on each of the eight learning modules, to facilitate videotaping sessions, and to conduct focus groups at participating high schools.

The four Phase I teachers prepared the original written module units and accompanying videotapes. The author of this document helped in the editing of ICEA Module materials and in the planning, development, and editing of two supporting videotapes for the ICEA Project materials, Statistics and the Tour of the Iowa Department of Criminal Investigation, but the four teachers did most of the work. Another graduate student assembled all of the written materials into the ICEA notebook.

The Principal Investigators (PIs) (Drs. Downs, Simonson, and Greenbowe—Phase I, Drs. Downs, Simonson, and Greenbowe—Phase II, Drs. Downs and Greenbowe—Phase III, and Drs. Downs, Greenbowe. and Phye—Phase IV) drafted the original idea and re-crafted the ICEA Project each of the years the grant was renewed. The author's input was requested by the Project's PIs during each set of meetings for the creation and later revisions of the ICEA Project grant. The PIs made the major decisions about strategies and budgeting for each successive Phase of the Project, while the author worked to implement the strategies with the teachers and keep the daily workings of the Project within the prescribed budgetary allowances.

At the outset of the second semester of Phase II, the author was appointed ICEA Project Manager when Charles Schlosser turned his attention to completing his graduate work. As ICEA Project Manager, the author managed the day-to-day workings of the Project during Phases II, III, and IV. This included

- Each year of the Project, scheduling three teacher gatherings (August, December, and June) on the ISU campus (overseeing paperwork for teacher stipends, reserving motel rooms, arranging meals [catering, transportation, shopping], preparing written materials for distribution, organizing and conducting teacher focus groups, collecting Project artifacts for the ICEA archives [student materials teachers contributed, any videotapes of past classes or meetings for the overall ICEA video library]);
- Arranging regularly scheduled ICN teacher sub-group staff meetings (approximately every three weeks throughout the academic year—teacher volunteers helped with this);
- Scheduling and conducting yearly statewide ICN informational meetings (when trying to recruit new teachers);
- Conducting student focus groups (with a partner or a trained focus group team) in selected schools, then analyzing and reporting the results;
- Conducting teacher focus groups (with a partner or a trained focus group team) during three yearly ICEA teacher meetings, then analyzing and reporting the results;
- Preparing regular written reports documenting yearly ICEA events—these were kept for the ICEA archives but were also submitted to U.S. Department of Education Star Schools Grant personnel to include in their yearly report;
- Making yearly presentations about the ICEA Project at local, state, and national meetings (sometimes with one of the PIs, sometimes alone); these events are listed in Appendix A.

- Supervising of miscellaneous small projects related to the ICEA Project (e.g., the reproduction, packaging, and statewide shipping of the ICEA Module Package for Iowa Public Television; preparing a document for the U.S. Department of Education summarizing which of the National Science Education Standards was met by the eight ICEA Modules and three supporting ICEA Videotapes; cataloguing the ICEA videotapes contributed by different ICEA teachers for the ICEA archives; helping to design and integrate the ISU Materials Sciences Scanning Electron Microscope (SEM) with the ICEA Project, including providing forensic samples to the microscopists, helping to design the ICEA SEM web pages, and helping to arrange use of the SEM.
- Helping with the design, drafting, and editing of the ICEA brochure, the ICEA videotapes for the ICEA Module Packet, and the 23-minute ICEA overview videotape, "The Right Chemistry".

Throughout this document, from the outset of the second semester of Phase II until the Project's end, whenever mention is made of "Project personnel" undertaking some task, conducting a meeting, etc., those efforts are under the direct guidance of or are actually being conducted by the author of this document. Manuscripts produced during the course of this Project were written primarily by this author. Co-authors provided editorial advice.

II. CHAPTER 2. LITERATURE REVIEW

The two most important aspects of the ICEA Project have been the focus on student-centered learning opportunities and distance education communication technologies, especially the use of two-way interactive television and electronic mail to overcome the geographical isolation of the individual teachers and their classes, bringing groups together to collaborate and communicate. Student-centered active-learning classrooms and distance education communication technologies (two-way interactive telecommunications, electronic mail, and the Internet), therefore, are the focal point of this literature review. Input concerning all aspects of the Project was obtained via qualitative focus group interviews with teachers and students. A discussion of the use of focus groups and focus group protocol is also included in this chapter.

A. Communication Technologies and Distance Education

In empirical terms, distance education is "an organizational and technological framework for providing instruction at a distance...When the teacher and student(s) are separated by geography, technology is used to bridge the gap" (Boling and Robinson, 1999, p. 169). Even more, "...the interactive classroom bridges rather than creates distances, facilitates communication among geographically diverse groups, and encourages an interactive teaching and learning style that utilizes camera, computer, and video technology to enhance both teaching and learning for its widely dispersed participants" (Paterson, 1999, p. 20). Further, an interactive classroom can "...bridge geographical, social, cultural, and developmental distances; to provide immediate access; and to open the classroom walls to the world" (Paterson, 1999, p. 20). Simple consideration of this idea alone provides a myriad of possibilities for investigation. This review of the literature will be confined to the use of distance learning technologies as instructional and communication tools without concentrating on the sociological ramifications.

One of the most obvious characteristics of the distance education literature is the anecdotal nature of many of the reports (Hanson, 1997). The vast majority of what is written about distance learning is qualitative in nature: opinion, case-related, how-to articles, and second-hand reports that do not include original research (Merisotis and Phipps, 1999; Paterson, 1999).

1. Factors in distance learning research

The usual factors investigated by distance learning research (Hanson, 1997; Cyrs, 1997; Simonson, Smaldino, Albright, and Zvacek, 2000) include:

a. Student outcomes (grades, examination scores);

b. Student attitudes about learning through distance education;

c. Overall student satisfaction toward distance learning;

d. The distant learner's equivalent learning experience to the local student;

e. Distance education theory;

f. Technology.

Video-based interactive instruction is a generally accepted technology. Cyrs (1997) cites comparison studies looking at the learning outcomes of students in traditional and television learning classes. It was found that the students in televised learning classrooms had no significant differences in learning outcomes from their traditional counterparts. Cyrs (1997) further notes that analysis of the role of television in leaning found it to be a delivery system that provides the opportunity to deliver material to more than one location without changing it an any manner. There is no influence on the quality of instruction by the technology used to deliver it. In fact, Clark (1983) offered the argument that "...media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition," p.445. (Clark's 1983 statement did not take into consideration interactive media.) In point of fact, telelearning provides students at a distance with the same learning opportunities as the students on site (Cyrs). This presumes media as a delivery mode, without considering the possibility for interactivity.

In a follow-up study, Cyrs (1997) notes that related research determined that the proximity of the instructor did not influence the outcome of learning. Students learn from an organized, quality curriculum that is well-facilitated. Simonson and Schlosser (1995) verified that students learning at a distance achieve at an equivalent level to those learning on site in the more traditional setting with an instructor on site. Simonson and Schlosser further note that students actively engaged in distance learning sessions have demonstrated a higher level of knowledge of the subject following instruction. The quality of the learning depends largely on the ability of the participants (both instructors and students) to effectively cooperate and communicate (Lochte, 1993). "Technology is not as important as the interface between it and the human beings involved," (Lochte, p. 59). But. it should be noted that different technologies foster different interfaces.

Because technologies as delivery systems have been so crucial to the growth of distance education, research has reflected rather than driven practice (McIsaac and Gunawardena, 1996). All of these factors make encompassing conclusions difficult. But it is also these aspects that provide countless interesting studies for consideration. There is still a lot to learn about distance education and the implications of its use.

2. Myths about distance learning

Television is a part of life that has helped to shape the twentieth century—commerce, politics, and a view of the world (Srivastava, 2002). Most viewers are passive consumers of televised information, entertainment, and advertising as controlled by media moguls. *Interactive* telelearning breaks away from the paradigm of passivity and focuses on dynamic human communication. Participants are actively involved in creating the telelearning environment. *Interactive* television is more like a two-way interpersonal communication device similar to a telephone than traditional one-way television delivery is (Lochte, 1993).

Cyrs (1997) refutes a series of myths about telelearning.

a. Telecourses promote passive learning.

b. Students cannot learn as well or as much over instructional television.

c. Instructors can teach over television the same way as they do in their traditional classes.

d. Telecourses are simplistic and watered-down versions of traditional courses.

e. Telecourses are a passing fad.

f. Telecourses are not cost effective.

g. Telecourses dehumanize students.

h. Packaged telecourses are not of the same quality as traditional courses.

i. Students learn more effectively in a live classroom with the instructor physically present.

j. Instructors lose control when a telecourse is videotaped.

3. Some facts of distance learning

Comparisons of the achievements of distance learners with traditional learners or comparing distance learners to traditional learners using different technologies show no statistically significant difference between the two learning groups (McIsaac and Gunawardena, 1996; Maushak, 1997). Although no technology can replace face-to-face mentoring, modeling of communication and interpersonal skills can be similar. Lochte (1993), Schlosser (personal communication, October, 1994), Maushak, Merisotis and Phipps (1999), Felder and Brent (2000a and 2000b), and Simonson et al. (2000), report the distance learning literature suggests:

a. Distance education is just as effective as traditional education with regards to learner outcomes.

b. Regardless of technology employed, distance learners generally have a more favorable attitude toward distance education than traditional learners.

c. Distance learners feel they learn as well as if they were in a regular classroom, and maintain scores and grades comparable to their local learning peers.

d. Successful distance learners tend to be abstract learners who are intrinsically motivated and possess the ability to focus on their studies without outside intervention.

e. While interaction seems intuitively important to the learning experience, interaction should not be added without some intended purpose or goal.

f. Focusing on building collaboration and group interaction may be more important than focusing on *individual* participation. This takes additional instructor effort. Working via electronic mail or videoconferencing, virtual teams can almost duplicate face-to-face interactions.

g. Each form of distance education technology has its own advantages and disadvantages in making contributions to the overall quality of the learning experience. The instructor should adjust accordingly.

h. Passive instruction using technology does not promote much learning no matter how dynamic and entertaining the "talking head" is or how appealing the graphics are.

The focus in any ICN session must be on optimization of the learning experience for the students, both local and distant. The learner *must* be engaged in the process. The student becomes more active and cooperative in the learning process during interactive television sessions (Cyrs, 1997).

4. Shortcomings of distance education research

Merisotis and Phipps (1999) cite shortcomings of current distance education research, contending there is more work to be done.

a. Much of the current research does not control for extraneous variables and therefore cannot show cause and effect—cannot rule out differences other than the technology.

b. Most subjects of the studies are not randomly selected, using instead the more convenient intact groups available by virtue of classroom apportioning (i.e., distant vs. local learners).

c. The validity and reliability of instruments used may not measure what is purported or what reflects the purpose of the instruction.

d. Studies do not control for the attitudes between student and faculty participants.

5. Gaps in distance education research

Merisotis and Phipps (1999) further contend that there remain gaps in the research. These include the following ideas:

a. Research investigates student outcomes for individual courses rather than for total academic programs. Would a total distance-learning program be equivalent to a total traditional academic program?

b. What are the differences among students besides whether they learn in a traditional setting or at a distance? Are they equivalent groups before the learning experience? Is there any control for this in the analysis of the studies?

c. Why is the dropout rate higher for distant learners than it is for local learners? Are they less engaged in the class due to the distance? Do they not form relationships with distant classmates or the instructor that might otherwise retain them in class?

d. How do student learning styles relate to the use of technology? Is there variation?

e. In what way could the use of multiple technologies affect student learning? Could an instructor capitalize on this?

f. Is the current research theory-based?

g. Does the research investigate the role of on-line digital resources (i.e., their availability, adequacy, and usefulness)?

6. Concerns for secondary teachers

Texley (1993), Cyrs (1997), Kennephol and Last (1997), Miller (1996), Sorenson (1997), Tillotson and Henriques (1997), Gosmire and Vondrette (2001), Schopp and Rothernel (2001), Simonson and Sparks (2001), and Boschmann (2003) provide a list of possible concerns for secondary teachers considering using the ICN. They include:

a. Coordination of schedules between schools (Iowa's TEN different bell schedules present challenges);
b. ICN scheduling problems (the network is not always available on demand);
c. Laboratory sessions (the hands-on experiential component cannot easily be transmitted via the ICN—perhaps making science the most challenging subject to be taught at a distance) ;
d. Distributing materials between sites (requires adequate pre-planning);
e. Lack of local support staff (only availability, willingness, time, and more training can remediate this problem);
f. Costs associated with using the ICN (manageable at this time, but if the ICN is privatized, all of this could change);
g. Lack of training (teachers or students who have not practiced using the equipment will struggle and fumble—viewers will be bored);
h. Preparation time needed by teachers (more preparation time is required to prepare smooth and seamless ICN usage than is required for traditional classroom preparation);
i. Teachers are too busy to teach via the ICN (the preparation time required is more than they are ready to accept);
j. Lack of incentives (either monetary or in the form of release time) for teaching (why use the ICN which requires more pre-planning and preparation time when it would be simpler to conduct "business as usual"?);

k. Most administrators do not understand ICN teachers' needs (the equipment, extra preparation time, and training considerations);

l. Difficulty in establishing cooperative relationships among schools (scheduling issues due to disparate bell schedules, vacation times, teacher in-service days, parent teacher conferences, etc.);

m. Negative attitude of teachers towards the ICN (it is a different kind of teaching tool—why change from the status quo?);

n. Lack of student interest (does it mean more work? what do we get out of it?).

o. Relationships between local and distant teachers and students (does the distance affect the rapport among local and distant teachers and their students?)

p. Reaching distant students (can teachers "read the faces" of distant students?)

q. The feel of the course (can there still be a feeling of informality and interaction between teachers and students when using the ICN?)

7. Evaluation will guide practice

Evaluation of the effectiveness of a telelearning project is necessary and feedback must be immediate (Lochte, 1993; Sorenson, 1997). Usefulness to the learner group, user acceptance, user comfort are all issues to consider to make the learning experience as effective for students at a distance as for local peers. Both faculty and students should complete an evaluation, using both objective and subjective questions (Lochte). Project design can be modified in light of feedback from both faculty and students.

8. Technology is a teaching and learning tool

Two-way interactive telelearning creates an effective learning environment. Although nothing can replace two people interacting in the same classroom, distance interaction is a viable alternative when learning experiences compare favorably. This is influenced by instructor competence, student motivation, lesson design, and logistics.

The ICN environment allows teachers to improve their pedagogical skills and to use technology as an enhancement tool within existing curricula (Flemister, Sexton, and Beach, 1994; Merisotis and Phipps, 1999). Charron and Obbink (1993), Cyrs (1997), and Paterson (1999) note that the distance learning experience intensifies and motivates good teaching when sensible teacher-learner pedagogies are utilized. Exemplary teaching and productive learning may be made easier in distance education classrooms without walls where socioeconomic, regional, and physical obstacles to accessing education are substantially surmounted (Paterson).

9. Two-way interactive distance learning

Much has been written about the use of two-way interactive television as a distance-learning tool (Lochte, 1993; Willis, 1994; Hanson, 1997; Cyrs, 1997; Simonson et al., 2000). Once considered a special form of education, two-way interactive distance education practices have become part of the accepted modes of delivery (McIsaac and Gunawardena, 1996).

There are a plethora of technologies available to the public for the facilitation of distance learning. Choosing the correct tools is part of what is important in the design of a curriculum. The ICN was designed to be a two-way interactive means of communication. Garrison (1990) stated: "Education, whether it be at a distance or not, is dependent upon two-way communication. There is an increasing realization in the educational community that simply accessing information is not sufficient. In an educational experience, information must be shared, critically analyzed, and applied in order to become knowledge" (p. 13). Srivastava (2002) further observes that the value of the *interactive* television experience lies in the effort that the participants make to become engaged in the interactive communication process. This same effort is not required of passive consumers of static video.

Using two-way interactive video for distance learning is a form of educational communication that permits teachers and students, separated by distance, to synchronously see, hear, and talk with each other from classrooms equipped with cameras, television monitors, microphones, and speakers (Myers, 1994). Interactive technology classrooms are efficient cost effective additions to the widening community of learners (Paterson, 1999).

Technology issues of access—the "haves" vs. the "have-nots"—can influence a program. All sites must have equal access to technology to be equally involved in the learning process (Schoenfelder, 1997). It is important to remember that a guiding tenet in distance learning is that technology cannot replace the human factor in education (Merisotis and Phipps, 1999). There can be substantial interaction among students and distant peers or students and teachers at a distance. Students perceive that it is easier and more enjoyable for them to learn using face-to-face interactivity (Srivastava, 2002). This is possible using the ICN's two-way interactive video. But these meetings cannot replace quality on-site face-to-face encounters.

Although much of the distance education literature focuses on the role of technology in learning, other factors still retain a large degree of importance. These include meaningful learning tasks and objectives, learner characteristics, and motivation of the student and the instructor (Lochte, 1993; Merisotis and Phipps, 1999). The technology may influence perceptions of these characteristics. For example, due to the novelty effect of using technology, students might be more inclined to become involved in coursework than they would have been without the enhancement of the tools. Teachers report that students who previously might have dropped out of their courses after the first term of the academic year were staying in the course in part because of the ICN component (Ehlers, Hartman, Hepburn, and Murphy, personal communication, January 1997).

If learning tasks are not perceived to integrate well into the curriculum, students will not embrace their use. They will vocalize their dissatisfaction. A teacher who is not well prepared in a traditional classroom setting will find adapting to a distance-learning environment to be difficult (Merisotis and Phipps). A teacher who prepares well to teach in a traditional classroom will not find herself or himself challenged to prepare well to teach in a distance-learning classroom.

Little information appears in the literature concerning the use of two-way interactive video systems as a tool primarily for interactive networking among faculty (i.e., use beyond that of a teaching tool).

B. The Iowa Communications Network, ICN

1. Overview of the ICN

A variety of technologies have characterized the history of distance education in the United States. Two-way interactive fiber optics communications systems developed in the latter 1980s and early 1990s have provided the technologies for the Iowa Communications Network, a system that delivers the high quality desirable for synchronous, interactive distance learning opportunities (Maushak, 1997; Simonson et al., 2000). Travel time and travel expenses are eliminated as the ICN provides a communication network for Iowa's high school chemistry teachers, offering them the opportunity to extend their information base and develop individual information and communication networks (Texley, 1993; Cyrs, 1997; Merkley, Bozik, and Oakland, 1997; Sorenson, 1997; Anderson and Kent, 2002).

The greatest numbers of distance students in the past have been adult learners (Sorenson, 1997). The U.S. Department of Education's Star Schools Program has opened distance learning to high school students. Distance education theory and practice is, by its very nature, constantly evolving and adapting itself to ever-emerging technologies, especially that of electronic communication (Hanson, 1997).

Distance learning as outlined by Coldeway's Distance Learning Quadrant (Simonson et al., 2000) can be:

a. Same time, same place;

b. Same time, different place;

c. Different time, same place;

d. Different time, different place.

Distance education as promoted by the Iowa Communications Network is a same time, different place scenario. Students receive materials synchronously and are able to interact with each other and their instructors in real time. Students are able to learn at the same time in a variety of different locations using one or more technologies (the ICN, electronic mail, the Internet, and CU-SeeMe).

The ICN can be adapted to a variety of specific needs. Because there are over 775 ICN classrooms across the state, the ICN has the ability to improve facilities available to specific audiences through this vast network. The distance learning classroom supplies students on all sites with essentially equivalent access to all the learning experiences created in any one of the linked classrooms (Paterson, 1999).

2. The ICN classroom

a. ICN technology

The ICN classroom technology spoils a teacher (Schlosser, personal communication, August, 1994; Graf, personal communication, September, 1995; Tillotson and Henriques, 1997; Simonson et al., 2000). There are a variety of tools at her or his fingertips. The instructor can use a quality overhead display camera system, a videotape player, a slide projector, a computer linked to the Internet, and cameras directed at the teacher presentation station, as well as at the local students in attendance. In most ICN classrooms, there is also a telephone and routinely a FAX machine as well. There is usually nearby access to a photocopy machine. No traditional classroom has these same desirable facilities collected in one classroom location for the teacher (although the current classroom begins to approach this level of technology availability and clouds the distinction between distance and traditional education as classrooms become more multimedia-centered (McIsaac and Gunawardena, 1996)).

b. Students

Students are not self-selected, which means that there is a great range of abilities across the distinct classroom groups (Paterson, 1999). The ICN is a tool for the many, not specifically limited to any one school district, any particular school type (i.e., rural, suburban, or urban), or any particular type of student (e.g., honors or advanced placement, AP).

The ICN classroom provides many electronic resources for student use. Students value the ability to use the equipment and the fact that they are trusted to do so. When students use the equipment, they feel like a partner in the learning process (Lochte, 1993). It is also motivating and enjoyable. As the school year progresses, ICN interactions became more and more natural for them. Students report no fear of the challenges of using distance technologies. They learn how to use the technologies with enthusiasm. They become proficient at maneuvering camera control as they integrate video segments or presentation software components into their telepresentation sessions. Use of the equipment never intimidates students as it sometimes does teachers.

3. Suggested changes for ICN classrooms

Tillotson and Henriques (1997) suggest changes that could be made to the current ICN interactive distance learning classroom:

a. Make the equipment more flexible to allow more mobility around the classroom rather than the feeling of being tethered in one spot.

b. Design the classroom with more flexibility making it possible to install laboratory equipment.

Miller (1996) recommends devising pilot programs that include a laboratory component integrating the interactive ICN technologies to illustrate practical alternatives to traditional methods of facilitating laboratory activities.

4. Professional development

Providing teachers with equipment and staff development opportunities to learn to use the ICN technology are equally important (Clark, 1993; Lochte, 1993; Cyrs, 1997; Merkley et al., 1997; Schlosser, 1997; Sorenson, 1997; Tillotson and Henriques (1997); Burke, 1998; Burke, 1999; Anderson and Kent, 2002). Until someone uses the equipment, they have no idea what it entails or how quickly they will adapt to its use (Lochte, 1993); therefore, novices need to start teaching as soon as possible for maximum benefit. Teachers need to assume some level of ownership of the ICN to be relaxed using it as a communication tool (Merkley et al.). Not only is the appropriate training required for teachers at a distance, but it is critical for aspiring distance educators to be given local and project-wide administrative support that substantiates backing of the importance of the role of distance education.

Merkley et al. (1997) recommend that ICN-oriented staff development must include:

a. Methods to establish and maintain effective communication between interacting sites;

b. Methods to increase interaction;

c. Strategies for encouraging motivation among presenters and receivers;

d. Techniques for planning and managing organizational details, etc.;

e. Awareness of the time demands of distance-delivered courses.

Proper training accommodates differences in awareness, comprehension, comfort, and learning styles. "Ultimately, it is the opportunity for meaningful involvement, professional development, and institutional support that are the key factors in promoting faculty receptivity and significant contributions to distance education programs" (Merkley et al., 1997, p. 39). The amount of time required for training depends on the aptitudes and attitudes of the people in each class, the number of participants, and the level of expertise required. Anderson and Kent (2002) recommend extensive training prior to the first day to decrease any inherent reluctance or anxiety that a teacher may have about teaching via interactive television technology.

Teachers can benefit noticeably from interaction with mentoring colleagues as they grapple with the teaching nuances of distance education (Felder, 1993b; Merkley et al.). Transfer of knowledge and skills is effective when instruction takes place shortly before teachers begin teaching their own classes (Lochte, 1993; Myers, 1994). But, as Paterson (1999) notes, the distance learning classroom provides easy access to technology. With simple training and practice, the equipment becomes as natural for teachers and students to use as the chalkboard is.

Beyond teacher training for ICN use, teachers adopting new classroom practices would benefit from a concerted, experiential training program in those new methods. McNeal (1998) observes that most instructors do not adopt new teaching strategies by simply learning about them—it is better if they *experience* being taught in this manner. Training may be more sophisticated than they have experienced (Herman, 1998). They should practice, get feedback, and obtain support from their associates. The most successful contemporary classroom practices engage students through the spontaneity of hands-on participation in the learning process. They endeavor to learn together. Faculty should become comfortable with facilitating rather than directing these kinds of group sessions. They can do so by experiencing the sessions themselves (Crowther, 1999).

McNeal (1998) outlines an active workshop process to help faculty achieve this comfort level. Training workshops should provide active exercises to engage participants. A facilitator guides activities at the proper level of challenge and engagement that encourages dynamic interaction as well as the possibility for faculty bonding. The workshop environment parallels classroom organization and structure as well as the active learning strategies that the faculty may want to adapt to their own classroom. Within their workshop role as learners, teachers can reflect on both the value of collaboration and what their own role is in their group.

From the outset, the facilitator must set the tone of collaborative problem-solving. A well-crafted, engaging opening activity avoids faculty passive observation, disengagement or skepticism. Good ice-breakers need to be hands-on exercises that use faculty members' previous knowledge and skills and are complicated enough to provide challenge. They should be outside the expertise and experience of most participants and open-ended enough so that there is more than one possible approach to the solution of the problem. The small groups should present their findings to the entire group. After discussion, there needs to be closure.

The group should discuss what they have learned about the collaborative nature of the activity *both* as learners and as teachers. These kinds of activities encourage positive interaction, as well as increase faculty motivation to use similar activities themselves. The more familiar the process is, the more likely the instructor is to try the method.

5. Mentoring

As one very important aspect of professional development, mentoring among teachers is recommended (Bullard and Felder, 2003). Mentors provide the support network that novices require at the outset of undertaking a different instructional approach. A person cannot become comfortable with an alternate approach to instruction during a one semester course, let alone a three-day (or less) training workshop (Felder, 1993b). Mentors can help novices find an individual approach suited to their own teaching strengths, personalities, student populations, and school and district administrative constraints. Felder recommends that mentors should in some way be compensated.

When a novice is challenged with some problem, the mentor may *suggest* a way of devising a solution, but should then withdraw, remaining at a distance and observing how the novice copes rather than trying to interfere to solve the problem (Felder, 1993b). Bullard and Felder (2003) cite multiple benefits that the mentee derives from a mentor-mentee relationship. The mentee:

a. Receives frequent demonstrations of good teaching practices and has the opportunity to implement them;
b. Is provided effective feedback on her/his performance;
c. Has some reprieve from the responsibility of developing content materials from scratch;
d. Does not experience as much apprehension of "going it alone";
e. Discovers a sounding board for new ideas;
f. Receives help with questions and problems;

g. Is able to teach class at a higher level the first time;

h. Finds a colleague who has her or his best interest at heart;

i. Is in a position to offer the mentor new ideas from the novice perspective.

Mentoring team debriefing sessions provide instructors with the opportunities to discuss what strategies, activities, etc. are being contemplated or what has already been accomplished. As the novices become more experienced, they gradually assume more autonomy, and are less dependent on mentors.

6. Teacher preparation time

Teaching *goals* remain the same whether teaching at a distance or in the traditional classroom (Tillotson and Henriques, 1997). But, planning for teaching at a distance involves time for the modification of current materials and creation of new materials (Graf, personal communication, March, 1995; Cyrs, 1997; Merkley et al., 1997; Sorenson, 1997; Simonson et al., 2000). The amount of time dedicated to planning and reorganizing traditional curriculum to adapt it to two-way interactive distance learning environments impacts the quality of telesessions as well as how thoroughly students learn (Cyrs). Although the role of the teacher tends to be that of facilitator, the amount of work to keep all of the interactive groups interrelating can easily more than *triple* the traditional tasks of the teachers (Flemister et al., 1994). Support personnel and guidance are needed to provide instructors with the time to adapt traditional materials and to devise new materials designed to utilize the flexibility of two-way interactive ICN technologies. One cannot simply walk into a distance education session and "wing it". A concerted effort is required to prepare an organized cohesive lesson plan. Teachers considered principles of visual thinking, student engagement, use of study guides, presentation skills, telecourse organization and planning, and technical skills essential for producing two-way interactive modules and ICN sessions (Schlosser, 1997). Any developmental efforts on the design and implementation of interactive telelearning materials can lead to the improvement of a teacher's performance in the traditional classroom as well as improved communication with students and colleagues.

7. Development of materials

It is important to pay special attention to the development of strategies and curricular materials to be implemented at a distance. Learning modules must be designed and modified for implementation as *tools to be used with* synchronous interactive cooperative ICN sessions. Materials must be prepared in a more detailed way for students working to understand the strategies that they need to employ to communicate effectively using the two-way interactive communications system (Cyrs, 1997). Project activities must be organized well—a systematic approach to educational coordination and implementation is crucial (Myers, 1994). "Down time" is magnified on television (Lochte, 1993).

Further, Myers (1994) notes that educational planning requires developing a coordination plan (membership, timeline, milestones and completion dates, and problem-solving strategies), establishing committees and their responsibilities (goals and objectives, membership and responsibilities of the committees, and schedules), resolving instructional issues (who will teach on the system, how materials are exchanged), developing policy (remote-site discipline, coordination of grading policies, student attendance, teacher absence, preparation time, training to use the ICN classroom and ICN equipment, school bell and calendar schedule coordination, module offerings and schedule, distance learning policy, extracurricular access to the network and classrooms), and defining teacher training requirements (so that the most efficient and effective use of the network occurs).

8. Principles and strategies for effective teleteaching

Lochte (1993), Cyrs (1997), and Boaz (1999) summarize principles of and strategies for effective teleteaching and telelearning. Boaz advises that the focus should be on the individuals, not the technology. The outcome(s) of the interactions is what is important, not the means by which they occur. The technology should become invisible to the communication process.

A teacher should:

a. Encourage active learning by creating an active teleclassroom that engages students, and gets them involved in their own learning.

Activities must relate, be meaningful, and be doable. Students must be engaged in the learning process. The emphasis is on higher level application and critical thinking skills. To keep their attention, students should be involved in interactive exercises between 30-50% of the time.

Students must learn through discovery and exploration. The teacher must be the guide or catalyst who facilitates this process. A mixture of technologies, both synchronous and asynchronous allow the most opportunity for interaction.

Instructors prepare the experiences and activities to allow the students to have fun as they learn so that they want to pursue the topic(s).

b. Communicate high expectations that students perceive to be achievable.

Cyrs recommends that the students be convinced that they can succeed in learning activities and can use what they have learned. This is the reason real world tasks should be designed to connect with discipline-oriented concepts.

c. Emphasize time spent on learning tasks.

d. Respect diversity in the classroom and different methods of learning.

Instructors encourage tolerance, discourage snide remarks, criticisms, sarcasm, or any types of remarks or behavior that might embarrass any student. Students must remember that although the push to talk microphones may not pick up harsh comments without being depressed, the teacher microphone might. Students who are unfamiliar with a distance learning environment are unaware of communication protocols and prefer to be provided with guidelines for what is appropriate behavior.

e. Encourage student/instructor contact before and after class.

The teacher must remember that instructor impact on the students is actually *greater before and after* class than it is *during* class.

f. Promote cooperative learning among students.

The premise of cooperative learning is that knowledge is socially constructed. Collaboration over a distance promotes a sense of unity. No one individual on the team contributes more than the team as a whole. The strength of the team is the sum of its parts. Critical thinking is fostered by teamwork. Evaluation has a two-fold emphasis: the group project provides a common grade for each team member and the individual is assessed via contribution to the group effort by both instructor and peer appraisal.

g. Provide punctual feedback to students on learning achievement.

Positive timely input from instructors to their students is recommended. In addition, instructors are encouraged to solicit feedback on how the class is going for the students.

h. Communicate and link teaching and learning goals and objectives in ways that students understand them.

In order for student-centered learning to be effective, students should have some idea of their own learning goals.

i. Scaffold and connect newly acquired information to prior knowledge.

j. Present the information in personally meaningful ways. In designing the telecourse organization, syllabus, and handouts, employ analogies and metaphors to show the content structure.

Anything that classmates both on-site and at a distance can do to help one another to organize their learning experiences in a better way is beneficial to the success of learner outcomes across schools.

k. Provide adequate and appropriate practice for transfer and application of skills.

A student might know information, but not know how to apply what is known. Learning opportunities to explore this are recommended.

l. Motivate students in any conceivable way. Explain why they should learn something, what the benefits are to them if they learn it, and how they can apply the skill or data immediately.

m. Advocate elevated processing of learning through tests, questions, activities, and exercises that are based on high-level learning performance objectives—students learn as they are assessed.

Students who are assessed on the basis of higher order critical thinking skills and application of concepts are apt to recall more than those tested over memory recall alone. They will also retain it longer.

n. Visualize key concepts and ideas and share the visual picture.

Students play with technology every day. They are comfortable "Internet surfing". They play video games and computer games. They communicate via electronic mail. Their parents have videotaped them for posterity since infancy. It is, however, somewhat novel to them to apply these technologies to their school work. Teachers should capitalize on this familiarity to encourage them to utilize as many of these technologies as they are able to prepare visually-based collaborative lessons for ICN presentation. Students have a marvelous ability to create presentations which their instructors could not even imagine. They are intrigued and motivated by the opportunity to explore and have fun, with the excuse of learning. Just as cleverly-prepared commercial advertisements catch their attention, if lessons are prepared creatively, students will find them appealing and remember the "point(s)" of the lesson.

o. Articulate your instructor philosophy and model of teaching and learning—students are "in charge" of their own learning.

p. Know who you are as a teacher and the priority of teaching in your career.

Students intuitively know if an instructor has a genuine interest in them and what they are accomplishing, or whether the instructor is serving as a care provider merely marking time until the end of the class period (or the end of a career).

q. Take best advantage of in interactive telelearning environment.

1) Consider the camera to be just another student and include it in all conversations and interactions.

2) Use a good visual aid to interpret a lesson, focus attention, alleviate monotony. Look at visual aids at the greatest distance on the poorest television monitor available before using them.

3) Practice with the equipment so that there is no fumbling. It is best to demonstrate competence.

4) Have a contingency plan—it is a *must* in case of network down time.

5) Design and develop purposeful tactics or methods for good student engagement.

C. Electronic mail

Electronic mail is a non-confrontational electronic delivery system offering service twenty four hours a day, seven days a week that can be used in synchronous or asynchronous mode for communications with correspondents located anywhere in the world (Cyrs, 1997). E-mail is ideal for clear communication (Marbach-Ad and Sokolove, 2001). Messages can be sent to groups of persons or to individuals. Messages can be stored or archived. The unstructured nature of e-mail provides a simple, convenient means of communication.

Electronic mail is the most common asynchronous communication tool (Simonson et al., 2000). Electronic mail provides correspondents with the opportunity for collaboration. It allows direct one-on-one interaction for those communicating. Students can interact with other students, with their own teacher, or with other teachers; and teachers can interact with their own students, other students, or with other teachers.

The use of e-mail is beneficial to students. It provides an alternate means for interaction, thereby expanding student learning environments. Continued use of e-mail allows improvements of reading, writing, and communication skills (Hedges and Mania-Farnell, 1998; Pence, 1999); discussions are expanded beyond the actual classroom; there is a motivation for writing and for natural communication (Frizler, 1999). Advantages of electronic mail are that it allows for self-pacing of collaborations and allows time for reflection before response (Angelo and Cross, 1993; Marbach-ad and Sokolove, 2000; Simonson et al., 2000). For example, students are assigned to read a text and then to write corresponding questions about the material. Composing these questions serves to help them realize what they do and do not understand about what they have read.

Use of electronic mail encourages student questions because it is private, secure, and essentially non-threatening (Marbach-Ad and Sokolove, 2001). Because it is asynchronous, e-mail allows students to compose messages and review them before sending them. This yields more understandable, better-crafted questions and answers. And, the act of writing itself is a good way to make ideas clearer and improve comprehension. Using electronic mail, every student has an equal opportunity to share thoughts (assuming every student has equal access to a computer able to send and receive electronic mail) (Angelo and Cross; Mania-Farnell; Frizler).

Pence (1999) believes that cooperative electronic mail interactions are an effective communication technology for introductory chemistry. Electronic mail bolsters and can even enhance active learning (Marbach-Ad and Sokolove, 2001). The combination of cooperative learning and electronic mail provides a new means of allowing students to interact. They feel they can disclose their feelings with relative anonymity. At the same time it encourages them to improve their social and communication skills via technological interactions. Electronic mail increases the opportunity for interactions, both student-student and student-instructor. Using e-mail helps students feel more comfortable asking questions. They can include inquiries of a more personal nature (procedural questions, questions about examinations, quizzes, assignments, and questions about grades). The students who would never ask a question in, during, or after class are not as hesitant to pose it via e-mail (Marbach-Ad and Sokolove, 2000). During e-mail communication, an instructor who notes that a student holds some kind of misconception is in a position to make an immediate correction (Marbach-Ad and Sokolove, 2001). Cooperative learning implementing electronic mail as one means of enhanced communication has a positive effect on student learning and retention (Dougherty, Bowen, Berger, Rees, Mellon, and Pulliam, 1995; Palmquist, 2000).

Disadvantages of e-mail are few (beyond the lack of access), but may include the lack of immediate feedback and the length of time required to carry on an asynchronous "discussion" (although synchronous communication is possible), whereas ICN communication is always a synchronous process (Simonson et al., 2000) .

D. The Internet

Internet-based activities should not be assigned simply to make use of the Internet as a resource. Research questions can be designed to use other more traditional reference sources (such as an encyclopedia, etc.).

Frizler (1999) recommends assessing the comfort and skill levels of students in regards to technology to know how to pair students who have technology experience, with students who do not. Not unexpectedly, students seem to assign themselves in working groups like this, without teacher intervention.

Designing viable Internet activities necessitates several considerations by the instructor (Frizler, 1999):

a. Do the students have a place to work on their Internet task? Are there open computer labs for students?

b. Is there a computer classroom that could be used to demonstrate Internet search techniques for an entire group?

Frizler (1999) advises putting together Internet materials by collaborating with a group of instructors. Teachers can design and critique their materials among their group prior to using them. Modifications of materials can be accomplished in the same way, via use, evaluation, and assessment by a teacher group.

Frizler (1999) recommends that an Internet-based learning package should be evaluated from the perspective of teaching *and* learning. Students should be questioned as to how they felt they benefited from having an Internet component in their class. In concert with the dynamic nature of the Internet, once a set of materials has been designed and implemented, teachers should constantly ask themselves how activities can be revised to improve them.

E. Focus Group Evaluation

Conducting focus group interviews can provide critical qualitative input that shapes the development of research.

1. What is a focus group?

A focus group is a type of topical interview (i.e., deal primarily with explaining an event or describing a process) that addresses questions to a group of individuals who have been specifically assembled for the purpose of interacting with a questioner and fellow group members about a particular set of topics of interest to the researcher. Topical interviews seek detailed factual information and pertain to what happened, when, and why (Rubin and Rubin, 1995). Techniques for focus groups were designed in the 1940s and 1950s (Esterberg, 2002). Gall, Borg, and Gall (1996) and Francisco, Nakhleh, Nurrenbern, and Miller (2002) define a focus group as a “carefully planned discussion” designed to obtain perceptions on a defined area of interest in a “permissive, non-threatening environment”. It is conducted with a small group of people by an experienced interviewer who attempts to elicit a variety of perspectives. There should be no fewer than four nor more than twelve participants (Morgan 1988; Greenbaum, 1998). The discussion is relaxed, comfortable, and often gratifying for participants as they share their ideas and perceptions. Group members influence each other by responding to ideas and comments raised in the discussion. Ideas flow from a guided interchange. The data evolves from group communication.

Focus groups are comparatively easy to conduct and are one means of collecting a large amount of qualitative data. The research can be done relatively cheaply and quickly. A larger variety of responses can be collected via focus group protocol than by individual interviews. Feminists feel that focus groups especially empower women, permitting them a voice by equalizing the power balance between researcher and interviewee (Esterberg, 2002).

Interactions *among* the participants encourage them to share their thoughts, explaining feelings, perceptions, and convictions, opinions, and attitudes that they might not otherwise reveal or think to share if they were interviewed as separate individuals (Rubin and Rubin, 1995). These multi-faceted dialogues can probe issues more deeply than simple interview responses. This serves to "maximize the benefits and minimize the limitations of group dynamics" (Greenbaum, 1998, p.27). There is safety in numbers. Participant ideas work off of one another. The format is not rigidly structured, in order to encourage respondents to express their own ideas in their own words. The interview questions are relatively broad in nature. This holds the discussion on track but allow for spontaneity; it places no limit on the scope of the conversation and is an effort to garner as much information as possible from all respondents.

Conducting focus group interviews is a highly effective method for collecting information (Morgan, 1988; Chudowsky and Behuniak, 1998; Greenbaum, 1998; Francisco et al., 2002). The use of focus groups is a dynamic research method that provides a rich source of contextual information about selected specific topics not available via the less flexible survey approach. The primary characteristic of focus groups is the intentional use of the group interaction to produce data and insights that would be less available without the contact found in a group—the synergy of the group provides a richer response than would be available from the individuals—the whole is greater than sum of the parts.

Group interviews can produce valuable data with relatively little overt input from the researcher. Focus group interviews should pay attention to the difference between what participants find interesting and what they find important. Interaction is integral to success and must be encouraged to maximize the quality of the output from the session. If a session does not contain significant interaction, one of the most important benefits is lost. Differences in perspective are uncovered by how questions are posed and answered. Issues are explored about how focus group participants agree and disagree. The moderator encourages the participants to discuss a topic until their points of agreement and disagreement become evident. The moderator facilitates efforts to resolve differences and build consensus.

2. Advantages and strengths of focus groups

The strength of focus groups lies in their capacity to explore topics and engender hypotheses. The most important factor is finding a group of participants who are comfortable interacting with one another and who are not hesitant to share their opinions without constraint (Esterberg, 2002). There are several advantages that focus group interviews have over survey methodology (Morgan, 1988; Chudowsky and Behuniak, 1998; Greenbaum, 1998; Esterberg, 2002; Francisco et al., 2002).

a. Focus groups provide the opportunity to gather unanticipated responses. Group members have the opportunity to comment in response to the opinions of other respondents. From these unexpected responses, ideas that had not previously been considered can be investigated. A paper and pencil survey is limited to the questions asked. There is not a possibility to clarify or explore other related or even unrelated ideas. During a focus group, one idea engenders another or series of others.

b. Focus groups are a practical approach to gain an insight into the character and intensity of the emotional response of the participants. Focus groups are better suited to topics of attitudes and cognitions than other kinds of qualitative research. Cognitive processes are revealed through focus group interaction in ways that it would not be possible to observe otherwise. No computer analysis of survey responses can gauge the feelings of respondents in the same way as the unbiased conductor of a focus group who can pay attention to the nonverbal aspects of the interactions and observe body language along with respondent interactions. Audiotaped recordings of the transcript are able to depict emotional nuances that written surveys could not detect.

c. The anecdotal evidence collected through group interaction may provide significant points and added appeal and interest for the reader. This is part of a larger effort to triangulate different forms of data collection on the same topic. The independent self-contained nature of the focus group is a crucial feature of its ability to contribute to triangulation. Focus groups treat the perceptions of participants as the basis for a discussion among a collection of individuals whose ideas may be subtly or widely different from one another. Survey compilations may provide a skeleton of information pursuant to an issue or issues, but focus group responses fill out the skeleton multidimensionally.

d. Interactions within the group may produce insights not otherwise obtained using other methods. Scripted questions (called the moderator guide) lead the discussion, ensuring that a set common core of questions is asked of all participants; but there is a freedom to explore other issues. Respondents may raise some points not considered by the focus group organizer or facilitator and not available by a set of one-dimensional survey responses. Focus groups are useful when it comes to investigating WHAT participants think, but they excel at uncovering WHY participants think as they do (Morgan, 1988; Greenbaum, 1998).

The focus group approach avoids putting interviewers into a leadership role. They introduce themselves in such a way as to establish trust and rapport among the participants. Prior to conducting the formal focus group, they converse with participants to create a relaxed atmosphere. But it is the participants who "run" the focus group.

3. Features of the focus group

The three most important features of the focus group (Greenbaum, 1998) are

1. The choice of moderator;
2. The moderator guide;
3. The recruiting of appropriate participants.

a. Moderator

The moderator is the most important element in the focus group process (Greenbaum, 1998). She or he works to develop a comfortable atmosphere so that those participating are willing to talk in front of people they may not already know (Rubin and Rubin, 1995). The moderator is responsible to conduct research in advance to prepare for conducting the focus group, to prepare the moderator guide, to set the tone and implement the focus group in such a way as to accomplish the research objectives, and finally, to complete a post-focus group analysis and report.

Moderators facilitate discussion without interjecting opinions or comments. Neither does their tone of voice or nonverbal response give any indication of their own opinion. They must also be prepared to ask probing questions if a response is not clear or to redirect discussions that stray too much from the topic under consideration. Leaders should also be acutely attuned to make note of nonverbal information that might be shared during the focus group. They should be prepared to read body language that might communicate respondent opinions. They are trying to elicit overall participant reaction to their questions. In addition, moderators try to determine participant concerns, suggestions, and recommendations participants have for future work. Deviations from the moderator guide can be made in order to foster a productive topic of discussion; but no pre-planned topics should be abandoned.

Greenbaum (1998) likens the focus group moderator to an orchestra conductor. She or he give overall direction while encouraging the participants to do most of the work (talking) (Rubin and Rubin, 1995). The selection of an appropriate moderator makes the difference between a successful group that provides exceptional information and a group that provides mediocre or ambiguous information.

1) Moderator characteristics. Morgan (1988), Greenbaum (19998), and Glesne (1999) outline a number of characteristics that a good focus group leader should have. Some characteristics can be learned, others are inherent personality traits.

A moderator should be:

a) Personable. The moderator should be congenial in order to encourage rapport with participants who should want to become actively involved in the discussion to please the moderator. If this is not achieved, participants may not discuss openly and the worth of resultant discussions is not equivalent.
b) Well-organized. The moderator should adequately prepare prior to focus group sessions by reviewing the moderator guide, as well as any questions that the research team has, to be certain that all is understood.
c) A good listener. The moderator guides the discussion based on what has already transpired.

Glesne (1999) suggests that a skilled moderator should be able to

a) Anticipate how to phrase questions for the audience—i.e., students require different treatment from instructors.
b) Play the role of being naive—the moderator should make no assumptions nor interject any opinions, but rather, encourage the participants to provide these.
c) Be non-directive—probe without sharing opinion, guide without dictating.

d) Be therapeutic—provide the participant with a forum to share opinions but also unburden themselves of strong feelings that they have kept suppressed.

The successful leader should have a high energy level from start to finish-to avoid the boringness that could develop if the group interaction is not dynamic or members are not highly engaged in the process of discussion. Some degree of experience with the process of conducting a focus group is advantageous. Experience with the project or topic(s) under discussion is beneficial, but not essential. The leader should be a quick learner—an accomplished moderator should be able to quickly acquire enough information about the topic at hand to create an effective moderator guide as well as facilitate successful group sessions while always remaining objective. The moderator should have good communication skills—via input in composing the moderator guide, asking questions during the process of conducting the focus group, and in drafting the final report.

One very important skill the moderator should possess is a good short-term auditory memory. This is so that the leader can remember comments made earlier in a session in order to relate them to later statements. Morgan (1988) and Greenbaum (1998) recommend that a good moderator should be able to

a) Paraphrase, restate, or clarify participant comments.
b) Sequence comments logically to tie them together.
c) Interpret results.
d) Draw conclusions, make recommendations beyond the scope of the group.
e) Identify key points in a topic and focus on them.
f) Listen and search for points to elicit from participants.

The focus group moderator asks questions to launch the dialogue, but then simply facilitates or guides, letting participants take primary responsibility for sharing their views and eliciting the views of others in the group. The topic is introduced in a general fashion. The focus group leader is there to learn from the group. All questions are asked in clear terms and investigate only one idea. Initial questions are non-controversial and uncomplicated, in order to set the tone and build trust. The moderator moves at a pace sufficient to accommodate all topics thoroughly without hindering discussion in any one area. Pragmatically, the skilled focus group leader will end the focus group session within 10 minutes of the agreed time.

Esterberg (2002) suggests that if the focus group moderator is of the same racial or ethnic background as the members of the group, rapport may be more easily achieved, leading to a more successful focus group. There were no observations made about the gender of the moderator and successful focus group interviews.

2) Moderator involvement. Low levels of moderator involvement are important when goals include doing full-scale content analysis. If not, the results could characterize what the moderator, rather than the participants, thought was exciting or of consequence.

High levels of moderator involvement are more appropriate when there is a strong externally generated agenda. The moderator can

a) Guide interaction in the group.

b) Steer irrelevant conversation back on track.

c) Initiate new discussion when the group dynamic begins to lag.

d) Guarantee that the group does not quash convictions that differ from the majority.

e) Discourage dominant participants.

f) Include reticent participants.

b. Moderator guide.

Moderators work from a draft outline called the moderator guide, designed to accommodate and accomplish the research objectives. The moderator guide should be prepared with as much time and attention as a questionnaire for quantitative study would be prepared. External stimuli need to be adequately incorporated. For example, participants may need to be reminded of the different aspects of the topic to be discussed before the beginning of the focus group. The summary should be brief but thorough—if it is insufficiently presented, the results are not useful. The summary should be communicated to the participants as clearly as possible but without bias.

The goal is to have the participants do most of the talking, cued by probes from the prepared guide.

c. Participants

1) **Time.** The duration of a focus group is usually fixed at one to two hours. There is only a finite amount of time that volunteer (or paid) participants can continue to pay attention to the topic at hand and make meaningful contributions. After too much time, attention wanes and results lose value.

2) **Number of groups.** The number of groups is the primary dimension of variability in planning focus group research studies. Researchers can establish a target number of groups in the planning stage, but should be flexible when making the decision about the final number. The more homogeneous groups are, the fewer will be needed. The goal is homegeneity in background, not in participant attitude. If the moderator can anticipate what will be said next in a group, then the research is done and there is no need for a focus group interview. Getting to this point usually requires the analysis of three to four groups (Morgan, 1988). The moderator can adjust the number of groups by gauging whether additional discussion is producing new ideas. If the research goal is a detailed content examination with relatively unstructured groups then six to eight or more groups will be necessary (Morgan, 1988).

3) **Members.** Members of the focus group are selected to provide the highest quality feedback on the topics being explored. Focus groups can be composed of members of a pre-existing group. When participants are members of an already established group, the members must all be relatively homogeneous (Morgan, 1988; Greenbaum, 1998) and on an equal basis (Gall et al., 1996).

4) Group size. Only a relatively restricted range of group sizes is pragmatic for an interview session. Focus group size is relatively small, on average, seven to ten members in order to allow for a variety of opinions to be sampled without precluding the opportunity to share among any of the participants. Four is the smallest size for a successful focus group and the upper limit is about 12. It is important to over-recruit by 20% , although the actual extent of over-recruitment depends on several aspects: where the groups are held, who the participants are, whether they are being compensated for taking part, and how critical the size range is for the overall strategy of the research (Morgan, 1988; Greenbaum, 1998; Esterberg, 2002). The more participants who are included, the more difficult it is to manage their discussion. Larger groups characteristically require a higher degree of moderator involvement and it requires an experienced moderator to control a larger group without constant efforts at keeping on task.

5) Timely arrival. All members must be together at the same time and place for the focus group to be effective. When members of a pre-existing group are missing, the focus group may not have the breadth and depth that would be possible with all members present. Respondents who arrive late or leave early also deprive the facilitators of their express opinion about the issues that they are unable to discuss during their absence.

d. Record of the focus group

1) Audiotaping. Both audiotaping and handwritten note taking strategies can be used to record focus group comments. Gall et al., (1996) note that audiotaping has several advantages over note taking. Audiotaping provides a complete documentation of the focus group conversation. It can be played and replayed to elicit pertinent information. There could be an unconscious bias in the process of note taking wherein the recorder fails to record all comments, having decided that they may have been irrelevant, unimportant, or the like. With an audiotape system, all comments can be retrieved. Using an audiotape protocol also speeds up the interview process. Finally, audiotaped comments can be analyzed by more than one evaluator (for purposes of confirming interrater reliability).

Choice of physical facilities must be made with tape recording clearly in mind. Transcripts of the audiotape are the basic data that the research produces. It is essential to ensure the quality of the recorded data. Few respondents have any qualms about the need to audiotape to collect a record of the discussion. It should be noted, however, that for some participants, if they feel that an audio record of their comments is being made, they might hesitate to share ideas and feelings about controversial topics.

2) Handwritten notes. Handwritten note-taking organizes the data as it is being collected. Gall et al., (1996) observe that note taking may distract the respondents during the interview process, especially if participants are discussing controversial or sensitive issues. Watching someone transcribe their comments could serve to unnerve them.

3) Dual recording. To attempt to eliminate some of these difficulties associated with note taking and audio taping, two focus group facilitators can worked together. The first (leader) engages in the dialogue with respondents, the second acts as recorder. The "leader" posed the questions; the recorder simultaneously monitors the audiotape system and takes notes. Respondents interact with and pay more attention to the "leader", while the recorder conducts the business of data collection, becoming essentially transparent to the process. Participants pay little or no attention to the recorder unless she or he turns a page while taking notes or turns over the audiotape at the halfway point in the interview.

This dual recording method (note-taking *and* audio-taping) ensures the collection of the desired information. One method supports the other (Esterberg, 2002).

e. Problems with focus groups

The use of focus group interviews themselves can be problematic (Chudowsky and Behuniak, 1998).

1) Small sample sizes limit the generalizability of the results. It is difficult to use large samples for focus groups because of the time required to provide each participant with the opportunity for adequate reflection on the issue. A reasonable group size (12 or less) promotes respondent interaction that can be more naturally conversational.

2) Participants need to raise issues themselves. If the group does not raise an issue, it may exist but just not be voiced. The researcher would not be aware of a major point because it has not been mentioned. If an issue suggests itself to the facilitator as the focus group progresses, she or he is in a position to introduce the idea to the group.

3) Determining the degree of concern raised within the focus groups can be difficult. A strongly expressed view at one or two focus group sites could be particular to those individual sites or could be indication of a much more widely held concern. Facilitators need to elicit elaborating comments to clarify this.

Any limitations in using focus groups could be remedied by combining focus group methodologies with other data collection techniques. These combinations could provide a strategy such as the following:

1) Conduct a limited number of targeted focus groups to get at or evolve the ideas.
2) Use the feedback generated from the focus groups to devise a proper survey for a more global inquiry.
3) Conduct a random sample survey of test sites.
4) Summarize all results to provide the broadest basis for validating the assessment.

It should be noted that supplementing focus groups with questionnaires may have disadvantages. The two methods may be mutually contaminating to one another. For example, completing a questionnaire prior to a focus group can tend to direct group discussion, while conducting the focus group first may change participants' attitudes.

Using questionnaires can also introduce complications. It is more difficult to accommodate participants who arrive late when using pre-questionnaires. If the participant has not completed a questionnaire similar to fellow members of the focus group, information is missing for one of the participants who is an influence on discussion in the whole group. If, instead, there is a post-questionnaire, there may be those participants who leave prior to supplying the necessary post-interview data.

The use of questionnaires has its advantages. Collecting background data provides a more complete picture of the group participating. The information can help constitute the moderator notes after each session.

f. Group dynamics

The moderator must be able to enhance group dynamics during the session. The group dynamics that occur when people interact about a given topic generate more information than one might get from individual interviews. There is a synergy among participants. The sum of their interaction as engaged participants in the focus group is greater than the additive value of individual interviews with each of them would be. An effective moderator can motivate the people in a session to communicate with each other as a way of exploring issues of common agreement or disagreement, generating a more complete picture of attitudes than from each individual. Unresponsive interactions could impede the productivity and effectiveness of a focus group.

A few participants should not be allowed to affect the participation of others. Unless special care is taken by the moderator during the discussion, some members can significantly influence other participants' reactions to specific questions or in their reporting their own ideas. The presence of others is helpful in the focus group but also may hinder the smooth flow.

g. Participant authenticity

Some participants provide only positive feedback in order to please the moderator. One solution to this problem is to have participants write down their own opinions before beginning the focus group. If participants are encouraged to articulate their beliefs before progressing, they come to better realize their own perspective on the matter. They remain truer to their original opinion and are not as easily influenced by other members of the group. This results in more honesty when individual viewpoints are shared.

h. Dominant personalities

One vocally opinionated person could dominate a focus group session and influence the contributions of others. Some participants will hesitate to speak in this kind of situation (Rubin and Rubin, 1995). When dominant personalities threaten the productive dynamics of a focus group, some action must be taken to ensure an unbiased final product. The moderator takes active control and reminds the group that their objective is to hear from everyone about how they each feel. The leader can directly call on quieter members to solicit their opinions.

Another tactic used is enforced silence—the moderator essentially ignores the dominant person. Although a strategy of this sort can create some resentment on the part of the group as a whole, the moderator can explain the problem by sharing the conviction that it is important for everyone in group to participate and that each view is as important as the next (trying to do this without alienation).

i. Session descriptions

The room chosen for the focus group must be large enough that participants do not have to sit too closely to each other. If they are not comfortable, the entire focus group dynamic will be less effective. The room should be as soundproof as possible to eliminate potential distractions.

j. Ground rules

Esterberg (2002) recommends that the moderator speak to the issue of confidentiality so that participants are aware that they should not discuss what they have seen and heard during the focus group once they leave the room. All focus group members are encouraged to participate, with no one person dominating. There can be only one person speaking at a time. No one can carry on side conversations with neighbors.

k. Bias

A focus group is highly subjective. Observers must strive for impartiality. All observers may not interpret what happened during the focus group session in the same way. Biased observers may interpret comments through preconceived disposition that allows only the input that fits the bias and no other input. If results are reported on this basis, the resulting research is tainted.

Biased moderators produce data that reproduces those biases. Moderators should have "understanding empathy and disciplined detachment," (Morgan, 1988, p. 50). The moderator must maintain a completely objective perspective throughout the process so that final report accurately and objectively summarizes the factual information and provides independent interpretation. This account could be used in the future to refer back to results of past focus groups.

l. Interest level

The moderator may find it helpful to begin the focus group with questions that will be of most interest to the participants, not necessarily those of most interest to the researcher. In this way, the participants become engaged in sharing their thoughts and the focus group dynamic is assured.

m. Analysis

Focus group data embodies the words and evidence of all participants interviewed, but they are interpreted by the researcher. A focus group analysis should not try to quantify results of focus group session, it should utilize them to elaborate on quantitative results. It must not overemphasize the opinions shared by those who seem to provide the "desired" input. It must try to get a general overview of the major strengths and weaknesses of the concept.

Focus group analysis is of two basic types, ethnographic summary and systematic coding. An ethnographic summary relies more on direct quotation of group discussion points.

Systematic coding via content analysis produces numerical descriptions of the data. Although either could be used effectively, there is additional efficacy from combining the two. For example, it is useful to include characteristic quotes in a quantitative summary of data. In reporting and summarizing, the moderator is challenged to strike a balance between the direct quotation of the participants and a summary of their discussion(s). Too much quoting is not preferred (could be seen as filler) nor is too much summarization (too dry). It is important to distinguish which topics are more significant and concentrate on thorough portrayal of only what is most important.

Painstaking analysis of the results of one or two focus groups elicits themes leading to a general idea of what has been learned. More than one person can examine the transcriptions and the two analyses can be compared. Morgan (1988) and Greenbaum (1998) recommend that the focus group report include about one-third participant quotations, with the rest divided between setting the stage for quotations and interpreting the implications of the quotations.

F. The Changing Emphasis in the Classroom— Away from “Coverage” to "Understanding"

1. The learning process

We begin to learn when we are born and ideally continue to do so until we die. Hooper and Hannifin (1988) outline three stages of learning:

a. Students can discriminate between examples but are unable to apply their knowledge to new situations or provide in-depth explanations.

b. Students undertake restructuring—some transfer of knowledge is possible, but they are not able to thoroughly explain.

c. Students able to solve novel problems as well as explain them.

These parallel Jean Piaget's four stages of cognitive development (Pressley, 1996):

a. Sensorimotor (0-2 years) when intelligence takes the form of motor actions (not connected to things outside the child);

b. Preoperational (3-7 years) when intelligence is intuitive in nature; children can think in symbolic terms—pretend, verbalize, understand past and future; however, cause and effect, and concepts such as time and comparison are not attainable;

c. Concrete operational (8-11) when the cognitive structure is logical but depends on concrete referents; trying to reason through a problem with several aspects is still a reach at this stage;

d. Formal operational (12-15 years) when thinking involves abstractions, such as mathematical problem solving, understanding methodology, proposing hypotheses.

The way we learn adapts to different stages in our lives. Much of what is first learned by an infant is task-oriented; there is an interest in learning for the sake of learning. The learner does self-evaluation, deciding whether or not performance is adequate, and whether the effort expended has been appropriate (Ward and Bodner, 1993). If not, the learner strives to achieve at what is personally deemed an acceptable level. Deep learning strategies are developed.

With maturity comes a shift away from task orientation to ego-orientation wherein success or failure is self-attributed to ability. Ego-oriented learning is more superficial. Students learn more effectively in a task-oriented mode. Task orientation also encourages life-long learning. An instructor can encourage task orientation by emphasizing the *process* of learning and de-emphasizing grades, competition among peers, and comparisons among students (Ward and Bodner, 1993). Grading on an absolute scale rather than on a "curve" can foster cooperative learning—students are not competing against each other for grades. Curve grading makes students reluctant to work together (Paulson, 1999; Greenbowe and Burke, 2003). Curve grading supports competition. Self-improvement merits reward and final grades reflect it.

McDermott (1991) notes that the curriculum is not well-matched to students. A large number arrive inadequately prepared for the level of instruction the instructor is prepared to provide. Students will learn by direct experience with several different methods and the process of inquiry. Learners need a curriculum that can involve the widest spectrum of students (Bodner, 1992) and accommodate the widest variety of learning styles (Bretz, 2004).

2. A new path

Why design curriculum to be activity-based collaborative hands-on experimental modules and interactive sharing via the ICN rather than a "talking-head" lecture-based delivery? Boling and Robinson (1999) observe that student learning is enhanced by the use of post-lecture cooperative learning activities. Student discussion of results and sharing of ideas following a chemistry laboratory experience have occurred in classrooms that have been less didactically oriented, i.e., where the teacher has promoted it. But, typically, these interactions have not extended *outside* the classroom. Inter-classroom exchanges for students could help them to capitalize on their mutual enthusiasm and to become aware of the commonalty of their overall learning experiences. Technology is integrated into the curriculum through collaboration, cooperation, and communication in a setting where computers and classrooms linked through a fiber optic network is common (Flemister et al., 1994).

It is generally recognized that changes should be considered in chemistry course offerings at the secondary and post-secondary level. The curriculum of chemical education has been under intense scrutiny for the past twenty years. Many capable students are driven from science by their inability to tolerate the traditional lecture approach and by the student passivity observed in many introductory level science courses (Tobias, 1990; Dinan, 2002). This has been especially noted with nontraditional students (Dinan and Frydrychowski, 1995). The "disappointment" of college science (Soja, 1992, p. 4) rests in a number of factors:

a. The focus is on *how* not *why*;

b. Material seems irrelevant or too difficult;

c. There is too much stress or focus on abstract problem solving and not enough opportunity for significant hands-on tasks;

d. Too often, there is little prospect to propose, plan, and complete experiments;

e. The competitive atmosphere is disagreeable.

In the chemistry curriculum, it has long been recommended that fewer topics be treated (Gillespie, 1991; Rickard, 1992; Spencer, 1992) with more emphasis placed on learning and understanding rather than the "cult of coverage" (Stucke, 1996; Klionsky, 1998; Paulson, 1999). There is evidence to suggest that less is more—covering less material, but doing it well, may produce better students. Felder (1992) believes the emphasis should be shifted from "What do I want to cover?" to "What do I want students to be able to do when they have finished with a class session?" Seymour (2002) recommends a shift in emphasis from teaching to learning, centering classroom practice on making advances in student understanding, reasoning, application, and learning retention.

There is more of a focus on the *way* material is taught rather than *what* the curriculum is. Rather than trying to implement substantial curricular change, the *way* material is presented should become of prime concern (McDermott, 1993; Bodner, 1992). Much of the way teacher-centered chemistry courses have been conducted produces knowledge without understanding. Students memorize a plethora of facts that they cannot use to explain real world situations. For example, after a lesson on specific heat, students cannot explain why the temperature of the water in a nearby lake will not be "warm" to the touch until weeks after the outdoor temperature seems to be warm and summer-like. The system continues to self-perpetuate unless there is some kind of intervention (Ewell, 1997). Faculty and administrators involved in the redesign of existing curricula appropriate too much time for the discussion of what should be "covered" and not enough time is dedicated to looking at how learning theory impacts this (Klionsky, 1998).

Passive learners are in part to blame. Students who merely sit in class trying to determine what it is they must know "for the test", spend precious little time thinking about what it is they could actually be *learning*. After taking an exam, 50% of what was memorized is lost (Crowther, 1999). Over a period of weeks, the amount of material forgotten is closer to 90% (Crowther). Mere listening and passive absorption are reasons for poor performance (Worrell, 1992). Rote memorization is the typical strategy for students when the amount of material is excessive. Students find it to be difficult to distinguish or differentiate between what is important and what is not. They are overwhelmed by what appears to be the sheer magnitude of facts and problem types. This leads to a lack of comprehension. Memorization takes over when understanding cannot be achieved.

Instructors spend so much time building the basic "nuts and bolts" with students, that little attention is directed to why these basic concepts are important, or how the individual topics and concepts fit together. An instructor can provide some guidance in this respect, but students must assume responsibility to construct meaning. Moore (1999) asserts that learning is a "do-it-yourself" activity (p. 723). The learner must be active, working to think and learn for herself or himself, not because it is for a grade or to please the teacher (Johnson and Malinowski, 2001). Learning needs to be conceived of as something a *learner does*, not something that is *done to a learner* (Johnson, Johnson, and Smith, 1991 and Johnson and Johnson, 1996; NSES, 1996; Mazur, 1997). Active tasks that focus student attention on mastering important skills and ideas, provides better understanding than massive transmission-type instruction (Worrell, 1992).

3. Lecture is not the answer

Much of what transpires in a traditional classroom is the product of custom, economics, and tradition rather than the result of pedagogical research (Spencer, 1993). Conventional lecture is not the preferred mode of teaching for student success (Lagowski, 1990; Francisco, Nicoll, and Trautmann, 1998; French and Russell, 2001; Meltzer and Manivannan, 2002; Clark and Smith, 2004; Cooper, 2004; Fitzpatrick, 2004) . Formal lectures are inefficient and large class sizes distance the student from the mentor (Bunce and Hutchinson, 1993). Wink (1999) notes, "Faithful presentation of material is not an effective creating of a learning experience," (p.315). It may be more efficient in terms of "covering" material. It may take less time. "Lecture is not teaching, nor is listening learning," (Lagowski, p. 811).

Substantial learning does not occur via the lecture method (Birk and Foster, 1993; Crowther, 1999). The degree of learning that occurs in chemistry is independent of the lecturer; attendance at a lecture has only marginal effect on student performance (Dinan and Frydrychowski, 1995; Hake, 1998) . Historically, lectures are the least effective way of building conceptual knowledge, and "often provide students with answers to questions they don't understand" (Herron, 1984, p. 850). Lecture does not allow a student the time for enough reflective thinking to confirm her or his own comprehension. Students may *seem* to follow and "understand" a lecture at any given time, but are not be able to explain the concept(s) at a later time. They are unable to make the transition from "understanding" to application (Klionsky, 1998). Less than 15% pay attention to the information shared and what is imparted does not initiate active learning in a lecture situation (Frey, 1997).

There is an old adage, "You can lead a horse to water, but you cannot make it drink." In a teacher-centered environment, the instructor may "cover" a large amount of material efficiently (Klionsky, 1998). This does not guarantee that the students learn or understand what is being presented (Francisco et al., 1998). Information is not transmitted intact. *Telling* is not *teaching*. "Teaching by telling is an ineffective mode of instruction for most students," (McDermott, 1993, p. 295). Static lecture is not the answer (Spencer, 1999). Focusing on the content material itself produces a relatively inert learning environment.

"Students, especially those in the sciences, do not learn as efficiently from the traditional lecture method as they do when they are presented with interactive or experiential learning opportunities," (Leonard, 2000, p. 387). Lecture does not stimulate active learning, but rather, encourages passive learning and requires only minimal student interaction (Leonard, 2000; Buxeda and Moore, 2000). It is easier for most students to attend a lecture in passive mode: "...they need only to be able to take notes, memorize rather than understand and synthesize," (Klionsky, p.336). The instructor has already pre-processed the information and transmits it in some way to the students (Reeve, Hammond, and Bradshaw, 2004). Klionsky shares a *student* comment : "Education is the only business where you can give customers less product and they'll be happier" (p.336). Passive students are not independent learners nor are they active problem solvers (Mazur, 1997; Fitzpatrick, 2004). There needs to be a shift from an instructional, knowledge transmission paradigm to a learning paradigm with students as the focus of activity in the classroom (Wink, 1999). Changing the focus from content to the learner can create a more dynamic learning environment (Miller, 1993).

The focus of teaching is about *how* students learn. And students learn in a variety of ways (Lagowski, 1990) including: seeing, hearing, reflecting, acting, reasoning logically, reasoning intuitively, memorizing, visualizing, drawing analogies, building mathematical models, steadily, or in bits. Teaching and learning are not synonymous (Herron, 1984). The gap between what is taught and what is learned is frequently a larger one than most instructors are prepared to admit (McDermott, 1993). "We can teach—and teach well—without having students learn. People who don't want to learn usually don't; people who want to learn, may [sic]" (Bodner, 1992, p. 187). Instructors can teach about a topic, teach how to accomplish a task, but might not be able to get students to do it (Lederman, personal communication, April, 1996).

Mere attendance at and inactive observation of a lecture presentation does not advance involvement in learning, because observing and learning are two separate processes (Moore, 1996). In the usual lecture, 5% of students are actively involved, 95% of students are not (Felder, 1992).

Felder (1991) asserts that "What routinely goes on in most college classes is not teaching and learning but stenography" (p. 133). "Such records of lectures can be created by rote process...There may be little learning potential in this process because there is only weak association between recorded symbols and the concepts," (Dougherty, 1997, p. 723). In preparing for delivery, the instructor interacts with the subject matter. In class, the teacher orates rather than interacts, and the student transcribes (Caprio and Micikas, 1997). Crowther (1999) notes that students to not exert much energy to understand what they are learning because they are too concerned with trying to take notes instead of trying to internalize what is being shared. Most of them file away their notes until the next examination. "*Anything* you can do to reverse this and there's success" (Felder, 1992, p. 19).

In a formal lecture situation, students retain 70% of the first ten minutes-worth of material; this falls off to 20% during the last ten minutes (Felder, 1991; Felder, 1992; Felder, 1995e; Williams, 1995). Even if an instructor speaks at the recommended rate of 100-120 words per minute so as not to overwhelm students (Peters, 2002), attention wanes after the first twenty to twenty-five minutes of a lecture presentation (Cooper, 1995; Olmsted, 1999; Cooper, 2005). Cooper (2005) cites studies of heart rate, note-taking, and factual recall supporting this phenomenon. Cronin Jones (2003) notes that students in cognitive overload experience dilation of the pupils of the eye which instructors observe as a "glazed expression". Spencer (1999) contends that usually no more than half of the students are attentive *at any one time*. Crowther (1999) believes this number is less than 15%. Lord (1994) believes that several days after the class, students remember only 20% of what they have heard during a traditional lecture.

This does not begin to address the poor note-taking skills even the brightest students may have. A large proportion of students have not had prior training for learning these strategies. At the pace that material is delivered, students are frantically scribbling to write everything and may miss half of what is said. As they are writing, they do not know how to identify main ideas or organize information (Cronin Jones). The best note-takers are students with the best backgrounds and these students rarely capture more than 30% of the information shared during the class period; the biggest problem for instructors is that all students take notes at different rates (Rowe, 1983).

Johnstone (1993) notes, "To learn, students have to unpack what is taught to them, then repack it in a way that suits their previous knowledge and their own learning style" (p. 704). The brain stores information at the rate of 5-10 seconds per chunk of information (Rowe, 1983). Lecture material enters a student's short-term memory, is sorted, organized, and sent to long-term memory. The more unfamiliar the new facts and information are, the more quickly short term memory is saturated. The more elaborate or complicated the new material is, the more time is required to handle it and store it. Usually, the flow of ideas in lecture is at a more rapid pace than the rate of this somewhat complicated mental processing. Students can be quickly overwhelmed.

Rowe (1983) provides further insight into the difficulties encountered by students via the lecture model. There are four kinds of mental lapses students experience.

a. Short term memory is overloaded with too many ideas bombarding the student at one time.

b. The more complex the idea is, the more time it takes to make meaning of it and store it appropriately.

c. Symbols, terms, and explanations used in the text may differ from those used in the lecture.

d. Something said in class may divert a student's thought process from the matter at hand.

This makes the constant barrage of ideas "delivered" in a typical lecture situation to be somewhat overpowering for the average student.

4. Focus on students

a. Student learning

Traditional teaching of general chemistry has followed a didactic forum, focused on the teacher and the subject, not on the students. Students are better served when the focus is on them as learners, not copying what the teacher puts on the chalkboard or overhead projector

(McDermott, 1993). Student learning, not teaching, is the most important aspect of the course (Moore, 1999). Students, not teachers, are in control of their *own* learning (Hand, personal communication, 2004). This is to say that students must learn for themselves—learning cannot be done for them.

The thrust of activity in the classroom should be on facilitating learning, not on teaching (Woods, 1998). Learning is facilitated when the instructor spends less time talking and more time listening to what students say (Herron, 1984). Students should be made responsible for parts of the learning process (Woods). They are more successful when they are actively engaged in investigating and constructing their own understanding (Redish, Saul, and Steinberg, 1997; Johnson and Malinowski, 2001; Reeve, Hammond, and Bradshaw, 2004). Research has demonstrated that learning is more permanent and meaningful when done actively (Sojka, 1992). Students should do active work at least every twenty minutes (Felder, 1995e). Active learning techniques can make the "lecture" session more interactive (Herron, 1983; Anderson, 1997; and Russell, 1997) and the learning more meaningful. Active learning is more effective than passive attendance (Buxeda and Moore, 2000). Meaningful learning for students must be the goal. Only when students are actively involved with their own learning does the class take on a dynamic nature (Hartman, 1996). Motivation in any form encourages student active learning (Mazur, 1997).

McDermott (1993) observes, "Meaningful learning, which comes from the ability to interpret and use knowledge in situations different from those in which initially acquired, requires that students be intellectually active. Development of a functional understanding cannot take place unless students themselves go through the reasoning involved in development and application of concepts. Moreover, to be able to transfer a reasoning skill from one context to another, students need multiple opportunities to use that same skill in different contexts. The entire process takes time. Inevitably, this constraint places a limit on both the breadth of material that can be covered and the pace at which instruction can progress. New topics cannot be added without omitting others. Choices must be made," p.298.

Some small group work is more effective than a lecture-only format (Springer, Stanne, and Donovan, 1999). A facilitator should *guide* students to an understanding of concepts (French and Russell, 2001). Lecture emphasis should shift toward the instructor modeling good techniques of problem solving and concept development, explaining more of the dynamic thought processes being used as well as what the results mean. The goal is for the student to apply thinking and reasoning skills *along with* content knowledge to solve problems. The strategy is to engage the entire group in *construction* of science concepts and principles rather than relying on a straight lecture presentation. Students appreciate the opportunity to think about their learning during lecture (Steiner, 1980). Solutions to problems are *developed* and the critical thinking process *modeled*, rather than shown in an algorithmic manner.

One major focus in chemical education is cultivating student reasoning and critical thinking ability in the context of problem solving and decision making ability (Zoller, 1993). Prevalent teaching methods do not reflect much insight into effective problem-solving strategies and reflect the need for improvement (Reif, 1983). Algorithmic exercises do not improve students' critical thinking skills (Spencer, 1999). They may even thwart them. "Chemical knowledge is conceived by students as rigid body of facts revealed by an authority (the professor or text) and the student role is to return knowledge, without processing, to the authority" (Zoller, p. 195). The strategies Zoller suggests are important to foster higher order cognitive thinking skills include team work in class, in the laboratory, on homework exercises, and active participation in the learning process. To this end, the instructor can ask higher level cognitive questions that have been developed to encourage involvement and to guide thinking. Good questions are more effective than good answers when it comes to learning (Matlock, 1994; Moore, 1999). The students must reflect on what is said—their responses determine the direction the session takes, what material is undertaken, and in what order. The instructor should be effective at involving all of the students in a discussion in order that meaningful interactivity and learning have an opportunity to occur. This is the challenge in a large group. If a teacher can redirect a student's question to back to the individual, or to a cooperative group, the students have more opportunity to think and process, to arrive at their *own* answer, and therefore to learn.

Matlock (1994) further reminds us that we do students no favors by directly answering their questions. Doing so stilts their inquisitive spirit. By directly providing students information that a teacher thinks is vital to transmit, students depend on the instructor to dictate what is important and interesting, and do not develop the ability of being able to distinguish the important from the trivial information that they have gathered in their class notes. This obfuscates their ability to think critically (Oliver-Hoyo, 2003). They try to memorize everything as being important.

Moving from a teacher-centered course to a student-centered environment begins with the teacher's attitude (Bunce, 1993). There must be respect for the learner, especially the student's inherent desire to learn. Instructors must know their students, what about chemistry is difficult for their learners, and what can be done about alleviating or lessening that difficulty.

The use of multiple learning methods in an interactive student-centered forum endeavors to promote student success. Participation is enhanced. Different modes of interactivity develop metacognitive skills among students. They learn to contemplate, and develop and improve their own thinking strategies.

b. Learning styles

Most instructors teach using their own predominant learning style (Leonard, 2000). Students may have a different learning style from their instructor. Many college-age people are visually oriented (Lagowski, 1990). Visual learners remember what they see (pictures, diagrams, symbols) and prefer visual demonstrations. Auditory learners recall what they hear and then say. They prefer discussions, verbal explanations, and learn by explaining to others. Finally, kinesthetic learners depend on the senses and learn by feelings, tastes, and smells.

Stice (1987) reports that students retain 10% of what they read, 26% of what they hear, 30% of what they see, 50% of what they see and hear, 70% of what they say, and 90% of what they say and do. This provides the argument for *interactive* participation of some kind.

Today's more diverse populations require more variety in teaching methods in order to effectively address a variety of student learning styles (Pressley, 1996; Uno, 1999; Leonard, 2000). Integration of new knowledge is impacted by prior knowledge and science experience, but also by learning style (Bretz, 2004). This can sometimes lead to difficulties with communicating ideas (Spencer, 1999; Francisco et al., 2002). The closer the learning style of the instructor and learner, the more the learner tends to retain information longer, interpret and employ it effectively, and have a better attitude (Felder, 1993a). Conversely, students who encounter a learning style that does not come close to matching their own are bored, do not pay attention, may perform poorly on quizzes and examinations, are discouraged about their classwork, their program of study, and themselves (Lagowski, 1990). This results in low test scores, indifferent students, low attendance, and an elevated drop rate.

The challenge is how to reach students whose learning style is poorly matched with that of the instructor (Felder, Leonard, and Porter, 1992). For example, as Francisco et al. (1998) note, students with deductive passive learning styles benefit more from a traditional approach by the instructor, while those with a more inductive active learning style benefit from cooperative learning. Students learn best through different senses. Concrete learners learn through touch, taste, and smell; intuitive or abstract learners use the senses of hearing and sight (Leonard). There is much work to be done in this area. It is encouraging to note that the student's preferred learning style is not permanent (Bretz, 2004) and may be adaptable to the learning environment provided. For example, by deciding what to assess and how to assess it, the instructor is actually more influential on student learning strategies than the student's learning style preference may be (Bretz, 2004). The effective instructor should stretch students to encourage them to expand their learning style inventory beyond the comfortable and familiar. However, when a number of students are involved, it is still advisable to attempt to accommodate as many different learning styles as possible to provide students with the help they need to learn how to learn. The primary focus of education must be learning to learn. Stretching learning styles may be more important than learning the content in many courses.

(There is a paucity of information regarding student learning styles and the use of interactive television [Anderson and Kent, 2002]. Independent learners achieve more and seem to hold a higher opinion about distance education. Frequently, however, the choice of education at a distance is a matter of saving travel and time, not a means of accommodating a particular learning style.)

Not all students learn information the first time it is presented to them. Students have different needs and difficulties, and this affects retention of learned information (Felder, 1995a). Alternate approaches or presentations help reinforce the material; reiteration of concepts, especially via peer interactions, helps to promote mastery of material. It is not necessary to completely refrain from lecture—lecture is sometimes useful (Orzechowski, 1995). Short lecture presentations can highlight important concepts and can direct students' attention to key areas. Supporting follow-up cooperative group discussions can help students to identify and clarify points of confusion.

The majority of students are willing to take responsibility for their own success or failure. They know that their success is influenced by factors in their own control (Carter and Brickhouse, 1989; Orzechowski, 1995). Students realize that lack of attendance and participation, and failure to work assigned exercises are detrimental to their success. As one student observed, "We should be made to take some responsibility for our education and not just have information spoon-fed to us and spit it out" (Orzechowski, p. 348).

An instructor in a student-centered classroom encourages students to take responsibility for their own learning not just in their class, but across the curriculum and throughout life.

The chemistry learning process includes three facets—demonstration, exploration and discussion (Miller, 1993). Each facet is equally important in its own right, yet there is overlap. Students *participate* in demonstration and exploration activities. The instructor may demonstrate or the students share demonstrations among themselves, such as in laboratory. The inquiry *process* is more important than the *final answer* because it promotes critical thinking via exploration, evaluation, creation, and synthesis (Uno, 1999). Students practice the scientific method: observation and discovery, formulation of hypotheses, and testing of hypotheses. Discussions lead them to question, create, invent and expand their knowledge base. Working in cooperative groups, they learn to respect diversity of methods and opinions. Perhaps, most importantly, they gain an appreciation of the fact that doing chemistry is a cooperative human activity (Miller).

5. A student-centered classroom

a. Students must be actively involved in the learning process

The logical beginning is how students' minds work (Spencer, 1993). Understanding of the learning process has evolved. Cognitive and behavioral research has begun to provide more information about how the learner's mind works, as outlined earlier in this chapter (Rowe, 1983; Lawson, Benford, Bloom, Carlson, Falconer, Hestenes, Judson, Puburn, Sawada, Turley, and Wycoff, 2002). The learning *process* must complement the material being studied (Spencer). For example, highlighting material from students' majors helps students to have more interest as they learn; accessing prior knowledge can provide a scaffold for students on which they can build, a hook to capture more information to tie into existing knowledge. This strategy makes useful applications easier to tailor course content to select disciplines.

Rather than reflecting the progress that has been made in pedagogical research, too often many of the common chemistry classroom practices and teaching strategies (homework problems, instructor demonstrations, working example problems on the chalkboard) do not stimulate student processing skills. Simply stating a fact to a learner causes little cognitive demand on them. Students can passively copy information or make an observations without becoming actively engaged, without absorbing any of it. Encouraging them to reason requires them to engage in higher level cognitive processing. The more engaged in processing a student is, the more likely the person will retain something of what has been processed (Lyle and Robinson, 2002). "Keeping students mentally active is the key to successful teaching," (Brooks, 1984).

Learning is better achieved interactively rather than by a one-way transmission process (Haller, Gallagher, Weldon, and Felder, 2000). When learning is a dynamic process, students and instructors, as well as students and peers, exchange information and ideas. The process is also more enjoyable for students (who are *doing* something) and their instructors (who are participating in learning in action) (Caprio and Micikas, 1997). Active learning connects instructors more closely with students and their learning (Miller, 1993). Students active in the learning process who can give explanations to others will achieve at a higher level because explaining requires making connections between new and existing information (Hooper and Hannafin, 1988).

A student-centered, non-threatening learning environment, helps students become active learners. The teacher must be willing to relinquish "control" of the class. In a student-centered classroom, the relationship between teacher and learner is altered. The instructor is no longer the source of knowledge and center of activity. Students are partners in the teaching and learning. Students are more involved both time-wise and in the depth to which they interact with concepts and ideas. All students are engaged and participate more successfully. They pay closer attention to peers. They learn that they can creatively and correctly generate ideas among themselves, with guidance from the instructor if and when needed.

Student-focused active learning promotes student success at several levels—academic, sociological, and psychological. Active learning engages a student not just at the content level but in higher order thinking skills, moving up Bloom's taxonomy (Bloom, 1956; Johnson and Malinowski, 2001) to the levels of application, analysis, synthesis of ideas, and evaluation of results. (As a review, Bloom's taxonomy includes [from lowest to highest levels]: knowledge, comprehension, application, analysis, synthesis, evaluation).

More interactive hands-on experiences generate enthusiasm among students. They are challenged by the activities and have a more positive attitude toward their learning experiences (Dinan, 2002). As partners in the learning process, students are responsible for their own learning and suffer the consequences if they are not proactive. An effective active learning environment furnishes students with the support, tools, and resources they need to be successful. Student active learning models the working world where the responsibility for learning rest squarely on the individual. Attendance is an important factor—students determine that their own learning cannot take place when they are absent.

b. Teacher adaptations

Felder (1993b) contends that "College teaching may be one of only two vocations for which neither experience nor training is presumed necessary—parenting is the other" (p.288). Most teachers teach as they were taught, with an emphasis on supplying instruction rather than generating active student learning (Felder, 1999; Spencer, 1999; Lawson, Benford, Bloom, Carlson, Falconer, Hestenes, Judson, Puburn, Sawada, Turley, and Wycoff, 2002; Seymour, 2002; Tien, Roth, and Kampmeier, 2002; Bretz, 2004; Cracolice, 2004). The more pre-service teachers are encouraged to focus on student-centered strategies and techniques, the more this obviously will impact successive generations of teachers and their students.

Buxeda and Moore (2000) advise that the teacher should evaluate her or his teaching style. She or he should be aware of the diversity of learning styles in the classroom and enrich teaching accordingly. Once an instructor knows what areas need change, engaging learning activities should be developed to meet these needs. Active learning methodologies should be tailored to a course and appropriate for various types of student learning styles. New instructional objectives engender new activities requiring different kinds of assessment.

A student-centered classroom does not imply a chaotic meeting of novices trying to learn all by themselves. Instructors who make an attempt to understand the source of student difficulties and adapt to them in their curricular development and assessment procedures focus on the student-centered classroom. Carter and Brickhouse (1989), report there may be a disparity between student and instructor views of what makes chemistry difficult and what can be done about it. Right or wrong perceptions are not so much a concern as are disparate perceptions of the chemistry classroom and how these views influence what is learned. If instructors are not aware of what causes students difficulties, it is less likely they will create a classroom environment that is able to remediate those difficulties. In active learning, both teachers and their students think, ask questions, and propose strategies as they talk about science. Generally, instructors concerned with student success focus their energies on providing learning opportunities to foster correct conceptual understanding of chemistry. Caprio and Micikas (1997) note that "this is not a trivial challenge" (p. 220).

For some instructors, the matter of teacher control is an issue. Although superficially it appears that the teacher has lost control of a student-centered classroom, instructor importance is much more subtle. As she or he coaches and guides students, the instructor still exerts a definable influence on the group.

c. Learning theory

Novice chemistry students are expected to gain an understanding of the concepts underlying chemical principles. But, learning is a process of integrating incoming information with previously constructed knowledge (Bunce, 1993; Novak, 1993; Leonard, 2000). "The most important single factor influencing learning is what the learner already knows" (Ausubel, 1968, p. 12). This includes both declarative knowledge (knowing *that*) and procedural knowledge (knowing *how).*

Von Glaserfeld (1987) defines constructivism as the theory that knowledge is not basically acquired or obtained but dynamically built and that the functional role of cognition is adaptive and assists in the organizing of a person's experiential world. Constructivism promotes and encourages a meaningful grasp and comprehension of science.

Knowledge construction is in the mind of the learner. Shiland (1999) suggests five postulates of constructivism:

1) Leaning requires mental activity—knowledge cannot simply be presented;
2) Naive theory affects learning—new knowledge must be related to information the learner already knows; but, a learner's preconceptions or misconceptions may interfere with her or his ability to learn something new or make unbiased observations; the learners personal theory must be made explicit to allow her or him to compare incoming information with this existing theory;
3) Because learning occurs from dissatisfaction with present knowledge, students need experiences to create cognitive conflict and dissatisfaction with their present conceptions; until existing concepts are able to predict the outcome of experience, the restructuring of present understanding is impossible;
4) Social component—meaning is constructed in fruitful dialog with others;
5) Learning needs to be applied in new ways to new situations to depict the usefulness of new concepts.

The National Science Education Standards (NSES, 1996) support a constructivist approach. Shiland (1999) outlines those aspects of constructivism reflected in the NSES:

1) Students who are actively engaged take responsibility for their own learning;

2) Student preconceptions are detected by whatever means the instructor can devise;
3) The instructor creates exercises to challenge and conflict with present knowledge;
4) Cooperative group work is essential;
5) Students find enhanced applications.

Both students and their instructors must acknowledge that effective constructivist learning is an active, student-centered process if integrating newly acquired concepts into existing individual knowledge frameworks (Preszler, 2004).

Learners build upon prior experiences. The student's personal neural network organizes and relates previously-learned knowledge. New understanding is constructed by the learner as an outcome of new experiences. Each learner interprets new experiences and constructs new knowledge based on the previously existing network (Gabel, 1999; Leonard, 2000).

A student's culture, prior knowledge, past experiences, and interests are important to the design of curriculum (Crowther, 1999). He recommends including:

1) Hands-on investigative laboratory experiences, if they are problem-centered; students must use their own schema to interpret what is perceived.
2) Active cognitive engagement.
3) Work in small groups stimulating higher level thinking and providing extended opportunities for cognitive restructuring.
4) Higher level assessment—an assessment causing students to reach higher levels of cognition is what binds all portions of the learning experience together.

Knowledge is increased when the information that students confront interacts with existing perceptions (Lord, 1994). They make sense of the new by association with the old. Peers are important in the learning process; by explaining to some other person, students ascertain whether they understand (Gabel, 1999). With colleagues, they learn more information, remember it for a more extended period of time, and value the social approach.

d. Diversity in learning techniques

Using student active learning techniques in science education reinforces lifelong learning and communication skills (Tessier, 2004). Implementing active learning requires much more than just the volition to do so. An instructor must establish an active learning *environment* rather than simply employing "active" techniques (Johnson and Malinowski, 2001). Sustaining such a student-centered learning atmosphere demands concerted, continuous effort and thought. "The students are not necessarily going to enjoy the experience of good teaching *theory*," p. 120 (French and Russell, 2001). Once a new learning strategy is tried, if not rejected, it is tried again and again to make it work for the group and the learning situation. Thus, teacher preparation for active learning has a higher intensity level, is more time-consuming and rigorous, but more enjoyable, and stimulating (Lord, 1994; Kovac, 1999; French and Russell, 2001; Johnson and Malinowski, 2001).

Learning is not so much a function of the professor doing the teaching, as it is the student's doing the work to understand and learn the material (Birk and Foster, 1993). Traditionally, information is provided by the text and the professor, and it must be integrated into a student's pre-existing knowledge base. To do this, the learner must be actively involved. Knowledge acquired by rote learning will not be absorbed (Novak, 1993). In a traditional lecture, particularly in a large group setting, success may be difficult to assess—there may be a mismatch between the ways the instruction is presented and the way the learner learns. Learning experiences matched to student learning styles are key (whether in a behaviorist or constructivist learning environment).

Instructors may overlook the fact that most students learn better in different ways from traditional approaches. They should try to diversify their teaching methods to accommodate the needs of a diverse group of students. Leonard (2000) lists recommendations:

1) Use more active learning exercises. Make learning opportunities attractive and stimulating to both teachers and students. Provide learning based on

experiences by which students make connection to the world.

2) Create a constructivist learning environment—ask questions to encourage inquiry. This allows conceptual processing time.

3) Provide opportunities for students to experience or be exposed to concepts in the laboratory *before* lecture so that students learn by an progression from the concrete hands-on to the abstract minds-on aspect. This furnishes students with a conceptual framework and advanced organizers, by helping to introduce new information into existing neural networks.

4) Accommodate the methods by which different students learn by different learning approaches. For example, use visuals and manipulables for making the abstract more concrete.

The use of student active learning strategies is one of the goals of education (Hatcher-Skeers and Aragon, 2002) and is becoming more prevalent in college classrooms (Kovac, 1999; Wimpfheimer, 2002) along with pre-college learning environments. Active learning encourages students to learn how to learn (Johnson and Malinowski, 2001). In order to maximize student success, the central focus in the classroom must be on the active learner and what can be done to enhance student achievement and creativity (Miller, 1993). One way to do this is to promote collaborative learning activities.

Meaningful learning is tied to experience. Interactive lecture, group learning, or experiential learning (e.g., laboratory) provide more opportunities for students to process, interpret, internalize the concepts experienced. Lack of appropriate learning strategies (especially student-centered ones) are the largest variable in contributing to attrition in science majors (Leonard, 2000).

Student work in collaborative groups is central to constructing an effective learning environment because it provides the opportunity for students to make their understanding clear through interaction with one another (Leonard, 2000).

Most learning gains occur when the responsibility for learning resides with the students (Thomas, personal communication, March, 1995). "Teachers do not cause learning; learners do" (Novak, 1993, p. 53). Teachers cannot "control" learning, students do (Hand, personal communication, August, 2003). Success rests on the concerted efforts of an instructor or an instructional team to *facilitate* rather than *dictate* how students learn (Bodner, 1986; Birk and Kurtz, 1996; Raber, 1998). The focus of instructional efforts should be on comprehension rather than on rote memorization. As the teacher employs active learning techniques, the learning session becomes more interactive. Learners are encouraged to think critically. Each student has something to contribute (Howell, 1996). Students are more motivated (Ward and Bodner, 1993). The teacher is a guide for rather than a purveyor of information. This is interactive constructivism—students make meaning out of their reflections on interactions with the physical world and other people (Henriques, 1997).

Student active learning strategies are not integrated overnight. Success is not automatic or immediate Felder (1995f). There can be resistance among teachers and students alike. Dinan and Frydrychowski (1995) list several instructor assumptions and fallacies about the student-centered classroom and group work:

1) If a professor has not lectured on material it has not been "covered".
2) The use of small groups to cover course material is inefficient and results in decreased coverage.
3) Use of small group methods lead the instructor to have less control.

Students do not enthusiastically support and pursue these non-traditional teaching and learning techniques at the outset because *understanding* requires more time and effort than merely getting by with an adequate or acceptable grade (Moore, 1998). Given the time to develop an understanding, students eventually prefer pursuing the skills they acquire via group collaboration (Felder, 1996), rather than passively taking notes in lecture.

6. Cooperative and collaborative learning in groups

The circumstance of learning can be competitive (students operate against one other with a goal that only one or two can achieve), independent (students work alone with objectives disconnected to other students) and cooperative (students work jointly to attain a mutual goal, each relying on other(s) for success). Of the three, cooperative learning is the most important (Johnson, Johnson, and Holubec, 1986). As early as 1945, the American Chemical Society Committee on Professional Training mandated the inclusion of team work into existing curricula (Cooper, 2004).

Students who learn by doing and becoming involved are able to retain and comprehend more than those who merely listen (Cooper, 1995). Teachers need to incorporate into learning exercises a sense of inquiry, critical thinking, communication and teamwork, and development of life-long learning skills. Cooperative learning is an instructional technique whereby students work together in small fixed groups on a structured task (Cooper; Nurrenbern, 1995).

From as early as the end of the 19th-century, more than 1000 studies have been done on the effects of cooperative learning on student learning outcomes (Slavin, 1995). Johnson, Johnson, and Smith (1991) note that more is known about the effectiveness of cooperative learning than is known about lecturing or almost any other aspect of education. "The best answer to the question, 'What is the most effective method of teaching?' is that it depends on the goal, the student, the content, and the teacher. But the next best answer is, 'evidence that peer teaching is extremely effective for a wide range of goals, content, and students of different levels and personalities'" (McKeachie, 1996, p. 159). "Links between cooperative learning theory, research, and practice have been characterized as one of the greatest success stories in the history of educational research" (Springer et al., 1999, p. 21). Results are based on a variety of age levels, subject areas, diversity, and ethnicity (Johnson & Johnson, 1985).

This approach is effective for diverse student groups of heterogeneous learning styles, personality types, genders, and ethnicities (Felder, 1993c). Nontraditional students, and minorities especially benefit from cooperative group learning (Hanson and Wolfskill, 2000). There are strong positive results for women engaged in cooperative group learning as long as there is not gender bias in their groups (i.e., there must be an equal number of women and men OR more women than men in the learning group [Haller et al., 2000]). Women prefer cooperative group work over competitive classroom situations (Felder, 1996; Frey, 1997). Both introverts and extroverts are facilitated (Felder, 1995a).

Springer et al. (1999), Snodgrass and Bevevino (2000), and Shibley and Zimmaro (2002), and Cooper (2004) draw the distinction between collaborative and cooperative learning. Cooper (2004) describes them as opposite ends of the collaborative spectrum with the distinction being the amount of structure present in each learning situation. Cooperative learning is a more structured endeavor wherein small groups work together toward a common goal. The group members take specific roles and each member is accountable for her or his own learning. Collaborative learning assumes that students participating in activities are competent in the social skills required to work in peer groups. This implies that they have a cooperative-type learning background (Snodgrass and Bevevino). Collaborative learning is a much less structured process wherein participants negotiate their goals, define their problems, develop their procedures, and construct their knowledge in small groups. Evaluation in cooperative groups is usually done as the entire group. In collaborative groups, evaluation is more often individual.

The use of cooperative groups encourages active participation among students, creating an environment where students actively engage in learning the material by sharing insights and ideas. The best way to learn is to teach yourself or someone else (Haller et al., 2000). Active learning strategies may incorporate transfer of knowledge sequences during which some students take the role of teacher and others take the role of student. They provide each other with feedback and teach one another in a cooperative, non-threatening environment. They develop communication skills, becoming not only peer learners, but teachers as well

(Henderson and Mirafzal, 1999). Cooperative learning provides students with more thorough learning and more pleasure in teaching peers (Klionsky, 1998). Students who actively provide explanations to peers show higher achievement themselves (Hooper and Hannifin, 1988). This is true within an individual group, or across groups within a learning environment (Windschitl, 2001). They develop listening skills in a group and group work helps them to improve their language skills, especially those who are international students (Paulson, 1999). Students work together to maximize their own and their group mates' successful learning (Martin, 1996).

7. Learning to use cooperative strategies

Cooperative learning is not just group work. Johnson, Johnson, and Smith (1991) observe that merely putting students into learning groups is not the same think as structuring cooperation between them.

The following listing outlines the differences between group work and cooperative learning (Snodgrass and Bevevino, 2000).

Group work	Cooperative learning
Students work on their own.	Students are dependent on each other.
Some students do all of the work.	Each student is accountable for the work and the learning.
Group competition is not related to task.	Groups are formed based on task to be completed.
Social skills are not taught.	The teacher provides instruction in social skills.
The teacher does not participate in the group work.	The teacher closely supervises groups.

a. Instructor role

Many faculty have no training in small group activities (Dinan and Frydrychowski, 1995). To successfully implement cooperative learning requires time, patience, and some preparation by the instructor. Simply putting students together in a group and telling them to do a task does not work. A portion of the class period must be devoted to teaching students *how* to work effectively in groups. Constant vigilance, clear student-teacher communication, and instructional guidance are critical to success (Kogut, 1997). It does take more instructor time to plan and administer a course with cooperative learning. As noted previously, the teacher surrenders a certain amount of control of the classroom dynamics over to students. This can be a daunting undertaking for someone schooled in traditional methods of didactic instruction (Felder, 1996; Thomas, personal communication, October, 1996). This feeling of disequilibrium is overcome relatively quickly once the instructor realizes the overall benefit to students.

Felder (1995b, 1995c, and 1995d), Felder, Felder, and Dietz (1998), Felder and Brent (2000b), and Seymour (2002) recommend that the instructor use a series of guidelines to create a student-centered classroom. Certain of these items will later be elaborated.
The instructor should:

1) Set the stage making it clear from the first class meeting what group work entails, why it is useful, and therefore why it is required.
2) Implement student active learning strategies by making changes gradually—the more features of cooperative learning a teacher uses, the more improvements will be observed. This is limited only by the instructor's imagination. Students have an infinite ability to learn when effectively motivated.
3) Form heterogeneous teams of three to four students who are balanced in knowledge and skills.
4) Provide introductory team-building exercises to develop team camaraderie, the ability to work together, and cohesiveness.
5) Share pointers and advice from previously successful students.
6) Give clear directions with regards to assignments and communication tools.
7) Assign the groups to write team goals.
8) Clarify students' learning goals and align them with course assessment.

9) Monitor team progress, be available to consult or to provide coaching when teams have trouble. A team coordinator is needed to keep each team on task.

10) Intervene when necessary to help the teams to overcome interpersonal problems. One suggestion is an active listening exercise—one side must repeat the case to first side's satisfaction without any attempt to counter what has been shared.

11) Collect peer ratings of individual participation and use them to adjust team assignment of grades. Rewarding exceptional team members and penalizing non-contributors helps to avoid conflicts and resentments that may occur when students work on group projects.

12) Anticipate problems, get feedback and respond to it, get help when necessary.

13) Redesign assessments to engage students in their own learning and design a component of the assessment that will give feedback to the instructor about the effectiveness of the work.

b. Student response

There may be initial student resistance to the process of active learning because students must take responsibility for their own learning. This may be new to some. Felder (1995f) has observed that students go through the steps associated with trauma or grief.

1) Shock: The old way is *out*???!!!
2) Denial: This, too, shall pass.
3) Strong emotion: This CANNOT be happening!
4) Resistance: I am NOT going to do it.
5) Surrender and acceptance: It may be *stupid*, but since it IS my *grade*...
6) Struggle and exploration: Others get it, I WILL get it, too.
7) Return of confidence: I AM getting it!
8) Integration and success: Aha!

Resistance is natural. Providing instructor help during the transition from traditional dependent learning to autonomous independent learning is valid and recommended as outlined above. The entire class should be involved in strategies for dealing with common problems (Haller et al., 2000). Students will be happier relying on themselves to puzzle through a challenge. Asking a question of the group and soliciting a group response is not as threatening to the students and they are more likely to answer. Metacognitively, they learn by engagement and action, not by observation.

Group work supports a larger range of learning styles. Dougherty, Bowen, Berger, Rees, Mellon, and Pulliam (1995), report higher retention and improved student performance using structured cooperative groups. Students spend less time studying alone, and more time studying and discussing class work with peers. There is a change in focus from individual knowledge acquired singly to public knowledge constructed by a group of students. The classroom becomes a knowledge-building community that empowers students to contribute to each other's learning by social construction of collective knowledge (Gilbert and Driscoll, 2002).

Students learn better through interaction (Spencer, 1999). A Vygotskian sense of social community develops (Tingle and Good, 1990; Felder, 1996; Towns, 1997). Learning occurs as a socially negotiated collaborative process—learners learn from their group interactions (Collis and Smith, 1997; Hand and Keys, 1999; Keys, Hand, Prain, and Collins, 1999; Rudd, Greenbowe, and Hand, 2001; Rudd, Greenbowe, Hand, and Legg, 2001). Social negotiation of knowledge is the purpose of collaboration—groups of learners can collaboratively construct more meaningful knowledge than individuals can alone (Jonassen, 1996; Spencer, 1999). The main focus is the development of a collective knowledge base and improving the problem-solving expertise of the learners (Gilbert and Driscoll, 2002). The use of groups that require peer interaction to construct a concept provides insight and direction for the weaker students and reinforcement for the stronger students (Worrell, 1992).

Social discourse is the crux of the collaborative knowledge building community (Slavin, 1991) and is an effective strategy for developing conceptual understanding. To explain to another person, one must understand a concept or idea oneself; the combined knowledge of two or more contributors makes generating solutions to problems easier (Duch, 1996). Those receiving help show significant improvement, as do those who provide the help (Hooper and Hannafin, 1988). The ability to cooperate is a building block for success in life. Cooperative group deliberation assists students in confirming or changing their current understanding to construct new knowledge (Lyle and Robinson, 2002). Felder, Felder, and Dietz (1998) note that there are obviously more peer interactions with cooperative classroom work than in a traditional setting. And, more students become involved over time (Howell, 1996). "The more people you have thinking about a problem, the more likely someone is to have an idea that will lead to at least beginning to solve it. 'Two heads are better than one.'" (student focus group comment, 2000).

8. Student groups

Various procedures for assigning students to small groups seem not to affect student achievement (Springer et al., 1999). Group performance improves with time—the longer the group works in concert, the more efficient and effective they become (Sherman, 1988; Felder, 1996; Felder et al., 1998). Student reaction to group work positively favors group homework and in-class work instead of individual tasks (Felder, 1996). Group work reduces the isolation some student feel in science (Duch, 1996). Students put more resolve and effort into group work. Receiving help in a group may instill more personal feeling into the situation, therefore more effort may be expended (Hooper and Hannafin 1988). Whereas alone they might abandon their own independent efforts in less time, students are reluctant to disappoint their fellow group members (Felder). Students perform well in group work because they may be embarrassed not to perform when peers are depending on them. They can elicit encouragement from their fellow group members, and will persevere longer working with their group. When asked midway through an academic term whether they would like to be reassigned to different groups, students prefer to stay with their assigned groups (Shibley and Zimmaro, 2002).

The work world depends on teamwork and group interactions, while education has emphasized a focus on individual performance in the classroom, the laboratory, and by written assessments (Frey, 1997). Students entering the workforce must have communication and problem-solving skills and be independent thinkers who can perform well as team members (Buxeda and Moore, 1999). Industrial recruiters seek students who have had the experience of the teamwork required in collaborative groups (Felder, 1996; Lair, personal communication, March, 1997; Towns, 1998). In fact, a major concern of industrial chemists is the lack of team experience among new college graduates (Paulson, 1999).

Collaborative exercises enhance the preparation of students for later professional collaborations (Towns, 1998; Paulson, 1999; Spencer, 1999). The interpersonal and communication skills that develop during group work are important to employability, productivity, and career success (Towns). A background in team problem solving is desirable in an industrial setting (Lair, personal communication, 1997; Towns). For a number of well-recognized industrial leaders, the literature provided to prospective job candidates highlights corporate team work across all levels. More individuals are fired from positions because of an inability to work with others than because they are unable to do their work (Uno, 1999). Cooperative group work rather than competitive individual work is the approach taken in many careers outside of academia; cooperative learning activities and skills, therefore, prepare students to be better communicators and listeners in future collaborative situations (Cooper, 1995). Listening to lecture does not nurture the interactive skills necessary to an industrial career (Buxeda and Moore, 1999). Too many graduates of fine academic programs go out into the world unprepared to think on their feet because no one has taught them to reason critically or to engage in problem-solving exercises that would stretch them beyond what is outlined in class as being important to know. Neither is there a prolonged motivation for continued or life-long learning (Springer et al., 1999).

a. Group tasks and strategies

Cooperative groups of students formed to solve problems undertake exercises that challenge them more than the example problems presented by the instructor. Tasks must be chosen that require the active engagement of *all* group members in order to achieve success—if not all contribute, group success is imperiled. Cooperative groups assigned a clearly defined task with vague guidelines (as opposed to a vaguely defined problem with clear guidelines) are required to engage themselves in fruitful discussion in order to outline a feasible solution to a learning problem. The scope and framework of the task is restricted only by the teacher's creativity and the student's rising to the challenge. The undertaking is created (designed and drafted) so that group members depend on each other to accomplish it (interdependence) (Nurrenbern, 1995). Typical problems are not algorithmic, but, rather, require students to disembed information.

The group is encouraged to work collaboratively to investigate multiple alternatives to solving the problem. Each member of the group is engaged in the process; the group must determine how to accomplish the stated objective of the undertaking; and both the group and the individual participants are responsible to each other and to the instructor for the end product(s) of the work. In the process, they learn to rely on themselves and each other to reason through a solution. For meaningful learning to occur, students must think through the ideas for themselves (De Jong, Acampo, and Verdonk 1995). To that end, the teacher serves less as the source of knowledge, but more as a guide. The less the outside guidance and input, the more ownership and pride the group feels and the more they will ultimately learn. Students develop a collective sense of self-reliance as they formulate higher order metacognitive skills.

In collaborative learning, students each contribute significant portions of information. Strategies applied as effective instructional tools encourage all students to participate by actively making meaning. Collaborative learning promotes the *quantity* of knowledge students are able to accumulate, and provides for the development of more *quality* through depth of understanding.

It is imperative that heterogeneous cooperative groups assigned by the instructor are used *from the outset of a semester.* Waiting too long to establish groups interrupts already functioning social units or interferes with the class functioning "normally". Immediate formation of groups makes the groups as much a normal part of the class as any other learning strategy or tool (Sherman, 1988). It trains students to understand that group work is a division of responsibility, not just a division of tasks and sub-tasks (Nurrenbern, 1995). There must be interdependence *between* members as well as personal responsibility and accountability *among* members. It is interesting to note that May (1993) suggests that interdependence is a higher order skill than independence (which is higher than dependence).

b. Some direct instruction

In order to provide sufficient background to guarantee laboratory safety, their instructor may transmit certain information directly. Chemistry faculty members must help students concretely understand the nature of matter, developing appropriate concepts about the microscopic world and other models of chemical behavior (Robinson, 1997). But, for "regular" material, the instructor teaching less may result in the student learning more and in a more timely fashion. Teacher guidance in problem solving provides input for the active learners who are in the process of constructing their own knowledge (Banerjee and Vidyapati, 1997). Internal construction of knowledge is preferable to external passive reception of knowledge (Herron, 1983).

9. Cooperative Laboratory Experience

Science education is both content (lecture) and process (laboratory). A grave shortcoming of many introductory science courses is that students learn a minimum about how to "do" science (Lawson, Rissing, and Faeth, 1990). They can regurgitate facts, but do not experience science as a process of describing and attempting to explain nature. If they can be taught how to "do" science, they will learn to learn, a central objective of the educational experience. They will be more motivated and interested.

Science instruction should include a quality laboratory experience (Lazarowitz and Tamir, 1994; Freedman, 1997; Bodner, 1992; Gallet, 1998; Herman, 1998; Oliver-Hoyo, 2003; Oliver-Hoyo, Allen, and Anderson, 2004). Taking a chemistry course without an appropriately designed laboratory component is similar to reading about playing basketball, but never actually dribbling a ball on a court, making a shot, or playing a game.

Lab should be more than just an experience of process skills—it should be an integral component of understanding science (chemistry). Progress is incremental (Shiland, 1999). The laboratory is the ultimate environment for *both* active and cooperative learning (Hass, 2000). Students must use active modes of learning—they must use experimental learning that actively engages their senses. If a formal laboratory component is not a well-coordinated part of the learning experience (i.e., integrating the material being studied in class), it is a waste.

a. Hands-on, minds-on inquiry vs. verification exercises

People discover and learn in real life through the process of inquiry, basing their new understanding on what they already know (Lord, 1999). Most of the time, this is through collaboration with friends or coworkers.

Students learn little from laboratory experiences the way they are commonly structured (Ricci and Ditzler, 1991; Lagowski, 1998; Gabel, 1999). Students who perform verification laboratory exercises spend the majority of their time following traditional cookbook directions and have minimal time left for peer discussions (Hilosky, Sutman, and Schmuckler, 1998). They learn how to complete laboratory tasks, but not much more (Lazarowitz and Tamir, 1994). Hands-on minds-on exercises make it possible for students to observe chemical phenomena on the macroscopic level and relate this to the symbolic and microscopic level (Pavelich and Abraham, 1979; Gabel, 1993). Gathering data in a laboratory format is the most effective introduction to a concept for a student (Abraham, 1988). Using the laboratory experience before encountering a concept in the lecture provides instruction from the concrete to the abstract. Students discuss their findings during the laboratory and develop concepts during discussion. Pseudo-laboratory experiments or laboratory activities depend on hands-on investigative experiences. Concepts first discovered through pseudo-laboratory or laboratory experiences can later be explained in the more formal classroom setting—the instructor can help to facilitate student understanding more effectively if the students first have generated or experienced the concept. Hands-on learner-centered activities promote direct student learning experiences from which construction of a deeper understanding of chemical principles and concepts evolves (Blakely, 2000; Burke and Walton, 2002). Students actively engaged in laboratory exercises achieve greater understanding of concepts than a lecture demonstration or description could provide them (Uno, 1990), especially if the students interact cooperatively (Herron and Nurrenbern, 1999; Hass, 2000; Oliver-Hoyo, Allen, and Anderson, 2004). Group dynamics are important (Selco, Roberts, and Wacks, 2003). The "laboratory first" strategy introduces students at the concrete and descriptive level of cognitive awareness (the macroscopic world) and then moves them to more abstract (microscopic) and symbolic levels (Abraham, 1988; Rickard, 1992).

1) Verification. This is fundamentally opposite to current traditional practice, sometimes referred to as verification laboratories, during which students confirm in the laboratory what they have been or will be told in the lecture, concepts to which they have been exposed prior to the laboratory experience (Pavelich and Abraham, 1979; Ward and Herron, 1980; Abraham and Renner, 1986; Renner, 1988). In the typical verification laboratory experience, the students read an introduction to the laboratory (some background and a description of the concept(s) to be explored) as well as a "cook-book" or step-by-step procedure before going to the laboratory. It is assumed that they have understood to some extent what they have read. The procedure for the experiment, the data to be collected, and results to be obtained are all neatly outlined. Students like these kinds of experiments because they know exactly what to do (Adams, 1998). Teaching assistants and instructors rarely allow students to go astray and so they never really get to try to solve an experimental problem (Brooks, 1984). The only input from the student is to execute each segment, carefully logging measurements taken. They may not understand the concept being studied or the results obtained. But, if they can follow directions or copy what a peer is doing, they can accomplish the task, without any true understanding of what they have done or learned. Students themselves recognize this.

Pickering (1987) notes: "One of the worst features of most laboratory manuals seems...to be that the students' results are rarely used for much. Never are the students forced to reconcile results or confronted with a challenge to what is naively predictable," (p. 522). Traditional verification laboratory exercises serve to benefit the instructor more than they benefit the student (Montes and Rockley, 2002). Because they are more structured, they are easy to supervise and help students understand (in terms of the mechanics), are quieter, and are normally found to be successful for the student—she or he will be able to get some kind of results. The teacher is familiar with the expected outcome. Often the students are also familiar enough with the outcome that they are sometimes able to fabricate data. The disadvantages cited by Leonard (1991) and Montes and Rockley (2002) are that passive students find verification labs can be boring. Because the procedure is "spelled out", there is little opportunity for students to practice separating relevant from irrelevant information and procedure. This prevents students from building a conceptual framework to which new learning experiences connect. They do not make the appropriate mental connections because there are usually an onerous number of steps to the procedure that they must complete in a given amount of time. They usually pay more attention to "getting through" these steps than paying attention to what they have learned. There is no flexibility in procedure, nor is there any individualization. With the uniformity of procedure, there is no excitement of discovery.

All student's perspectives are the same, there is no need for discussion of results. It can be easy for students to manufacture data or copy from one another. There is no learning from unexpected results because there are none.

2) Incorporating constructivism and inquiry. Because learning requires mental activity, laboratory experiences should be modified to capitalize on this aspect. To do this, Shiland (1999) shares ideas including the following:

a) Let student groups
   i) determine pertinent variables
   ii) draft procedures;
   iii) list their predictions before the laboratory experiment;
   iv) draft data tables;
   v) craft a standardized format to organize report work; and
   vi) identify sources of error or propose modifications to experimental procedures;

b) Prepare laboratory exercises so that the approach and solution are not obvious form the outset;

c) Conduct laboratory exercises before discussing concepts in the classroom to generate interest and detect existing misconceptions to be addressed by a more formal discussion;

d) Focus on the social negotiation of meaning by emphasizing group interactions;

e) Provide learners with the chance of incorporating the new ideas in a different situation.

The ultimate laboratory experience would be one for which students are not provided instructions and must decide their own procedure (Pickering, 1989). It has been found that guided or open inquiry laboratory situations are enthusiastically embraced by students, even those with poor backgrounds (Pavelich and Abraham, 1979). Students like the challenges that discovery or guided inquiry labs present (Adams, 1998). Guided inquiry laboratory exercises begin with specific (or sometimes nonspecific) experimental instructions rather than a conceptual introduction. The single most important ingredient in a successful inquiry-based laboratory is active student involvement (Crandall, 1997; Uno, 1999; Seymour, 2002). Once they take ownership, there is more interest and engagement (Haller et al., 2000). This can be achieved when the content is varied, connected to real-world applications, and involving substances outside the students' usual real of experience (i.e., not water, salt, sugar, or some other relatively common household substances) (Howard and Boone, 1997).

Students are motivated. They know which problem they are trying to solve and devise the procedure(s) used to do so. The work they do to arrive at their strategies must be graded for them to take it seriously (Mazlo, Dormedy, Niemoth-Anderson, Urlacher, Carson, Haas, and Kelter, 2001).

Unlike those who complete traditional verification labs, those who have done an inquiry exercise are more able to describe what they have done (Uno, 1990), and more able to evaluate the process as well as propose changes to the experimental procedure (Berg, Bergedahl, Lundberg, and Tibell, 2003). They experience more of a sense of self-satisfaction and accomplishment (Uno). This implies that they think about what they are doing and do not simply perform rote procedures with no thought given to the results.

Uno (1990; 1999) and Howard and Boone (1997) observe that students engaged in inquiry-style activities develop skills that include:

a) Constructing questions;

b) Asking good questions;

c) Observing;

d) Hypothesizing;

e) Predicting;

f) Designing investigations to solve problems;

g) Measuring accurately;

h) Processing and interpreting data;

i) Drawing conclusions;

j) Inferring (deductive reasoning);

k) Generalizing (inductive reasoning);

l) Recognizing assumptions;

m) Understanding limitations;

n) Relating cause and effect;

o) Making rational judgment;

p) Mastering principles;

q) Explaining;

r) Applying knowledge to new situations;

s) Working to share information and learn together

t) Formulating conclusions.

Not all chemistry concepts should be taught via inquiry methods. Those that are facilitated in this way should have an experimental approach, operate smoothly (error-free), be well-paced, use easily learned techniques, and should provide dependable and reproducible results (Crandall, 1997; Howard and Boone, 1997). Effective inquiry exercises (Uno, 1990):

a) Demonstrate cause and effect relations (the instructor guides the effect and has the students attempt to determine the cause or the instructor describes the cause and has the students predict the effect);

b) Can be used to compare and contrast; or

c) Can be used to discover patterns.

Students are asked questions about the data they collect as they proceed. They analyze and explain the data themselves, i.e., the teacher does not do this for them. This may be done alone, with a partner, with a group, or by consulting with the instructor who will act as guide to their inquiries. The fruitfulness of open discussion benefits all parties—learners share new ideas or think more deeply about existing ideas. The more thorough the discussion, the more likely all students are to come away with a deeper understanding. Students learn what negotiations are necessary when "doing science" (Montes and Rockley, 2002).

The purpose of hands-on minds-on activities is to present the student with the subject matter, supplying concrete experiences with the concepts before they are encountered in a more abstract fashion in the formal discussion period. The hands-on activity period could easily be the first time learners would be made aware of certain concepts. It serves as the learning environment where the initial understanding of a concept can be constructed by the students. . The opportunity to undertake authentic research is something that high school chemistry students *can* do (Hapkiewicz, 1999).

Uno (1990) advocates inquiry strategies because they:

a) Pique student curiosity and may, if only briefly, return learners to a time in their life when they were curious about everything;
b) May help students to become less close-minded, take risks, and assume more responsibility in their learning;
c) Be more unbiased and accurate in their work.
d) Help students to learn that science is a dynamic process of investigation not an inert accumulation of established or inalterable facts.

b. Cooperative work in the laboratory

Cooperative learning is important to science because of the prevalent use of group instruction and the practice of science involving working collaboratively with others (Watson and Marshall, 1995). In addition, the cooperative approach has a positive effect on laboratory learning experiences (Smith, Hinckley, and Volk, 1991). Students work together to find success and improved understanding in their work. Concepts are constructed that can then be successfully applied in the formal classroom (Hand and Keys, 1999; Keys, Hand, Prain, and

Collins, 1999; Rudd, Greenbowe, and Hand, 2001; Rudd, Greenbowe, Hand, and Legg, 2001). Cooperation is better on immediate achievement and retention (Watson and Marshall). Students benefit from activities that relate both the scientific method and team work (Shibley, 2001). This encourages scientific reflection—students incorporate a sentence or two in each laboratory report to summarize what worked well in their group and what required refinement. (Shibley). What knowledge students gained about chemistry in addition to inclusion of student opinion of group dynamics, provides an instructor with information about the group's progress and their ability to function (Shibley). If a group is not functioning well, according to student reflections, the instructor can intervene and supply aid to ameliorate group dynamics.

10. Focusing on the group and group dynamics

Human society, as we know it, is built on the ability to cooperate with others (Slavin, 1995). There are many overlapping cooperative groups in daily life: family members, neighbors, work colleagues, clubs, and teams. In modern society, cooperation in face-to-face groups is increasingly important. Scientists must be able to cooperate effectively with other scientists (peers), with technicians, and with both graduate and undergraduate students. A corporate executive must cooperate with superiors, other executives, salespersons, suppliers, and those for whom the executive is a superior. Politicians must be able to negotiate with other peer leaders as well as communicate with members of their constituencies. Instructors must be able to work effectively with students, colleagues, institutional staff personnel, and, at times, parents. Each of these relationships may also have competitive components to them. But, cooperative teams outperform competitive individuals (Qin, Johnson, and Johnson, 1995).

Frequently, episodes in the home and at the workplace revolve around the *interdependence* of coworkers. Traditional family life is frequently cooperatively based. Therefore, students are able to accept cooperative work because they have seen it modeled outside the school environment. Use of cooperative learning helps students to develop professional life skills—community-building and team-building. This is relevant to the career goals of many (Felder, 1995d). "Team work is a way of life in the real world. It is a major factor of how you are 'tested' at work" (Felder, 1999, p. 238).

In cooperative learning situations, subject matter knowledge increases—the sum of the parts working together are beneficial each to the other. Group work creates a rapport among members. Students in a group become a support system to one another—they see where they "fit in", they rely on one another, they trust each other, and they develop positive interdependence (Ross, 1994; Towns, Kreke, and Fields, 2000). Students develop appropriate attitudes toward challenging work on shared tasks—tasks are more accessible, more doable when group members share their expertise and are willing to take risks. They learn to "think on their feet" (Ross, 1994). With the feeling of group community, students will undertake more challenging tasks because they expect to succeed based on the group effort (Katz, 1996; Wright, 1996; Towns, 1998). They become more independent learners. There is more group processing of information (Martin, 1996).

Children enter school having varying familiarity with, and ability to engage in cooperative group work (McCaslin and Good, 1996). Gallet (1998) and Towns (1998) cite two fallacies of cooperative group work for the uninitiated: first, that students even know *how* to work together and, second, if they do know *how* to work together, that they *will.* Successfully operating cooperative groups do not happen without significant work on the part of the instructor and the group members themselves (Felder, 1995f).

a. Facilitating effective cooperative learning

Johnson and Johnson (1985), Schmuck (1985), Sharan (1985), Hooper and Hannafin (1988), Slavin (1995), and Martin (1996) outline principles of and goals for facilitating effective cooperative learning.

1) Appropriate grouping. A heterogeneous group is more productive (Johnson and Johnson, 1985). Interaction and achievement are positively related in heterogeneous groups (Hooper and Hannifin, 1988). Heterogeneous group variables include ability, achievement, gender (equal numbers of women and men or more women than men), ethnicity, age, attitude to subject, and leadership ability (Watson and Marshall, 1995). Heterogeneity allows for more elaborative thinking, repeated exchanges of explanations, and more open dispositions resulting in superior reasoning, enhanced profoundness of understanding, and improved retention (Johnson, Johnson, and Holubec, 1986). Students must learn to collaborate with teammates with whom they would not necessarily choose to work or who might be different from them in capability, learning style, or background (Uno, 1999).

a) Formal or informal. The cooperative groups are either formal (students work together for from one class period to several weeks) or informal (students work together for a few minutes up to one class period). Emphasis should be placed on the idea that some individuals learn by explaining their own understanding of a concept or problem to their peers. Groups can also serve as stress reducers for the more anxious student—peer help is available to them. Especially important to the student is to be cognizant that they will be held personally accountable for learning as well as for understanding that all members of the group contribute something (Cooper, 1995). Positive interdependence among group members while retaining personal responsibility are two important features of cooperative groups (Hyde and Kovac, 2001).

b) Forming groups. It is best that groups are selected by the instructor (Nurrenbern, 1995; Shibley, 2001), accommodating all variables of heterogeneity possible. In heterogeneous well-designed groups, each individual group is a microcosm of the entire class in academic achievement level, gender, ethnicity, etc. (Slavin, 1985). Self-selected groups tend to be homogeneous, socially oriented, and less work oriented (Johnson, Johnson, and Holubec, 1986; Hooper and Hannifin, 1991; Trautwein, Racke, and Hillman, 1996). Hagen (2000) notes that one factor to consider if groups are to work outside of school time is their work schedules. The instructor should make this a very real part of the grouping process.

There is no statistically significant difference between individual problem solvers and heterogeneous group problem solvers. Therefore, heterogeneous grouping is usually recommended despite the fact that Tingle and Good (1990), Hooper and Hannifin (1988), Okebukola and Ogunniyi (1984), and Watson (1995) provide evidence that refutes this. It has been found that although low achievers may benefit from group work, high achievers may not. For example, in a 1988 study, Hooper and Hannifin found that higher ability students in heterogeneous groups performed at a level 9% lower than high ability students in homogeneous groups.

Okebukola and Ogunniyi (1984) did confirm that low and medium achievers in heterogeneous groups learned from high achievers, improving their cognitive achievement level. Those students of lower ability in heterogeneous groups can gather more individual explanations from peer group members than would be possible from the lone instructor (Hooper and Hannifin, 1988).

c) Group size. Groups should be large enough for significant interaction, but not too large (Fraser, 1993). Teams of three or four students who are balanced in knowledge and skills are desirable (Felder and Brent, 2000a). Nurrenbern (1995) recommends groups have from four to seven members. Instructors can try several strategies, always remembering that group size should make it possible for all members to be actively engaged in mutual discussion and achieving the goals set for them (Johnson, Johnson, and Holubec, 1986; Carpenter and McMillan, 2003). Loss of motivation associated with social loafing increases with larger group size (Hooper and Hannifin, 1988). Shibley (2001) and Oliver-Hoyo, Allen, and Anderson (2004) suggest that groups of three provide enough work for all to contribute, allow members to meet challenges without deferring to more aggressive students, while still providing sufficient diversity.

d) Physical space. Room design is important to encourage student engagement and work (Fraser, 1993). An instructor should arrange the cooperative classroom so that student groups are in circles close enough to see one another's work and hear one another speak. There should be a clear walkway for the facilitator to move among the groups. But, the groupings should be far enough apart to afford privacy. (Johnson, Johnson, and Holubec, 1996). Fraser prefers to see students work together around a common table.

2) Distributed leadership.

a) Roles. It is important for all members to have assigned group roles (that can include some variations on each of the following: scribe, encourager, praiser, equipment purveyor, gatekeeper, checker, timekeeper or taskmaster, reflector, and group tension-reliever) and to rotate those roles regularly. Each individual must be an active contributing part of the team. There is equal sharing of tasks; taking turns in different group roles. To do this takes forethought by the instructor in creating an environment where the students actively engage in the material by sharing insights, providing each other feedback, and teaching each other in a non-intimidating, non-competitive atmosphere. This fosters the three important aspects of group work—cooperation, collaboration, and communication.

It is imperative that the instructor explains to the students why it is important to learn to work cooperatively as well as trains them how to do so (Towns, 1997; Towns, Sauder, Stout, Long, and Zielinski, 1997; Felder, 1995c; Felder and Brent, 2000a; Snodgrass and Bevevino, 2000). The instructor who models cooperative behaviors whenever possible will teach more than the subject matter of the course (Felder; McCaslin and Good, 1996).

b) Design of work. Group work should be designed to build from each student's experiences, talents, and abilities, encouraging dynamic participation from each group member (Towns, 1997; Shibley, 2001). Student responsibility lies in part in keeping each other on task, and in part in using higher level critical thinking skills. Group work must be worthwhile—it cannot be simple busy work (Nurrenbern, 1995). It should be comprised of opportunities for active construction of concepts via discussion and should foster team development (Uno, 1999). The combined expertise of group members must be valuable to solve problems (Haller et al., 2000). Cooperative group work must be well designed with appropriate incentives (and penalties) or students can spend more time carrying out tasks than reflectively thinking about the meaning of the process. Setting aside time for in-class group work is best (Nurrenbern). It should also be valued by including it as part of overall student assessment (Uno). Nurrenbern recommends that it should comprise up to 20% of the course grade.

3) Team building. A group member's sense of belonging to the group instills trust and collegiality. It increases motivation to perform and promotes learning better than competition (Slavin, 1995). Students learn to rely on group experts rather than professors (Martin, 1996).

College teams are predominantly first year students who are facing a rigorous course load along with adapting to life in college (Hanson and Wolfskill, 2000). It is of some consolation for students to share common experiences, interests, dilemmas, worries, and resources to help each other (Hanson and Wolfskill). Peer mentoring can be more effective than faculty help (Hanson and Wolfskill). Students should promote peers' efforts, provide encouraging feedback, and involve all members as part of the learning process.

4) Positive interdependence. Achievement is derived from positive interdependence (Nurrenbern, 1995; Uno, 1999). It is an essential prerequisite to effective group interaction and learning. Members of the group depend on one another for critical bits of information or for the execution of tasks crucial to group success. Students should be periodically reminded that they are working *together* and that their *joint* efforts produce the desired outcome. A group is successful only when each individual is successful. There is no product if each member does not contribute. If student-student interdependence is structured properly, students value the subject area more, achieve at a higher level, and use a higher level of reasoning strategies more frequently (Tingle and Good, 1990). Johnson, Johnson, and Holubec (1986) and Martin (1996) suggest that positive interdependence is the central factor in the group's interaction, productiveness, perseverance, sustained motivation, camaraderie, and sense of community. Interdependence structured to foster cooperative group tasks is meant to guarantee that everyone has learned the material and ensure each individual's success (Martin). Activities are structured so that a group is needed to accomplish the intended goal(s) better than any one individual could. No student does every component of the overall task. Rather, students are accountable for coordinating their efforts to be certain that no stone is left unturned. Positive interdependence can be generated in a number of ways including positive goals, rewards, resources, or assigned roles and tasks.

5) Skills acquisition. It is important to address social skills in the process of implementing collaborative learning strategies in the classroom (Snodgrass and Bevevino, 2000). Social awareness of acceptance and interpersonal support should evolve in the group. Learning the social skills essential for peer interaction helps students to determine that it is more suitable at times to lead and at other times to follow. This provides students with good lessons in lifetime skills. The quality and characteristics of the cognitive processing that occurs as students attempt to clarify or illustrate an idea or try to understand explanations offered by peers, helps those students to employ elaborative and metacognitive strategies and higher level reasoning more regularly than they would as independent learners (Herron and Nurrenbern, 1999).

Skills are identified and acquired with appropriate guidance. Hooper and Hannifin (1988) recommend that training in effective interaction helps to improve efficacy of group work. For example, an introductory activity is necessary to facilitate team building (Shibley, 2001). Any non-threatening activity to allow students time to observe how group dynamics work is satisfactory. At the same time, group roles should be explained.

6) Group autonomy. Students make their own decisions within their group without outside intervention. Because each group has a different blend, different groups may approach their objectives in a variety of ways. Instructors should respect this group autonomy and intervene only when necessary.

7) Individual responsibility and accountability. Attendance is required (Fraser, 1993). Activities are designed to help students feel some degree of ownership and control (Katz, 1996). Each group member must prove that she or he has learned without the assistance of others; this ensures that each student demonstrates academic and social growth. Facilitators can promote interaction by high individual accountability. Grading is designed to ensure individual accountability and reward group performance (Dinan and Frydrychowski, 1995). This encourages better quantitative and qualitative interactions. It may also motivate higher achievers to help the lower achievers to make an effort to contribute more (Hooper and Hannifin, 1988). For example, one strategy to motivate all members of a group is to award a bonus of five points on an exam if all group members score an average of 75 points or more (Oliver Hoyo, Allen, and Anderson, 2004).

8) Teacher as facilitator. Teacher and student roles are flexible in well-functioning groups (Haller, Gallagher, Weldon, and Felder, 2000). In the most directive role, the teacher supervises, guides, and coaches learning rather than delivering information. In her or his least directive role, she or he serves as student advocate (Katz, 1996), consultant (Uno, 1999), or just another accessible resource (Caprio, 1994). The teacher role is to support, encourage, and sometimes to act as a catalyst (Orzechowski, 1995). The teacher listens to each group to find out what individual and overall student needs are. In cooperative learning, the teacher masters better how to set the pace. One challenge is to set the correct amount of pressure to keep student moving but allow them adequate time to process the material (Hyde and Kovak, 2001). Teachers distribute attention more equitably when mentoring than when dispensing information (Herron, and Nurrenbern, 1999). As noted earlier, students learn to help in teaching or do the teaching themselves (Felder, 1993c; Martin, 1996).

9) Group processing and self-evaluation. The effectiveness of group learning depends on the amount and kind of interaction among members (Peterson and Swing, 1985). Both those who are willing to provide explanations *and* those willing to receive explanations in a group setting are higher achievers. The more detailed (higher order) the explanation, the better the achievement. Better listeners are expected to demonstrate higher achievement. Attitude is important—if a student perceives a peer's explanation to be good, achievement is increased. If a student judges her or his own explanation to be good, she or he achieves at a higher level (Peterson and Swing).

Students are involved in monitoring their own progress and assessing their own group performance. Members should be aware of whether they are appropriately carrying out their responsibilities and whether they are learning.

Shibley (2001) suggests that students reflect on the group dynamics and ponder the following questions:

a) Were there differences of opinion about the solution?

b) How did the group come to final decision?

c) Did everyone have the opportunity to contribute to a final decision?

The class can discuss methods used by each group to determine whether changes are needed. Desired behaviors can be specified in a group contract at the start of the term (Johnson, Johnson, and Holubec, 1996).

It is difficult for students to objectively evaluate the advantages and disadvantages of collaborative work. They can only compare to traditional didactic classes they have taken in the past. Students should evaluate their experience at the end of their course, and also after they have progressed in a coursework sequence or program (after more experience with later coursework in their field of study [Klionsky, 1998]).

10) Equal opportunities for success among all members. No member should have any advantage over another (Cohen, 1994). If all are working toward the common goal of learning together and there is no underlying competition, all members should help one another to achieve. Group incentives are preferable to individual incentives. (Hooper and Hannafin, 1988).

11) Team competition. Although cooperative learning fosters collaboration, students are accustomed to comparing performance levels and are used to competition for grades (Okebukola, 1985). If there is to be any competition in cooperative learning classrooms, it should be good-natured and inter-group (between members of different groups), but not intra-group competition (between members of the same group). The two aspects can be combined so that there is cooperation within groups but competition between groups (Okebukola). But, there should be inter-group cooperation as well (Johnson, Johnson, and Holubec, 1996).

12) Individual needs adaptations. As best they are able to do so, group members accommodate the special needs of any one member. When necessary, an instructor may suggest how this can be accomplished.

13) Social relationships in a cooperative group. Group work is a way to achieve equity among learners on the team (Cohen, 1994). Students encounter a number of different kinds of social relationships in cooperative groups.

a) *Intragroup diversity relationships*: when group members of different ethnicities interact at equal levels within the group, they develop supportive relationships, because group members work toward a mutual objective (Slavin, 1995). Cooperative groups break down the dichotomy in minority groups between work and peer relations (Fraser, 1993). While learning academically, students simultaneously learn that they can interact with persons of different ethnicities and have fun doing so. These kinds of group interactions may be the first encounters some students have had with others outside their ethnic group. Most of these relationships are successful, harmonious, and persist outside the classroom.

b) *Self-esteem*: students experience increased self-esteem as an outcome of cooperative learning. Students feel more liked by their classmates when they interact with them, and they feel more academically successful when they interact with classmates to achieve the solution to a common problem. Students are more motivated because of supportive peer evaluation (Felder, 1993c). In cooperative learning, the frequency of group work has a positive correlation with most areas of self-rated satisfaction and all areas self-reported growth (Felder).

c) *Retention*: students who work together cooperatively like school more than those working competitively. They like their fellow students more. They are more likely to help other students, to cooperate well, and to have the attitude that cooperation is useful. They will have the supportive attitude that they want their classmates to succeed, and they will have the perception that their fellow classmates want them to succeed. This perception actually does foster achievement. For example, in a study by Fraser (1993) among students engaged in collaborative group work , the pass rate increased by 15% for whites, by 65% for disadvantaged students, and by 28% for the class as a whole.

14) Tasks. The critical attribute of cooperative task work is that learning activities must be suitable for group work. Is the problem a task that demands true group interdependence or some other type of problem that does not require collaboration for success (Cohen, 1994)?

For new information to be assimilated, it must be somehow connected to information already stored in memory. Group work tends to facilitate that process because the group members together may be more successful at finding those connections than any one individual can alone. In addition, students learn more by having to explain to someone else (Springer et al., 1999) or by listening to an explanation from a peer.

11. Problem-solving and learning tasks

Instructors should assign straightforward problems to set the stage, then assign increasingly more challenging ones (Fraser, 1993). Students work in their cooperative groups to produce their own solutions (Fraser). They can then discuss them with another group or groups or in a larger, class-wide forum. Student problems are solved more efficiently, saving time when groups are collaborative—they communicate with each other on a technical level (Fraser). Problem solving in groups shows each student that there is more than one "right" way to solve problems. (Duch, 1996). Reflection about a cooperative activity should help a group to coalesce and learn about how and why multiple perspectives are required (Shibley, 2001). "Problem solving in groups is less stressful, allowing for clearer thinking. Groups working together can solve anything if they try hard enough" (Duch, p. 329).

The instructor should present some real-world problems that can be solved by the course (Felder, 1995c; Oliver-Hoyo, Allen, and Anderson, 2004). This is a useful method of introducing new topics (Woods, 1998) and generates motivation and enthusiasm. Because the structure of knowledge is affected by the context in which it is learned, *how* students learn affects their ability to apply *what* they have learned (Woods, 1998, Johnson and Malinowski, 2001; Hewlett, 2004). It is less about *what is learned* as *how it is learned*, less about the *right answer* as it is the *right approach* (Oliver-Hoyo, Allen, and Anderson). Active learning and connections to real-world applications help students to learn chemistry and apply knowledge appropriately (Duch, 1996). Scientific knowledge acquired in a problem-based context is more likely to be retained and synthesized (Duch). The use of open-ended applied problems engages students and they can more readily reproduce their thinking in future applications (Felder, 1991).

12. Benefits of cooperative learning

To learn in a meaningful way, students must actively process information (Towns, 1997). Many students learn *best* through active collaborative small-group work. "Cooperative efforts produce higher quality problem-solving, exchanges of information, insight, generation of a variety of strategies, ability to translate problems to equations, and development of shared cognitive representations" (Qin, Johnson, and Johnson, 1995, p. 130).

Students who participate in small group work persevere through science courses to a greater extent than do students in more traditional settings (Springer et al., 1999). In fact, Felder (1993a) observes not only positive academic outcomes, but also a few students whose choice of career gravitates to college teaching (Felder, 1999). Implementing some small group work is more effective than a lecture-only format because cooperative groups utilize positive interdependence, individual accountability, face-to-face promotive interaction, thereby teaching members interpersonal and small-group skills, and structuring group processing. High school students working together outperform their counterparts who work alone (Boling and Robinson, 1999).

Benefits of cooperative learning occur on two levels, that of the subject or academic aspect and that of the student or environment aspect.

a. Subject benefits

The use of cooperative techniques helps student to construct a big-picture view of what they are trying to understand (Towns, 1997). Subject matter benefits are numerous (Cooper, 1994; Cooper, 1995; Dinan and Frydrychowski, 1995; Nurrenbern, 1995; Felder, 1996; Kerns, 1996; Kogut, 1997; Towns, 1997; Towns, 1998; Springer et al., 1999; Bowen, 2000; Haller et al., 2000; Hanson and Wolfskill, 2000; Snodgrass and Bevevino, 2000; Hyde and Kovak, 2001; Dinan, 2002; Shibley and Zimmaro, 2002; Carpenter and McMillan, 2003; Cooper, 2004; Oliver-Hoyo, Allen, and Anderson, 2004; Preszler, 2004) and include :

1) Higher subject matter achievement and higher achievement overall; e.g., Bowen (2000) notes that medical students performing in a cooperative learning environment score 14 percentile points higher on achievement exams than their counterparts in a traditional learning environment.
2) A more positive attitude toward the subject AND the course, especially among underrepresented groups and women;
3) Better retention among nontraditional students;

4) Better overall retention and lower absenteeism—students do not want to let team members down;
5) A move away from rote learning toward an enhanced conceptual development;
6) Increased satisfaction with the learning experience;
7) Increased student mastery—students come to class prepared;
8) In general, a warmer classroom climate.

Bowen (2000) cites student persistence in science, technology, engineering, and mathematics (STEM) courses as 22% greater for students in cooperative learning environments than for students in more traditional curricula. Seymour and Hewitt (1997) believe the attrition in STEM courses is not a natural consequence of differing abilities among students, but, rather, that classroom climate and activity levels are determining factors.

The more time students expend working collaboratively, especially during the class meeting period, the more favorable their learning-related attitudes become, both in the subject, as well as overall (Dougherty, 1997; Springer et al., 1999). Active students feel that they are more a part of the class rather than passive observers.

b. Student benefits

The benefits of collaborative and cooperative group work for students are well-documented in the literature (Johnson and Johnson, 1985; Slavin, 1985; Hooper and Hannafin, 1988; Steiner, 1988; Hurley, 1993; Cooper, 1995; Fleming, 1995; Nurrenbern, 1995; Qin, Johnson, and Johnson, 1995; Slavin, 1995; Felder, 1996; Harwood, 1996; Katz, 1996; Kerns, 1996; Martin 1996; Wright, 1996; Towns, 1997; Felder, Felder, and Dietz, 1998; Towns, 1998; Uno, 1999; Wright, Millar, Kosciuk, Penberthy, Williams, and Wampold, 1998; Boling and Robinson, 1999; Clouston and Kleinman, 1999; Herron and Nurrenbern, 1999; Springer et al., 1999; Haller et al., 2000; Hanson and Wolfskill, 2000; Hass, 2000; Snodgrass and Bevevino, 2000; Towns et al., 2000; Brawner, Felder, Allen, and Brent, 2002; Dinan, 2002; Shibley and Zimmaro, 2002; Carpenter and McMillan, 2003; Selco, Roberts, and Wacks, 2003; Seetharaman and Musier-Forsyth, 2003; Oliver-Hoyo, Allen, and Anderson, 2004; Preszler, 2004; Shapiro, private communication, 2004; Swarat, Drane, Smith, Light, and Pinto, 2004: Cooper, 2005). These benefits may not all be as obvious to students are they are to observant faculty (Ross, 1994). These benefits include, but are not limited to:

1) Individual accountability—Students take more responsibility for their own learning; they feel a sense of ownership and control they have not previously experienced;
2) Greater active involvement (engagement) in the learning process;
3) A better sense of self-esteem;
4) More motivation—students are in control of their own learning;
5) More independence and resourcefulness;
6) Higher-level and abstract thinking skills that require deeper processing;
7) Sharper critical thinking;
8) More reflective thinking;
9) More metacognitive activity by comparing and discussing;
10) Higher reasoning skills;
11) More cognitive interpersonal skills;
12) Better acceptance of peer differences (i.e., learning about diversity);
13) Increased social skills (ability to exhibit leadership and understand the complexities of the group power structure; ability to communicate about science while working with peers to organize and interpret knowledge);
14) Increased appreciation of the value of course content;
15) Reduced anxiety or stress; less alienation and anonymity;
16) Better accommodation of the opinions of various members;
17) Diversification of skills and deeper engagement in problem solving;

18) Acquired problem-solving skills transfer and assimilate to other courses;

19) Developing interdisciplinary thinking;

20) Appreciating a peer's perspective;

21) Peer reinforcement of concepts, encouragement, support, nurturing, motivation, recognition, and involvement;

22) Serving as models for peers;

23) Higher quality of learning—more time on task and sharing ideas related to the learning task;

24) Better management of their own and others' resources (time, talents);

25) Improved coordination of their own work with others and as a result learning what they do and do not understand;

26) Learning how to obtain information from peers—rather than depending on the instructor;

27) Learning *which* peers to ask for help;

28) Valuing shared work—with an increased emphasis on conceptual understanding;

29) Developing an expanded understanding of self and of others;

30) Learning that all people (including themselves) have strengths and weaknesses;

31) Developing patience;

32) Being more creative;

33) Recognizing, accepting, and correcting errors;

34) Learning from failures;

35) Developing more self-confidence, learning to become more self-sufficient;

36) Learning self-directed planning—estimating their own reserve of time and energy and learning to spend more time outside of class studying;

37) Learning to rehearse information orally and integrate it, especially explanations of how to approach tasks; i.e., communication skills are important;

38) Finding small group work leads to more positive attitude, especially among women; women prefer collaborative opportunities to learn rather than those that are competitive;

39) Having numerous opportunities to make decisions over the course of a term;

40) Learning to offer advice and provide feedback to peers;

41) Learning to have realistic expectations (it is a relief for students to know that others struggle with the same problems and how they do it);

42) Learning to pursue common goals;

43) Preparing in advance to avoid appearing ignorant;

44) Learning to formulate better, higher level questions;

45) Listening better;

46) Learning to defend answers;

47) Making the class discussions more focused;

48) Having more in-depth experiences;

49) Nurturing study skills;

50) Benefiting from research experiences;

51) Developing the ability to problem-find as well as problem-solve;

52) More positive attitude toward the instructor;

53) Decreased dependence on the instructor;

54) Increased awareness that there is more than one way to solve a problem.

Students develop appropriate attitudes toward challenging work on shared tasks—tasks are more accessible, more doable when group members share their expertise and are willing to take risks. A group environment provides students with a forum for idea exchange, an opportunity to give or receive guidance and advice to or from others, and confront their own knowledge (Fleming, 1995; Swarat, Drane, Smith, Light, and Pinto, 2004). They learn to "think on their feet" (Ross, 1994). With the feeling of group community, students will undertake more challenging tasks because they expect to succeed based on the group effort (Katz, 1996; Wright, 1996; Towns, 1999). They become more independent learners. There is more group processing of information (Martin, 1996).

c. Peer mentoring

Students actively involved in group work are mentored by peers (Kogut, 1997; Dougherty et al., 1995; Fleming, 1995; Qin, Johnson, and Johnson, 1995; Towns, 1998; Uno, 1999; Herron and Nurrenbern, 1999; Hanson and Wolfskill, 2000; Hass, 2000; Snodgrass and Bevevino, 2000; Shibley and Zimmaro, 2002). With peer mentoring, students:

1) Are better prepared before and during learning experiences (e.g., laboratory);
2) Have fewer irrelevant or distracting thoughts, i.e., stay on task;
3) Can observe peers' strategies for solving problems;
4) Have better independent problem-solving ability based on their group work background;
5) Get and provide peer feedback on ideas; also provide teacher feedback;
6) Receive psychological support and acceptance—students who experience cooperative learning believe they are liked, supported, and accepted by other students and that other students care about how much they learn and want to help them learn; the more students believe other students support them, the more likely they are to want to work harder (Johnson and Johnson, 1985).
7) Solve more difficult problems than if working individually, and generate a variety of strategies to do so;
8) Spend more time synthesizing and integrating concepts;
9) Have higher potential for achievement;
10) Move away from the habit of rote learning to collectively making sense of a concept;
11) Can confront their own misconceptions;

12) Have a better attitude toward learning;

13) Perceive working with others helps to improve their grade;

14) Have more self-confidence with group support in the face of intimidating science work;

15) Learn to work with people who might be completely different from them;

16) Care about assisting one another.

Alternative modes of instruction (besides lecture) are possible, even in classrooms that contain 400 or more students at a time (Herron, 1984). Cooperative learning is just one of several tools used in the student-centered classroom. Using this technique, an instructor may discuss less material than in a traditional class, but it will be more in depth. Students can sometimes teach one another concepts within their groups more quickly and efficiently than an instructor delivering information can. More frequent informal small-group discussions among students or with a teacher, lead to more sustained higher-order thinking or better problem-solving ability, but not necessarily to greater content knowledge (Springer et al., 1999). Student performance does not suffer and students perceive that adequate material has been presented to prepare them for examinations (Bodner, 1992; Clouston and Kleinman, 1994).

The benefits of student-student interactions outweigh those of student-teacher interactions. Piaget's and Vygotsky's emphasis on experience and social interaction supports this (Steiner, 1980). Shibley and Zimmaro (2002) observe that "Conversation with people we regard as our peers—our equals, members of our own community—is almost always the most productive kind of conversation" (p. 748). In addition, because students often learn more effectively when someone above, but near their educational level or zone of proximal development helps them (Vygotsky, 1987), compared to instructors or even teaching assistants, peers are excellent tutors. Peers share the same experiences and beliefs with one another. This creates a learning environment characterized by trust and support (Swarat, Drane, Smith, Light, and Pinto, 2004).

Students are guided to take control of their own learning—the course belongs to them (Hyde and Kovac, 2001). The classroom atmosphere is more casual, more conducive to learning. Instructors spend less time answering the same questions because student groups discuss them before asking. Often, they resolve an issue without having to ask the instructor or teaching assistant (Martin, 1996; Shibley and Zimmaro, 2002). Teams engage more students at one time (Selco, Roberts, and Wacks, 2003). Having other team members depend on them keeps the weaker students from becoming distracted or disengaged with the learning activity (Selco, Roberts, and Wacks). Academic teams, like sports teams, practice together to help one another to improve, but also learn and develop skills as individuals (Hanson and Wolfskill, 2000). There are constant small intra-group discussions as well as some inter-group discussions. This makes for a more dynamic classroom than would be true of a traditional environment (Windschitl, 2001). Eventually, the more experienced students are with cooperative learning exercises, the more they feel *able* to express their ideas and feelings in large *and* small groups. They also have a greater willingness and desire to express their ideas to the larger class, which creates a more positive feeling toward the instructional experience (Johnson & Johnson, 1985).

13. Why does group learning work?

The argument has been presented that active student learning via group work is beneficial to the student sociologically, personally, and academically. But why? There is much less research to explain the why than there is the how. Obviously, students are more engaged with their learning goals when placed in an interactive task-oriented situation than they would be during a comparable "lecture" period. Cooper speculates (2005) suggests that students involved in effective group work struggle to construct or comprehend challenging concepts together. In a non-threatening environment, they are able to negotiate their understanding by verbalizing their reasoning—explaining *how* they know *what* they know. This leads them to examine and analyze how they came to construct their knowledge. In the process, they achieve a deeper realization of the concept(s) they have come to know. Novices at all levels realize that to teach another person or group about a concept or idea requires them to understand in the first place.

14. Drawbacks

However, cooperative group work is not a panacea (Adam and Slater, 2001). Strategies are constantly tried and modified to achieve success (Bianchini, 1997). What are the drawbacks of cooperative learning? Several potential pitfalls can be discussed (Bodner, 1992; Cooper, 1995; Felder, 1996; Kogut, 1997; Towns, 1998; Hatcher-Skeers, 2002; Cooper, 2005).

a. "Covering" course material

The most common fear among both instructors and students is failing to "cover" the same quantity of course material. Student active learning strategies take time. But even when a professor delivers an eloquent lecture about material, does the student learn? Formal instruction can be used to emphasize important points and depict connections between related topics so that the course does not appear to be a series of disjointed topics separated by periodic examinations. Cooperative learning fosters independent thinking. A better ability to process independently is more of a benefit to students than it would be for them to sit through a certain number of hours of "lecture" material, just to say that they have "covered" it.

b. Time factor

Is cooperative learning a time drain? Could a teacher efficiently explain a certain topic more clearly than the time sink of students trying to puzzle through an exercise, negotiate meaning with one another, and together construct the concept? Frequent informal discussions among students or with a teacher lead to more higher-order thinking or problem-solving ability, but not necessarily to greater content knowledge (Springer et al., 1999). Where should the sacrifice come—in the realm of efficient delivery and receipt of content knowledge or the discussions that could lead to higher levels of cognitive processing?

With practice, an instructor becomes proficient at understanding whether and when she or he should provide information rather than have students construct it. Some material, such as quantum chemistry, for example, does not lend itself to being constructed by novices.

c. Classroom management

Using cooperative learning forces the instructor to surrender what had formerly been complete classroom control. The instructor must adjust to being more of an adaptable guide, coach, or facilitator than sole source of all knowledge. There will ideally be a different atmosphere in the classroom—one of animated discovery. Student questions and thinking may serve to dictate the direction taken by the instructor. This challenges the instructor to think on her or his feet. But, the instructor does not "lose complete control" of the students.

d. Freeloading

Will lower-ability students simply rely on the work of those who understand more than they do? Heller and Hollabaugh (1992) and Heller, Keith, and Anderson (1992) find this is not true. Students as a rule realize the mutual benefits of group work and attempt to make contributions to group work, even if they are minor, in order not to let down their peers or to look uninformed in front of their peers. Also, helping another student does not affect any student's ability to earn a high grade because all are graded on the same predetermined scale—there is no grading curve in criterion-referenced grading.

But, a student may not accomplish the share of the task(s) assigned to her or him and would then let down her or his peers. The instructor must try to guide group dynamics so that this cannot occur. Peers are reticent to confront a laggard in the group. The instructor must work to create a classroom atmosphere that supports constructive criticism.

The strategy recommended to discourage students from relying too much on the group is to limit the cooperative group grade to only 20%-30% of the total grade for each individual (Cooper, 1994; Nurrenbern, 1995). This means that the major responsibility still lies with the individual, but that cooperative work *can* benefit the learner who wishes it to do so.

Some stronger students fear that weaker peers will cause the group grade to be lowered. An instructor can suggest that the weaker students take responsibility to prepare a draft or outline of a group report and the stronger students contribute what they presume will improve what has been prepared. This recognizes the weaker students as being able to contribute "their part" to the end product.

e. Student absence

What impact does student absence have? Student absence is definitely a problem in a cooperative learning classroom. Both the absent student and the group suffer (Hyde and Kovac, 2001). Although the group may exchange information with the student at some later time, the dynamics are not the same. Students who are mentally engaged by collaborative work will choose to attend class in lieu of avoiding the work.

f. Students who prefer not to work in a group

Some students prefer to work individually. This may be due to previous bad experiences with cooperative group work. Or, it may be a learning style or personality trait. The instructor must be able to justify cooperative group work to this type of individual and fit the person into a group that works effectively to alleviate the person's concerns or negative opinions.

15. Obstacles

Left alone to accomplish collaborative projects, students may encounter some of the following obstacles or difficulties. The solution to them rests with the teacher being available to provide adequate facilitation. Some suggestions for teacher remediation follow each of the potential obstacles.

a. Students value the product more than the process and increase the pace of their work to obtain the product. The teacher must question students along the way to encourage them to become more engaged in the process than concerned with finishing the product. It is not the goal to finish the assignment, but rather to understand each part of the assignment on which they are working.

b. Students may value group processes more than academic products. If it appears that a task goes by the wayside as the students interact socially, the teacher can remind group members of their overall goals and, if necessary, redistribute group members so that they will focus on goals rather than social interactions with peers.

c. Misconceptions can be reinforced if peers have the same ones (Martin, 1996). The teacher, by non-intrusive observation must be prepared to interject statements or questions that could lead the students to develop acceptable interpretations of concepts. This develops out of student trust and respect for the teacher's ability to guide but not decide what meaning the students are creating and thereby learning in the process.

d. Shift dependency from the teacher to peers. If students begin to depend solely on peers for information, some misconceptions or misinformation might be introduced to the learning process. Teachers must be attentive to ensure that they are still approachable to be consulted as a source of some information as well.

e. Students receive different attention and status. If it appears that student groups are serving to accentuate a student's popularity or ego, teachers must intervene to reaffirm the validity of the task at hand. Group members will definitely have different abilities—which necessitates different dynamics as to who does the work and how they accomplish it. The goal is that all contribute and that the group would not function as well without the contributions of each member.

f. Students may learn to avoid contribution. Peers may not always insist on the accountability of all group members. Teachers must attend to equal participation by all members. If not all participate, the teacher must encourage group members to insist that all contribute. Assessment should include a participant component.

g. Students may not believe they are able to contribute. If peers from the group are unable or unwilling to coax their colleague to participate, the teacher may need to facilitate by asking a question she or he knows the reluctant student will be able to answer. Using this kind of strategy, the teacher helps the student to develop confidence and evolve as a productive group member.

h. Work assigned to cooperative groups often does not appear on tests which gives the message that the work is not important. Some method of assessment must justify the value of the tasks to validate their importance.

i. Unless the group goals are chosen by the members, it makes little sense to them to pursue them. Although there are certain learning goals that are necessarily developed, the teacher may allow the students to decide in what way or in what order they are to be achieved.

j. Working in close proximity, achievement differences are more evident, which may mean that the higher achiever may dominate a more passive lower achiever. The teacher may be able to intervene by careful questioning of the lower achiever to provide him or her with the opportunity to demonstrate an ability to achieve.

Even under optimal circumstances, group work may not provide the same quality of learning to all students (Bianchini, 1997). But it is important to reflect on the philosophy of Springer et al. (1999) that any progress in the direction of getting students more actively involved should be complimented, not admonished, even if one or more elements of a certain technique or strategy are not executed according to "dogma".

16. Group consistency

One interesting facet of group work is the desire among most groups to remain intact over time. Most team members, given the opportunity to change or rearrange groups, prefer to keep the same groups. Research supports this observation. Consistent groups are more effective than groups whose membership changes over time (Shibley and Zimmaro, 2002). Indeed, students who form group relationships in one course may continue these relationships into subsequent courses. Cohesive groups are stable groups. Stability relates to achievement and satisfaction (Shibley and Zimmaro). The disadvantage of this is that sometimes students are not provided the opportunity to interact with as many other students unless some directed activity requires it.

G. Summary of the Literature Review

Curriculum development and implementation can be enhanced by the use of interactive distance communication technologies. Aspects of distance education research, including the use of the Iowa Communications Network to supply two-way interactive video in tandem with electronic mail exchanges and use of the Internet as a resource and reference are explored.

Factors involved in planning and conducting appropriate and thorough qualitative focus group evaluative research, as well as interpreting the information collected, are discussed in depth.

Finally, a comprehensive outline of collaborative classroom approaches, including an examination of the benefits and disadvantages of these practices, is provided.

III. CHAPTER 3. LITERATURE REVIEW AS APPLIED TO THE ICEA PROJECT

In essence, the development of the ICEA Project was studied and evaluated from two separate yet intimately related perspectives: (a) student-student, student-teacher, or student-guest interactions in local classrooms and between distant classrooms and (b) teacher-teacher or teacher-Project personnel interactions on-site or at a distance. As noted in the previous chapter, the factors most impacting the Project were the use of cutting edge communication technologies, using qualitative focus group interviews to monitor student and teacher input, and creating a student-centered learning environment.

It should be noted that the ICEA Project was not geared toward gifted and talented high school students; the majority of students were in basic college preparatory programs, as opposed to honors or AP programs.

A. Communication Technologies.

The ICEA Project capitalized on the use of the ICN, electronic mail, CUSeeMe cameras, and the Internet for communication among teachers, among students, and between the two groups. At the outset of the ICEA Project, all four of the original schools were relatively equivalent in their technologies or adequate compensations could be made to make them so. Lack of access to technology did not become problematic for any one teacher or school until Phase III (this discussion will appear in the overview of Phase III, found in Chapter 6 of this document).

In the ICEA Project, teachers and students alike had a high comfort level with the ICN technology, finding that it afforded them the same kind of experiences as if they were all gathered in one location. But, they *always* desired the opportunity to meet and talk with each other in person in an informal setting (Schlosser, 1997; Burke, 1998; Burke, 1999). Regular on-site teacher meetings could achieve this for instructors, but the sheer volume of students precluded any out-of-class meeting for them, other than incidental happenstance unrelated to the Project (e.g., at an academic or sporting event or in a mall, etc.).

The use of the ICN's two-way interactive video systems as a tool for interactive networking among faculty (rather than as purely a teaching tool) was fundamentally important to the ICEA Project and crucial to its success.

If overall communication was a primary concern of the ICEA Project, the second most important facet of the Project was the training and support provided to the ICEA teachers by faculty and staff at Iowa State University. This assistance was crucial to the success of the Project (Ehlers, Hartman, Hepburn, and Murphy, personal communication, May, 1997). Mentoring was a SIGNIFICANT factor of the ICEA Project from the outset, but especially after Phase II. Mentoring also included facilitating training workshops. Although many of planning issues were highlighted and discussed at length during the planning and Phase I implementation of the ICEA process and resultant products, some evolved over time.

A project is not difficult if planning is comprehensive. Leadership is critical to success. Myers (1994) recommends getting people committed to project success. It is suggested that a productive interactive team would include content specialists, instructional designers, media specialists, specialists in learner behavior, and curriculum development to generate quality learning modules (Sorenson, 1997). Every attempt was made to create an ICEA design team composed of these kinds of individuals. The resultant curricular materials and implementation process offered proof of successful execution of this development goal (Burke and Greenbowe, 1998).

Every attempt was made to emphasize time spent on learning tasks. For the more open-ended design of the ICEA modules, students had to learn to manage their time appropriately. Broadcast air time (via the ICN) was also restricted, so that the students had to prepare well to efficiently utilize the time allotted to them. If they spent part of their time organizing in front of the camera, their distant classmates were less apt to pay attention to them when they started their presentation or less likely to take seriously the material they were presenting. Any television viewers have a low tolerance for having their time wasted by tape delays, broadcasting errors, or dead air time..

The majority of students in a more traditional classrooms could not access the equipment that students could in this Project (Simonson, 2000). Student activities were designed to allow them to have fun as they learned. The ICEA Project Forensics unit accomplished this better than any of the other learning modules.

The thrust of the ICEA Project was to promote student-student and student teacher interaction and learning. The ICEA teachers drafted a code of behavior to be read to all participants prior to their first on-air session (Appendix B).

Students at a distance needed to feel as if they were included. The way in which this Project employed the ICN produced a secure feeling of student inclusivity at all sites. Student survey responses reported no feelings of being left out of any activity, presentation, discussion, or conversation session. Teachers also felt that the ICN provided them with a secure sense of inclusiveness during ICN "staff" meetings. Using the ICN became transparent. It served as a useful communication tool to include a larger audience than possible at just one site.

From the outset, the object of each ICEA module was made clear to students so that they were working toward an understanding of a concept. Teachers in the ICEA Project designed successive lessons to build on earlier ones, reflecting the philosophy that students should build their new knowledge on the scaffold of prior understanding.

Using their real world module experiences to make the connection between past knowledge and new information made the students into more independent, self-reliant learners. For this reason, real-world applications of chemistry concepts and principles as illustrated by the ICEA learning modules were useful in the transfer or application of chemistry knowledge.

If teachers model enthusiasm for learning, students will be attuned to it and will benefit from their example. Sharing sessions over the ICN by guests who are experts in the field of forensics were extremely popular with students and teachers alike. Guests were so motivated by student questions that they extended the duration of the time spent visiting with students. Students were so enthusiastic about guest sharing sessions that they generated a number of spontaneous questions to supplant the "canned" questions they had previously drafted for the session.

1. The role of the ICN in the ICEA

Why use the ICN for the ICEA Project? Merkley et al. (1997) cite the benefit of the ICN as a means for teachers to receive information or assistance from other professionals. The ICN can transport people and experiences to classrooms to expand traditional instruction practices or provide completely new alternatives (Wortmann, 1992;Schoenfelder, 1997). What is the role of the ICN in the ICEA? This question can be answered on two levels—for students and for teachers.

a. Students

There is some initial student reluctance to interact because it entails use of push-to-talk microphones. This eliminates some of the spontaneity related to traditional classroom dynamics (Tillotson and Henriques, 1997). But, through the use of fiber optics and two-way full motion video technology, as well as utilizing the availability of CUSeeMe technology, electronic mail, and the Internet, teachers had the opportunity to provide chemistry students with a multi-interactive distance-learning environment (Flemister et al., 1994). The ICN provided users with quality synchronous communication capabilities. Because the technology allowed for same time, different place interactivity, participants could exchange information, data, ideas, and suggestions in real time, face-to-face, even if at a distance. The high quality full motion video allowed participants to read body language and perceive the nuances of intonation and inflection in the voices of peers at a distance. These subtleties could not be transmitted via electronic mail, FAX, or the Internet, nor be as readily observed using CUSeeMe cameras. The instantaneous response possible with ICN technology provided timely feedback about issues or concerns of the day, as well as the opportunity to ask and answer questions of immediate import.

Distance education via the ICN can improve learning experiences, expand horizons, and encourage group collaboration by exposing students to concepts, activities, and people not accessible in their own schools (Schoenfelder, 1997). It can expand the pool of teachers to include community leaders, local and international experts, and people for whom travel to any locale outside their own is unfeasible, impractical, or inconvenient (Wortmann, 1992; Boaz, 1999; Paterson, 1999). The distance learning experience makes people, resources, and information readily accessible in *real time* without regard to their physical distance from each other (Paterson). For example, ICEA ICN classes interviewed forensics experts (detectives, police officers, state troopers, sheriffs, deputies, and pathologists) as well as legal experts (judges, defense attorneys, and prosecutors). Wortmann notes that inviting guest speakers to the classroom increases learning in the classroom and improves community-school relations. Not only do the students learn from the experts, the experts learn from the students. The experts even learn from the experts. "Through speakers, the students, school, and community become a learning team, " Wortmann (p. 22). Moore (2003) notes that the teacher also joins her/his students as a part of the learning team. After guest speakers have been invited to interact with students, they frequently request to return. In addition, some have become aware of particular needs in the school and are able to arrange for community assistance to the instructor or school system.

Regardless of the technology employed, students find distance learning courses satisfactory and compare them favorably with typical classroom-based instruction. As noted earlier, learning outcomes for students using technology at a distance are similar to those of students in a more traditional setting. Students do equally well as distant learners as they do as on-site learners (Tillotson and Henriques, 1997) and sometimes better (Simonson et. al., 2000).

Students prefer a high level of interaction among peers at all the sites that participate in an ICN session. The more overall interaction among students (as opposed to individual participation), the higher their satisfaction (Fulford and Zhang, 1993), and the more they maintain the sense of existing as a unified class (Boaz, 1999). However, Fulford and Zhang found that with increased exposure to interactive sessions, perceived level of interaction and satisfaction begin to decrease.

When mistakes are made while teaching at a distance via the ICN, the distant learners communicate the nature of the difficulty in whatever way they can and are encouraged to do so at the earliest opportunity. For example, participants reminded classmates to depress the button on the push-to-talk microphones if they could not hear what was being said. Students were reminded that they were within earshot of the teacher microphone if they were making inappropriate comments. Teachers and distant classmates also corrected clowning around or making inappropriate gestures while on camera. In some respects, students were less tolerant of horseplay than their teachers were. They considered ICN time to be valuable, important, and not worth wasting. They did not want the actions of a few individuals to threaten continued use of the network.

Televised instruction with no warm human in the room might be daunting to high school students who are used to teacher-directed, monitored, and regulated classrooms (Paterson, 1999). Communication between teacher and student, student and student, or teacher and teacher is the focus of the two-way interactivity of the ICN. To capitalize on learning at its greatest potential, participants at ICN sessions learned to communicate as if they *were* face-to-face. Given the appropriate training, time to familiarize themselves with the equipment, and opportunity to integrate ICN technology into their interactive presentations, students' satisfaction increased.

Traditional curricula (characterized by memorized facts, the teacher as the primary dispenser of information, passive learners, and no need to employ current technologies to collect data) cannot support education reform when merely transplanted to an ICN distance education room (Cyrs, 1997). Content and delivery must be rethought. Multiple instructional techniques incorporated effectively improve student achievement. If the learning exercises are not perceived to integrate well into the existing curriculum, the students will not support their use (Merisotis and Phipps, 1999). Learners taking an active role in their own classrooms must support student collaboration over a distance. The use of pure lecture does not support effective interactive sessions. Student groups do become more active and cooperative in the learning process in interactive telesessions (Cyrs). Knowledge and attitudes are affected by this collaborative effort (Flemister et al.). Such a paradigm shift initiates the necessity to modify teaching methods (Flemister et al., 1994; Cyrs). Curricular changes that evolve as the result of this kind of collaborative effort will shape the culture of tomorrow.

b. Teachers

The traditional role of the teacher is expanded in cooperative distance learning projects. An emphasis on new and different teaching skills from the traditional course are necessary (Cyrs, 1997). An instructor's traditional teaching style may not "work" on interactive television (Anderson and Kent, 2002). She or he may have to use a method which is less familiar, thereby increasing required class preparation time. A teacher who is not well-prepared in a traditional classroom setting will find it difficult to adapt to an ICN distance learning environment (Merisotis and Phipps, 1999). Willis (1994) and Anderson and Kent (2002) emphasize that teachers need to design learning experiences that require student involvement and participation. Not only does the teacher need to have an understanding of how to use the technologies available, and to plan appropriate activity-based lessons for this type of environment (Cyrs), but she also needs to develop networks with teachers at other ICN sites to share materials and equipment (Flemister et al., 1994).

Teachers and student alike believe that it is important to identify the goals and objectives of each ICN session at the outset; in addition, they believe that it is important for teachers to vary learning activities within a single class. Students at a distance feel more strongly about this issue than local students do. The more variety there is in ICN visual materials and activities, the more learning is improved (Cyrs, 1997; Schoenfelder, 1997).

The teacher can use the camera to focus on the students, thus taking the focus away from her. This is something that cannot be done in the regular classroom. From preschool days in the traditional classroom, children discover that the focal point is on a lone adult at the front of the classroom rather than on them. Students are not encouraged to talk to each other. In the traditional classroom, talking is discouraged, and is sometimes a punishable offense. In an interactive ICN learning environment, the camera can focus on learner-to-learner interactions, eliminating the teacher altogether (Paterson, 1999). Two-way interactive distance education technology has the responsibility and the opportunity to nurture a student-centered learning environment (Olcott and Wright, 1995). Learning via interactive distance education favors the student-centered classroom as opposed to the teacher-centered classroom (Cyrs, 1997). The traditional "lecture" has been supplanted with student-directed learning modules.

The four Phase I ICEA chemistry instructors were strong proponents of the use of the ICN. They were not unlike a large number of instructors studied across the state. Neither teachers' years of teaching experience nor educational level seem to affect their convictions as to whether curriculum competencies can be communicated via interactive telelessons, nor did the amount of time they had spent as an instructor impact their knowledge, ability, interest, and sentiments as related to interactive teleteaching techniques (Bigilaki, Torrie, and Hausafus, 1997). The teachers recognized the limitations of the ICN for science courses for not all experiences can be managed over the system, i.e., laboratory demonstrations or experiments (Miller, 1996).

All four Phase I teachers were quick to emphasize that "We're using the ICN to help in the classroom, but we're not *teaching* over the ICN...We're using the ICN as a good communications tool, not as an instructional content delivery system. We've used the ICN for what it does the best and not made it the sole delivery mechanism for chemistry..." (Ehlers, Hartman, Hepburn, and Murphy, personal communication, June, 1997).

"The ICN that we used for weekly or regular conferencing (formative evaluation) and for teacher planning and teacher development, I think, was probably for me and as far as the Project goes, an important aspect. Because we're pretty used to it, to me it's no different to meet in the ICN room at a distance than it is to sit here in person (face-to-face)..." (Ehlers, personal communication, June, 1997). This comment supports the equivalency theory of distance education which purports that the more equivalent the learning situation of the distant learner is to the learning situation of the traditional local learner, the more equivalent the learning outcomes are (Simonson *et al.*, 2000). It is particularly appropriately applied to ICEA teacher interactions.

"Writing the last five modules, the clarifications, the corrections, what was going well with the module we were on, what was going wrong, what kind of ideas you had...the weekly hour and a half ICN staff meeting was very valuable for coordination of the Project. I don't think the Project could have gone without it..." (Hartman, personal communication, June, 1997).

This sentiment is mirrored in the literature. Formative feedback for a project should be established from the outset. Lochte (1993) notes that teachers should communicate their ongoing experiences and findings with each other frequently. This is crucial to the diffusion and evaluation process.

Are technological advances in the field of distance education surpassing the understanding of how to usefully integrate them? Is there too much enthusiasm about using distance education technologies for the sheer purpose of using them as opposed to using them as a teaching/learning improvement (Merisotis and Phipps, 1999)?

Was the ICEA Project designed merely to capitalize on the use of the Iowa Communications Network? Were grant moneys obtained simply by writing a proposal to employ Iowa's two-way interactive fiber optic technologies? The answer to these questions is a resounding no! It may have been an opportune time to write a grant to utilize Iowa's distance education communication technology system. The use of the ICN and related distance technologies was a means to an end. The ICEA modules were not created as an answer to "How can we use the ICN more?". Rather, the modules integrated the ICN and distance communication technologies to expand the capabilities of the Project—as a teaching/learning improvement.

The Iowa Chemistry Education Alliance Project succeeded because of the creativity and innovativeness of the ICEA Project teachers (and to some extent, their support staff and school administrations) and because of the availability of the ICN as a communication tool among the master high school chemistry teachers and support staff at Iowa State University. Without the weekly ICN "staff" meetings, teachers would have had to rely solely on electronic mail, telephone, and FAX. They emphatically stressed that the ICN was critical to their successful execution of the Project. Use of the two-way interactive fiber optic ICN system was appropriate to the task under construction. Use of the ICN increased the efficiency and effectiveness of moving the Project forward.

The use of the ICN during Phase I of the ICEA Project showcased what characterized the ICEA Project as a whole—its dynamic nature. As the teachers taught one set of lessons, they were in the process of designing others. Designing and critiquing was accomplished via the ICN in conjunction with electronic mail and CUSeeMe cameras. Later lessons incorporated skills and concepts that had been developed and honed in earlier units. As each unit was undertaken, ongoing ICN, electronic mail, and CUSeeMe camera "discussions" allowed for modification to materials and/or procedures in use at the time. This dynamic process would not have been possible even five years earlier without the cutting-edge multimedia technologies available to the Project.

An undertaking like the Iowa Chemistry Education Alliance Project provided students with the opportunity to collaborate with distant peers. They were held more accountable for their own learning. They felt accountable to understand the material(s) that they were responsible to present to local and distant learners so that they were able to "teach" their peers about what they wished to convey. Use of distance technology began to make the divisions among schools and school districts indistinguishable. Paterson (1999) notes that the use of interactive classrooms without walls could allow students to progress on their own personal continuum of learning, taking courses when they are conceptually ready to take them, obscuring the boundaries among elementary, middle, and high school and post secondary education.

Electronic mail communication was an integral component of the ICEA Project. Because the ICEA Project attempts to utilize cutting edge technologies, the use of the Internet was expected. The ICEA student modules provided a number of recommended interactive Internet projects that encouraged students to collect and input data (Miller, 1996). At a number of the smaller schools, especially in the earlier days of its existence, the ICEA Project fell short in these areas. Sometimes, the only computer with Internet access belonged to the teacher. This necessitated modification of Internet search activities so that a smaller number of students would need to have a computer available to them. It also encouraged more self-reliance among student groups with a member or members who had access to the Internet outside of the classroom. Enthusiastic learners took the responsibility to pursue the answers to their questions at home or at the local public library. After leaving school for the day, they would do their Internet research, and returned the next day to report their findings to peers. This is one example of the many tangible ways that students became less reliant on the instructor and more self-reliant. They assumed responsibility for their own learning and that of others.

B. Focus Groups—An Integral Part.

Evaluation guided practice in tailoring the ICEA Project to teacher and student needs. The bulk of teacher and student feedback for the ICEA Project was obtained by conducting quantitative demographic and attitude surveys in addition to qualitative focus group interviews. Focus groups conducted by ICEA personnel explored student and teacher attitudes about the ICEA Project as well as investigated ideas about how the Project might be modified. It was the results of these contributions from the student groups and the ICEA teacher groups that shaped the development of each successive phase of the ICEA Project. And it was these sessions that ICEA Project leaders used to ascertain student and teacher satisfaction with all aspects of the Project. Focus groups were a critical component of the ICEA Project research. From ICEA teacher focus groups conducted after each of the four "official" phases of the Project, many of the concerns voiced through teacher feedback were addressed immediately by Project personnel.

Focus groups can be composed of members of a pre-existing group, such as in the ICEA Project with the students in a particular class or the teachers working on the Project. When participants are members of an already established group, the members must all be relatively homogeneous (Morgan, 1988; Greenbaum, 1998) and on an equal basis (Gall et al., 1996). This is why ICEA teacher focus groups included members of only one ICEA Phase at a time (i.e., Group 1 = Phase I Teachers; Group 2 = Phase II Teachers; Group 3 = Phase III Teachers) or members of Phases which had been in existence approximately the same amount of time so that there was no feeling of superiority or inadequacy among participants (i.e., Group 1 = Phases I & II Teachers; Group 2 = Phase III Teachers; Group 3 = Phase IV Teachers).

Using two facilitators in tandem during the ICEA Project served to ameliorate some of the problems associated with note-taking and audio taping practices. For example, during one focus group, a microphone battery stopped functioning. At that point, there was no longer any audio record of the thought-sharing process. This could have been a tragic loss of data. However, the consistently comprehensive notes taken by the focus group recorder provided an account of the bulk of the conversation. Only when the conversation became so animated that it was impossible to keep up with regular note-taking practices was the written record incomplete. There was, however, enough information to prove useful.

The ICEA Student Survey collected information about one week prior to student focus group interviews. This advance process provided the desired information. Because it was collected well in advance of the focus group interview, and there was built-in "wait time", it did not seem to strongly impact student feedback during the interview sessions.

Student focus groups for the ICEA Project were conducted at rural, suburban, and urban locations to determine whether there were any differences in student opinion among those students attending the different school types. Focus group research in general does not predict differences among subjects from diverse geographical locations (Greenbaum, 1998), nor were there any observed during the different phases of the ICEA Project, so there was no concerted effort to talk with students at *all* twenty-five school locations.

C. The Iowa Chemistry Education Alliance Project— A Blend of Collaboration with Distance Technologies

Every distance learning session or class is unique to the purpose and the clientele it serves. Designers and teachers must tailor what will be learned to their own needs and technology plan (Williams and Paprock, 1999). Designers must be committed to the successful production of a quality learning experience. Teacher beliefs and experiences determine how and when they use cooperative activities to affect academic or social goals.

Merrill (2002) proposes five fundamental principles of design. Learning is advanced when:

1. Learners are engaged in solving real-world problems and tasks.
2. Existing knowledge is activated as the foundation for new knowledge—later tasks build on earlier ones.

3. New knowledge is demonstrated to the learner—she or he is shown how to use the ICN as a teaching tool.
4. New knowledge is applied by the learner.
5. New knowledge is integrated into the learner's existing knowledge background.

The ICEA Project is built on these principles (although Project strategies were designed earlier than Merrill's observations were formally made). The Phase I ICEA teachers incorporated hands-on group activities in each of the eight modules they designed. As the Phase I academic year progressed, they found themselves turning more and more to integration of cooperative exercises into their traditional, "non-ICEA" curriculum as well. Teachers in Phases II, III, and IV reported the same progressive evolution away from didactic classroom "telling" sessions.

Why was the ICEA curriculum designed to be activity-based collaborative hands-on experimental modules and interactive sharing via the ICN rather than a "talking-head" lecture-based delivery? Boling and Robinson (1999) observe that student learning is enhanced by the use of post-lecture cooperative learning activities. Student discussion of results and sharing of ideas following a chemistry laboratory experience have occurred in classrooms that have been less didactically oriented, i.e., where the teacher has promoted it. But, typically, these interactions have not extended *outside* the classroom. The ICEA Project attempts to provide inter-classroom exchanges for students to help them to capitalize on their mutual enthusiasm and to become aware of the commonalty of their overall learning experiences. Technology is integrated into the curriculum through collaboration, cooperation, and communication in a setting where computers and classrooms linked through a fiber optic network is common (Flemister et al., 1994).

1. The ICEA Project Curriculum

What were some of the design features of the ICEA Project Curriculum?

a. Teacher facilitator

The teacher was a facilitator. The student became more accountable to her or himself, the teacher, and her/his peers, taking more responsibility for her or his own learning. Knowledge was constructed through common, shared experiences among all learners.

By undertaking the collaborative ICEA modular learning units, teachers validated their belief in the student-centered classroom. They relinquished "control" so that the students designed and modified their own learning. Teachers served as resource personnel as the students became accountable for their learning. The more the teachers modeled good practices of facilitating and mentoring, the more seriously students took the responsibility of learning on their own.

b. Exploring to learn

Of primary importance is not so much how teachers teach, but, rather, how students learn. The focus of the Iowa Chemistry Education Alliance Project was highlighting hands-on group learning forums during which students constructed their own conceptual understanding via discussion with peers (both local and at a distance).

Hands-on, minds-on, interactive, grade-level specific lessons were designed by the Phase I ICEA Project teachers. They provided an active transition from the traditional teacher-centered classroom to a more student-centered classroom. The learning experiences encouraged students to explore ICN and distance learning technologies, then engage in process skills to manipulate materials to construct an understanding of a concept. After exploration, the students engaged in question and answer or discussion sessions. first with local, then with distant peers so that together the concept could be invented by the students in their group(s). A student-centered follow-up expansion activity was planned to reinforce the concept learned.

The ICEA presentation model via interactive ICN sessions followed a method described by Kagan (1985) as the coop-coop technique. Students were grouped in teams, but teams were more than a time-saving, practical solution. Teams increased student learning tremendously. Via peer guidance and negotiation, students knew what to learn and what to share. The hands-on, minds-on learning exercises increased student communication on topics of mutual interest. For students, the sharing of references, resources, and ideas and increased involvement was an investment in learning. Knowing they would share what they learned with other students statewide appeared to be a powerful motivational device. Formal practice sessions were useful in the on-site classroom. Local peers reinforced and supported student groups chosen to present their findings via the network to distant classmates . Groups relied on the other local groups to give them feedback following their in-class presentation before they presented via the ICN to groups across the state. The teacher gave control of the classroom to the group. Group members became responsible for how the time and equipment were used during their ICN presentation. Students took this responsibility seriously. Little time was wasted during ICN sessions with the exception of equipment failure or "down-time".

c. National Science Education Standards

One of the hallmarks of the ICEA Project was coordination of the National Science Standards (1996) with the hands-on ICEA activities. The hands-on real-world activities of the ICEA learning modules provided students with authentic research experiences, which is one of the goals of the National Science Education Standards, NSES (National Science Education Standards, 1996; Hapkiewicz, 1999). They come away with an understanding that learning is something they themselves must do. No instructor does it for or to them. Not only do the ICEA modules match the NSES (see Appendix C), but they are more engaging than traditional verification exercises.

Methods of assessment for evaluation of student performance (rubrics) were developed based on the National Science Education Standards (Lundsford and Melear, 2004). Student achievement in activity-based classrooms shows marked improvement when assessment is designed to include a hands-on portion, a pictorial portion, and a set of questions that causes the student to apply the concepts taught (Wygoda and Teague, 1995). In the distance-learning environment, a multi-faceted approach to assessment gives a more accurate picture of the progress at hand.

d. Integrating more content areas

As teachers became more adept at creating lessons in a distance-learning environment, eventually their preparation expanded to include approaches for integrating more content areas.

e. Teacher mentoring and networking

Teacher mentoring and networking obliterated geographical isolation and created a cohesive, dynamic group of facilitators.

Miller (1996) and Wortmann (1992) recommended what ICEA Phase I teachers had designed in 1995: guest scientists or experts shared their field of study with the students through conversation and interactions about content, video segments, and demonstrations. Students were able to ask questions and pursue a conversation with guests on an adult level. Students took electronic filed trips, visiting other classrooms and guests without leaving their own classrooms

Students in learning groups at different sites worked together to create concepts, share experimental findings, and engage in discussions of activities performed. Assessment was based on the progress of the entire group. This cooperative group learning promoted positive interdependence—how well students worked together was one criterion for receiving a favorable grade. As the students continued to share information and learn from one another, across school districts, the cultural barriers (e.g., school rivalries) that could have existed among the different sites disappeared. Students realized that they were more alike than different. They recognized that although certain schools had certain kinds of reputations (derived mainly by way of athletic competitions and/or rivalries), students were all struggling with the same chemistry concepts, the same kinds of homework assignments, and the same frustrations with difficulty of material. Students sympathized with each other. .This was a critically important outcome of the ICEA Project.

It is important to remember that the most carefully designed curriculum materials and strategies require student cooperation if they are to be successful (Cardellini, 2002). The remainder of this dissertation is intended to document this.

IV. Chapter 4. THE IOWA CHEMISTRY EDUCATION ALLIANCE PHASE I—ESSENCE AND ESSENTIALS

A. Development of the Idea

In the Fall of 1995, all five hundred Iowa chemistry teachers were surveyed by the Iowa Chemistry Education Alliance, ICEA, to determine their needs for and attitudes toward technology, communication, and collaboration. Among the notable findings were (Schlosser, 1997):

1. Iowa chemistry teachers had minimal communication with other chemistry teachers in Iowa, but believed it to be important that they substantially increase communication with their peers.
2. Iowa chemistry teachers wanted to reduce the amount of lecturing in their classrooms and increase the amounts of discussion and cooperative learning.
3. Iowa chemistry teachers were not using the ICN but believed that it was "somewhat important" that they used the ICN, at least on occasion.

Each of these findings had implications for the ICEA, which proposed to create both a method (*process*) and the tools (*product*) that could help Iowa chemistry teachers to improve communications with each other, alter their methods of instruction to reach a wider variety of students, and to use the ICN to accomplish needed changes.

1. Teacher training

Identification of teacher concerns was necessary before designing in-service workshops that could address the needs of the teachers (Fagan, 1997). Participants knew that establishing a flexible, collaborative environment with access to several effective and convenient means of communication would be critical to the success of the Project. Instructors knew that use of the two-way interactive ICN technology would be an integral factor. It would allow for real-time communication among teachers and their students.

Cyrs (1997) emphasizes three main points about the use of interactive or instructional television: instructors must be well-trained in the use of instructional television, have a support staff, and have time to develop their materials. The ICEA Project provided aspects of each of those elements to the Phase I master teachers (Schlosser, 1997). During the summer of 1996 prior to design of the ICEA modules, a three-week workshop was held in part at Iowa State University and in part at each of the participating high schools. This workshop provided the base upon which was built the close collaboration among the four ICEA teachers and the other Project participants (the PIs, the graduate student support staff, and the ICN schedulers).

Because lack of training is the largest single problem of teleteaching (Cyrs, 1997), it was one of the first considerations in the preparation of the four master teachers for participation in the ICEA. To hone their communication skills, the four teachers were given training in distance teaching and learning techniques, the use of interactive technologies, cooperative learning, student active learning strategies, multiple intelligences, learning styles, etc. This training was provided by Iowa State University personnel. With this background, they were able to draft the lessons and exercises to accompany the ICEA modules they designed. These modules had the purpose of training their students to collaborate interactively using the ICN technology. Part of the teachers' stipend that first year "bought" them preparatory time during the summer of 1996 as well as release time of one class period from their regular teaching load for the academic year 1996-1997.

2. The ICEA Model

Appendix A provides an outline of the philosophies espoused and the events scheduled for those planning and attending Iowa Chemistry Education Alliance preparatory meetings/workshop. This workshop marked the creation and evolution of the "ICEA Model", a basic, common sense approach to teacher preparation for the ICEA Project. The formation of the ICEA and development of the ICEA Model are recounted in a separate report (in Appendix D) and in a *Journal of Chemical Education* manuscript (Burke and Greenbowe, 1998).

Some important factors have been outlined for those beginning use of the ICN system and equipment (Tillotson and Henriques, 1997).

1. Hands-on practice teaching is of greatest value.
2. A component of learning about the capabilities of the system is important.
3. A session answering more specific questions must be included.

These issues, in part, were addressed by the videotaped series entitled Foundations and Applications of Distance Education. Each teacher was provided a copy to watch and study. Teachers participated in a practice ICN session. Students conducted practice sessions of their own. But, until the teachers and students successfully conducted a session interactively, there was still an element of trepidation. After a short amount of use, the technology became transparent (Ehlers, personal communication, May, 1997; Tillotson and Henriques, 1997).

Creative and enthusiastic teachers who have access to computers can put together intriguing exercises to engage students (Frizler, 1999). This does not happen spontaneously. No small effort is involved. The ICEA Model was developed for the benefit of the participating teachers. A concerted effort was made to design a preservice experience that would provide a well-rounded background for those wishing to develop a hands-on student-oriented set of modular activities that could be seamlessly integrated into the existing curriculum at each of the four schools.

Skills for teaching at a distance can be more important in that venue than in a traditional classroom (Cyrs, 1997). The ICEA Project activities were designed to avoid the "talking head" syndrome that had become associated with televised delivery systems. Communication among students at various sites was made to be more interactive and less "delivery" oriented. The four Phase I teachers each experienced aspects of components they desired to incorporate into the ICEA learning modules (multiple learning styles, student active learning strategies, etc.). It was intended that the model serve as the methodology for future preparation of potential ICEA teacher candidates.

Facets of the ICEA Model include:

1. Team building exercises;
    a. "Ice breaker" activities;
    b. Activities to build trust among team members;
    c. Discussions about content subject matter to serve the purpose of "breaking the ice" and building trust;
2. Distance education training and practice sessions;
3. Training in student active learning, cooperative learning, assessment methodology, multiple intelligences, and creative thinking;
4. Training in presentation software (e.g., PowerPoint) and related technologies;
5. Collaborative drafting of content modules;
6. Implementation and modification of content modules.

3. Four ICEA Phase I Teachers

Prior to beginning work on the ICEA Project, the four Phase I teachers (listed in Appendix E) had been acquainted with one another for ten years or more. Richard Ehlers taught chemistry and physics classes at Perry High School in Perry. Ken Hartman taught chemistry and computer classes at Ames High School in Ames. Jeff Hepburn taught chemistry classes at Dowling High School in West Des Moines. And, Don Murphy taught chemistry classes at Hoover High School in Des Moines. Each of the schools was located in the central Iowa Area Education Agency 11, which meant that all were located within a 45-mile driving radius of each other and of Des Moines. This would require under an hour of driving time for the group to assemble at any one of the high school locations or for the teachers to drive to Iowa State University in Ames for a face-to-face meeting.

The four high school teachers had recently been colleagues in the DaVinci Project (Schlosser, 1997), a collaborative effort of multimedia development among Iowa middle school and high school art and science teachers. The goal of the DaVinci Project was to convene scholars, students, and teachers of chemistry and art in order for them to collaborate to develop multimedia materials to visualize and explain basic issues and concepts in the realms of both chemistry and art. Observation of the quality accomplishments by the four teachers in their DaVinci Project endeavors suggested that they would be highly qualified to work on the ICEA Project.

Because of their past close affiliation, it was unnecessary for the four teachers to follow the ICEA model exactly. They were able to forego the "ice breaking" and collaborative team building activities which would have been requisite for a group of strangers. They were content to share coffee, doughnuts, and "shop talk" to create the collegial atmosphere in which they would immerse themselves for the ensuing eighteen months of module creation, implementation, and modification.

It was this closeness of past association that instilled in each of the four teachers a deep personal and professional respect for their fellow team members. This kinship drew them together in a common goal and served to enhance their spirit of collaboration throughout the sometimes arduous challenges of Project development. This was the means by which they, in their own words, were able to "gel as a team".

The three-week ICEA teacher workshop was designed by staff personnel from Iowa State University who had been charged with creating an appropriate environment (Frizler, 1999) in which the four teachers could learn about

a. Distance education principles and practices;
b. Student active learning and cooperative learning along with appropriately coordinated assessment;
c. Multiple intelligences and learning styles;

d. Presentation software;

as well as create the content-based supplemental modules based on *real-world hands-on* chemistry activities. This workshop and ensuing ICEA teacher training workshops were ideally directed toward both the use of the ICN equipment as it applied to classroom work as well as toward chemistry curriculum reform. Further, the geographic isolation felt by the teachers could be remedied by creating the support network of colleagues at each of the four schools as well as at Iowa State University (Mitchell, Shubert, and Herman, 1999).

Several teaching objectives on which these lessons were based included: attitude and motivation, critical thinking, collaboration, problem solving, and application of course material. Frizler (1999) recognizes these same criteria as fundamental to construction of curriculum.

4. New skills

Teachers gathered on the Iowa State University campus to learn new skills and to collaborate on creating their modular materials. The first week, they learned about distance education principles and practices through a series of videotapes ("Foundations and Applications of Distance Education") provided by Iowa Public Television for this purpose. It was important to engender in them a high comfort level with the ICN equipment as well as the modified curriculum. The more they learned, the more effectively they would be able to trouble-shoot during the academic year. The Phase I teachers wanted to be as independent as possible. Achieving a comfort level with the equipment during their training would provide them the practice they needed to model flawless implementation in front of their students. Teachers would need to orient their students to the technical side of the Project, but also to the inevitable need for some kind of universally understood protocol for appropriate communication and behavior (Boaz, 1999; Appendix B). The teachers knew there was a credibility issue. Each needed to be well-versed in the use of the ICN as well as ICN protocol *before* implementing it in their own classroom.

During the morning, they attended sessions of an ongoing Iowa State University-sponsored class about distance education and the use of the ICN. They learned to use the technologies available in every ICN classroom. Each teacher practiced delivering short lessons using the ISU ICN venue.

In addition to learning about distance education practices, the four teachers were provided with sessions concerning student active learning, collaborative learning, multiple intelligences, and different learning styles. They practiced taking the role of classroom facilitator rather than classroom director. They learned to relinquish "control" in order to allow students to take responsibility for their *own* learning. In the process of creating their chemistry content modules, they modeled good practices of collaborative behaviors. A session related to multiple intelligences made the teachers aware of the many learning styles that might be found among students in their classes. They discussed how they could modify their teaching styles to attempt to accommodate multiple learning styles.

5. Prototype module development

During afternoon sessions, teachers deliberated about which chemistry concepts to highlight in the supplemental modules they worked to create. A skeleton was drafted to outline prospective selected topics. The teachers decided to work in pairs on each modular topic. The team determined which pairs would take responsibility for each individual module. They then began to work on the elaboration of subtopics that could comfortably be contained in each unit.

At the end of this first week of ICEA training, the four teachers had produced a working prototype of what was to become an ICEA module. It consisted of:

A. A goal.

B. Learning objectives.

C. Activities designed to achieve the objectives.

   1. Classroom activities.

   2. ICN activities.

3. Internet activities.

D. Teaching strategies.

E. Grading rubrics.

1. Teacher assessment of students.

2. Student self-assessment (when appropriate).

For the next two weeks, module development continued. Working locations varied. Teachers rotated among the participating schools so that all Project personnel could become acquainted with each school's facilities (chemistry classroom, chemistry laboratory, and ICN classroom).

Teacher attitudes were positive about the introductory ICN training. The content, organization, environment, and personnel seemed to suit them. This was enough to sustain their enthusiasm and maintain their interest in the use and classroom integration of the system. They eventually conveyed this same enthusiasm to their students.

But, as has been found in other distance education projects (Merkley et al., 1997), these experienced teachers needed continued guidance and encouragement from Project support personnel. Their use of the ICN was unique, not relegated to the traditional delivery of instruction but rather, used as a collaborative communication tool among the networked teachers or their students.

Later in the year, as recommended by Mitchell *et al.* (1999), chemical instrument sharing (i.e., one school lending equipment to another) was coupled with teacher training. Teachers mentored one another so that all four became familiar with alternate instrumentation they may not have used in the past.

6. Support personnel

Support personnel are the key to a well run distance education experience (Tillotson and Henriques, 1997). The four teachers credited support from personnel at ISU as being partially responsible for the Project's success (Ehlers, R; Hartman, K.; Hepburn, J.; and Murphy, D., personal communication, May, 1997). Assistance from the Iowa State University support structure was critical at the beginning when the teachers were training with the ICN equipment because none had extensive experience prior to the Project.

The longer the teachers in the ICEA interacted with each other, the less dependent on support staff they were. It was envisioned that the ICEA could eventually be a self-sustaining entity. Essentially, it became just that.

7. Supplemental materials

During the first months of the academic year, the four teachers specified and ordered materials required for developing and delivering the Project's eight modules. This included reference books, chemical test kits, computer software, and computer hardware (including memory chips and external drives). Whenever possible, all requested materials were procured and distributed by Project support staff.

8. "Staff meetings"

Throughout the academic year, as the supplementary curriculum was developed and implemented in the high school classrooms, the four teachers, joined by other Project support staff, held weekly 90-minute "staff" meetings via the ICN. During these meetings, evaluation of the most recent ICN-delivered lessons and planning for upcoming lessons were the predominant topics. Discussions could be broad or could include the minutest of detail. Teachers interacted as if they were in the same room with one another or with Project personnel. Use of the ICN technology was seamless. Participants were unaware the ICN was being used—it was if they were meeting face-to-face in the same room. Meetings were focused. Teachers effectively used every second of "air time". After particularly intense work sessions, the teachers could banter back and forth in light-hearted camaraderie. The work always came first. These meetings, as well as multiple daily electronic mail communications helped the teachers to keep pace with their colleagues in order to keep the students "on the same page".

The teachers identified these regular meetings as crucial to the success of the Project. Vital informal teleconferencing, via the Internet application CUSeeMe, allowed the teachers (and, in some cases, their students) to stay in touch on a daily basis, and at little or no cost. Teachers interacted face-to-face using the CUSeeMe camera system. They also used desk-top camera systems to transmit information via the Internet. For example, during one modular unit, students used a titration endpoint color change to analyze an experimental system. Teachers utilized their desktop cameras to determine and agree on the intensity of color change to be construed as the "endpoint" of the chemical reaction. This could not have been achieved via electronic mail or FAX communication. In addition to electronic mailings, FAX messages were exchanged with regularity, sometimes several times a day. The close, collaborative spirit begun at the initial three-week workshop was revitalized by holding occasional face-to-face meetings at Iowa State University. Purely social meetings (barbecues, luncheons, and dinners) among the teachers, their supportive spouses, and Iowa State support personnel characterized the friendships that evolved during the Project. Not only were the teachers and support staff a closely-knit group, but their spouses also became friends.

B. Modules

1. Module development—A dynamic ongoing process

Teachers and students alike believe that it is important to identify the objective of each class meeting at the start of the session; in addition, they believe that it is important for teachers to vary learning activities within a single class—students at a distance felt most strongly about this issue. The more variety in visual materials used, the more learning is improved (Schoenfelder, 1997, Boaz, 1999). Handouts distributed during interactive collaborative telesessions provide direction and structure as well as keep students engaged and on task while others present (Cyrs, 1997). Teachers found this to be *critical.*

Before beginning the process of module development, teachers considered a number of things. Some keys to success as outlined by Cyrs (1997) and Boaz (1999) included:

1. Modifying an existing traditional curriculum for delivery at a distance through the use of audio (ICN), video (ICN and CUSeeMe), computing (databases), print (electronic mail and the Internet), and combinations of these media.

2. Thinking visually about lesson design and presentation—how would it look on the video screen (leading to the use of presentation software packages such as PowerPoint).

3. Describing how to identify and develop interactive strategies, activities, and exercises for use on site in remote ICN classrooms.

4. Analyzing how presenters look, sound, and move on television. Practicing use of the ICN technology themselves and with student groups prior to actual "air time" to reduce tensions about “being on television” as well as getting episodes of horse play out of the way prior to an interactive session with distant classmates.

5. Explaining the administrative and disciplinary policies that support distance learning programs.

Project participants understood the importance of producing effective instructional materials including lesson plans, video vignettes of lessons conducted over the ICN, references, etc. Materials produced were documented in such a way that they could be adopted by other educators who were not associated with the ICEA group. Lesson guides provided explicit directions for the individual units as well as how to integrate the use of the ICN into a lesson. Success of the lesson *could not* revolve around implementation of ICN technologies. Lessons were hands-on collaborative exercises with one important goal being stimulating interactivity. The upshot of this was that collaborative lessons could be done by students in any high school chemistry class anywhere in the world without the ICN and related technologies in the event that such equipment is not available on site.

The four chemistry teachers took the lead in developing an eight-module supplemental high school chemistry curriculum to be implemented via the ICN and other communication technologies (e.g., electronic mail, CUSeeMe). Each of the eight modules that compose the supplemental curriculum were designed by a pair of teachers. The pairs varied with each module, so that all four teachers had the experience of working with one another to design and implement two modules, one each semester. The same pairs of chemistry teachers who designed a module, took a primary role when the module was facilitated in the classroom and during related sharing sessions via the ICN. By both designing and facilitating the lessons, the teacher pairs efficiently and effectively integrated them into the existing curriculum at all four schools.

The four chemistry teachers used the "Science Teaching Standards", "Science Content Standards", and the "Science Education Program Standards" sections from the National Science Education Standards (1996) to help to guide them as they created the ICEA supplemental chemistry curriculum. Appendix C presents the document that was drafted to attribute which of the standards were supported by components of each learning module or accompanying videotape.

All eight modules created by the four teachers will be described at this time. Only three modules had been completed at the outset of the 1996-1997 academic year. For the remaining module drafts, the rest of the creating was done *during* the academic year at the same time as the first modules in the set were being implemented. The challenge of continuing creativity in the face of ongoing module implementation was at times daunting.

2. Overview description of the eight ICEA learning modules

The eight modules created by the teachers are described in detail in the next section. A brief summary is made of each of the modules here.

Module 1. Introduction: Communication Tools & Protocols. Students learn to use equipment in the ICN room, electronic mail, and the Internet. In addition, student groups research and report on a favorite chemical or element.

Module 2. Data Collection and Statistical Analysis. Student groups at different schools determine the density of a variety of brands of soda pop. Members of a class at a local site determine and compare the density of the *regular* variety of one brand with the density of the *diet* variety of the same brand as determined by a class at a remote site. Students learn basic statistics.

Module 3. Laboratory Separation of a Mixture. Given the task of separating a five-component mixture of known solids, student groups of four students each research the properties of the solids, determine a strategy for separating them, meet via the ICN to discuss their proposed separation approach/techniques with a similar group at a distant site, and finally execute the separation procedure in their local laboratory.

Module 4. Forensics. Students are divided into seven groups to analyze different kinds of evidence found at a crime scene in order to determine how the evidence supports the probable guilt or innocence of a list of suspects.

Guest speakers share expertise in the fields of forensics, law, criminalistics, and related topics via the ICN.

Module 5. Chemical Instrumentation-Spectrophotometry. Students use spectrophotometric analysis to determine the percentage copper in a post-1982 U.S. penny. They are encouraged to do an Internet search to determine the actual reference value for the percentage copper. Local groups compare and discuss their results with distant classmates.

Module 6. Food Science: Titration Determination of Vitamin C in Orange Juice. Guest speakers share information about nutrition, food chemistry, and other topically pertinent materials via the ICN.

Using a variety of brands and types of orange juice, students determine their Vitamin C content and make comparisons in terms of cost per gram of Vitamin C. Groups compare and discuss their results with distant classmates.

Module 7. Research Reports. From a list of potential topics provided by an instructor, groups of three students each select one of the topics and prepare an ICN report to present to local and distant classmates.

Module 8. Field Research—Water Analysis. Students collect water samples from local ponds, lakes, rivers, creeks, and swimming pools to perform a battery of chemical tests and share results via the ICN.

There are three accompanying videotapes. The first, "A Room with a View" and "Foundations and Applications of Distance Education" (mentioned earlier as having been used in the teachers' distance education training session), provide an overview of distance education practices and principles. There are two videotapes related to specific modules that were produced: "Data Analysis—Basic Statistics" (for Module 2, *Data Collection and Statistical Analysis*) and "Tour of the Iowa Division of Criminal Investigation (DCI) Criminalistics Laboratory" (for Module 4, *Forensics*).

An instructional guide describing the eight modules and outlining effective procedures for their delivery and assessment was developed to be included in the module notebook. It portrays each of the modules and suggests ways in which each may be successfully used in the classroom. Further, the guide traces, step-by-step, the manner in which ICEA participants created and used the supplementary curriculum. The process described may have broad applications for collaborative curriculum development and teaching projects beyond the chemistry classroom. Any discipline could be adapted to the ICEA approach.

An ICEA web site was developed to describe the Project and related ICEA activities (classroom events and meetings). The URL for this web site is:

www.educ.iastate.edu/Projects/ICEA/homepage11.html

A videographer from the Media Resources Center (now known as the Instructional Technology Center) at Iowa State University traveled to each high school chemistry classroom to videotape segments of several modules as they were used by teachers and students. The videotaped portions were eventually used to document the process of implementing the modules, and as supporting visuals for a short video documentary describing the ICEA Model and Project, "The Right Chemistry—The Iowa Chemistry Education Alliance" (described in more detail in Chapter 7).

The four teachers had a goal of selecting appropriate technologies and computer programs that could enhance learning chemistry concepts for high school students. During the three-week workshop that began the Project, the four teachers used and evaluated a number of computer-based conceptual instructional packages from leading suppliers of educational materials for chemistry faculty.

The development of sophisticated animations and visualizations by any outside contractor was rejected. Software enabling creation of images of molecular structures was purchased by the Project for use by the four chemistry teachers.

3. First year use of modules

During their summertime experience, the teachers outlined each of the eight modular units envisioned for the ICEA notebook. The goal of the ICEA modular units was to provide Iowa high school chemistry students with real world experiences to help to motivate them to make connections between their experiences and learning, between real life and chemistry concepts. Cyrs (1997) notes that as students become intrinsically motivated, information is acquired, internalized, and used. Cooperative projects get students actively involved in their learning. Learners are able to achieve at higher levels if activities challenge their critical thinking skills.

Teams of two teachers took responsibility for the design and execution of each module. At the outset of the academic year, three modules were nearly completed. Therefore, as they worked to facilitate module implementation with their students during that first semester, Phase I teachers were also designing and writing the procedures, rubrics, and assessments for the remaining modules. The four master teachers had an uncanny ability to anticipate stumbling blocks before they occurred. They had the intuitive foresight to know when to begin to formulate strategies for lessons that might still be two to three weeks away from implementation so that, when the time came to implement them, they could be seamlessly integrated into the existing curriculum. The pace was frenetic at times, and the teachers questioned whether they would be able to successfully develop the package they had envisioned. But, successful they were.

The first four modules were used during the Fall Semester of 1996.

a. Module 1. Introduction: Communication Tools & Protocols

Students are reluctant to participate in an interactive television class until they feel comfortable doing so. It has been advised that the first interactive television session should be organized to allow students to become acquainted with each other . This would eliminate fears associated with feeling that their comments might not be well-received by peers (Schoenfelder, 1997).

Module 1 was designed to facilitate the active use of ICN technologies for the students. Teachers and students had to be comfortable with using the technology so that communication and subsequently learning were not thwarted (Boaz, 1999). The first module introduced students to appropriate protocols for using the Internet, electronic mail, and the ICN. Simulated ICN sessions allowed students to acclimate themselves to ICN equipment usage prior to an actual "live" broadcast. Students saw themselves and their teacher "on camera" via the in-classroom monitoring system. They learned how to integrate use of the equipment (student, teacher, and overhead cameras, computer, and videotape recorder) into presentations.

To learn about each other, students from different schools were paired and exchanged personal information using electronic mail. This included their name, year in school, kinds of pets, and what their plans were after high school graduation. On the first day of using the ICN system, students from different schools met over the network to introduce one another. At alternating sites, students presented a short biography about their distant classmates with whom they had communicated using electronic mail. This process had been devised by the four teachers, but the strategy is outlined in the literature (Boaz, 1999). Students at all four sites spent approximately equivalent amounts of time presenting, in order to keep all sites equally involved in the learning process (Schoenfelder, 1997). Teachers wanted to assure this from the outset. Scheduling was done so that all four sites were active whenever possible. This was done to accommodate students at each participating school. But, it was also found that this was a suitably comfortable number of sites to have interacting at one time. The strategy is supported by Bigilaki et al. (1997) who found that 22% of the respondents in their study preferred to teach with three to five active classroom sites. In future ICN planning sessions, teachers tried to coordinate scheduling no more than four sites at once, often scheduling only three.

During a second related session, students also used the ICN to present a description of a favorite element or compound, employing visual displays as tools. For example, one group discussed nitrogen by elaborating its role in life cycles using diagrams. They used liquid nitrogen to demonstrate some of its physical properties and the effect of its low temperatures on common objects.

Another group talked about the role of mercury and its compounds. One student donned a shiny steel helmet and acted out the role of a mercury droplet which skittered around just out of reach as it eluded cleanup. This module reinforced the dynamic nature of the activities possible using a two-way interactive video system.

Teachers reported that their students learned a lot from one another about elements and compounds. Throughout the rest of the academic year, they recalled and used information they had learned during these introductory "favorite element" presentations. One teacher commented that it was the first time for students to be aware and learn about new terms (for example, distinguishing between elements and compounds) so early in the semester (Richard Ehlers, personal communication, 1996). This provided a solid foundation for further formal lessons about the concepts later in the academic year.

At the end of Phase I, there were more high school students participating in the ICEA Project who were comfortable with ICN technology than there were Iowa high school *teachers* who had achieved a similar comfort level. This observation was based on the familiarity the four Phase I teachers had with the state of the art for ICN at that time.

Because interactive television is a visual medium, teachers and student presenters needed to be made aware of the role of physical movement, dress, body language, facial expression, enthusiasm, and self confidence in how their presentation comes across (Cyrs, 1997). Teachers observed that their students seemed to dress better on ICN presentation days. They also were more aware of and concerned about how they came across to distant classmates. They tried to make their presentations as high a quality as they could. They became somewhat competitive in their attempts to outshine their distant classmates.

Students were encouraged to refine their presentation skills to prepare more visually appealing graphics, to engage their distant classmates. In order to best utilize interactive television's visual medium, students in the ICEA Project were encouraged to generate a minimum of three visual aids for each presentation, especially the introductory "Favorite Element or Chemical" presentation (Cyrs, 1997).

They quickly found that the traditional preparation of presentation materials fell short of meeting the needs of distant learners. For example, students were disappointed to find that the scraps of notebook paper on which they made notes did not serve them well as overhead display materials. Nor did students benefit from trying to present their laboratory data and results on large pieces of posterboard. Neither the "teacher" camera, nor the overhead display camera could capture the entire piece of work for display to distant classmates.

Students learned that the use of PowerPoint presentation software allowed them to easily prepare a legible, professional mechanism for the delivery of their ideas. They learned from their teachers (who had been provided guidance in their training sessions) that presentation materials should follow a 3 X 4 aspect ratio with a minimum of six words per line and six lines per PowerPoint slide (or overhead transparency slide); fonts (sans-serif) should be at least 24 point for ease of legibility (Lochte, 1993; Schlosser, personal communication, October, 1994; Graf, personal communication, September, 1995; Simonson, personal communication, November, 1995; Smaldino, personal communication, September, 1996; Cyrs, 1997; Simonson et al., 2000). The more students integrated graphics, pictures, and other visual materials, the more they were able to communicate information by a variety of methods, adding visual interest to what they were displaying (Boaz, 1999).

b. Module 2. Data Collection and Statistical Analysis (The Soda Pop Module)

In the second module, students learned how to use a hand-held calculator to determine the statistical mean, range, and standard deviation for a density data set. This lesson was presented seven times throughout the class day to all other distant classes by the same ICEA teacher via the ICN. Because of the boring repetitiveness of this task (the teacher tried to repeat the lesson identically seven times) and in order to assure that each succeeding group was presented the *same exact* information, it was decided that the presentation should be videotaped and shown to each class independent of an ICN broadcast. This approach would provide greater flexibility for individual classrooms (teachers could use the videotape when convenient to their schedules), the tape could be stopped and replayed in the case of questions arising about the material, the expense of ICN broadcasting would be saved, and the dreaded ICN "talking head" syndrome could be avoided. This modification to Module 2 was one of the more useful changes made in the original ICEA materials.

In their own laboratories, students performed a density analysis of both diet and regular varieties of four name-brand carbonated beverages. Soda pop is a common everyday substance with which students come in contact on a daily basis. The concept of density is vaguely familiar, the question of soda density is somewhat interesting for students (Herrick, Nestor, and Benedetto, 1999).

Carbonation was removed from soda samples by allowing the samples to degas over a period of several days to a week. Instructors reminded one another to begin the degassing process in order to have their solutions prepared in advance and on time. Degassing is needed because bubbles interfere with volume measurements. Students collected, compiled, and calculated data for the density of their assigned soda sample. Student groups measured masses and volumes for at least ten samples, plotted mass-versus-volume graphs of their data, and calculated sample densities from the slopes of the plotted lines. Each class calculated a statistical mean, range, and standard deviation for their densities. Students in one class studied the *diet* variety of Brand A. Distant learners in at another school analyzed the *regular* variety of Brand A. They exchanged data with distant classroom group via electronic mail. They then shared and compared the accuracy of their results over the ICN using charts, graphs, and PowerPoint presentations. By comparing their calculations, students statistically demonstrated that there is a difference in the densities of diet (average density, d_{av} = 0.95 g/mL) and regular (d_{av} = 1.02 g/mL) sodas. One of their instructors provided a graphic visual demonstration of the difference in densities over the ICN by placing cans of diet and regular sodas in a large clear container filled with water (d=1.00 g/mL). The can containing regular soda sank to the bottom due to all of the extra sugar; the can containing diet soda floated.

This experiment introduces students to the scientific method, teaching concepts of solution and concentration. Students learn about new analytical techniques. Herrick et al. (1999) note that by this exercise, students learn the advantages and disadvantages of using volumetric glassware. They find the experiment interesting and they learn something from it.

c. Module 3. Laboratory Separations

To understand the concept of separation, students performed radial chromatographic partitioning of water-soluble black ink into its component parts (Becker, Idhe, Cox, and Sarquis, 1992). Black ink spots were marked on a porous piece of filter paper. The tip of the paper was placed in water. Water crept along the filter paper until it reached the black ink marks. Different components of the black ink have different affinities for water. Some travel through the porous paper along with the moving water front, others remain behind. The water caused the differently-colored components of the black ink to move apart from one another, creating beautifully-patterned arrays of color that were dependent on the brand of pen used. Different companies use different combinations of colors (pink, orange, yellow, green, aqua, blue, violet, and purple) for "black" ink. This was an attention-getting learning session. Once they knew a little more about the concept, students were ready to begin the second separation exercise in Module 3.

Collaborative groups at each school did library research and devised a plan about how to separate a five-component mixture consisting of iron filings, sand, benzoic acid, salt, and sawdust. To share their ideas about how to accomplish the separation and to foster collaborative interdependence, students at one high school site met and questioned students at a distant site via the ICN during a ten-minute strategy session. The goal was to discuss and compare their independent plans. Often after the first group had shared its strategy, the second group agreed that they had a nearly identical plan. Sometimes, suggestions were shared between the groups. Routinely, the students were confident that their plans would work. So, they went to the laboratory to try them.

Collaborative groups worked on-site to separate the dry solids. As they worked in the laboratory, they ran into several procedural difficulties. When put into water, the sawdust sank to the bottom along with other components of the mixture. Students had thought that it would float on top of the water so that it could be separated. The teachers did not tell the students how to solve the problem.

At this point the students groups took advantage of CUSeeMe and electronic mail technologies to immediately communicate with their distant classmates in order to resolve the problem. A number of different techniques were suggested and tried. One of the most creative approaches was used by a group who remembered that a static charge could be placed on a balloon by rubbing it against clothing or hair. The group used this technique to generate a static charge that was then used to attract the sawdust out of the mixture, leaving the other components unaffected.

Students intuitively used magnets to remove the iron filings from the mixture. In their enthusiasm, some forgot to leave the magnets in the plastic storage bag as they had been advised. Students then had difficulty removing filings DIRECTLY from the magnet. Eventually, students were faced with separating sand , salt, and benzoic acid. They learned they could dissolve the mixture in water and filter out the sand, leaving only dissolved salt and benzoic acid. Critical thinking skills were required to separate dissolved components of the solution of salt and benzoic acid. By chilling the mixture they were able to cause the benzoic acid to recrystallize. After filtering again, they evaporated the water from the residual sample of salt solution. All that remained were salt crystals. Students were asked to package the individual components from the mixture in separate plastic bags and staple their samples to their report forms.

d. Module 4. Forensics

The Forensic Science unit was the most practical, popular, and motivating of the eight supplemental modules. An imaginary crime scene devised by the four teachers provided an opportunity to collect evidence for each of seven analysis teams at the four schools. Students were assigned roles of classroom manager, leaders for the seven evidence teams, team members, and a class photographer who took digital pictures during the analyses. Each team analyzed one of the following aspects of the "crime": (1) Fingerprints, (2) Hair, (3) Fibers, (4) Handwriting and Digital Photography, (5) Glass Samples, (6) Powders, and (7) Ink. Cooperatively, team members examined the "crime scene" evidence and compared it to samples taken from eight potential "suspects".

In the midst of these analyses, the students were given the opportunity to question guest experts. For one day, a United States District Court attorney, two Iowa Department of Criminal Investigation agents, a metropolitan prosecuting attorney, a city police officer, and a fingerprint expert were physically present at one or two ICN classroom sites, but available to students in all of the classrooms connected via the ICN. Not all guests were present at the same time, but more than one guest was usually present each period.

In an attempt to gain a better understanding of their analyses, students had prepared questions for the experts in advance. Interaction among students at all sites and their guests was thought-provoking and exciting. Guests were impressed with the mature, high quality of student questions. And, guests enjoyed interacting with their own colleagues (the other guests) at distant sites. Students appreciated the efforts of the experts to provide them with as much varied information as the students desired.

Having spoken with experts, the students returned to the classroom to weigh the evidence collected. It was another exercise in critical thinking skills. Collaborative groups consulted with one another via electronic mail or CUSeeMe. During an ICN sharing session, each group presented the evidence, analysis, and reasoning that they felt vindicated one suspect or implicated the guilty culprit. Not all classrooms had been given the same samples to analyze. One group may have analyzed hair, ink, and glass samples for suspects 1-4, where another group might have evaluated fiber, fingerprint, handwriting, and powder evidence for suspects 5-8. Students had to examine the evidence from all schools for all suspects in all areas before they could render an opinion about culpability. This was a true exercise in positive interdependence.

Only the two teachers who had designed the exercises actually knew who they had implicated by the evidence they provided students. The students were never told who the guilty party was. This was done in order to best replicate real-life situations. For some students, this was extremely disturbing because they realized the implications that errors in forensic evidence evaluation could lead to improper conviction of suspects. The Forensics Module exercised students' critical thinking skills, and required more intuitive reasoning than the previous three modules had.

These first four modules were implemented at the rate of one per month and integrated reasonably well into the traditional introductory chemistry curriculum. Students found the Forensics module to be their favorite unit of the first term.

Modules Five through Eight supplemented the established chemistry curriculum during Spring Semester 1997, beginning in late January after first semester examinations were completed at all of the schools. Students employed critical thinking skills to solve another series of real-world chemistry puzzles. They were challenged to apply principles and skills learned in each of the earlier modules to analyze successively more rigorous problems.

e. Module 5. Chemical Instrumentation—Spectrophotometry (Copper Penny Module)

To learn the chemical skill of colorimetric and spectrophotometric analysis, students determined the per cent copper in a post-1982 United States penny. Teachers explained colorimetry and Beer's Law relationships prior to the students' laboratory work. Classes were divided into separate investigating groups, each using a different analytical instrument: an inexpensive Blocktronic colorimeter, a more expensive Vernier colorimetry device, and a Spectronic-20 spectrophotometer. One goal of the exercise was to show students that different instruments have different ranges of accuracy and precision, but that each could provide some degree of information.

The copper percentages determined by students ranged from 1.26% to 6.4%. Internet research at the United States Mint web site helped to determine that post-1982 United States pennies contain only 2.5% copper—a thin shell over the surface of a previously-imprinted zinc core. As all students shared their results via electronic mail, FAX, and eventually over the ICN, they realized that the large number of pieces of data collected and shared by all of the groups at all four of the sites provided them with a better opportunity to correctly process the information than they would have had with just the percentages collected in their individual classes. In addition, they found that not all teams were able to obtain accurate results. Using statistical techniques they had learned in the second module to decide which data was usable and which should be discarded, students learned even more about the importance of being careful in a sensitive chemical analysis. They learned that *just* following the directions did not always lead to a meaningful result. They learned to pay attention to *how* they followed those instructions. Many concluded that they were certain they could repeat the experiment and obtain more accurate and valid results.

The analysis of coins stimulated a lot of interest among students. They wanted to analyze other copper coins. This lead to an interesting study of Canadian pennies that will be discussed in Chapter 7 and Appendix F.

f. Module 6. Food Science: Titration of Vitamin C in Orange Juice

The purpose of this module was to investigate the Vitamin C content of orange juice. Students began the sixth module with an all-day ICN session during which they were able to interview expert guests including dietitians, a food chemist, a quality control official from a local dairy, and others. There were two to three experts available per class period, some at the same site, and some at different sites. Just as with the guest session for the forensic experts, these nutrition experts enjoyed their session interactions. They respected the quality, thought-provoking student questions they received about diet, nutrition, and components of foods.

Students began experimental work by standardizing a 2,6-dichloroindophenol solution. For some of them, it was a first experience at performing an experiment of this type (a redox titration). There were two aspects to their analysis. Half of the students in each class looked at the Vitamin C content of fresh versus frozen juices, as well as different brands of orange juice. They considered how Vitamin C content varied with brand of juice. They prepared cost analyses ($/gram Vitamin C).

The effects of temperature and time on Vitamin C content were investigated by the other half of the class. Vitamin C content was monitored on freshly-made, one-day-old, two-day-old, three-day-old, and four-day-old samples of juice that were refrigerated, kept at room temperature, warmed to 30-35°C, or heated to 40-45°C.

Another component of this module included an Internet search for facts about ascorbic acid and its molecular structure, worldwide orange juice production, importation of orange juice in the United States, scurvy, and other relevant topics. Students collaborated via electronic mail, FAX, and CUSeeMe to compare their findings. They shared their analysis and results during an ICN session. It was found that the store brand juice contained the smallest amount of ascorbic acid and was most cost effective. Freshly squeezed juice from oranges contained the most ascorbic acid and was determined to be the most expensive. Results were somewhat inconclusive about the effects of time and temperature on Vitamin C content . Further work would be required to investigate this.

g. Module 7. Research Reports

The module on Scientific Presentations was based on student-generated ideas. Early in the spring semester, students were polled for their suggestions for research report topics. Results were listed. Nine categories were chosen by student vote. They included Astronomy, Atmospheric Chemistry, the Electromagnetic Spectrum, Energy, Food, Forensics, Medicine, New Materials, and Pollution. Students were directed to select appropriate sub-themes to research and present in report format.

To avoid repetition, one teacher collected the students' areas of interest, coordinated and scheduled the selection of topics accordingly. Two days were allocated for ICN delivery of presentations with eight to twelve reports presented per topic. Students were enthusiastic because after spending time in research, they felt an ownership of the topic and wanted to share what they had learned. Presentations reflected their diligent efforts. In addition to an ICN report, each presentation also included an abstract that could be posted on the ICEA home page. This served as a written record of the kinds of topics that students chose to investigate.

Due to the sizable number of students who would be sharing information, ICN time was limited to 1.5 minutes per person presenting. Students found this module to be an interesting exposure to a variety of topics not usually encountered in a traditional chemistry curriculum. But, they also found it to be the least interactive exercise (they tired just listening to so many reports—there was no time for questions) and therefore one of the least likely to be on the list for modules to do again if funding was procured for another year.

h. Module 8. Field Research—Water Analysis

The culminating module activity incorporated all of the skills the students had accumulated during the academic year. They utilized analytical chemistry capabilities, collaboration strategies, communication abilities, statistical skills, and presentation techniques. This module was designed to emphasize inquiry. There was no pre-determined "right answer". This was without a doubt the most sophisticated of the ICEA exercises.

Students and teachers collaborated to design a field experience to analyze water quality. They studied water in wells, school water fountains, rivers, streams, lakes, ponds, aquariums, etc. Using Hach ™ water test kits (Hach, 1996), the students collected the data, analyzed the water supply for a series of possible chemical components including chloride, nitrate, nitrite, phosphate, and hardness, and presented the results via the ICN. Although students found the lab work motivating, there was not enough interactivity during the ICN reporting sessions. Students judged them to be repetitive and boring. Students and teachers would have liked to have spent a more extensive time periods on this module in order to learn more about the vast information pool associated with water chemistry. They would also have liked to design collaborative studies to be done by groups of students in various locations. For example, one suggestion was to monitor river water quality at one site and then another site further downstream to determine whether there was a difference.

4. Modifications of modules

Students found out a lot about cooperative learning this first year of the ICEA. In addition, they learned a substantial quantity of chemistry. But, their teachers learned even more. Because they had created the ICEA modular materials, they could easily determine how, why, where, and when modifications were needed. Modules were edited with the understanding that the process of modification would be dynamic—ongoing and evolving, even while the module was being done in class. Whenever one of the teachers had a suggestion to improve any one module, if it met with the approval of the other teachers, it was implemented immediately, even if some students had already completed that same portion of an experiment or procedure. It was this vigorous *dynamic* process that created the high-quality eight-module notebook of supplemental ICEA curricular activities.

In a two-week summer workshop following the academic year 1996-1997, teachers edited their work to include all modifications that had been made through the formative evaluation of initial implementation with students. The entire two-week period was spent reassessing the suggested modifications and changes that teachers had noted during implementation of each module through the course of the academic year. The same pairs of teachers who had taken the lead to design each of the modules, took the responsibility to edit each module. At the completing of this daunting task, they had developed the ICEA Modules Notebook, one part of the finished ICEA product.

5. Ancillary videotapes

During this same workshop period, teachers planned the videotaping of the statistical analysis segment. It was decided that a comprehensive videotape designed to answer the scope and variety of questions that had arisen during the original implementation of Module 2 would lead to a better understanding of the principles of statistics. Recall that one teacher had repeated the same presentation seven times via ICN broadcasts during the introductory ICN session for Module 2. Additionally, the teachers had learned more about the kinds of calculations the students made. It was hoped that this videotape could eliminate some of the confusion students had experienced earlier.

The availability of this videotape to accompany Module 2 provided the teachers with greater independence in planning and integrating a statistics lesson into their curriculum. They could incorporate use of the videotaped lesson when it would be most convenient to their own class schedules (working around unannounced assemblies, fire drills, etc.), not when the ICN classroom was available for an ICN lesson. To address questions arising about the material, the tape could be paused or replayed as often as necessary. Using the videotape as an information tool saved the expense of an ICN broadcast. Creation of this accompanying videotape made significant improvement to the original ICEA materials for Module 2.

During the 1997 ICEA Summer Workshop, the ICEA teachers and support staff toured the Iowa Department of Criminal Investigation (DCI) in Des Moines, Iowa. Trying to provide tours of the facility for all of the students in each of the classes involved in the ICEA Project would have been an impossible undertaking. Project personnel took advantage of the technological expertise available to them to devise a supporting videotape for the Forensics unit. Iowa State University videographers created a videotaped tour of the facility with related information about each of the main subdivisions at the DCI. Via the resulting videotape, students were able to learn more about forensic analyses and evidence handling. This was another vital addition to the ICEA package and completed the ICEA *product*—eight learning modules with three supporting videotapes. (Recall the first videotape provided instruction about the use of the ICN and the second was the instructional video about statistics.)

C. Use of the ICN as a Communication Tool for Faculty

It is important to note the critical importance of the ICN as a communication tool for the teachers in the ICEA Project. Without the ability to interact via this two-way exchange technology, the success of the Project would certainly have been in serious jeopardy. This was repeatedly emphasized by the four teachers during focus group interviews as well as in personal communication (Richard Ehlers, personal communication, August, 1996; Ken Hartman, personal communication, August, 1996; Jeff Hepburn, personal communication, August, 1996; Don Murphy, personal communication, August, 1996).

Teachers exchanged a plethora of written materials via electronic mail and a smaller number of interchanges occurred via FAX. But that kind of exchange proved cumbersome as the many details necessary for successful execution of modules continued to amass. The teachers met ninety minutes each week via the ICN debating the benefits and disadvantages of proposed strategies for each module. Other "housekeeping" details could also be handled. Ninety minutes went by quickly. The intensity of these work sessions was peppered with an abundance of good-natured humorous exchanges. It was obvious the teachers deeply respected one another's contributions and collegial peers became fast friends.

D. Phase I Dissemination

Dissemination of information about the ICEA Project was an ongoing process that happened as the Project evolved. Some opportunities to describe the ICEA Project occurred during the academic year, and some after the school year had terminated. The following list provides an overview of dissemination efforts in the form of presentations:

- August 1996—14th Biennial Conference on Chemical Education, Clemson, South Carolina (informal information presentation before the first semester began)
- February 1997—Iowa Distance Learning Association, Ames, Iowa (formal presentation)
- March, 1997—National Science Teachers Association, New Orleans, Louisiana (formal presentation)
- April 1997—Iowa Academy of Science, Dubuque, Iowa (formal presentation)

- May 1997—Statewide ICN presentation to high school chemistry teachers: eight ICN sites with teachers attending who had responded to an ICEA interest survey (formal presentation)
- August 1997—Chem Ed 1997, Minneapolis, Minnesota (formal presentation)

Additional efforts included a formal presentation by the Phase I teachers at the Fall 1997 meeting of the Iowa Science Teachers Association, ISTA. The four Phase I teachers presented information about the Project and proposed Phase II changes. This informational meeting intrigued some in attendance to make inquiries about how they could participate in Phase II.

E. Student and Teacher Perceptions During Phase I

Student participants were surveyed at the beginning and end of the 1996-1997 school year. Student focus groups were conducted at each of the participating schools. Additionally, a teacher focus group was conducted at the end of the Project summer meeting.

1. Student focus groups

Near the end of the 1996-1997 academic year, student focus groups were conducted at each of the participating high schools to assess student reaction to the ICEA Project. Teachers arranged for groups of six to twelve student volunteers to share their thoughts with Project personnel. Following focus group protocols outlined in Chapter 2, Project personnel collected a tremendous amount of information that was useful to Project evaluation. Modifications to the Project for successive phases depended in part on the outcome of these focus group interviews.

Students shared positive attitudes toward a number of aspects of their involvement in the ICEA Project:

- Sessions conducted over the ICN (i.e., sessions designed as part of the ICEA Project) were better-organized than the regular class sessions.
- Experts who visited classrooms in person and via the ICN were fun and interesting.
- The Forensics Module was overwhelmingly voted the best module.

- Students enjoyed relating the modules to real life and wanted additional tie-ins. Students wanted to learn in the context of practical applications, using hands-on activities with significance and relevance.

- Students appreciated opportunities for collaboration and wanted more of these opportunities.

Students were critical of a number of aspects of the Project, some of which were under the control of their teachers and others which were not.

- Students believed that too many modules were conducted in the allotted time, that they were too rushed, and that they were too repetitious. Accordingly, students expressed a desire for fewer modules, with more time for each. (This view was echoed by the four teachers during their own focus group in comments outlined below.)

- Students perceived that the modules (over which they were not tested) were not integrated into the curriculum; they interrupted the regular course units and were unrelated to the regular units. Students did not always understand the purpose of the modules and their ICN activities, nor understand that they were related to their traditional lessons. They did not always make a connection between "regular" coursework and ICEA units. The instructors had coordinated materials well with the existing curriculum—students just did not perceive the good match probably because they were not tested over the material.

- Students valued discussion, interaction, and collaboration during ICN sessions. There were no mentions of any "barrier attitude" toward the ICN technology. Number-related activities (presentations), however, were regarded as boring and not worthwhile.

- Students had some difficulties accessing and using some of the communication technologies employed in the Project, such as CUSeeMe and the Internet. Not all schools enjoyed the same level of availability of technology. Students expressed a desire for better directions on how to use equipment.

- The disparity of school bell schedules caused problems for the students and teachers alike.

2. Survey of student attitudes

At the end of the 1996-1997 school year, all participating students were surveyed about their attitudes toward their experiences with using the ICN in their chemistry classes. Although focus group sessions had been conducted and some of the same kinds of issues were investigated, Project personnel desired a more global overview of student perceptions. Focus groups included at most a dozen students per school or roughly only 50 students out of the 300 in the total student group.

Comments paralleled the smaller subset of students who had participated in focus group interviews. In general, the students corroborated positive attitudes toward the ICN and its use for implementing the ICEA modules. More than two-thirds of the students felt that they were as comfortable in the ICN classroom as in a regular classroom.

More than three-quarters of the students agreed that:

- Use of the ICN was an important part of their chemistry class.
- The ICN-delivered sessions were more interesting than the regular classes.
- They actively participated in ICN sessions.
- They were comfortable in front of their distant classmates.
- Use of the ICN expanded their learning opportunities.
- They had a positive attitude toward the ICN.
- The ICN should be part of future chemistry classes.

Students related a less positive attitude toward some other aspects of their ICN-related experiences. Only forty-four percent of students agreed that they got to know distant teachers and only 36 percent agreed that they got to know distant classmates.

Approximately half of students (49%) believed that they learned as much in the ICN classroom as they did in the regular classroom. It should be noted, however, that the ICEA Project used the ICN primarily for presentation and collaboration rather than for direct instruction (for example, lecture). Student participation in ICN sessions was not graded.

3. Phase I teacher focus group

At the end of the summer workshop concluding their first year involvement in the ICEA Project, the four chemistry teachers participated in a focus group conducted by staff of Iowa State's Research Institute for Studies in Education (RISE) and the Technology Research and Evaluation Group (TREG). In general, the teachers considered the Project to be successful and their participation to be have been very effective. Among the more positive aspects they noted were:

- The nature of the Project, with its emphasis on high-tech communications technologies, led to the teachers' adoption of a variety of technologies in their classrooms. In the process, their students also gained expertise with a broad range of technologies, including the ICN, the Internet, electronic mail, CUSeeMe, and computer presentation software such as PowerPoint.

- The teachers were given a very large measure of control over the content of the modules and the methods of instruction employed. They were at liberty to experiment, to break out of their routine, comfortable modes of instruction and class management.

- As a result of the teachers' study of student learning styles, multiple intelligences, and collaborative learning, the ICEA modules were designed to alter the traditional roles of teacher and learner. As students were given greater freedom and accountability, teachers adopted a role closer to that of facilitator.

The chemistry teachers also noted some difficulties and frustrations encountered during the ICEA Project:

- Creating and implementing the supplementary curriculum was more work than they had anticipated. They believed that undertaking the creation and implementation of eight modules was too challenging, and that six modules would have been more manageable.

- Further, the teachers wished they had created more modules before the school year began. Implementing modules *and* creating new modules while teaching their regular curriculum was stressful.

- Scheduling ICN time was a continual and frustrating problem. Identifying days during which all four classrooms could be connected simultaneously was sometimes difficult and made planning the modules and integrating them into the existing curriculum problematic.

- The teachers were disappointed in the inefficiency of the actual process of scheduling the ICN.

Following eighteen months of perseverance, the teachers were proud of their accomplishments and desired continued collaboration as well as continuation of the ICEA Project. There were no mentions of any hesitancy on the part of their administrators. They had created a dynamically evolving supplemental package that could be integrated into any existing high school chemistry curriculum. As one of them noted in the focus group, "We are not at the end. We're merely evolving. We've only taken one step. And so we're doing things that other teachers aren't doing in their classrooms, but five years from now they're going to be doing what we're doing now. The kind of things we've done will work just as well in social studies classes and English classes as they worked in chemistry classes."

F. Impact

There are three different aspects of the impact and benefits of the ICEA Project to consider: on high school chemistry students in whose classes the supplemental curriculum was implemented; on the four chemistry teachers, and on a broader audience of chemistry teachers to whom the dissemination efforts were directed.

1. Students

Approximately 300 high school chemistry students—sophomores, juniors, and seniors—participated in the ICEA Project Phase I. Students learned about chemistry in new ways designed to further more effective and active learning. Students themselves used or were shown a wide variety of instructional and communications technologies. They became comfortable using state of the art equipment that some other teachers in their schools had not yet used. Hands-on real-world activities motivated students and generated enthusiasm. Teachers noted an improved retention rate. At risk students chose to stay in the class, even if they were struggling. Interactive learning was a motivating factor for them.

2. Phase I teachers

The teachers benefited most directly from the ICEA Project. They utilized new technologies and instructional styles. They worked closely with each other, communicating at least daily, thereby overcoming the isolation they had each previously experienced in varying degrees. They also interacted regularly with support staff at Iowa State University. Although each was a master teacher at the outset, participation in the Project had had a rejuvenating effect on their outlook. All four enthusiastically sought to continue the Project into Phase II.

3. Teachers and Iowa State staff statewide and nationally

Hundreds of chemistry teachers attended presentations by the four chemistry teachers or Iowa State ICEA support staff members at state and national conferences. These generated interest among audience participants. Some eventually became Phase II participants. Formal presentations were listed earlier and included:

- February 1997—Iowa Distance Learning Association, Ames, Iowa
- March, 1997—National Science Teachers Association, New Orleans, Louisiana
- April 1997—Iowa Academy of Science, Dubuque, Iowa
- May 1997—Statewide ICN presentation to high school chemistry teachers: eight ICN sites with teachers attending who had responded to an ICEA interest survey
- August 1997—Chem Ed '97, Minneapolis, Minnesota
- October 1997—Iowa Science Teachers Association, Des Moines, Iowa

G. Schedules and Scheduling

The most serious problems that had to be addressed by all Project participants was that of schedules and scheduling. Each high school had a different academic calendar, with their school year beginning and ending on different dates and with vacations differing as well.

An even greater hindrance for scheduling collaborative events were the differing bell schedules at the four high schools. Because at the four schools there was only a twenty minute period when each of the day's class periods overlapped, collaboration times on the ICN tended to be truncated. To complicate matters, the overlap was at the beginning of the class period at one school, the middle of the period at another, and at the end of the period at a third school. Additionally, the teachers were forced to deal with unscheduled changes in class routines (e.g., scheduled and emergency school assemblies, snow days, fire drills, etc.). Teacher and student perseverance and ability to adapt allowed this arrangement to work.

Scheduling ICN sessions challenged the Project manager. Changes in ICN scheduling software helped to resolve some of the scheduling difficulties. However, changes in the Iowa

State University method of handling scheduling requests failed to allow meaningful improvement to the process. These scheduling difficulties plagued participants for the entire year.

H. Unanticipated Outcomes

The ICEA Project served as a springboard for a pair of smaller grants secured by the four teachers In an informal agreement with the Canon Camera Company, for the duration of the Project, each of the teachers received a desktop video camera that could be used with classroom television monitors, to present close-up views of chemical reactions observed during classroom demonstrations. At one site, this camera was connected to the ICN system to serve as an overhead camera. The teachers also received a grant from Eastman Kodak that provided each school with two Kodak digital cameras, accessories, and software. These cameras were used to document ICEA and other classroom activities. The cameras were also used to generate digital images which the students incorporated into PowerPoint presentations used in their ICN sessions.

I. What Was Learned from the Phase I Experience?

The Iowa Chemistry Education Alliance Project Phase I participants formed a cohesive team and created, implemented in the classroom, and modified a supplemental chemistry curriculum package. These materials were packaged so that they could eventually be distributed via Iowa's Area Education Agencies in order that other chemistry educators might benefit. The teachers who took the lead in creating the curriculum materials continued to collaborate, applying in their classrooms the skills learned and materials produced during their participation in the Project.

What could Project personnel take away from the experiences of the Phase I effort and apply to the planning of a second phase of the Project?

1. Teachers and Training

The ICEA Project team had developed a basic common sense formative process (referred to earlier as the ICEA Model) that could serve as a template for other projects wanting to achieve the same ends. Creating a collaborative team spirit was critical to the success of further developmental work. The teachers needed the respectful collegiality which they all shared to support one another through the arduous process of drafting, creating, and implementing the supplemental curriculum product. Because Phase I teachers had previously known and worked with one another, team-building exercises were not critical to Phase I team development. Team-building would, however, be an important component in future work with new participants joining the Project. Training in the principles and use of distance communications technology was also of primary importance. Finally, sessions helping the teachers to familiarize themselves with multiple learning styles and cooperative learning were invaluable.

2. Number of modules

The four teachers felt that developing and attempting to integrate eight modules into the existing curriculum had been too ambitious an undertaking. Students also felt that they were under too much stress trying to do the sometimes repetitious work associated with all eight modules. Teachers believed that it would be more realistic to plan to implement two modules each semester rather than four. They recommended that the Introductory and Statistical Analysis modules (Modules 1 and 2) would correlate best with the traditional first semester high school chemistry curriculum. It was surmised that the Spectrophotometric Analysis and Forensics modules (Modules 5 and 4 respectively) would best complement second semester material.

3. Module relevance

Students enjoyed the real-world practical aspects of the hands-on module activities. They wanted more of these situated learning opportunities to relate their personal experiences to their high school chemistry learning experience. Teachers believed that scheduling only two modules per semester would allow them to correlate the modules more closely with "regular" classroom material, making them seem more relevant. With a less stressful pace and more time to consider it, student groups could be encouraged to discover the connection between module materials and relevance to their traditional classwork as well as to their everyday lives.

4. Collaboration and ICN interaction

Students had requested more opportunities for collaboration with distant classmates and teachers. They did not perceive that they had formed any kind of relationship with students or teachers in distant classrooms. More collaborative activities would provide them with an occasion to solidify these relationships. More interactivity would promote an environment more nearly equivalent to their "normal" classroom.

In addition, students valued *collaborative* ICN activities in preference to *number-related* presentations. The latter were judged to be too boring (and with good reason). Exercises with more interactivity would need to be designed to reflect this input.

5. Disparity of bell schedules

The mismatch of the bell schedules at the four high schools caused problems for the students and teachers alike. Recall, during each ICN presentation session, *all* students were in attendance for only twenty minutes out of every hour because their class periods had only that fraction of overlap time.

The students felt that preparing a presentation required enough work of them that they disliked having to make that presentation to an empty distant classroom or to distant classmates who had to leave their classroom to make a class change during the middle of a presentation delivery. The teachers found it difficult to coordinate scheduling of ICN sessions in an equitable manner so that all students could feel confident that the work they did would be interactive and viewed and appreciated by another group. It was decided that for future ICEA work, it was imperative that every effort would be directed at pairing groups with nearly complementary school bell schedules. The number of interacting classrooms would need to increase by expanding the number of teachers implementing the ICEA curriculum.

6. Student use of technology

Students were given ample training on the use of the ICN classroom equipment. However, they expressed a need for better directions on how to use other equipment or communication techniques such as CUSeeMe, the Internet, or electronic mail. As recently as 1996-1997, access WAS an issue. Not all students had equal access, therefore not all had the same comfort level. Teachers planned to do more with technology integration with future ICEA groups.

Students also appreciated the opportunity to learn about presentation software such as PowerPoint. The exposure they received by using presentation software, in addition to viewing the presentations prepared by local and distant classmates, provided them with skills that would be applicable to other classes and future presentation opportunities. After viewing the professional appearance of a presentation prepared using PowerPoint, students did not return to using bits of notebook paper with penciled entries to share their data and ideas.

Students had a positive attitude toward the ICN. Its use expanded their learning opportunities and they believed that its use should remain a part of future chemistry classes. The chemistry teachers learned that it was more than the novelty of ICN technology that motivated the students. It served as the tool that made inter-school collaboration possible. Anecdotal evidence suggests that the ICEA Project with its ICN communication component improved student retention and attendance during that academic year. Students also felt that they had a certain advantage over peers whose classwork had not provided them with the opportunity to employ cutting edge communication technologies.

7. Teacher use of technology

The nature of the Project, with its emphasis on high-tech communication tools led the teachers to adopt a variety of new technologies in their classrooms. All four teachers had had a moderate comfort level with computer usage prior to ICEA Project participation. But, these teachers had not integrated the use of electronic mail, CUSeeMe, digital cameras, the Internet, nor presentation software packages (such as PowerPoint) in their daily classroom work. Each clearly became more confident and comfortable with these tools as the academic year progressed. Even if the ICEA Project had not been refunded, the teachers would have continued implementation of the modules into their curriculum as well as integrating the communication tools into their chemistry classroom routine.

8. Teacher role

Project personnel for the ICEA believed that the teachers should maintain the same autonomy in their classrooms as they had in the past. There was no interference from outside sources (Star Schools grant personnel, Iowa State University grant PIs, or Iowa State University support staff). Project personnel made invited visits to each of the four classrooms, but purely in the capacity of observers. The four teachers relinquished a modicum of control as their classrooms became more student-centered. Teachers learned to facilitate rather than to "lecture". Students learned to take more responsibility for their work. Fellow group members held them accountable as they analyzed experimental work and prepared reports to present to distant classmates via the ICN. In pondering this evolution of their roles in the classroom, teachers realized that they would need to model and facilitate this process for future ICEA teachers. Their role would become one of mentor to those new teachers needing to understand the necessity to step back and allow the students to construct their own learning and to formulate their own interactions.

J. ICN Presentation

A state-wide ICN presentation was made at the end of Phase I to acquaint Iowa high school teachers with the ICEA Project and to generate some degree of interest among them to participate in Phase II. This was done using the ICN to provide recipients with experience in viewing the four master teachers using the ICN technology as well as talking about student reactions to using it. Teacher willingness to participate was expected to become more positive as a result of experience with the technology and assurances from their peers that the ICEA modules could be integrated into an existing curriculum. Several instructors contacted ICEA personnel express their interest in learning more about the Project.

V. CHAPTER 5. THE IOWA CHEMISTRY EDUCATION ALLIANCE PHASE II—EXPANDING AND MODIFYING

A. Delays to Starting Phase II

As a result of various dissemination efforts during Phase I of the ICEA Project, interested high school chemistry teachers had contacted ICEA Project personnel to inquire about how and when they might become active participants in Phase II of the ICEA Project. Delays in Star Schools funding necessitated postponing any Phase II team-building activities prior to the commencement of the 1997-1998 academic year. Funding was not awarded until mid-November. Project personnel immediately began a concerted effort to recruit interested candidates for Phase II. A list of twelve individuals had been compiled based on three sources: personal inquiry by interested potential participants, a mail list generated after the state-wide ICN dissemination broadcast from the Spring of 1997, and recommendations of Phase I teachers, who were familiar with the cadre of Iowa high school chemistry teachers. Those teachers on the list of twelve were called and asked three questions.

a. Were they still interested in participating in Phase II of the ICEA Project?
b. Did their schools have an operating ICN room?
c. Could they meet with the staff the first weekend in December 1997 for orientation to the Project materials and training in the use of the ICN?

Because the 1997-1998 academic year had already begun, not all teachers who had initially expressed a desire to participate in Phase II were still interested. Of the original pool of potential candidates, eight were selected. A listing of the Phase II teachers and their schools is included in Appendix E. It was decided that for the smoothest adjustment for the newly enlisted teachers, each Phase I teacher would mentor two new Phase II teachers. The mentoring structure had several advantages. It provided novice ICEA teachers with a support structure to help them to adjust to the pace of the Project, anticipate unforeseen challenges, understand better how to incorporate the technology as well as the supplemental modules into their existing curriculum, and find answers to questions they did not know they had. This mentoring scheme was in large part responsible for the success of Phase II.

All four of the original teachers served as a resource for the modules undertaken during Phase II. The pair of individuals who had initially designed each module retained an interest in and took responsibility for their "own" modules when “training” the new teachers about that lesson.

B. Phase II Teachers

Phase II represented an expanded teacher pool. Three teachers from schools outside AEA 11 were welcomed. They included teachers at Cedar Rapids Prairie High School (AEA 10), Council Bluffs Abraham Lincoln High School (AEA 12) and Sioux City East High School (AEA 13). No longer were the teachers only a 45-minute drive from one another. Communication via the ICN, electronic mail, and CUSeeMe technologies became imperative.

C. Ensuing problems

There was little time available to provide the eight new ICEA Phase II teachers with the training and preparation that had been available to the Phase I teachers because the academic year had already begun. By the time Phase II teachers traveled to the Iowa State University campus in early December 1997 to become acquainted with the ICEA team, the first term was well under way and nearing completion. Phase II teachers met each other, the Phase I teachers, and the ISU support staff. Phase I teachers were able to provide the Phase II teachers with an overview of the ICEA modular approach as well as familiarize them with the contents of the ICEA module package. In addition, the new teachers were provided with a four-hour distance education training session. Iowa State University staff provided explanations about the fundamentals of the use of distance education technology and a basic session to practice using the ICN technology . Participants practiced techniques between remote classroom sites across the Iowa State University campus. They were later able to independently conduct their own classroom sessions having had this hands-on training.

Teachers from Phase I and Phase II spent eight hours scheduling interactive ICN sessions among the twelve sites. With more classes meeting, there were more possibilities to find overlapping (matching) time slots. Besides the student sessions, ICN "staff" meetings were scheduled for every two weeks. As was true in Phase I, these regular meetings were planned to enable the efficient and timely dissemination of information among participants as well as organized mentoring opportunities for the eight new teachers.

D. Modules Used in Phase II

As the result of insistent input from Phase I teachers and their students, the modules chosen for Phase II were selected to include a wide range of topics and skills. They were limited to four that could be integrated into the existing chemistry curricula at the twelve high schools with the least amount of difficulty. The four modules included (a) the Communications Tools and Protocols; (b) Data Collection and Statistical Analysis; (c) Instrumentation—Spectrophotometry; and (d) Forensics.

Evaluation of these modules was accomplished by the all of teachers as they incorporated them. Any needed modifications were made during implementation.

1. Modules selected for Phase II use and modifications

a. Module 1. Communication Tools and Protocols

It was thought to be critical to every phase of the ICEA Project that the students undertake the first module as an introduction to learn how to use the ICN and to practice communication skills. This module provided the students with an exposure to the philosophy of distance education and a non-threatening presentation exercise whereby they could practice using the ICN techniques and technology about which they had learned (by viewing the supporting videotapes).

For Module 1, there were few developmental changes. Due to the increased number of participating students, more pairs of students at different schools exchanged personal information via electronic mail. Using the ICN, they then introduced their partner to classmates in their own classroom and at distant sites. Over three hundred pairs interacted among the twelve schools. Orchestration of this scheduling task alone was daunting.

Student pairs prepared and delivered reports on favorite elements or chemicals to local classmates in their regular classroom. One group from each class was selected to present their report to distant classmates via the ICN. A substantially larger number of students interacted among the active ICN sites than had during Phase I.

b. Module 2. Data Collection and Statistical Analysis (The Soda Pop Module)

The Statistical Analysis module provided learners with an opportunity to utilize statistical methods of investigation. It was implemented to expose students to the principles of statistical analysis of data. There was an expansion of the Phase I statistics lesson to add the "Q-test" for rejection of outlying, questionable data (Christian, 1972; Harris, 1982). The information in the statistics lesson was delivered at each site via the ICEA module package supporting videotape entitled "Data Analysis and Basic Statistics" (each teacher's set of modular materials included this video). The videotape was produced specifically for this module so that all students would receive the same information and so that its scheduled use could be controlled by the teacher.

By using the statistics video, the Phase II study of the data analysis module was statistically more robust and sophisticated. Familiarity with these principles of statistics was thought to be beneficial for students in their high school chemistry class as well as for future college work. Few high schools traditionally provided their students with lessons about statistical methods of analysis. Statistical techniques learned in this module were later integrated into the analysis of the data concerning the % Cu in a post-1982 U.S. penny.

c. Module 5. Chemical Instrumentation—Spectrophotometry (Copper Penny Module)

Module 5, performed as the third ICEA learning unit during Phase II, enabled students to employ instruments with a range of sophistication to solve a problem about chemical analysis. The module activities were selected to provide the students with a real-world experience using a more sophisticated level of chemical skills. Statistical techniques that were learned during Module 2 work could be applied to instrumental analyses.

To undertake Module 5, the teachers collaborated to orchestrate an equipment exchange in order to provide all of the schools with at least two of the three types of instruments needed to analyze and share their data. This effort enabled schools that lacked particular types of instrumentation to participate at the same level of preparedness as the institutions whose laboratories were more well-equipped.

In addition, students undertook a more intensive Internet/World Wide Web investigation of coinage facts. Jeff Hepburn at Dowling designed a companion common examination question that was administered to some students to determine their comprehension of the concept of spectrophotometric analysis. This was the first time that ICEA students had been assessed via a common instrument. Data about this test question was collected by teachers, but, due to his own time constraints, no assessment or evaluation of the results was ever actually made by the teacher who spearheaded the effort.

d. Module 4. Forensics

The Forensics module posed a novel problem that required forensic evaluation of a crime scene to determine culpability of a suspect. It had been the most popular of the Phase I learning exercises and again provided real-world, hands-on analysis experiences.

For Module 4, a companion videotape entitled "Tour of the Iowa Division of Criminal Investigation (DCI) Criminalistics Laboratory", was used for the first time. Each teacher's set of modular materials included this video. The video provided students with a basic scenario of how experts undertake a professional forensics investigation, from the arrival of evidence, through its analysis, to the security of its storage. Learning about this real-life "chain of evidence" impressed students and teachers alike. Their reaction to the videotape was overwhelmingly positive.

During the Phase II Forensics unit, each of the teachers invited guest speakers to participate in an ICN session during which students could pose forensics questions that interested them. Many aspects of Forensic Science were explained by experts in a variety of fields. Guests included judges, attorneys, police detectives, police officers, a state patrol officer, and a county sheriff. Students found the availability of the guests and their willingness to answer any question to be very supportive of their learning. It was unquestionably one of their favorite activities, as revealed by the results of focus group interviews and student survey instruments administered at the end of the Spring Semester.

Because there was a larger student population in ICEA Phase II compared to ICEA Phase I, more students (approximately 700 compared to 400) were able to communicate with one another via the ICN. This created more opportunities for collaboration as well as encountering more instances of scheduling problems.

E. Phase II Assessment—Perceptions Based on Focus Group Comments by Teachers and Students

1. Students focus groups and survey of attitudes

Near the end of the academic year 1997-1998, student focus groups were conducted at the four original high schools and two of the eight new participating high schools to gauge student reaction to the ICEA Project. A survey about student attitudes toward the ICEA Project and the ICN was also administered. Students shared their attitudes about a variety of aspects of their involvement in the ICEA Project. Much of what was shared echoed the same criticisms and suggested changes or improvements made a year earlier by the Phase I students.

a. Positive observations by students

1) Experts who visited classrooms in person and via ICN were fun and interesting. These guests contributed valuable information not available from their own teachers.

2) The forensics module was once again considered, overwhelmingly, the best module.

3) The ICEA Project provided the opportunity for students to use and apply the chemistry that they were learning. Students valued tie-ins between the ICEA hands-on modules and real life. They wanted additional tie-ins.

4) Students wanted to learn more in the context of practical applications, with hands-on activities that had meaning and relevance to them.

5) Students welcomed opportunities for collaboration with distant classmates. They wanted more activities to provide them with opportunities to interact.

6) Students learned from their interactions with distant peers how similar their school and life experiences were to one another.

7) Students learned from doing presentations—they realized the need to *know* the material to be able to explain it to their peers. They were accountable to answer questions from distant classmates or their teachers. If they did not know the material, they would not represent their class or their school well. In addition, they felt they would look stupid in front of distant students. This was a huge motivational factor for learning the material.

8) Students could interact on a non-competitive academic level, not merely at sporting events.

b. Student criticisms

Students were critical of a number of aspects of the Project, some of which their teachers could control and others that they could not control.

1) Again, students believed that too many modules were conducted, that they were too rushed, and that they were too repetitious. They recommended that fewer modules be undertaken, with more time for each. (This view was also reiterated by the teacher cohort, as will be noted below.) Although the original Phase II plans were to implement four modules over the entire academic year, the delayed start of ICEA Phase II forced the teachers to use the same accelerated pace they had used for

scheduling during Phase I, i.e., four modules during the Spring term (if they were to implement the desired four modules). In retrospect, it would have been advisable for the teachers to eliminate the third module (Module 5, the copper coin analysis), relax the pace, and concentrate on deeper understanding of the concepts in Modules 1, 2, and 4.

2) Students perceived that the modules (over which they were not tested) were not well-integrated into the curriculum; they interrupted the regular course units and seemed unrelated to the "regular" units. This was partially the opinion of several unhappy individuals who influenced their peers. Yes, Modules 1 and 2 would have coordinated better with the first semester topics than they did with second semester topics. They were thought to be repetitious of materials that had already been studied. Students feared that they would not "cover" all of the important college preparatory chemistry topics if they were doing ICEA modules. Students did not always understand the purpose of the modules and their ICN activities. Was this more a problem of student attitude, or failure of the teachers to "set the stage" in a convincing manner?

3) Although vastly improved in availability, students still had occasional difficulties accessing and using some of the communication technologies at their disposal for the Project, such as CUSeeMe and the Internet. Some learners still need better directions on how to use equipment. Part of this problem is due to the fact that the students taking the course are at several grade levels (sophomore, junior and senior). Older students are more mature and have usually had more opportunity for exposure to use of the Internet, for example.

4) Students still complained about the differences in school bell schedules. Because class schedules were not always comparable, student presentations might be scheduled for participation for three full classes of students or more at a time when

a part of the group would have to leave for a class change. This was distracting to the presenting class. The worst situations were student presentations that were scheduled when no other distant classmates were in attendance. What was the incentive to use the ICN system to present to empty distant classrooms if this was supposed to be an *interactive **ICN*** presentation?

5) Students suggested involving more schools at a time (they reported that only one or two in addition to their own school at any one time did not seem to be much different from just their own classroom and thought that more students would be better) even to the point of suggesting that the students at schools from another state be invited to participate.

c. Student suggestions for improvement

Students also offered recommendations for improvements to the Project.

1) Students suggested that more opportunities for interactive communication, collaboration, and discussion would be beneficial to all. (This echoes Phase I student comments.)

2) Students perceived that time was at a premium. They suggested starting modules earlier in the academic year so that more time on each project would be possible and so that there would still be time to learn "textbook" chemistry. They were not aware that the delay in starting had been due to grant funding complications.

2. Phase II teacher focus group

Phase I teachers and Phase II teachers were interviewed in two separate focus groups in order to provide each group with an individual forum for comment.

Common themes emerged. Both groups focused first on student-related, then on teacher-related issues.

a. Teacher observations of students

1) Both groups of teachers observed that students were more independent. Students learned real life skills. They were held responsible for their own learning as well as being more accountable for having work ready *on time*. The teacher role evolved into more that of a facilitator of learning rather than the "source of knowledge". They provided students with the means to find the answer themselves while monitoring progress. Teachers gladly observed that students would try to tackle a problem ***before*** asking for help from their instructor. Students achieved a higher level of satisfaction and accomplishment at being able to reason through and explain a problem. They performed better on a laboratory test at the end of the semester, according to one teacher. They also became more organized.

2) There were several aspects of technology issues. Teachers observed that students benefited from the use of technology and the interaction with other students as has been mentioned above. They were exposed to technology in the form of ICN room equipment, presentation software, data analysis, graphing and spreadsheet software, chemistry instrumentation, graphing calculators, and digital cameras. As their comfort level with technology increased throughout the term, so did their confidence and poise while presenting information to local and distant classmates. Students best enjoyed the activities during which they maximized *communication* with distant peers. They preferred a more interactive and less numbers-oriented format.

3) Collaboration, not competition, was a goal. Teachers perceived that students benefited immeasurably from their collaborative activities. Usually students in schools are in *competitive* sports activities with each other rather than working *collaboratively* together on academic activities. Teachers observed the positive influence of the academic collaboration in the students' social development.

Further, collaborative activities reduced peer competition in the local classroom. Learners saw themselves as colleagues working for a common goal, a perception that continued through the end of the school year. Especially when they produced their presentations for distant classmates, the students worked hard with one another to create a final product that would represent their school well. School pride and loyalty were tangible during ICN presentation sessions. In that respect, there was an evident "competition" to "keep up with the Jones's". If a group at one school introduced a particularly effective technique during an ICN presentation, several groups at different schools would invariably "copy" and try to improve on that technique during the next round of ICN presentations. This favored more improved presentations but also saw the evolution of more motivated, enthusiastic, mature students.

4) Also, students integrated (cross-disciplinary) skills. For example, the statistics module provided them with exercises in mathematics. Communication skills developed in speech and English classes served students well during ICN presentations. Keyboarding and data entry skills learned in computer class were also useful.

Some skills were developed as a result of the Project. Students learned graphing techniques, learned about and used graphing calculators and spreadsheet and presentation software packages, and utilized sophisticated analytical chemistry instrumentation. Those who had had practice using graphing calculators in mathematics class, were able to help peers to learn some skills for using the calculators as well as instill in their friends a respect for the tremendous power of the graphing calculator to perform successfully for the students. These techniques and skills were of considerable use to students in later coursework.

5) Some students perceived that the ICEA modules were an "add-on" to the regular curriculum. They did not value them as a valid part of their chemistry course. This is because the ICEA grant did not provide funding to start until mid-way through the academic year. If nothing else, probably the single most important aspect that Phase II taught Project personnel was that student attitude is strongly affected as much by *when* the ICEA materials are introduced to them as how they are introduced. For learners to value the ICEA experience, it

must be a part of the entire academic year, introduced immediately at the outset. Implementation from the first day of class is imperative to validate the process of the ICEA. The enthusiasm with which the instructor introduces the ICEA concept sets the tone for all facets of the Project in her or his classroom.

b. Teacher issues

The Project introduced extra time requirements and presented scheduling challenges for teachers. But, they thought they had learned much during their interaction with one another. This ability to communicate with teaching peers alleviated feelings of isolation. It provided all teachers with the opportunity to learn about what is going on in Iowa high school chemistry classrooms all around the state, not in their district alone.

1) Phase I teachers. Phase I teachers specifically benefited from the experience of having previously used the supplementary curricular materials. They were more relaxed. They were better able to anticipate, among other things, student reactions, potential problems, and aspects of the curriculum where their mentoring would be of particular use to Phase II teachers. They were able to make changes in their classes, planning for ideas and concepts that would follow during the term. They could tell differences in their students' responses to the ICEA materials during Phase II just because of their own familiarity with the Project.

Because of their past experiences in module development and implementation, Phase I teachers served as natural mentors to Phase II teachers. Phase II teachers found this to be an invaluable resource for them. They characterized the mentoring process as a positive experience. They found their mentors to be non-judgmental and willing to provide answers to any questions, no matter how routine. All teachers were encouraged to operate as independently as they were comfortable. In addition, mentors solicited suggestions from the newer teachers for improvements that could be made. This encouraged the Phase II teachers to participate more actively since their opinion was valued. Phase II teachers felt that they were treated as professionals and equals to the Phase I teachers in all respects.

Phase I teachers valued the fresh outlook that Phase II teachers had brought to the Project. Because Phase I teachers had drafted the modules, they appreciated suggestions and feedback that Phase II teachers could provide because Phase II teachers did not have the same emotional investment as the Phase I creators of the materials had.

2) Phase II teachers. Phase II teachers found participation in the ICEA effort to be challenging. Although they had all of the ICEA supplemental materials, at times they struggled to incorporate the materials in a timely fashion while still progressing in their "normal" curriculum. Mentors were able to provide useful suggestions as to how much time to allow for different stages of a module and in that way guided their newer colleagues in the planning and implementation of each latest module. One Phase II teacher reported that he had over 300 electronic mail messages sent in the time period of one semester, noting that at no previous time had he ever communicated with that regularity or at that level with other teachers.

Communication among teachers was not limited to ICEA matters. Provided with the opportunity for interchange, teachers discussed *all* aspects of teaching, administrative, and curricular issues. Moreover, teachers shared instruments, software, and chemistry glassware in order to ensure adequate stocking for all schools and their students.

c. ICEA teacher suggestions for improvement in Phase III

Several suggestions were offered for further development of the Project in anticipation of a Phase III effort during the academic year 1998-1999.

1) Participating teachers needed to be committed and needed to communicate better.
2) More face-to-face (same time, same place) communication was needed, not just e-mail and ICN. Face-to-face communication provided more opportunity to highlight potential problems and clarify questions. More work seemed to be accomplished in a face-to-face venue.
3) Teachers must bond early in the Project.

4) Summer workshops were needed where teachers could get together. In a low-stress summertime environment, peers could become acquainted and acclimated with the supplemental materials and technologies that they would employ.
5) Interaction between students in different schools would need to be improved. An alternate methodology to simple presentation might enhance interaction and get students to open up to each other. Simple presentation was too much "talking head syndrome". Students wanted to make a more personal connection with distant classmates—teachers must determine how they could facilitate that happening.
6) The number of modules covered in a semester would need to be reduced from four to two and the modules would need to be coordinated with the material being covered in the text.
7) Teachers wanted to see the budget and how the Project was organized before a new phase of the Project started.
8) A Project-wide policy should be set for how students would be expected to behave when they were in the ICN classroom and a mechanism provided for what the resultant actions will be for failure to abide by the agreed-upon ICN room protocol.
9) The ICN origination site should be moved around throughout the semester (if that was possible with ICN protocols) so that it was not always the same school. In this way, students at all schools could feel the pride of being the originating site, i.e., trusted with the responsibility to moderate the sessions for the day.
10) An effort should formally be made to arrange for the ICEA students at different sites around the state to meet with one another outside the classroom.

F. Benefits of the ICEA

1. Students

Approximately 700 high school chemistry students—sophomores, juniors, and seniors—participated in the ICEA Project Phase II. This was more than twice the number of student participants in ICEA Phase I. During the semester of the supplemental curriculum implementation, students learned about chemistry in new ways--ways designed to foster more effective and active learning. Students perceived a new accountability for their own learning. Classrooms became more student-centered and less focused on a lecturing teacher. Students were also exposed to and used a variety of instructional and communications technologies (the ICN, the Internet, electronic mail, and CUSeeMe). While interacting with distant peers via the ICN, students became more poised, self-assured, and confident.

2. Teachers

The teachers themselves benefited in a number of ways from the ICEA Project. They employed new technologies and instructional styles. They worked closely with each other, communicating on a near-daily basis and overcoming somewhat the isolation they each encountered in varying degrees. Experienced teachers from Phase I served as mentors to the novice teachers who joined the ICEA Project in Phase II. Phase II teachers learned from the experiences shared with them by their mentors as well as those shared by their students. They had not had the advantage of having previously worked through the ICEA modular materials and, as a result, learned along with their students, thanks to the support of the Phase I teachers, who sometimes literally "talked them through" some of their classroom experiences.

Having worked with the ICEA modules, teachers looked at teaching activities as more student-centered. They learned to relinquish control of the classroom to the students, who in turn held themselves more accountable for their own learning. The process is less teacher-driven and more student-driven. Students undertook a greater responsibility for accomplishing their learning tasks. Students reported acquiring more conceptual understanding as a result of being responsible to "teach it to distant classmates". A person learns better when responsible to teach someone else.

Participation in the Project presented all the teachers with the opportunity to share equipment for the modules on an as-needed basis. This expanded the resources of the individual schools into the pooled resources of the ICEA consortium group. Students benefited from the occasion to see and use instrumentation that would not have normally been available to them in their school system.

3. Teachers statewide and nationally

During ICEA Phase II, hundreds of chemistry teachers attended presentations by the ICEA chemistry teachers and ISU staff at local AEA, state, and national conferences. This attendance encouraged more instructors to apply to join the ICEA Project.

G. Phase II Information Activities and Dissemination

1. National presentation

During Spring 1998, a presentation about the ICEA Project Phases I and II was made by PI Tom Greenbowe at the University of Washington—Seattle at the American Chemistry Society Regional Meeting, Western Washington Section. These teachers were extremely impressed with the ICEA initiative and desired further information about the Project.

2. Statewide presentations

a. Iowa Science Teachers Fall Meeting, Des Moines, Fall 1997

The four Phase I teachers presented information about the Project and proposed Phase II changes at the Fall 1997 Meeting of the Iowa Science Teachers. This informational meeting convinced some attendees to make inquiries about participating in Phase II. A small number became participating members.

b. Other meetings

Other basic information-type meetings that spring included the Iowa Distance Learning Association, Ames, February, 1998 (by the teachers); Iowa State University Science Education Seminar, March, 1998 (by Project personnel); and the Iowa Academy of Science, Mason City, April, 1998 (by the teachers). Attendees at each of these presentations were impressed with the enthusiasm of the Phase I and Phase II teachers.

c. Statewide ICN informational presentation

Dissemination efforts for ICEA at the end of Phase II (academic year 1997-1998) included an informational meeting conducted in May at twelve sites around the state via Iowa Communications Network (ICN) interactive video technology. Together, the Phase I and Phase II teachers presented information about the Project. This informational meeting initiated a series of inquiries from attendees around the state who were eager to review the ICEA materials as well as to participate in a Phase III initiative. Twenty-five attendees questioned the twelve ICEA Phase II participating teachers about their experiences using ICEA supplemental curricular materials. Participants at the meeting also asked how to receive more information about becoming a part of the ICEA Project. A list of interested individuals was made so that contact could be made with them if and when funding was allocated for Phase III of the ICEA Project.

3. Iowa Department of Education brochure

In late May, 1998, a tri-fold brochure describing the ICEA Project activities in Phases I and II was circulated by Iowa Public Television in conjunction with the Iowa Department of Education. Copies were sent to all 474 high school chemistry teachers across Iowa. A short description of the ICEA Project, supplemental curriculum materials, and its supporting videotapes provided an overview of the Project. Teachers were given the opportunity to request examination copies of the ICEA modular materials to review and perhaps incorporate in their own curricula. Response was immediate. Over 90 respondents requested examination copies of the eight modules and accompanying videotapes. Although Project personnel were disappointed that more teachers did not respond, they realized that the teachers may have received the request cards after leaving for the summer. It was speculated that when returning in the Fall of 1998, many of the post cards were probably lodged among a collection of other mail accumulated over the summer and discarded along with the rest of it.

A large portion of the summer of 1998 was spent reproducing and packaging the ICEA module materials. The mailings were made in late September 1998. Unfortunately, because the materials were not received earlier, many teachers did not have the time to examine them or to incorporate them into their existing curriculum during that semester/academic year.

This dissemination effort interested other high school chemistry teachers in becoming participants in ICEA Phase III. The Phase III expansion effort was intended to involve participants from each of Iowa's fifteen Area Education Agencies. (Iowa had had fifteen Area Education Agencies until AEA 2, AEA 6, and AEA 7 merged to form AEA 267 on July 1, 2003).

H. ICEA Publications

1. International journal publication

a. A lengthy description of the ICEA Project was published in the *Journal of Chemical Education,* October, 1998 (Burke and Greenbowe, 1998).

2. Local news

Feature articles about the ICEA Project appeared in a number of newspapers local to participating schools. These human interest stories strengthened support among parents, administrators, and other community members.

I. Schedules and Scheduling

1. Teacher training

A detriment to the Project was the beginning of teacher training and mentoring activities for Phase II in December at the *end* of the first semester of classes rather than as a preservice workshop during the summer *prior to* the academic year. Teachers, especially the novices, felt somewhat unprepared and rushed as they tackled the modules with their students. Students, too, felt the strain of not enough general understanding of what was being undertaken by their instructors. ICEA Project training needs to begin prior to or at the outset of the academic year for teachers and students alike.

2. Student activities

Because the actual introduction of the ICEA module activities was not accomplished with the students until second semester, some perceived initial introductory activities as pointless. Statistical analyses of density were thought to be repetitious, because students had already learned about density in the first semester. Reinforcement and scaffolding on prior knowledge was not seen as productive, but, rather, as a waste of their time. They were afraid that peers in non-ICEA chemistry classes had a time advantage over them. They feared they would not "cover" what they needed to learn to prepare them for future college studies. Many expressed the desire to begin ICEA ICN activities at the outset of the academic year, predicting a better “fit” and flow with the “regular” curriculum. This exactly echoed instructor opinion on the same issue.

3. In-school scheduling

As had been true in ICEA Phase I, scheduling during Phase II proved to be a continuing challenge. Each of the educational institutions involved in the Project had differing school calendars, with their school year beginning and ending on differing dates and with vacations, scheduled at different times. Another challenge was block scheduling. This will be discussed below.

4. Bell schedules

An even greater challenge for scheduling collaborative events was the widely differing bell schedules at the high schools. Because there was still only 15-20 minutes when each of the day's class periods overlapped, collaboration times on the ICN tended to be truncated. As was true in Phase I, the overlap was sometimes at the beginning of the class period, sometimes at the middle, and sometimes at the end of the period. Students resented the time wasted waiting for other classes to “come on line” for collaboration. They felt they could make better use of their time learning in a regular class where activities *filled* the allotted time. It should be noted that the more experienced teachers involved their students in seat work during these periods of "wait time"; with practice, the novice teachers learned to do the same.

5. Block schedules

Finally, two schools used different versions of block scheduling throughout the semester, which meant that students there did not meet their chemistry classes on a daily basis. This affected the scheduling of most ICN sessions. Another challenge with one of the types of block scheduling was that a *full* year of chemistry was compressed into one semester. One of these teachers and her classes coordinated their time schedule on two *different* days to accommodate the block scheduling.

6. Teacher scheduling

To facilitate the scheduling process, the twelve teachers divided themselves into two separate groups (the "A" group and the "B" group) for the most expedient student collaborations. This provided a natural grouping for periodic teacher "staff" meetings. The diligence, experience, patience, and skill of the teachers (both accomplished and novice) allowed this arrangement to work.

7. Scheduling ICN sessions

Scheduling ICN sessions was also a challenge for the Project. As the use of the ICN system became more prevalent throughout the state, it became more difficult to schedule collaborative classroom opportunities. A large part of the difficulty during Phase II arose from the fact that scheduling could not be undertaken until December, 1997, well into the academic year. Other reservations for ICN time had been made much earlier by other schools with pre-approved funding resources. It was recommended that future scheduling requests be submitted and verified for the academic year much earlier during Phase III, than was done in Phase II.

J. U.S. West Grant for Development of ICEA Web Materials

Some members of the ICEA Project drafted a proposal to apply for a U.S. West grant to design, develop, and implement Internet-based materials to be utilized by the ICEA teachers and students. The grant was awarded in the Spring of 1998. A developmental workshop was begun during July, 1998. Some of the materials developed were designed to be incorporated as a supplement to the ICEA curriculum. The team especially targeted the Instrumentation-Spectrophotometry module (Module 5) for these supplemental materials. The team created a web site where information about spectroscopy could be found and used for students. The URL for this web site (now inactive) was:

(http://www.hydrogen.chem.iastate.edu/www/pennies/homepage.html)

In addition, at that site, a database was created which included statewide values for the % Cu in a post-1982 U.S. penny. To prepare students for use of this database tool, a less sophisticated prototype database was developed to use to collect information about the densities of the soda pop samples analyzed during the Statistics module. Although maintained for several years, these sites are no longer accessible.

K. What Was Learned during Phase II?

In early summer, 1998, Phase I and Phase II teachers met to debrief, discuss the modules, and make suggestions for ensuing ICEA planning. What had been learned during Phases I and II that would help in the designing of Phase III? Student surveys and focus groups along with teacher focus groups and comments made throughout the course of ICEA Phase II lead to the following conclusions about Phase II.

1. Teacher training and mentoring

Although the Phase II teachers felt they were well-mentored, they believed that a longer period of training was necessary at the beginning of the academic year to prepare them to create a more student-centered classroom while at the same time feeling comfortable with the ICEA materials. It was understood that funding delays had truncated their training sessions.

The recommendation was to provide an on-site meeting during which novice ICEA teachers could meet and get to know the experienced ICEA teachers. At the on-site meeting, teachers wanted to include training in use of the ICN, practice interactive ICN sessions, help to become familiar with all aspects of the ICEA learning modules that would be integrated into the existing curriculum for a particular academic year, and hands-on experience actually *doing* the ICEA activities.

2. Four ICEA Modules per academic year

At the conclusion of Phase I, teachers and students had clearly felt that the pace of implementing all eight ICEA modules was too overwhelming. It had been decided that only four modules would be integrated during Phase II. Due to the delay in funding, teachers and students began integrating the four ICEA modules into the second semester curriculum. Integrating four modules into one semester was essentially the same as integrating eight into two semesters. The pace was too rapid and stressful. Teachers and students alike recommended that no more than two modules be attempted any one semester.

3. Module relevance

Because the ICEA modules were not integrated into the curriculum until second semester, students had already had lessons related to learning about chemical elements (a part of ICEA learning Module 1) and density (a part of ICEA learning Module 2). Students felt that activities from these two modules were repetitive and were taking time away from what they should be learning to prepare themselves for college chemistry. Students viewed the lessons as repetitive "add-ons", tacked on to the "real" curriculum.

4. Begin at the beginning

Because funding was delayed and the Phase II ICEA activities were not begun until second semester, students did not feel the ICEA activities were a true part of their curriculum, but, rather, were added on to make more work for them. To validate the ICEA Project activities, they *must be* implemented from the outset of the academic year. This is supported in the literature—implementation of educational innovations must commence at the outset of the academic term to be seen as valid (Oliver-Hoyo, Allen, and Anderson, 2004). Both students and teachers felt the stress of the increased pace necessitated by integrating the ICEA materials.

5. Collaboration and ICN interaction

Students requested more opportunities to collaborate and interact with distant classmates and teachers. They requested ICN sessions be scheduled simply to talk with one another. They did not feel that they had forged any real relationships with distant classmates or their teachers. They believed that more activities where they could have opportunities to collaborate would help them to develop friendships at a distance. They did not find the ICN environment to be too artificial, but thought that further interactivity would create a more "normal" or equivalent environment.

Students requested that teachers expand ICEA activities to make them less a repetitive reporting session (presenting numerical data), and more interactive exchanges.

6. Disparity of bell schedules

Students saw no point in making ICN presentations to empty distant classrooms. Why waste the time, effort, and money to schedule an ICN session when there would or could be no interaction?

Students and teachers alike felt that the best strategy to maximize student interaction among grouped schools would be to schedule classes at schools with approximately the same bell schedules to collaborate via ICN to share information. Perhaps this could be facilitated by the greater pool of classes if there would be an expansion in the number of schools for Phase III.

7. Student use of technology

Student use of technology was an important facet of the Project. Students became more poised and confident in their presentation skills. They felt advantaged compared to local classmates who did not have the experience of participating in ICN interactive sessions.

Students were satisfied with their training on the use of the ICN classroom equipment. Teachers had planned to do more with technology integration (ICN equipment or communication techniques such as CUSeeMe, the Internet, the World Wide Web, or electronic mail) and use of presentation software such as PowerPoint with the Phase II ICEA group. During Phase II, students seemed to have more access to these technologies and software packages, although some still lagged behind. Interacting with students who were more facile with these techniques motivated the groups with less exposure to become more familiar with incorporating these techniques.

Students continued to express a positive attitude toward the ICN. The use of ICN sessions provided them learning opportunities they had never experienced. Like their Phase I counterparts, Phase II students also believed that ICN use should remain a part of future chemistry classes. The chemistry teachers once again observed that it was more than the novelty of ICN technology that motivated the students. Students valued their ability to collaborate between schools. Anecdotal evidence suggests that the ICEA Project with its ICN communication component again improved retention during that academic year.

8. Teacher use of technology

As was true during Phase I, the Phase II teachers integrated use of technology into their daily classroom routine. They had previously not incorporated electronic mail, CUSeeMe, and the Internet, nor presentation software packages such as PowerPoint. Phase I mentors helped Phase II novices to learn the value of these techniques. All teachers realized the value of expanding the walls of their classrooms to include national and international resources made available via the Internet and students and teachers across the state.

9. Teacher role

Phase I teachers were excellent facilitators for Phase II teachers. Phase II teachers credited their success to the mentoring they had received. They belied the mentoring process had been crucial and suggested a continuing mentoring structure for Phase II if the ICEA Project again received funding. Project personnel observed that the mentoring process had helped Phase I and Phase II teachers to realize an autonomy of sorts that did not require outside intervention. Given the opportunity to conduct a planning meeting, Principal Investigators

(PIs) for the Project were convinced that teachers would be able to draft their strategies for preparation, training, and mentoring should the Project receive re-funding for ICEA Phase III.

VI. CHAPTER 6. THE IOWA CHEMISTRY EDUCATION ALLIANCE PHASE III—"THE RIGHT CHEMISTRY"

A. Phase III—the REAL Test

What had been learned in Phases I and II? Focus group and opinion survey input from teachers and students provided some clear messages for the planning of Phase III.

Based on exit focus group interviews from the ICEA teachers in May of 1998, Project personnel had determined that the Phase II teachers felt under-prepared to begin the ICEA Project and also felt rushed throughout the semester. The teachers indicated that they must bond early in the Project and participate in summer training workshops where they could get together to become acquainted and learn about the ICEA supplemental materials and technologies before starting the school year.

The recommendation was made to re-institute a longer preparatory training workshop that would include sessions about distance learning, cooperative and collaborative work among schools, and hands-on laboratory work by the teachers executing the same modular units that their students would undertake. These aspects of the training workshop had been suggested by Phase II teachers during an ICEA focus group session the previous spring. The literature supports experiential training (McNeal, 1998; Oliver-Hoyo, Allen, and Anderson, 2004). In addition, it was realized that a larger portion of time would need to be devoted to scheduling of ICN class meetings than had been necessary the first two years because of the increase in the sheer number of participating classes.

Students had emphasized that their interactions among the different schools must be improved. They wanted less emphasis on data crunching and more of an emphasis on making a learning connection with distant peers. Teachers should facilitate that happening.

Both teachers and students recommended reducing the number of modules covered in a semester (four were too many!) and coordinating the modules to the material being covered in the text (so that the supplemental materials reinforced the "regular" curriculum). Teachers favored this for ease of facilitation and incorporation, students favored this so that it made sense to them where the material was integrated.

As a result of these recommendations, Dr. Gary Downs, principal investigator for the ICEA Project, was able to procure funding to provide Phase III teachers with a professional development workshop including the learning opportunities outlined above.

B. ICEA Summer Workshop, July 30-August 1, 1998

During the summer of 1998, a new group of high school chemistry teachers were invited to become collaborating members of the ICEA. Phase III of the ICEA saw the Project expand to include thirteen new high schools in addition to the twelve institutions already collaborating in Phases I and II. Participating high schools were located in ten different Iowa Area Education Agencies (please see Appendix E—Phase III Participants). During Phase I, all teachers were located in AEA 11; Phase II participation expanded to include AEAs 10, 12, and 13. During Phase III, only AEAs 1, 6, 7, 15, and 16 did not have schools represented in the ICEA.

Based on the strong recommendations of Phase I and Phase II teachers, a "preservice" summer workshop was designed and held for the new Phase III participants to meet with the "seasoned" veteran teachers and to learn about the ICEA materials. Phase III participants met one another and the Phase I and Phase II teachers for the first time at an Iowa State University workshop held July 30-August 1, 1998. A mentoring hierarchy was designed so that the Phase I teachers would advise the Phase II teachers and the Phase II teachers would mentor the Phase III teachers. Teachers shared their academic schedules. Six subgroups (designated by the colors Red, Orange, Yellow, Green, Blue, and Tan) were formed to coordinate the planning of two-way interactive collaborative ICN student sessions as well as faculty “staff” meetings at participating high school sites (please see Appendix G). Each of the six groups was able to draft a tentative ICN scheduling plan for the entire academic year.

In order to facilitate the new members' understanding of the module activities and how they could be integrated into an already-existing curriculum, all teachers discussed the introductory module about learning to use communication technologies and the strategies they had employed or might suggest to other teachers to involve their students. The group reached a common consensus on goals and objectives to be accomplished by their students.

A session was conducted about distance education technologies and equipment that prepared the teachers to use the ICN. After a brief explanation and demonstration of the ICN equipment, participants paired with each other and interviewed each other face-to-face. In order to better learn to use the ICN equipment, they assembled in two different ICN classrooms on the Iowa State University campus to practice using the ICN technology. They prepared a summary of what they had learned about each other during their on-site interviews and presented this to peers in a distant classroom. They achieved a tolerable comfort level with the equipment and their own television "presence".

Faculty members then split into two smaller groups. Half of the members of the group stayed on-site at Iowa State University and the others traveled three miles off campus to Ames High School. All participants worked through the Data Analysis module laboratory experiences, even to the point of carrying out the experimentation, in order to prepare to use the same exercises with their own students later in the fall. The novice ICEA Phase III teachers ran the soda pop density experiment scheme. Then, mentored by Phase II teachers, they analyzed their resultant data and prepared a short PowerPoint presentation to share their findings. After finishing their laboratory analysis, the entire group gathered in ICN classrooms at Iowa State University and at Ames High School and shared data and results via a live ICN broadcast between the Ames High School and Iowa State University sites. They did this in order to simulate the kind of experience their students would be expected to have. Each participant was again able to practice using appropriate ICN equipment before the session was completed. Participating in these practice ICN sessions provided them with more insight into what their teaching experience would resemble. Their mentors were able to offer suggestions as they practiced.

Participants who had joined the Project during Phase II (Academic Year 1997-1998) had not had a summer workshop session similar to this one. As has been discussed earlier, due to the extremely late award of funding, there had not been an opportunity for this to occur. Phase II teachers observed that this Phase III welcoming, training, and mentoring workshop had benefited them almost as much as it had the new Phase III participants, because the cohesiveness of the sessions showed them the entire picture (in the vision of the four designers) of what the ICEA Project tries to accomplish. They reported feeling much more connected to the group than they had the previous year. The Phase II and Phase III teachers recognized that networking with one another provided each group with an opportunity to learn a sizable amount about the metacognitive reasoning and critical thinking skills that went into module design. Those teachers who were most familiar with the modules passed along recommendations, hints, and anecdotes to peers who had not yet shared the laboratory experiences with their students. The seasoned veterans of the ICEA Project told their peers that they would learn the most about the modules by working through them the first time with their students. And, they also confided that they were *still* learning from their students after having been through the materials twice before.

C. Timely Integration of Modules in Phase III

1. Overview

The first semester of the academic year 1998-1999 saw over 1800 students at twenty-five Iowa high schools interacting with distant peers via electronic mail, Quick Cam, CUSeeMe technology, and the ICN. Students found their experiences to be exciting and looked forward to more ICN sessions with distant classmates. Teachers observed their students evolving into more independent learners as they assumed increased responsibility for their own learning.

During Phase III, the issues discussed earlier in this chapter were addressed. A concerted effort was made to introduce the ICEA Project activities immediately into the regular curriculum in order to validate the Project from the outset. Teachers carefully strategized how they would integrate the modules at a pace comfortable for the students and for themselves as well as in a timely fashion in order to provide as seamless a transition for the students as possible between their traditional curriculum and the ICEA units so that they did not characterize the ICEA units as ICN chemistry versus "regular" chemistry.

2. Modules Used in Phase III

For Phase III of the ICEA Project, teachers implemented four of the eight original modules. A wide range of chemistry topics and skills are found in the four selected modules. Teachers evaluated and modified modules as they implemented them. They are listed here in the order they were undertaken.

Module 1. Introduction: Communication Tools and Protocols—September/October 1998

Module 2. Data Collection and Statistical Analysis—October/November 1998

Module 5. Chemical Instrumentation—Spectrophotometry—February/March 1999

Module 4. Forensics—March/April 1999

Because there was a larger student population in ICEA Phase III (1800 students) compared to ICEA Phase I (300 students) and Phase II (700 students), more students were able to collaborate with one another via the ICN. This was one of the intended goals of Phase III of the ICEA Project. Further collaborative opportunities were provided via electronic mail exchanges, especially while the students worked on the Forensics module.

3. Fall Semester, 1998

a. Module 1, Introduction: Communication Tools and Protocols

It was thought to be critical that the students undertake the Introduction module to learn how to use the ICN and to practice communication skills. However, some minor modifications were made. Students at the *same* schools interviewed one another to exchange personal information. (During Phases I & II, students had been at different schools.) Using the ICN, they introduced their local partner to classmates in their own classroom and at distant sites. Over seven hundred pairs interacted among the schools. Teachers commented that this was a good way for them and for their students to get to know one another earlier in the term than they usually did. In addition, more different kinds of interesting information about students surfaced than usually did (sometimes during the entire school year). Further conversations ensued wherein peers asked one another to elaborate about unique aspects of their lives. More of these kinds of out-of-class exchanges were fostered by the initial ICN presentations (and the availability of e-mail follow-up) than had previously been observed by teachers. Students who might not have chatted in the past were sharing ideas and anecdotes. This set the tone for collaboration rather than competition in the classroom.

Students collaborated at their individual schools preparing reports on favorite elements or chemicals to present to local classmates. They were required to include at least three forms of media in their presentation. One group from each class was selected by their peers to report to distant classmates at three or four other schools via the ICN. A large number of students interacted in this way to exchange information. The creativity of student groups was apparent. More sophisticated uses of technology were evident during presentations. More students used presentation software packages such as PowerPoint than had in previous years and more students incorporated visual or videotaped portions in their presentations. As the ICEA Project evolved, students were clearly more comfortable with supporting technologies than the Phase I and Phase II students had appeared to be.

The experience of making these particular presentations stood out in the minds of many of the students when they recounted their ICEA experiences in focus groups at the end of the academic year. They recalled important facts about the chemical of interest that they might never have known without the favorite element/chemical presentation. They also became aware of how they could push themselves to higher levels of creativity to show distant peers what they were capable of achieving. Students always paid attention to the method of presentation used by distant peers. They might not have been able to repeat what was said, but they were aware of how it was said. A well-organized and technologically sophisticated presentation seemed to influence other students and motivated them to improve their presentations.

b. Module 2, Data Collection and Analysis (The Soda Pop Lab)

Module 2, Data Collection and Analysis, was implemented in the statewide analysis of the density of diet and regular soda pops, providing learners with an opportunity to utilize statistical methods of investigation. A new facet of the statistical analysis of a variety of brands of soda pop included the use of an Internet pilot data base that the teachers had developed. There, students could post their data about soda pop density and compare their results with distant classmates analyzing the same brand of soda pop. The URL for this database (now inactive) was

http://205.221.129.250/ICEA/density.htm.

Data was shared across the state. Different students in Phase III exchanged more messages containing information about Module 2 using this Internet database than they had in the past during Phases I and II via electronic mail.

4. ICEA Teacher Workshop, December 11-12, 1998

Participating teachers returned to Iowa State University at the end of the first semester to share their experiences. A round table exchange of sorts was held so that all participants could provide their impressions about student interactions during the fall semester. A spirited discussion ensued. Participants concluded that the two interactive modules on which students had worked first semester (Introduction: Communication Tools and Protocols and the Data Collection and Statistical Analysis) had provided them with beneficial real-world experiences. Students and teachers alike had found the modules to be introduced in a timely manner and that they had integrated smoothly into the existing curriculum.

In Module 1, sharing information about elements or chemicals provided students with exposure to information about substances they might never have had occasion to investigate. Students retained some facts from these reports for the entire academic year and frequently referred back to their element or chemical or to information shared by someone else. Teachers were convinced that students learned more about basic chemistry ideas earlier in the term as a result of this unit.

Because soda pop had become the beverage of choice for so many, students were easily able to relate to the real-world nature of the Module 2, Data Collection and Analysis. Use of the statewide database provided them with the opportunity to include a larger number of data points in their density analysis as well as to appreciate the fact that the more data collected in an experiment, the less the spurious data points stood out.

Focus groups were conducted with each of the three individual groups of teachers—Phases I, II, and III. All of the teachers in the smaller focus groups separately reconfirmed earlier statements that had been made in the large group exchange. Students had liked the first two modules they had used during the months of September, October, and November, and had missed using the ICN and interacting with distant peers during the month of December. Teachers expressed a worry about a potential loss of student momentum and motivation during the six week period of ICN "down time" including the December 1998 - January 1999 holidays, first semester final exams, and semester break. Teachers suggested that, in the future, a third module could probably be implemented in late November and early December. Module 3, Chemical Separations, was suggested as timely for curriculum coordination at that point in the semester.

As observed above, teachers noted that the ICEA extracurricular modular materials integrated smoothly with the existing high school chemistry curriculum. Students found the authentic experiences offered by ICEA exercises to make chemistry more a part of the real world for them.

One very important aspect of the ICEA Project was parental involvement and support. Parents respected the ICN component of the curriculum as a viable alternative approach to collaborative interaction in their children's education. During parent-teacher conferences, they reported their support and enthusiasm for the opportunities for personal growth and social development offered by the ICN Project and its related activities. They confided to the teachers that they would have liked to have had the same opportunities and experiences when they took chemistry. The teachers agreed that they, too, would have welcomed the same experience.

As had been seen in Phases I and II, the every other week ICN "staff meeting" was still critical to successful communication among ICEA teachers during Phase III. Although the novice Phase III teachers had worked through the module activities during the summer workshop before classes began, when the time approached to experience the activities in a laboratory situation with their own students, the teachers had many questions about logistics, procedures, anticipated difficulties, etc. The ICEA Phase III mentoring hierarchy was designed to make this process as smooth as possible. It was extremely successful.

During the December on-site meeting, teachers worked through each of the two remaining modules scheduled for the second semester: Instrumentation/Spectrophotometric Analysis (actually Module 5 by number), and Forensics (Module 4), in order to anticipate the difficulties they and their students might later encounter at home in their own laboratory environments. In addition, while the Phase III teachers worked through the two upcoming experimental modules, Phase I and II teachers prepared the massive amounts of materials needed to assemble the evidence kits for the Forensics module in assembly-line fashion. Teachers were able to prepare their kits (a two hour endeavor) and take them back to their schools when they left Iowa State University. At the same time, because not all high schools have the same kinds of analytical equipment, instructors arranged to share instrumentation for the copper coin analysis exercise in the third module of the year (Module 5).

Teachers again noted how important the opportunity was for them to interact in person with one another and with Project personnel. The ICN is a phenomenal communication tool, but there is nothing equivalent to being able to meet face-to-face, exchanging eye contact, and reading facial expressions and body language in a way the ICN does not allow. Neither was there a time restriction in the interactions as there would be with an ICN session.

5. Modules used in Spring Semester, Phase III

a. Module 5, Chemical Instrumentation —Spectrophotometry (Copper Penny Lab)

Module 5 enabled students to employ instruments with a range of sophistication in order to seek the solution to a question about chemical analysis. As was true in Phase II, to undertake the Chemical Instrumentation—Spectrophotometry module, teachers coordinated an equipment interchange so that all of the schools would be able to operate with at least two of the three types of instruments needed to perform spectroscopic analysis and pool their data. All teachers had made arrangements with colleagues to borrow or share needed equipment. Teachers involved in this equipment exchange converged on Des Moines one Saturday morning in the early spring. Those with extra equipment brought it to share with those needing to borrow equipment. In this way, all schools were adequately prepared and were able to participate in the statewide spectroscopy data exchange.

During the early part of February, all ICEA students determined the Cu content of a post-1982 U.S. penny. Several select classes performed the same experiment on a newly-minted Canadian penny. Student ICN sessions about the "penny lab" began in the last week of February and the first week in March. Groups shared their lab results as well as discussed with distant classmates the results of their Internet searches for information about minting formulations for U.S. and Canadian pennies.

This module was expanded. Teachers and students used a new web site (similar to the web site data base used during Module 2) that was specifically designed to be integrated with this instrumentation and spectroscopy module. Development work was supported by a grant from U.S. West (described in the previous chapter). The URL for this site (now inactive) was:

http://hydrogen.chem.iastate.edu/www/pennies/homepage.html

This site included an introduction to color, the electromagnetic spectrum, a discussion of color absorption, colorimetry, coin composition, a section of teacher notes, and a glossary of terms about spectroscopy. Students were able to keep records of their spectrophotometric results in order to compile and compare data. Via the database, they could access *all* data generated by distant classmates.

In addition to laboratory work, students initiated an extensive Internet search to learn about coins, minting, etc. As a result of discovering a discrepancy in their own results for the percentage of copper in newly-minted Canadian pennies compared to the value reported by the Canadian Mint, students pursued an interesting discussion among several sites in Iowa with analysts at the Canadian mint. Teachers, satisfied with the consistency and reliability of their students' results, actually repeated the experiments themselves to determine where the error might be. They confirmed the results their students had obtained. Unless there was some element that was interfering with the chemical reactions used to dissolve the penny and prepare it for spectroscopic analysis, ICEA teams revealed a disparity between the experimental value of the percentage copper in a Canadian penny and that reported by officials at the Canadian Mint. Canadian officials speculated that what had been thought to be a pure zinc base core must actually be a zinc alloy doped with a minimal amount of copper. Students learned the value and validity of research in action.

Student ICN presentations about the per cent copper in a post-1982 U.S. penny were more sophisticated during Phase III because of the database that had been created and used. The database served as a useful tool for data collection and reference. After spring breaks at all of the participating high schools, teachers met via the ICN to reflect back positively and enthusiastically about learning activities for the third module and to make final arrangements for guest speakers for the Forensics unit.

b. Module 4, Forensics

Planning had been begun for the Forensics module while students and teachers worked on the "penny lab". Guest speakers for the Forensics unit (who would join the students via the ICN), needed to be invited early in the semester to allow them to arrange their work schedules appropriately. The teachers discussed the timing of how long each speaker would spend interacting with local and distant learners during the ICN sessions. All "evidence" kits had been distributed to teachers attending the December ICEA workshop. Discussions were held to familiarize Phase III teachers with the most efficient and intriguing means of setting up the Forensics module.

The exercise posed a novel problem that required forensic evaluation of a crime scene to determine culpability of a suspect. At the outset, the companion videotape "Tour of the Iowa Division of Criminal Investigation Criminalistics Laboratory" was again used as an introduction to the topic. The video set the scene to provide students with an idea of how experts conduct a professional forensics investigation. Especially stressed was the importance of the chain of evidence preservation and evaluation. Students were required to use this same approach in their classroom analysis of evidence. When their final arguments for the alleged guilt of a suspect were presented before the seated "judge", they needed to be ready to trace the chain of evidence from beginning to end so that it was clear that no tampering with the evidence could have occurred. If there was verification that the evidence was not accounted for at all times, the students' argument for potential guilt was thrown out by the officiating "judge".

Each of the teachers invited one or more guest speakers to participate in an ICN information-sharing interview session. Students prepared questions in advance and teachers arranged a round-table order of questioning. Judges, attorneys, police detectives, a state patrol officer, a police criminalistics photographer, a medical examiner, a fingerprint expert, high school liaison police officers, and a county sheriff shared a wide variety of tales in response to student queries. Students appreciated the guest sessions more than any of the other ICN sessions during the Project. Many aspects of forensic science were explained. They found the respect afforded them by their guest speakers and their guests' supportive willingness to answer any question asked by students, to be a novel and fun experience. They were so enthusiastic that as each session progressed, more and more spontaneous student questions evolved and the prepared questions could be abandoned. Guests were impressed enough with student interaction that some paid the classes a return visit in person, not via the ICN, to help with further forensic analysis. Other guests *asked* to be invited back to interact with students if the same activity was to be repeated in the next academic year.

In analyzing evidence collected at a "crime scene", students compared these analyses to evidence provided to them that had purportedly been collected for eight "suspects". These comparisons and resulting conclusions lead to a plethora of exchanged e-mail messages. Student groups around the state exchanged information, challenged evidence, and argued probable incrimination. In no other module and in no other phase of this Project had so many electronic mail messages been exchanged among student groups nor had so many collaborative "discussions" taken place. Student assessment of the evidence was competent and conclusive. An impartial reader was able to ascertain the identity of the "guilty party" by simple perusal of the electronic mail "evidence" claims because the "discussions" and "arguments" were so thorough.

In the past, the Forensics module had been the favorite of students and teachers alike. All participants (including the guest speakers themselves) learned interesting aspects of forensics and criminology during this unit. The Forensics module was overwhelmingly the students' favorite Phase III activity, as evidenced by student focus group interviews and student survey instruments administered at the end of the Spring Semester. Instructors believed that the module best reflected the goals and objectives of the ICEA philosophy—

helping students to become independent collaborators, accountable for their own learning. No other exercises generated more enthusiasm and interactivity. The module was so popular that several local newspapers carried human interest pieces featuring the story. In addition, a feature highlighting the ICEA Forensics Module and Dr. Gary Downs was carried in ***Inside Iowa State***, an Iowa State University publication (Brown, 1999).

The teachers planned that if funding would become available to renew the ICEA for Phase IV, they agreed to use the same four modules again, encouraging input from an as yet to be named new cadre of teachers and their students.

D. Phase III Dissemination

1. Tentative Dissemination Efforts, Spring 1999

Dr. Downs and Kathy Burke made an overview presentation about Phase III of the ICEA at the Iowa Academy of Science (IAS) meeting in Ames in April, 1999. Three ICEA Phase III teachers participated in the presentation and discussion. As is typical with presentations at the IAS meetings, session attendance was somewhat limited due to conflicts with other parallel sessions. But audience members in attendance seemed genuinely interested. Inquiries about possible participation in the ICEA Project were often generated from these kinds of sessions.

2. ICEA ICN Informational Meeting

On May 20, 1999, an ICN informational session about the ICEA Project past, present, and future was broadcast to interested viewers. In order to reach a wide spectrum of Iowa high school teachers, there were twelve ICN receive sites, located all around the state. There were participants from twenty-five different schools statewide. The session was intended to provide Iowa high school chemistry teachers who might be interested in learning more about the Project, the opportunity to ask questions directly of those teachers actually participating in the ICEA. Teachers from the various ICEA subgroups provided an overview of activities and confirmed their satisfaction with the program. Four teachers at distant sites contacted the ICEA office to indicate their interest in participating in the ICEA Project during Phase IV. Respondents to the ICEA Modules Survey (described later in this chapter) also had the opportunity to indicate their interest in learning more about the Project by asking questions directly of those actually experiencing it.

3. June 5, 1999

The ICEA Summer 1999 Teacher Conference was held at ISU on June 5, 1999. Participants conducted a debriefing session for the second semester ICEA activities, discussing the third and fourth modules, the Spring 1999 ICEA ICN statewide conference, the Spring 1999 Iowa Academy of Science presentation, and the Iowa Distance Learning Association meeting. Focus group interviews for Phase I, II, and III teachers provided ICEA personnel with indication of the satisfaction and success participants judged the Phase III session to have had. Teachers assembled in small groups to discuss strategies for introducing more aspects of interactivity to each of the four modules.

4. ICEA Brochure

Iowa State University ICEA Project personnel worked with ISU support staff to design an ICEA brochure. Several action photos highlighted a global summary statement and listing of Project modules. The product was an attractive concise but informative tri-fold full color glossy brochure that could be distributed at conferences, workshops, etc., and to high school administrators to explain the Project.

E. Unique Aspects of Phase III

1. The ICEA on Display

The ICEA Project became known as an exemplary collaborative statewide effort. As such, whenever there was a need for highlighting a successful College of Education endeavor, Project personnel were invited to participate.

a. Jischke broadcast

One example of showcasing the ICEA Project was Iowa State University President Martin Jischke's annual College of Education visit on March 11, 1999. In addition to a brief PowerPoint presentation by Project personnel at Iowa State University, an interactive ICN session between Dr. Jischke at the Iowa State University site and students and their teachers at several distant sites was arranged. Dr. Jischke asked questions of the distant students for about 15 minutes. Their enthusiasm and excitement about participation in the ICEA Project were tangible. Dr. Jischke's own daughter participated in the Project as a student at Ames High School.

b. Gmelch presentation

As part of a college-wide information dissemination, a presentation about the ICEA was given to Iowa State University's incoming Dean of the College of Education, Dr. Walt Gmelch. He was unaware of the dual nature of the Project (benefiting both students and their teachers). He appreciated the advantages to Iowa high school chemistry teachers (networking and technology implementation) as well as the value to their students (hands-on real-world application problems, improved communication skills, and technology implementation).

2. Iowa Public Television ICEA Modules Survey

In June, 1998, a promotional announcement (flier) from Iowa Public Television, IP-TV, had been sent to all high school chemistry teachers in Iowa to make them aware that the supplemental curricular materials (the notebook containing the eight modules and the three supporting videotapes) for the Iowa Chemistry Education Alliance Project had been reproduced and were available to any teacher who would be interested in procuring an examination copy. Roughly only 20% of the nearly 450 teachers contacted actually replied to request their own copies of the ICEA materials. It was speculated that the IP-TV offer had arrived during the summer break and that some teachers probably either never received the offer or threw the flier out without actually reading it as they cleared their mailboxes of all of the "junk" mail that had accumulated over the summertime. The teachers could place a request for the materials by returning an order form or calling personnel at Iowa Public Television. In September 1998, examination copies of the ICEA module package (the module notebook and three supporting videotapes) were mailed to nearly one hundred Iowa high school chemistry teachers who had requested them from Iowa Public Television.

In order to determine how these teachers evaluated the materials they had received, a survey was developed and sent to each person (see Appendix J). Respondents were asked what portion of the ICEA supplemental materials they had reviewed, how they had perceived their usefulness, whether they had incorporated any of the materials into their current class curriculum, and whether they would be interested in participating in Phase IV of the ICEA Project.

Information from the returned surveys was compiled and the results were analyzed for a report to Iowa Department of Education and Iowa Public Television personnel. Many of those teachers who replied indicated that they had not yet had and would not have time to evaluate the materials until the next summer (once the current academic year had started, they were and would continue to be too busy to examine the materials until the academic year was completed). A small percentage (less than fifteen of the teachers contacted) had reviewed segments of the package that seemed most enticing to them. They found the material to be interesting and thought that they would incorporate some portion into their traditional class work as the opportunity presented itself. A small number of these teachers asked to be contacted with further information about participation in Phase IV when the opportunity became available.

F. ICEA Participants Phase IV

Phase III ICEA participants were polled to determine how many wished to participate in ICEA Phase IV and when during the summer they would be available to meet with each other. All except one were interested in participation in Phase IV (That particular teacher did not have a chemistry teaching assignment for the 1999-2000 academic year. HE would be teaching physics instead.) Scheduling a meeting time in the summer was problematic because many of the participants had already made plans for summer. The group agreed to gather to meet face-to-face on August 20-21, 1999 at Lagomarcino Hall at ISU for Phase IV ICN scheduling and teacher review of and training for the four ICEA chemistry modules that would be shared with the students.

G. ICEA Web Page

During Phase III, an ICEA web page was designed and activated. The URL was

www.educ.iastate.edu/ci/treg/ICEA/homepage11.html

The page provided a history of the Project, a pictorial directory of Project personnel and teachers, journal article references about the Project, and a description of the eight ICEA modules. The home page served as a useful reference for those wanting to learn a little more information about the ICEA Project than the ICEA brochure was able to share.

H. Teacher Focus Groups

1. Focus Group Strategy

Focus groups were conducted separately with each group of teachers Phase I, II, and III in order to determine what their individual perceptions were of the 1998-1999 ICEA Project. Impressions of the teachers that had emerged during the December 1998 focus group sessions reconfirmed the express need for and value of the preliminary interactive, collaborative learning experiences. Focus group interviews were conducted following Phase III to determine final Phase III teacher impressions.

2. June 1999 Focus Group

a. Analysis

Analysis of June 1999 focus group information reiterated the necessity for interaction among all of the novice and experienced teachers prior to the beginning of Phase IV. Participants also saw the need to have an extended period of time set aside for the teachers to be able to work with one another on their teaching schedules in order to plan the most efficient use of ICN time. Grouping of teachers and schools that utilize block scheduling, for example, was critical to the success of those particular students' involvement in the Project. Finally, small subset groups of teachers should collaborate to modify the existing modules.

Other topics discussed during this meeting are summarized below. This was, perhaps, among the most informative of all of the focus group sessions conducted across the history of the Project and is analyzed in depth. Teachers conveyed their opinion that Phase III had achieved the ideal of the ICEA mission—to provide Iowa high school chemistry students and their teachers with supplemental hands-on activities with which to network, collaborate, and share results via the Iowa Communications Network, the Internet, electronic mail, FAX, and CUSeeMe. This was also the opinion of ICEA Project personnel.

Teachers shared thoughts about what had gone well during Phase III. Anonymous teacher comments are italicized. Detailed comments contribute to a valuable overview of the ICEA Project in its entirety, from outset to recommendations for what should follow.

1) **Pace.** The comfortable pace of using four modules over an entire academic year efficiently complemented the existing chemistry curricula statewide. The teachers going through the modules for the third time had the best perspective and could smoothly incorporate them into the curriculum. Opinion was 100% favorable that integrating the materials at the rate of two modules per semester provided a better "fit" and made the experience more meaningful to the students.

2) **More ICN work.** Students had requested more ICN work and wanted more opportunities for interaction. Teachers were still challenged by how to accomplish this. What was the most efficient and effective use of ICN time that would still allow students the opportunity to interact? How could more of the modules generate the same motivation and excited enthusiasm seen in the Forensics exercises?

3) Teacher networking. The collegiality, professional development, and networking provided by the ICEA Project were a tremendous benefit to all of the teachers—communication was the key. There was communication on a regular basis that allowed the teachers to realize that their problems were the same as those of colleagues statewide.

There was also the realization that the more experienced teachers had a great deal to share with their newer counterparts. There was mutual respect among the group members—novices for the more seasoned teachers, but also experienced teachers for the enthusiasm of the younger group. The Phase I teachers realized that they were not too old to learn; for them the younger teachers helped to reinstill some of the excitement and wonder of their earlier years.

For some teachers, the support of ICEA colleagues buoyed them in the face of negativity among local faculty peers who did not want to infuse technology into their curriculum.

An even more dramatic attestation to the value of collegial interaction was the observation of a biology teacher turned chemistry teacher. (The following quotation and all of the quotations cited in the ensuing sections of this chapter were made by unidentified focus group participants and are noted in italics. There will not be an individual citation made for each one.)

"I am one of those biology people who "fell into" teaching chemistry. I teach chemistry full time now. For me, to have the professional relationship with people who have more knowledge than I do or know those demonstrations that I certainly would not have, ...is phenomenal. I would have never felt comfortable. I am teaching AP chemistry next year. I barely have a minor in chemistry but I have learned so much from teaching it (the ICEA curriculum) and (from) other people that I am not as scared of it. So it has helped me to professionally grow in that area. Because I know that I've got people I can call at ten o'clock at night and go oh, my, help me!"

There was a large aspect of professional development.

"Just getting to talk to different teachers and doing things that you never would have learned yourself was important."

"If I want my kids to get better, then I play the best competition as a coach. And then they make a decision, do you get better or do you stay where you are? As a teacher you have to do the same thing ."

"When you try something that is innovative and new, you isolate yourself further. There is a lot of jealousy in this profession, lots of jealousy."

Even with the full support of ICEA peers available, teachers recommended that a first-year teacher should not be invited to participate in the ICEA Project. The stress of adjusting to teaching the subject is problematic enough without a) the need to adjust to the pressures and demands of an interactive distance education Project and b) modifying an existing curriculum.

"In our group we had a first year teacher who had no experience with the Project...it really put him at a disadvantage when he was just trying to figure out what was what...let alone be responsible to three other instructors and have his classroom responsible to three other classrooms."

4) National Science Education Standards. The ICEA "process" met the goals of the National Science Education Standards (1996). Teachers saw this clearly.

"I cannot think of a single school district initiative that this Project cannot cover. Cooperative learning, technology, dimensions of learning, I do not care what book you are talking about, this Project can be infused into it and because of that I think that is part of its power."

"It is connected to the National Standards."

"If the state is going to tell us Benchmarks (Benchmarks for Science Literacy, 1993) *and assessments, then here it is."*

"Alternative assessments. That is the power of this is because it encompasses education..."

"The students need portfolios of things that we have done and we have them all on video tapes—it is right there for them."

5) Teacher as guide. Teachers gradually evolved into facilitators rather than lecturers. The ICEA Project made teachers more aware of their craft.

"I was better at what I did because this whole Project forced me to be. I did things that I know that I would never have done without this Project and I had the resources to do it."

Students took the responsibility for their work, making the teacher more of a facilitator.

"I am somewhat of a control freak anyway. It made me take a step back and let them have control, it forced me...I can actually move around the room and really look at what is happening, as opposed to running to get this and running to get that."

Teachers moved away from the traditional teacher-centered classroom model.

"It lets leadership roles develop for the students."

"Whatever makes it better is going to, in the end, impact learning and impact kids. So everybody is winning."

6) Teacher as mentor. The mentoring process was labor-intensive and challenging but rewarding for all parties. The ICEA Project gave teachers a natural opportunity to network and what they themselves called a "community of professionals free". Via their electronic mail networking, any ICEA teacher could consult with any other(s) to discuss the Project, general teaching strategies, teaching demonstrations, student issues or concerns, administration challenges, etc.

During Phase III, teachers felt that their role as mentor was different from that of the four Phase I teachers the previous year. The Phase II teachers had had no experience with the modules. They had approached the Project in a "take-one-day-at-a-time" manner. Because during their training workshops, the Phase III teachers were able to work through the same labs that their students would do in the upcoming semester, they had a definite advantage that Phase I and Phase II teachers had not had. From the outset, they knew minimally what to expect. They were glad for the opportunity to anticipate problems they might encounter prior to their actual experience with the laboratory exercises. Having the resource network of experienced teachers was a bonus.

The mentoring process was successful.

"I felt that the confidence level was pretty high and so I was asking them questions that I wanted to know over the years."

"Nothing we asked or discussed ever felt like it was a stupid question. And, I can remember trying to trouble-shoot a lot of things and they never treated them like they were silly questions. They always addressed them and we always worked through them and things just ran beautifully.

7) Students' use of technology. Students learned to utilize cutting-edge technologies.

Local businesses (for example, Pioneer Seed) use ICN technology to communicate internationally. Students saw that they could do the same. One teacher reported *"...it has made a worthwhile connection to the community and made me more aware that I need to connect more to what is going on with our community people."*

Another teacher observed, *"We find ourselves infusing the technology in the ICN room into our classrooms, using the multimedia, using the overhead cameras, using the computer technology, and Web page and all those kinds of things as a daily tool."* To this, a colleague responded, *"The kids infuse it themselves. It is an expectation that they are going to have to do something like that. They are so used to the PowerPoint that I don't even have to bring it up. They just want to make sure that is okay to go on their own."*

The students recognized the development and evolution of their own comfort level, familiarity, and ease of operation of the technology as the year progressed.

8) Students' metacognitive skills. Students developed better metacognitive skills. They thought more about their own learning and thinking in order to prepare to share information with classmates, both local and distant. They also realized that to prepare to share information about a particular topic, a person needed to understand it all herself in order to explain it to others. This led students to prepare more thoroughly and to have a better appreciation of what their teacher did daily.

9) Teacher technology leaders. Teachers became technology "leaders" among their peers. Some ICEA teachers became the ICN room "expert" at their school.

The ICEA Project also made the school districts more aware of technologies that were available for use in the classroom. The ICEA teachers gained a reputation for knowing how to use the ICN room and its equipment. The use of technology by chemistry teachers infused into other disciplines. One teacher reported that her activities lead the English teacher and the speech teacher to try using the ICN.

"My peers see what I am doing. I have been asked to do in-service workshops on how to operate the ICN room and some of the teachers in the district are now doing things that I do. If I am going to be gone, I go into the ICN room and videotape myself in the ICN room and then have the sub play that video tape with the things that I want to be sure to get covered."

"Peers are using a little more technology...in the math department and one of the literature classes. The psychology class is doing quite a bit with it."

There is a certain implied pressure on colleagues. *"Biology teachers are starting to feel pressure to keep up now that our department chair who teaches biology has mentioned over and over 'I need to take PowerPoint and I need to get my notes on the Web and I need to start using ICN'."*

"The superintendent used to be my principal and now he is superintendent of the district. So, when he sticks his head in and sees what I am doing and then I go and request something, he knows that what I am requesting is going to be used. It is not going to be sitting on a shelf protected from students."

10) Increased enrollment. There was an observed increase in the number of students enrolling in chemistry so that they could be a part of the ICEA Project.

"I went from six periods of roughly twenty-five students in a class to next year when I have ten periods of thirty students in a class! I think that part of it is that the word has spread about this ICEA Project..."

"My kids from years past really came up and said that they didn't get to do that ICEA stuff the year after. They were hurt."

11) Student accountability. Students learned accountability and took pride in their work.

"They had the idea that what they were doing was significant because they had to present it in front of other people—kind of like the music teachers had known all along that if they had to present in front of the public they would practice a little more."

12) Student receptivity. Students were receptive to trying something new.

"It gave students who were more doers and talkers a chance to excel and enjoy chemistry rather than the ones who normally seem to excel at it (the more paper-oriented ones)."

13) Expanded scope. The new teachers expanded the scope and talent pool of the Project. Experienced teachers welcomed the fresh outlook of the novices on the Project as well as the curriculum and the discipline.

"I learned while I mentored. It was a win-win arrangement."

14) Scheduling. Scheduling was a very important part of making the Project work. Scheduling was the single worst problem. Sometimes students were unable to present their reports due to time constraints.

"When you only have 20 minutes, you could have five minutes of set-up time..."

Scheduling was problematic from the outset. Special problems included snow days, unexpectedly-scheduled all-school assemblies, and, sadly, funerals for schoolmates. Also frustrating was being told the nearest ICN room had been previously reserved for some other district activity, therefore, could not be scheduled for ICEA use. Yet, when the time came, it remained empty during the desired period that it could have been used for the Project.

Some of these problems would be solved by better access to scheduling through CISCO, the on-line ICN scheduling service that was used during Phase IV.

15) Statistics in high school chemistry. More concepts about statistics were explained and used in the high school chemistry curriculum than before the ICEA Project. During Phase III, this impacted over 1500 students.

16) More teacher interchange. There was more interchange (via the ICN, electronic mail, telephone, FAX, or face-to-face) among the teachers in the Des Moines metropolitan area, whether through the ICEA Project or in other professional matters.

17) Electronic mail communication. Electronic mail communication became second nature to teachers and students. Electronic mail messages were more easily exchanged than telephone calls.

18) The ICEA brochure. The ICEA brochure was an attractive and informative document that could be easily distributed to anyone interested in learning more about the ICEA Project. It was taken to every conference at which an ICEA presentation was made.

19) Flexible module implementation. The modules were good, but could be considered too prescriptive. The teachers realized there was a certain amount of flexibility that could be introduced by discussing among themselves what strategies they thought would best benefit their curriculum, campus, and students.

20) Correct ICN communication protocol. There was concern with correct communication protocol over the ICN. Classes discussed what was appropriate behavior and appropriate language for the ICN. Concern with appropriate communication over the ICN lead to an increased awareness of the general importance of communication in all aspects of daily life.

It was noted by several teachers that a good thing about the ICEA Project was that classes got to talk about *everything* impacting the Project, not just the science aspects. The use of the ICN fostered the ability to communicate for the students who participated. Not only were communication skills honed, students communicated about a topic they would not necessarily have chosen to discuss if the presentation was a speech they were delivering as a graded assignment. Use of the ICN promoted more discussion of all types in the classroom than had been observed in the past.

Students also learned the social art of interaction. They learned to network with other students across the state.

Teachers requested an ICN policy statement to use with all of their students. They agreed to reflect on some ideas about communications protocol and draft their thoughts prior to the Fall ICEA teacher meeting preceding Phase IV.

21) Cross-curricular work. In one school, students did a forensics lab in biology class as well as in chemistry class. The biology teachers felt territorial about their unit. The chemistry teacher reminded them that *"this is a perfect illustration of how you can do the same thing for different goals within what you are doing...it shows students how everything (both chemistry and biology) is interrelated..."*

More cross-curricular work was reported at another school. There, the mathematics teacher used the data collected in the density of soda pop experiment to demonstrate statistical principles. In addition, the computer applications used by the students for making reports tied into their computer science experiences. *"It is just making the whole school interactive with each other instead of...being isolated classrooms and subjects."* What is done in chemistry can be applied in mathematics, biology, computer class, physics, and chemistry, and vice versa.

22) Teacher coping. Teachers learned to be more tolerant of "glitches", whether it be equipment malfunction, scheduling, a snow day, etc. They found themselves developing new coping skills, more patience, or both.

23) Resources. There were, in some instances, radical disparities in resources. One teacher had no electronic mail service and a crudely equipped ICN room (one camera that could not be moved, one lapel microphone, and constant technical problems). Other schools had state of the art newly furnished ICN classrooms. As a team, students and teachers worked around problems in the excitement of participating.

24) Value of ICN interactions. ICN interactions provided a glimpse at the Iowa classroom in its may varied formats. Teachers were convinced the ICEA Project was worthy of their time and interest. Because of this, they worked with whatever ICN facilities were available to them Two urban high school teachers had little more than the bare minimum of ICN equipment to use when they began working with the Project. The facilities in one room were so primitive that students had to make presentations using poster boards, held up in front of the single stationary camera in the room That teacher was highly enthusiastic about the student benefits of the ICEA Project. She was able to negotiate an entire refurbishing of the school's ICN room. It was gutted and the newest state-of-the-art equipment was installed. This was all a result of student and parent enthusiasm over the ICEA Project, increased enrollment in chemistry classes, and improved student retention.

25) Future interactions among ICEA students. *"What we have not considered are future interactions among students who have participated in the ICEA Project as they move into college chemistry courses. Perhaps the shared past experience of ICEA participation may encourage collaborative study sessions at the college level."*

26) Real-world applications. The module activities provided students with real-world applications of chemistry. Students had to adjust to working to solve real-life chemistry problems when they were used to "cookbook" verification laboratory procedures from past science classes.

"They are just not used to the real world, because we have it so nicely organized for them. They are used to the cookbook-type world, where they have a lab and it tells you to do this, this, and this, when you are done, the bell is going to ring and then you are at the end of the period. But with a lot of our ICEA labs, you don't get done at the end of the periods and you have to save your stuff for the next day or conduct and e-mail "conversation", etc.

27) Impetus for change. *"You can apply so many different things (concepts) in one unit and that also is a good motivation for change for some of the other teachers that don't want to change or they don't want to try new things."*

"We, as teachers, need to be moved off center now and then. And when that happens, then we get an education. And, you get fired up a little bit and you are ready to come back and try something a little different. When you see someone else making a presentation and you know what the potentials are, it puts a little pressure on you to get on your kids and they will do better. Everyone benefits and that is what education is all about."

"The best and better become more isolated from the mediocrity that is out there and that is what happens. I think that it is natural."

"The Project puts the student in a little bit of a different perspective in terms of what they can and cannot do. The kids liked the idea of seeing other presentations and both aspects, saying that we could have worked a little bit harder or we were far better than they were."

28) Teacher communication. Communication among teachers was imperative for the smooth operation of the process from the point of view of in-class work and of the ICN sharing sessions. Otherwise, teachers felt disorganized or out of control.

"Sometimes I felt we went into our ICN session not knowing who was going to go first and what we were going to do when we were presenting and there was a lot of lag time..."

"Our peer mentor did a super job in organizing and setting up the time. Super and it was neat that we had that exchange going on, because I never felt too much out in the dark."

29) Teacher-student relationship. A new relationship was forged between teachers and students.

"I felt a little closer to some of my students in the sense that they felt a little closer to their teacher. Because they didn't see it as us versus them, which they didn't necessarily anyway, but there was a bond there that you were working toward a goal together."

b. Teacher suggestions.

The teachers offered some suggestions for the future:

1) Split Module One. Split Module One to do the second part of it, the Favorite Chemical, during the November-December time frame when there is a natural "gap" in ICN activity. This would require no more funding to be allocated for ICN time because it would be just shifted from the beginning to towards the end of the Fall term in November/December.

"It just helps build a little longer continuity and I think that the activity would be even more effective after they have had just a little more chemistry."

"Involve student school-school interaction a little more at that time. If I had a student doing argon and one of your kids is doing argon and one of yours is, too, then we should let them know who is assigned that element so that they can interact with each other, share some resources, some ideas and ways that they are going to create their visuals, etc. I guess we could encourage that because you have a longer block of time—there is a month or so, for kids to lead up to their ICN presentation."

2) Increase student interdependence. Re-design the lab exercises similar to the forensics modules so that every group is doing some different part of the lab and they have to communicate it to others to put it all together in order to increase active involvement among all students during ICN presentations. This would increase positive interdependence.

3) Tasks for the Fall 1999 ICEA Teacher Meeting:

a) Schedule ICN meeting times, paying special attention to "block" scheduling.

b) Rewrite/modify Modules 1, 2, 4, and 5 for more interactivity and positive interdependence among students at different sites. Get rid of repetitive numbers-based presentations (boring for students *and* teachers).

c) Outline strategies for more seamlessly integrating Modules 1 and 2 into the traditional high school chemistry curriculum for Fall 1999.

d) Provide training (collaborative learning, use of the ICN, advice about how to best facilitate the learning modules) for incoming Phase IV teachers.

4) Refocus the laboratory exercises. Refocus the laboratory exercises to introduce different variations on the exercises so that not all groups would repeatedly share the same information—create some kind of interdependence so that the students would want to pay attention to presentations by distant classmates. Make it more interactive.

5) Be certain to tailor the Project to fit the local curriculum. Adapt the scheduling of ICEA Project modules and related activities to correlate with the local curriculum as much as possible.

6) Final project. Make the students' final project be presented to someone other than to the teacher—this makes them more accountable.

"They took a little bit more effort in their work when they knew that someone else was going to be looking at their work other than just me..."

I. Student Focus Group and Survey Input

1. Survey Opinions about the Use of the ICN. Student input on the use of the ICN revealed attitudes similar to those seen in the past. Students felt the use of the ICN was an important component of their chemistry class. They thought that the ICN sessions were interesting, sometimes more so than their regular class. They felt comfortable with the ICN technology and actively participated during class sessions. Their comfort level in the ICN room and during presentations was equivalent to that during their regular class. They believed that the ICN expanded their learning opportunities, they valued interactions with guest speakers (local and via the ICN), and viewed the ICN as a collaborative tool. They wanted more opportunities to use the ICN for interaction with distant peers, and strongly supported the use of the ICN as a component of future chemistry classes.

2. Student Focus Group Input. The analysis of student focus groups provided strong evidence of the students' appreciation for the Forensics Module. They especially enjoyed the collaboration—having to work together in order to solve the crime. They also appreciated the input of the guest speakers who were able to validate the real-life applications of forensics.

Students acknowledged the tremendous opportunity to collaborate with distant classmates. Overall, it was intriguing to communicate with other students from different schools with whom they might not have had the opportunity to interact at any other time. They enjoyed seeing new faces and getting to share results with people other than their own classmates. The idea that they could actually talk with and present their ideas to people in a different part of the state was another element of what motivated them.

The students welcomed the opportunity to be able to compare and share results. They registered their wish for more interactivity among sites, as well as a desire for additional opportunities to use the ICN system.

Working on the ICEA modules in the classroom and in the laboratory presented students with a different environment, a different atmosphere. They valued the fact that they could get away from the "normal" chemistry class routine and do different things with different schools and students.

Along with this different atmosphere was the use of technology. The new equipment made the learning process more interesting. Students seemed to understand that they were going to need to be familiar with using technology for their future careers and recognized that this project allowed them the chance to become familiar with it.

Students had further suggestions for modifications. These included:

a. Students wanted to talk one-on-one with distant peers.

Many felt as though they had never really gotten to know the students from the other schools. They wanted more time to just communicate over the ICN with each other to get to know one another better. They were not aware of the cost per hour of ICN time.

b. Spending more time "on the ICN".

Student comments were divided as to what this actually meant. Some meant they wanted to do more projects. They wanted to be in the ICN room more than they were. These comments meant spending more days in the ICN room doing other things or exploring more than what was already being done.

Another issue with time on the ICN was that there was not enough time for all the presentations or to accomplish everything else. These comments were usually based on wanting to organize longer sessions using the ICN instead of just short time periods so that all students had time to present and so that there was always an "audience" at one or more remote sites.

c. Accommodate all participating school bell schedules.

Students believed that it was important to organize ICN sessions to best accommodate all participating school bell schedules so that students did not arrive or leave in the middle of peers' presentations.

Students were especially disturbed by this when their ICN presentations ended up being broadcast to empty distant classrooms. They could see no point in on-air time broadcast to no distant colleagues. Essentially, they were presenting to their own peers, which did NOT require the use of the ICN room/equipment. Why pay for a session not attended by distant classmates?

d. Redesign collaborative activities.

Students favored designing collaborative activities in such a way that presentations were not repetitive but actually provided new and interesting information.

If every school did the same presentations, this caused many of the students to see the Project as dull or boring. Since the presentations were over something that everyone had already done, the students did not feel that they were learning new information. They wanted to work on different aspects of a study, then get together over the ICN to share their portion. They wanted more activities like the Forensics Unit, that were built upon different schools holding different pieces of the puzzle and only completing the picture when they shared information via the ICN.

e. Improve basic equipment.

Procuring funding to improve equipment at those schools that lack the basic technology was necessary in order for the students there to participate at the same level as other schools (so that students at one school would not feel inferior to those at another school).

J. Phase III Observations

Phase III had "worked". All of what had been learned in Phases I and II had been used to design Phase III strategies and had been recognized as critical to ICEA Project success. Teacher training and mentoring for novice participants had been recommended, designed, and implemented for the Phase III teachers. It was quite useful to the group that during training, novice teachers (guided by Phase II mentors) should run through the laboratory exercises in the modules to be later implemented in their own classrooms. BOTH Phase II and Phase III teachers benefited and learned from the practice. With a larger number of students at more schools, there was more probability that different school bell schedules would match, and therefore, more student groups could meet via the ICN at any given time. The timing of module implementation during Phase III suited the needs of the local curricula. Students and teachers alike were comfortable with the pace of implementing two modules per semester.

Module collaboration was smooth. The integration of the use of Internet databases for the density of soda pop and the spectrophotometric analysis of the copper penny improved these investigations.

Teachers anticipated repeating their successes from Phase III during Phase IV by inviting another group of novice teachers to be mentored and trained to facilitate the ICEA Project for a new group of high school chemistry students across the state of Iowa.

VII. CHAPTER 7. THE IOWA CHEMISTRY EDUCATION ALLIANCE PHASE IV—A SHIFT IN EMPHASIS

A. A New Emphasis

Between ICEA Phases III and IV, Gary Downs (ISU, Curriculum and Instruction) retired and Gary Phye (ISU, Curriculum and Instruction) joined the Project as co-principal investigator along with Tom Greenbowe (ISU, Chemistry). Although he had retired, Gary Downs chose to stay connected with the Project during its final year of funding from the U.S. Department of Education as a paid consultant.

There was a new emphasis in Phase IV of the ICEA. The Project proceeded as it historically had in the past. The teachers and students integrated the same four modules into their curriculum that had been used during Phase III. However, in addition, Star Schools evaluators expressed a need for:

a. some kind of assessment of the impact of the ICEA Project on students and their teachers
b. documentation of how the ICEA Project was generated and how it evolved.

For this reason, four separate timelines were drafted for the ICEA Phase IV grant period. A brief descriptive overview of each is made here. The complete strategic plan for ICEA Phase IV is included in Appendix A, the timelines for each of the four funded phases of the ICEA Project.

1. Timeline 1, The ICEA Model

Dr. Gary Downs spearheaded the effort to document the ICEA Project. He outlined a draft of a document describing how the Project had been devised. In addition, he explained the outside support necessary for the four master teachers who created the ICEA package. This model was used as a guide for the development of the ICN component of the Teacher Education Alliance (TEA), another ICN-based distance education project. The ICEA Project also served as a model for a ninth grade science collaborative initiative to be described in greater detail later in this chapter.

2. Timeline 2, Student Assessment

As one of the ICEA Project principal investigators, Dr. Tom Greenbowe was assigned to develop an assessment to evaluate the impact of the ICEA Project on students. He worked with the ICEA teachers to design an instrument called the ICEA Chemistry Diagnostic to be administered as a pretest and a posttest. (A more extensive discussion of the ICEA Diagnostic study follows later in this chapter.)

3. Timeline 3, Teacher Assessment

Drs. Joanne Olson and Mike Clough, assistant professors of Curriculum and Instruction and science educators at Iowa State University, and Dr. Vaughn Prain, a visiting science educator from Australia, designed a study to observe ICEA teachers presenting a lesson related to an ICEA module as well as a lesson not related to an ICEA module. These observations monitored whether there was a difference in teacher behaviors between the two teaching situations. Their study is described in detail later in this chapter.

4. Timeline 4, Routine

Project personnel also facilitated the daily routine "business as usual" organizational details of the ICEA Project. This schedule paralleled the organization and timeline used in Phase III.

B. Phase IV Teacher and Student ICN Scheduling Groups

Six teacher subgroups (this year named after elements Einsteinium, Gold, Platinum, Plutonium, Silver, and Titanium) had a difficult time working out their first and second semester schedules for ICN meeting times. As was true in past years, differing bell schedules at the twenty-five high schools provided group schedulers with no end of challenges. In addition, trying to schedule schools following block scheduling with schools not following block scheduling was more than a little complicated. As had been true since Phase II, the most problematic scheduling was for those schools whose block schedules demanded that they teach an entire year's worth of material in one semester. Integration of the learning modules was more awkward for those teachers. But they believed that the "ICEA experience" benefited their students enough that the student gains were worth the inconveniences.

Weather-wise, winter 1999-2000 was mild and uneventful. This was an advantage to the ICEA Project. There were few weather-related school cancellations. This meant that there were not the same rescheduling difficulties that had been encountered during the prior three years of the ICEA Project (to the relief of those most directly related to coordinating ICN sessions).

C. ICEA Module 1—Communication Tools & Protocols

A group of ICEA teachers evaluated Module 1 materials over the summer and during the Fall 1999 ICEA workshop. Suggested editings and alterations for Module 1 were discussed. A modified scoring rubric, devised based on the work of the Module 1 evaluation group, was approved by all of the ICEA teachers and then sent out to each to use for the Fall 1999 semester.

In the past, ICN sessions for Module 1 (including student introductions as well as favorite chemical or element presentations) had been scheduled within a week or two of one another. During Phase IV, it was decided that, as always, the introductions were scheduled first—it was imperative that students would learn about ICN protocol and the correct use of the technology, as well as to meet and talk with distant peers for the first time. The favorite chemical presentation, however, was delayed until later in the term. Phase III teacher focus group reports had indicated that there seemed to be a large gap between the finish of Module 2 (the statistical analysis of the density of different soda pops) and the winter holidays/end of the first semester term. Delaying the favorite chemical presentation until later in November or in early December would close that gap. This allowed the students to have more exposure to chemistry and to have learned more chemical concepts before selecting a favorite element/chemical topic and reporting about it.

It was hoped that this engendered a more thorough understanding of what was presented about chemical elements or compounds during an ICN sharing session—both on the part of the presenter and the listeners. The teachers agreed that this modified timing of Module 1 was an improvement.

D. ICEA Diagnostic Quiz

In response to requests from the ICEA teachers, a 26-item high school chemistry content diagnostic instrument was designed to address basic concepts encountered in a typical high school chemistry class. The teachers worked with ICEA Project personnel from Iowa State to generate appropriate questions. A draft version was sent to all teachers for suggestions and modifications. A copy of the ICEA Diagnostic and answer key is included in Appendix K. The final diagnostic instrument (along with bubble-in answer sheets) was sent to each of the teachers to be administered to students *prior to* beginning participation in the ICEA Project in the Fall. Response sheets were returned to ISU for analysis. This same instrument was also administered at the *end* of the academic year. The purpose of using this instrument as both a pre-test and a posttest was to see how student performance on the diagnostic compared prior to and after participation in the ICEA Project.

There were 1600 students in the Phase IV experimental group at the outset. Phase IV teachers encouraged colleagues who were not participating in the ICEA Project to administer the same pre/post-instrument to their students. There were initially 200 students in this "control" group. This was considered good because the control group teachers had agreed to participate without really being a part of the Project.

Considering the ICEA Diagnostic scores of a control group (not ICEA Project students) vs. an ICEA Project group, an interesting study can be made at one Des Moines metropolitan high school. Theoretically, these students should be similar groups at the outset because they are all students attending the same high school.

Project personnel were not allowed to have access to prior GPA information about students and could not compare the two groups in that way. But, the student scores on the ICEA Diagnostic pretest show no statistically significant difference between the experimental and control group. In addition, there is not a statistically significant difference between either group or the overall performance by all experimental groups on the ICEA Diagnostic as a pretest. All groups are "equivalent" at the beginning of the year. However, it can be seen in Table 1 that the students in the Des Moines Metro experimental group scored statistically significantly higher on the ICEA Diagnostic administered as a posttest than did the Des Moines Metro control group. The Des Moines Metro experimental group scores averaged the same posttest score as the overall experimental group. This implies that the ICEA student groups made some learning gains during the academic year if the Des Moines Metro control group was representative of all high school groups at the outset. This was a basic pilot study. What role the ICEA Project played in the learning gains would have to be studied via some other means of teasing that information out of the data.

Table 1. ICEA Diagnostic Pretest and Posttest Scores

Institution	ICEA Diagnostic Pretest	ICEA Diagnostic Posttest
all schools combined	53%	61%
DSM Metro HS (exp. gp.)	52%	61%
DSM Metro HS (contr. gp.)	51%	55%

E. ICEA Student Survey

The ICEA Student Survey was also administered to provide a picture of the ICEA student demographics for 1999-2000. It was expected that the information obtained by this survey would agree well with past demographic information collected and it did. Although the number of participants grew each year, student demographics did not change substantially over the course of the Project. A copy of the ICEA Student Survey is included in Appendix L.

F. ICEA Student Demographics

The ICEA Student Survey provided the same demographic picture of the student participants as had been seen in past years. Of the 1770 students who responded to the 1999-2000 ICEA Student Survey, 56% were female, 64% were juniors (with 20% sophomores and 14% seniors), and 86% were Caucasian (with 2% African American, 2% Hispanic, 4% Asian, and 1% Native American). The majority of the students ranked themselves in the top 50% of their class.

Most students reported having had a positive past experience with science in general. Many had a basic science background : 82% had had two semesters of earth science, 88% had had two semesters of biology, 68% had had two semesters of physics, and 65% report having taken two semesters of some other high school science. They reported being confident in their knowledge and ability in science and expected to get a good grade (an "A" or a "B"). They had a positive attitude toward chemistry as well.

Students also described a solid basic mathematics background that they believed to be adequate for their chemistry studies: Of the total group, 90% had had two semesters of basic high school algebra, 68% had had two semesters of advanced high school algebra, 19% had had a semester of high school trigonometry, 34% had had two semesters of high school trigonometry, and 75% reported having taken two semesters of some other high school mathematics.

G. National Science Education Standards, NSES

When they were devised, the eight ICEA learning modules and three supporting videotapes were designed to reflect the National Science Education Standards (1996). The original module packet did not include any direct references to the NSES.

At the outset of Phase IV, an extensive listing was made of each of the National Science Education Standards as they coordinated with the materials in the ICEA Module packet. The document was circulated among the ICEA teachers for their feedback. Any necessary modifications were made. The finalized version was integrated into the existing ICEA module packet. The listing is found in Appendix C.

Teachers and Project personnel were now able to directly reference this document when specifying coordination between the ICEA curriculum and its support of the NSES.

H. ICEA Module 2—Data Collection and Statistical Analysis Activities.

Students undertook ICEA Module 2 activities, analyzed the density of diet and regular versions of a variety of brands of soda pop. This data was entered into the ICEA statewide database at

http://205.221.129.250/ICEA/density.htm

which is no longer an active link.

During Phase IV, students were unable to statistically demonstrate that there is a difference between the densities of the diet and regular varieties of a given brand of soda pop. Strangely enough, this was the fourth year for students to perform this laboratory exercise — therefore, it was thought that the "bugs" had been eliminated in the analysis process. But, it was the first year that the data did NOT distinguish between the densities of diet and regular sodas. Teachers speculated that students were not experienced enough with the use of more sophisticated pipette equipment that many had used for the first time, possibly without adequate practice. The resulting erroneous measurements lead to inconsistent final results. Teacher observation of students practicing using the pipettes confirmed their lack of skill in using the equipment. Failure to rinse the equipment adequately with soda pop solution (to get rid of water contamination that would dilute the test solution) , as well as failure to measure correctly were likely inaccuracies that could have resulted in compounded errors in density determinations.

Students did not entertain the possibility that their experimental technique was faulty. Instead, they questioned the quality control at one of the local bottling plants because their results did not support the general conclusion that regular soda pop is more dense than the diet version. This kind of result highlighted the real world connections that can be made with the studies done in the ICEA modules.

To address the issue of whether there WAS a problem with quality control at the bottling plant, contact was made with the local Coca Cola distributor to try to determine what the difference in densities *should* be. This information could not be provided locally. Project personnel were directed to contact an official at Coca Cola Corporate headquarters in Atlanta, Georgia. An interesting e-mail discussion ensued. A company representative actually accessed the ICEA Soda Pop Database to perform his own calculations using the data gathered by the ICEA students. He confirmed the results the students had obtained. He studied their data and attributed the inconsistencies in their numbers to the analysis techniques used by the students. He speculated that they had not collected valid data, therefore calculated erroneous results.

Student interest in real-world problems extended beyond the classroom. Chapter 5 of this work contained a discussion concerning student analysis of Canadian pennies. This chapter contains a brief account of investigation of soda pop density. A more extensive anecdotal report about these two real-world aspects of the ICEA Project was prepared at the request of Senator Tom Harkin, who had a keen interest in the outcomes of exemplary Star Schools-funded Projects. This report is found in Appendix F.

I. ICEA Featured at ISU-KSU Football Game

During the half-time program at the Iowa State-Kansas State football game (September 25, 1999), the ICEA Project was featured during a one-minute spot as an exemplary use of the Iowa Communications Network. Over 40,000 fans heard the promotional spot. Not many of the participating ICEA students attended the game, but several ICEA teachers from around the state and Iowa State University ICEA Project personnel were in attendance. They appreciated the recognition for the ICEA Project and for the Iowa State University College of Education.

J. Iowa Science Teachers' Meeting

Iowa State University ICEA Project personnel facilitated an information session about the ICEA Project at the Fall 1999 Iowa Science Teachers' meeting . Four participating ICEA high school chemistry teachers attended and contributed to the presentation. There was lively discussion and questions about future possibilities for participation. Each interested teacher in the audience was given an ICEA brochure with contact information.

Three of the Phase I teachers also presented a separate discussion session about the interactive Internet pages they had produced under a grant from U.S. West to be used for the ICEA Spectrophotometric Analysis Module (Module 5). (The fourth Phase I teacher had organized the entire Iowa Science Teachers meeting and was otherwise engaged, although he had shared equally in the creation process.) The session was also very well attended and generated further statewide interest in the ICEA Project.

K. ICEA Homepage

The ICEA web site was redesigned to move away from a heavily text-based offering to a more graphics-oriented product. The URL is still active at:

www.educ.iastate.edu/ci/treg/ICEA/homepage11.html

The home page included the ICEA logo and mission statement.

Associated (linked) pages included:

ICEA History—an overview of the Project's development.

ICEA Directory—photographs of participating members (teachers and Iowa State University personnel).

ICEA Modules—a description of the eight modules in the ICEA supplemental modules package.

What's New?—a listing of events for the current academic year.

Scanning Electron Microscope—a link to Iowa State University's Materials Science and

Engineering Project ExCEL, featuring the remote use of a scanning electron microscope via the Internet (discussed later in this chapter).

L. The ICEA Video

Three years of ICEA videotape history were compiled and edited to create a twenty-three-minute videotape, "The Right Chemistry", summarizing the history of the ICEA Project and the ICEA model of collaboration among teachers and students. This videotape provided a description of the Iowa Chemistry Education Alliance (ICEA) and the interactive modules that were developed by Phase I teachers. It presented an overview of the ICEA Project materials that comprised the product and process designed to supplement traditional teaching in high school chemistry classes, with the intent of increasing the enthusiasm and learning experiences for students making "real-world" connections. It alerted the viewer that the package combined traditional teaching with distance learning and networking not only to help motivate and interest students but also to benefit teachers.

A historical emphasis outlined the creation of the ICEA in 1996 with only four central Iowa high schools and traced its development to show that it increased to twenty-five high schools state-wide. It illustrated that by using the Iowa Communication Network, e-mail, the Internet, and CUSeeMe cameras, students and teachers were able to collaborate with one another about the results and procedures of the four supplemental learning modules completed throughout the year. The four modules featured in the videotape include:

1. Introduction: Communication Tools & Protocols (Module 1)
2. Data Collection and Statistical Analysis (Module 2)
3. Chemical Instrumentation—Spectrophotometry (Module 5)
4. Forensics (Module 4)

This videotape was used in a variety of venues—conference presentations about the ICEA, presentations about the ICN and ways it has been successfully used for collaborative interactions, and presentations about teacher preparation in collaborative projects similar to the

ICEA. The videotape was presented to incoming chemistry graduate students at a graduate student recruiting fair as an example of some of the research done by the Iowa State University Chemical Education Research Group.

Copies of the ICEA videotape were sent to each of the ICEA teachers, the fifteen Iowa Area Education Agencies, and to supporters at Iowa Public Television. Appendix N contains an AEA library catalog description of the ICEA videotape prepared for Iowa Area Education Agency libraries.

M. ICEA Journal Article

The ICEA Project was a hallmark use of the ICN and was featured in an article published in *Tech Trends*, November, 1999 (Burke and Greenbowe, 1999). This issue highlighted the exemplary innovativeness of the Project.

N. Grant Wood Technology Fair

A presentation about the ICEA Project was made at the annual Grant Wood Technology Fair held on November 5, 1999. The session was facilitated by Project personnel at an ICN classroom on the Iowa State University campus joined by three ICEA Project teachers at Prairie High School in Cedar Rapids. In addition to viewing a PowerPoint presentation about the Project, participants at Prairie High School were able to view the newly-finished ICEA Project videotape, "The Right Chemistry", as well as ask questions of the facilitating staff. It was a highly interactive telesession. Teacher representatives of the ICEA Project were able to share a good deal of information by answering the questions participating viewers posed.

O. ICEA Teacher Meeting December 3-4, 1999

1. The ICEA Diagnostic

Teachers and Project personnel met to discuss the results of the ICEA Student Survey (Fall 1999). There were no notable changes in the ICEA student demographics during that fall. Nor were there suggested changes to the ICEA Diagnostic (Fall 1999). Some explanation of the implications of the results of the ICEA Diagnostic pretest were noted. For example, analyzing the results of one of the spectroscopy questions alerted teachers to the presence of a misconception held by the majority of students. The question is shown below in Figure 1.

Initially, students believed that they should set the spectrophotometer for a red wavelength setting to detect red light. This concept was later addressed by material in Module 5 during the second semester of class work. After students studied Module 5 materials, they would answer the questions again when the ICEA Diagnostic was administered as a posttest.

Figure 1. ICEA Diagnostic Question about Spectroscopy.

If you have a red solution which you wish to analyze using a spectrophotometer, at which wavelength should you set the maximum absorbance of the instrument?

Wavelength (in nm)	Color
430-460	Blue
490-520	Green
575-585	Yellow
725-750	Red

a. 445 nm b.505 nm c. 580 nm d. 738 nm

Without "teaching to the test", instructors planned to allow their lesson to address that issue. At the end of the academic year, all teachers were eventually interested to learn that student performance on that particular question *remained the same*. This confirmed that the students tenaciously held on to that particular misconception and also implied that the teachers did not "teach to the test".

2. Faculty focus groups, December 1999

Two simultaneous focus groups were conducted with ICEA teachers during the December 1999 meeting. The first group was comprised of teachers from Phases I and II. The second group consisted of teachers from Phase III. No teacher new to Phase IV was able to attend.

a. Mentoring

Teachers reported that their mentoring network (whether in person, via the ICN or CU-SeeMe, or via e-mail) provided them appreciated instructional support and motivation. They valued the efficiency, immediacy, and personal appeal of face-to-face interactions possible using the ICN or CU-SeeMe technology and used these technologies quite often. "So much of what is communicated is not *what's* said but *how* it's said. Face-to-face communication is the key to making it work," (unidentified focus group participant, 1999). (On-site meetings allowed the teachers an extended period of time to talk with one another without the demands of students and work distracting them.)

"During Phase I, three of us were working on a problem with orange juice concentration related to Module 6, Analysis of Vitamin C. We solved it by being creative in the classrooms, taking the student flask and putting it in front of the CUSeeMe camera for the other teachers to see. Through talking to each other when the problem occurred, we were able to solve the problems during the module," (unidentified focus group participant, 1999). In this way, students observed first-hand the power of critical thinking and problem solving modeled right in front of them by their instructors.

This kind of problem solving by teachers was accomplished in the middle of a class period in the middle of a school day. All parties "met" via CUSeeMe cameras and used a classroom video camera integrated with a classroom computer to broadcast the image to one another. Based on the immediate visual exchange, teachers were able to agree on a standard "acceptable" color change and use that information during ongoing classes.

"The intensity of mentoring has dropped but more casual mentoring is going on. Collaborative mentoring goes on outside and inside the Project," (unidentified focus group participant, 1999).

b. Missed meetings

Iowa State support personnel were credited with contributing substantially to Project success. Teachers were critical of their colleagues who did not attend their on-site meetings, especially because of the frustrating problem of scheduling. For the most efficient scheduling, all the participating teachers needed to be present to be able to work out scheduling difficulties. In addition, teachers spent a substantial portion of each meeting talking about how to modify the modules; but those who were not present did not participate in the discussion nor did they contribute to it or benefit from the dialogue. Although concerned to keep their colleagues informed, teachers admitted they could not remember everything that had been said in order to pass it along to those not present. They were concentrating on thinking about their own classrooms; and as a result, those missing the meeting sometimes mistakenly did things the "old way", causing minor inconveniences for Project personnel.

Those in attendance concluded that missing the face-to-face meeting and still getting the materials would not help the teacher much because she or he would not know why the materials were needed. It would not be meaningful for those not attending because they would not have had the benefit of the discussion.

The communication that included mentoring involved those people who did not attend. They had to be mentored to be brought "up to speed."

c. Flexible modules

Teachers appreciated the flexibility of the ICEA modular materials. Changes could be made from module to module, from year to year. Each year was a learning experience. The teachers felt that the best thing about the ICEA Project was that they had the basic modules that could be adapted to their own group of students. They could take them in any direction they wanted to go. The modules were open-ended, meaning that they were used as a guide.

d. Expanding the Project again

Though optimistic that expanding the number of participants could be good for the Project, teachers expressed grave concerns about issues of scheduling an increased number of sites. However, the point was raised that larger numbers would provide more opportunities for matching bell and break or vacation schedules.

e. The National Science Education Standards

The ICEA Project focused on some of the National Science Education Standards (1996) that the traditional curriculum did not have (e.g., communications, interactions, cooperative activities, etc.). That is why the ICEA Project took advantage of quality chemistry programs that were already in place and supplemented them—to incorporate more of the National Science Education Standards. Student communications resulted in more than simple data exchange. Students learned about and from their peers across the state. Not all of what was learned was directly related to chemistry. There were also sociological implications to student interactions. For example, a group of students who had created a particularly fine PowerPoint presentation served as role models for their peers, who viewed the delivery and improved their own articulation the next time based on the example they had been provided. It was important for the students to see that other high school chemistry classes were just like their own.

f. Modules could be more interactive

Concerns were expressed that the ICEA student modules were still not collaborative enough. Students were not able to *interact* as much as they would prefer. This was an on-going concern. One solution suggested was that for a module like density to have each school experimentally determine the densities of different liquids and compare their results so they would all collect different results. But, there would need to be a *reason* why this would be important—there would need to be an incentive for sharing and caring about the results, i.e., a motivating factor causing the students to want to determine their results. For example, for

Module 2, the students might be asked to determine experimentally from a given list of soda pops, which was the densest soda pop.

With the larger group of 1600 students talking with one another statewide, there were some problems with the interaction between the classes. From time to time, negative attitudes developed as a result of rudeness among students. Teachers needed to curtail this before it became problematic.

g. Budgetary concerns

One major issue arose during Phase IV. Teachers were seriously concerned about the issue of Phase IV budget allocations. Teacher stipends had been drastically cut to provide more support personnel. Teachers felt strongly that some of their members should have been included in the meetings that led to changes in the budget process. They viewed it as a very large mistake that they were not included in deliberations. They felt strongly that at least the four original Phase I teachers should have been involved in the process from the very beginning, just as they had always been included before.

It had a tremendous effect on the feeling of ownership of the Project because the teachers rightfully felt they were an instrumental part in the Project success. The four original teachers were the reason the Project worked. Essentially, the teachers *were* the Project.

P. ICEA Teacher Videotaping and Observational Analysis

In an attempt to determine how ICEA modules impact ICEA teachers' teaching styles, Project personnel requested that six of the ICEA teachers (half of the Phase II teachers and the others Phase III teachers) videotape themselves facilitating an ICEA lesson and again during a later equivalent non-ICEA lesson. Neither segment was ICN-oriented. In order to cause the least amount of classroom distraction or disruption, teachers were asked to wear remote microphone devices interfaced with an independently operating video camera. This was done so that there was no outside party impacting daily classroom dynamics. These lessons were specifically designed to be as unintrusive as possible for the teachers in order to avoid having the students behave any differently from what was “normal” for their classroom. Two remote microphone and receiver sets were shared among the teachers. Teachers were scheduled to videotape two teaching sessions, one of which was related to Module 5, the spectrophotometric analysis of the percent copper in a post-1982 U.S. penny, and the other, an equivalent lesson later in the term that was not related to the ICEA supplemental curriculum. A specific coding schema was used to compare and contrast teacher behaviors and interactions with students.

It was observed that there was no significant difference in the way teachers facilitated an ICEA lesson compared to how they facilitated a non-ICEA lesson. Olson, Clough, and Prain concluded that despite the curricular reform effort of the ICEA Project, the observed teachers were still facilitating classroom sessions in a teacher-centered manner. Olson, Clough, and Prain recommended that a more student-centered approach might complement the ICEA efforts better. It should be noted that only five of twenty-five teachers were observed in this study. A similar follow-up study of ***ALL*** ICEA teachers could prove more informative. Observing all other ICEA teachers might yield different results.

Q. Physical Science Education through Distance Learning— An Offshoot of the ICEA Project

A Phase II ICEA teacher from Cedar Rapids Prairie High School and three other physical science teachers from high schools in Sheldon (a Phase III ICEA teacher), Des Moines (Hoover), and Harlan worked together to present their students with the opportunity to collaborate over a distance to learn about several topics included in physical science. The unit was one portion of a larger body of material students studied during Spring Semester, 2000. Patterned after the ICEA Project, students did an Introduction to Communications module very similar to the ICEA Module 1, Introduction to the ICN. Instead of the ICEA "Favorite Chemical" unit, students collaborated on "How Does It Work?". This unit had three emphases:

How does the human body work? (biology)

How does plastic work (i.e., how do we use plastics)? (chemistry, physical science)

How does a simple machine work? (physics)

The third segment of the unit was a study of amusement park rides with the emphasis on the scientific principles behind the rides and riding on them. Students prepared and discussed materials about the physics principles on which the rides are based. They focused on the physical stresses experienced by the human body as it passes through the ride experience. Then, students went to an amusement park and to try to conduct further experiments on-site and to draw conclusions from their activities.

Both students and teachers were surveyed. Teachers found this to be a series of highly motivating lessons for the students. Student opinion was overwhelmingly favorable. Learners enjoyed using the ICN and certainly found the topics under discussion to be interesting. There was no quantitative assessment component of this unit. Therefore, there was no statistical or anecdotal evidence of improved learning gains via this method.

R. The Scanning Electron Microscope, SEM

During the August 20, 1999 ICEA Teacher's Meeting, Dr. Scott Chumbley, professor of Materials Science and Engineering (MSE) at Iowa State University, provided ICEA teachers with an overview of an NSF-funded Project he directed (Chumbley, Hargrave, Constant, Hand, Andre, Thompson, 2002) that allowed high school students and teachers to submit samples to his department and then be able to analyze them using the MSE Scanning Electron Microscope (SEM) via the Internet. Students at remote locations were able to actually use the SEM instrumentation on the ISU campus, controlling its manipulations from their own classroom. Teachers and students were intrigued with the concept. Scott agreed to return to the ICEA Teacher's Meeting at the end of the semester to talk more about the Project and possible ways to integrate the use of SEM instrumentation into the ICEA Forensics unit for Spring Semester, 2000.

Scott returned to speak in greater detail as well as to demonstrate the capabilities of the SEM Web Project. He facilitated a session to explain more to the teachers about how the SEM might be integrated into the ICEA Forensics Unit. He designed an informational sheet to be shared with the teachers. He provided an undergraduate student from Materials Science and Engineering to do a demonstration of the SEM via the Internet so that the teachers could visualize its capabilities and plan for the upcoming Forensics module in April, 2000. He demonstrated the power of the SEM as an investigative tool, using samples of some of the same ICEA evidence materials that students would be provided (including salt, sugar, baking soda, and hair) from the ICEA Forensics module.

To prepare to integrate use of the SEM into the ICEA Forensics Module, an undergraduate student from Materials Science and Engineering department scanned a series of previously-prepared ICEA evidence samples. Digital files were stored on the SEM computer hard drive. "Evidence" and "Crime Scene" images were posted on the Internet in an ICEA reference library. Teachers were provided with "maps" of where evidence samples are placed on the SEM sample holders. That made it possible for them to operate the SEM instrumentation that was housed at Iowa State University from their remote location (if their computer had a large enough memory cache to accomplish the task).

Another undergraduate student was hired to prepare a series of Web pages (including the scanned images of evidence samples) for the ICEA portion of the MSE SEM Project. These pages were linked to the ICEA homepage,

www.educ.iastate.edu/ci/treg/ICEA/homepage11.html.

The reader is advised to view the SEM scans posted on the web site in order to appreciate the quality and usefulness of the evidence library. To access the scans, follow the "Scanning Electron Microscope" link to the "ICEA SEM" link to "The ICEA Library of SEM Photo Images". Once there, compare the crime scene scan for fiber, hair, plastic, or powder with any of the samples taken from suspects to see the process by which students made comparisons to connect suspect evidence to crime scene evidence. Recall, this is only one of the forensic avenues available to students to "solve" the puzzle. They also performed in-class chemical tests and made visual observations that may also have been helpful for identification.

Teachers were provided with the necessary instructions to access the SEM via the Internet and use it "live" in class to examine evidence. Few teachers had the required "computer power". Ken Hartman, Ames High School, borrowed a computer from his media department at Ames High School so that his students would have access to the full capabilities of the Web SEM. Ken, Larry Schwinger, Stuart-Menlo High School, and their students successfully operated the SEM at a distance from their respective schools. Students were intrigued with the ability to control their analysis of the evidence. Both teachers reported excitement with the dynamic on-line real-time use of the instrument, but frustration with the slow response time of the computers they were using.

Students at schools without computers that could integrate use of the "live" SEM instrumentation into the classroom could instead access the SEM image library to compare SEM scans of their samples with scanned images of evidence. Use of the SEM scans library was a new and helpful set of available tools. Students found this aspect of the Forensics unit to be useful and motivating for them.

S. Module Modifications, Modules 4 and 5

During the December Teacher Meeting, participants revisited Modules 4 (Forensics) and 5 (Spectrophotometry) to discuss the integration of suggested modifications to those modules.

1. ICEA Module 5—Chemical Instrumentation—Spectrophotometry (Copper Penny Module)

Module 5 had few modifications during Phase IV. Students completed experimental work on the Spectrophotometry Unit and over 300 sets of data were entered into the Spectrophotometry Data Base. Student groups met over the ICN to share results. Results were similar to those obtained during Phase III. Students were able to learn about the percentage compositions of several types of coins by way of their laboratory work with the addition of coordinated Internet research.

2. ICEA Module 4—Forensics

The Forensics module was well-received in ICEA chemistry classrooms across the state. Students viewed the videotaped tour of the Department of Criminal Investigation to learn about the handling of evidence. They had the opportunity to interact with forensic specialists as guests during ICN sessions prior to their hands-on laboratory experiences. They were introduced to the crime scene scenario, the evidence found there, and the evidence associated with eight possible suspects.

Beyond the Scanning Electron Microscope instrumentation being available, (as previously described), there was another new facet of the Forensics Module for Phase IV. To replace working with glass samples, one of the Phase II teachers was able to arrange to obtain donated samples of a variety of small plastic pellets from a local Iowa business. A new analysis procedure was devised using these pellets. Students were given vague indications that the plastics samples were somehow connected with a crime scene. There were evidence samples, purportedly collected at the crime scene, as well as reference samples. Two basic tests were performed. The first test was to observe whether the plastic pellets floated in water, alcohol, acetone, and/or vegetable oil or not. When warmed in a beaker of hot water, students were directed to observe whether the pellets softened. This new set of analyses seemed to go smoothly. Student curiosity was piqued. Instructors unanimously agreed to retain this set of experiments as part of the Forensics Module.

Students analyzed evidence samples and by comparison, tried to rule out various suspects on the basis of what they found. They convened an ICN session to discuss their evidence or lack thereof in an attempt to eliminate suspects for whom there was not enough evidence to warrant suspicion. For whatever reason, it was not as straightforward a process during Phase IV as it had been in previous years. Students and teachers alike found the task to be fairly challenging. This was surprising, in that it had been thought that the integration of the Scanning Electron Microscope component of the module would facilitate evidence evaluation to the point of making it too elementary. The Forensics unit was still the favorite ICEA module unit for the year because it had the most relevant, real-world applications, involved students in the most interdependent collaborative activities, and was the most motivating for students.

T. Spring 2000 Iowa Academy of Sciences Presentation: "The Right Chemistry", The ICEA Videotape.

The twenty-three minute videotape summarizing the history of the ICEA and the ICEA model of collaboration among teachers and students was the basis of the Spring 2000 Iowa Academy of Sciences presentation at the Des Moines Convention Center. Project personnel showed selected segments of the video and discussed questions posed by persons attending the session. As always, those persons learning about the ICEA Project for the first time were excited and interested in how they could learn more about it. Brochures were distributed and participants were referred to the ICEA homepage.

U. ICEA Spring 2000 Teacher Meeting

The ICEA Spring 2000 Teacher Meeting was held June 3, 2000 at Lagomarcino Hall on the ISU campus. General sessions included:

a. Debriefing and reflections on the past year of the ICEA Project
b. The use of the ICEA diagnostic instrument to measure student gains (pretest and posttest administrations discussed above)
c. A focus group session to assess teachers' reflections on Phase IV and an overview of the ICEA
d. An update by Drs. Joanne Olson, Mike Clough, and Vaughn Prain about teacher videotaping sessions
e. An update by Dr. Downs about his draft of the ICEA document
f. An update by Dr. Greenbowe about the use of assessment instruments and what they hoped to show
g. Brainstorming about the future of the ICEA Project

Most of these issues have been discussed in detail earlier in this chapter. The focal point of this meeting's discussions regarded how the ICEA Project could reorganize without external funding. Teachers who were interested in organizing Phase V agreed to determine whether the local administration at each individual school would consent to assume the costs of ICN television time. They agreed to meet again at Iowa State University in August, 2000 to arrange Phase V of the ICEA Project. Star School funding would expire at the end of September 2000. The ICEA Project had been designed and modified to allow the teachers maximum flexibility and freedom. Project personnel had tried to facilitate from the sidelines, providing the ICEA teachers with maximum independence.

How would they organize themselves to undertake Phase V without external funding? The teachers had the summer break to strategize what they would or could undertake in the Fall for academic year 2000-2001.

VIII. CHAPTER 8. THERE ARE NO MORE FEDERAL FUNDS TO SUPPORT THE ICEA PROJECT. WHERE DO WE GO FROM HERE? THE IOWA CHEMISTRY EDUCATION ALLIANCE PHASES V, VI, VII, AND VIII

A. ICEA Presentation—16th Biennial Conference on Chemical Education, Ann Arbor, Michigan

Project personnel presented an overview of the ICEA Project at the 16th Biennial Conference on Chemical Education in Ann Arbor, Michigan on July 31, 2000. This dissemination reached both a national and international audience. Response was enthusiastic. One teacher in attendance was an instructor from New York state and was interested in finding out more information in order to design a similar project for his own state. A short electronic mail communication ensued. The instructor was provided with as much information as he had requested. If a similar project *was* ever organized in the state of New York, the instructor did not share any further information with ICEA Project personnel.

B. The End of Department of Education Star Schools Funding

With federal funding no longer available to support the ICEA efforts for another year, the instructors were asked whether they would organize to continue the ICEA Project for another year if they had to operate without teacher stipends, ICN funding, and access to Iowa State University Project support personnel.

Because ICEA Project personnel had insisted on maintaining a hands-off management style over the years, the ICEA teachers were already comfortable in their role of organizing working groups as well as arranging ICN schedules. From the outset, the Project leadership had belonged to the teachers. As such, when funding expired, teachers were not dependent on guidance from Iowa State University personnel nor on federal dollars to survive.

A number of the teachers indicated that they wished to continue the Project. Minimal funding remained for ISU Project personnel to host an organizational meeting for Fall Semester 2000 as well as a recap ICN meeting at the end of the academic year in June 2001.

C. ICEA Phase V—Teacher Meeting August 26, 2000

Faced with the certain loss of Star Schools funding on September 30, 2000, ICEA teachers rallied to maintain the ICEA group. Not all Phase IV teachers chose to continue working with the ICEA Project. Thirteen agreed to meet with one another at Iowa State University on August 26, 2000 in order to share ideas on how to maintain aspects of the Project in the upcoming school year, and to arrange to form collaborative ICN student working groups for the academic year 2000-2001 (ICEA Phase V).

It was the teachers' desire to preserve the entity of the ICEA group in order to continue to pursue collaborative group work between local and distant students. They knew by student responses to ICEA surveys that their students very much enjoyed interacting with distant peers. Students found it stimulating and challenging to work on real world hands-on activities with students at other schools. They also found it reassuring that other students were faced with the same challenges of daily life in high school chemistry as they were. They valued having the opportunity to interact with distant classmates in an academic setting rather than during an athletic competition.

D. Changes Due to Lack of Funding

When Star Schools funding was terminated, some teachers found it to be a natural time to terminate their participation in the Project. For the teachers who chose to remain involved, several notable observations were made.

1. No stipends

There were *no* ICEA teacher stipends for 2000-2001 or beyond. The teachers who stayed together as the "ICEA Group" for Phase V were committed to the concept and method of the ICEA Project, not to remuneration. If this statement sounds at all harsh, it is the assessment that the teachers made about themselves.

2. No ICN support

There were *no* Star Schools funds to support interactive ICN sessions among students at the various schools. Teachers who chose to participate in the ICEA Project Phase V (and beyond) were required to procure funding from their school administrators to pay for network broadcast time. Before arriving at ISU for the Fall 2000 meeting, the teachers had talked with their local administration to determine whether and how their school would be able to pay for ICN time. It was speculated that the cost for each school to communicate with the same frequency as they had over the past four years required approximately $350 per school per academic year. This would allow teachers to communicate with each other and students to have interactive sessions. In light of the benefits to students, the teachers found this cost to be trivial. Because of the popularity of the Project with students and parents alike, administrators had become proponents of the ICEA Project. Teachers easily convinced their administrators to provide the appropriate funding.

3. On-site meeting

During the initial stages of Phase V, Iowa State University personnel provided teachers with the opportunity assemble to schedule student ICN sessions. There were minimal funds remaining in the ICEA budget that were reserved into a sheltered account in order to provide ICEA teachers with one more opportunity to meet via sponsorship by Iowa State University support personnel.

The same module implementation and ICN schedule followed during Phase IV was paralleled in Phase V. Student satisfaction ran high, teachers were also satisfied.

Although the academic year of 2000-2001 was extremely challenging to the ICEA ICN sessions (due to weather-imposed delays and cancellations), through the efforts of a core group of individuals, the ICEA Project continued through Phase V. These dedicated teachers shared the belief that the ICEA Project was so beneficial to their students that they were willing to seek and procure administrative financial support for ICN programming as well as dedicate classroom time and effort to integrate, incorporate, and facilitate the use of the ICN and ICEA modular materials. Students from Sioux City to Davenport, and many points between were able to interact and learn about real-world aspects of chemistry through the supplemental learning materials produced and incorporated into their "regular" curriculum via the ICEA Project.

E. Would There Be a Phase VI?

During an overall assessment session conducted via the ICN at the end of the academic year in June 2001 (supported via the last remaining ICEA Phase IV funding), the teachers decided to continue ICEA interactions during the following year as Phase VI. Dave Bolluyt from Adel, an ICEA teacher since Phase II, volunteered to coordinate grouping teachers and schools with similar bell and academic schedules. In addition, he organized ICN scheduling for the group.

In June 2001, the ICEA Phase V teachers gathered via the ICN to debrief about the past year and to discuss planning for Phase VI the next year. All of the teachers who were there expressed an interest in being involved. One of the Phase I teachers who had dropped out during Phase V let it be known that he and his students were interested in participating during Phase VI. It was decided that all of the interested teachers would send their teaching schedules to Dave Bolluyt, who would organize ICN working groups *and* schedule ICN time slots.

1. Phase VI participants

There was further attrition among the ICEA teachers moving from Phase V to Phase VI. Six teachers and their students began the ICEA Project Phase VI, five teachers finished. One had been forced to drop out due to life-threatening health problems.

2. Modules 1 and 2

During first semester of Phase VI, teachers integrated the same two ICEA modules that had been used in Phases III-V into the traditional curriculum. Students began the first semester with an introduction to the ICN via ICN interviews. They conducted a study of the density of soda pop products, creating a density database, sharing information using electronic mail, and comparing results via the ICN. They shared information about favorite elements/chemicals via the ICN. Students were motivated and learned a lot of interesting information from these presentations, just as past student groups had.

3. ICN scheduling

The process of ICN scheduling went well during Phase VI. The biggest problem was to arrange for one of the classes to be scheduled the first semester. There was no corresponding class meeting at the same time in any other school. That was potentially a very real problem due to the smaller pool of schools/classes. However, one of the distant classes was gracious enough to remain after their class dismissal and listen to reports from the "class without a partner".

One teacher found that there was a certain challenge to make the arrangement for switching from his "regular" classroom to the ICN room. In addition, trying to predict the school schedule to avoid conflicts was troublesome.

Because of the small group of teachers and students participating, organizers could schedule more easily around periods and days with conflicts. Rescheduling occurred most often when one of the teacher group had not anticipated schedule conflicts they'd "forgotten".

In light of state-wide budget constraints, the schools were still able to support the ICEA ICN sessions. It may have been difficult, but administrators had been whole-heartedly supportive of the ICEA Project from the outset. For the third year, one school district (Adel-Desoto-Minburn) coordinated ICN scheduling and took charge of bill payment for all of the ICN sessions. There were no problems with repayment.

4. Student reaction

The students found the ICEA Project to be a positive experience. They enjoyed the break from the normal routine as well as interacting with their peers in distant classrooms . Interestingly, other components of the Project that had once motivated students, no longer served that purpose. For example, presentation software (such as PowerPoint) has been around long enough that it was no longer novel or new, and as a result, it was not as exciting to students as it had been in the past. Many had already encountered and used PowerPoint prior to their ICN experiences.

5. A different module

Despite the tremendous popularity of the forensics unit, Phase VI teachers decided to implement Module 6, Food Chemistry: The Determination of Vitamin C in Orange Juice (the "Vitamin C module"). Each school decided on the experiment or experiments to be conducted during the Vitamin C module. Each group performed a titration of Vitamin C in orange juice, but the class or group in the class decided what to study and what to report. The exercise was similar to the laboratory that had been drafted for Module 6 during Phase I, but the Phase VI procedure did not include the use of indophenol as a titration endpoint indicator. Instead, the procedure substituted the use of a starch endpoint. It was found that experimental results using this option were not as accurate. However, the modified procedure accomplished the same purpose, was *much* cheaper, and the chemicals were easier to obtain. It was also more open than the original lab. It seemed to integrate into the curriculum well. Teachers like it, the students liked it, although "probably not as well as the forensics module," (Ehlers, private communication, 2002).

At one school, students used four different juices. Other schools did various brands of orange juice, or monitored Vitamin C content changes over time. Many of the students brought juices they drank at home, which gave them some sense of ownership, motivation, and enthusiasm. The module was well received by the students, and "felt really 'chemical' to them (their quote)," (Bolluyt, private communication, 2002). Both the teachers and the students liked the experiment. The ICN presentation had similarities to the penny lab as far as reported material (mg content and % content of Vitamin C, but relied on a different set of lab techniques. Most schools spread one presentation out over several groups, where each group did a part of the presentation. Each group designed their own presentation to report on their experiment and on their results. The reporting aspect was not as polished as it had been in the past.

6. Module 5

The Vitamin C unit was not completed until April (2002), which meant that students had to move directly to the penny procedure (Module 5, Chemical Instrumentation—Spectrophotometry) to complete that module before the end of the year. Lab work for the penny lab went well for most groups.

The teachers were satisfied with the set of labs they decided to use for Phase VI. Although the students had always liked the forensics module, it took a huge amount of time both inside and outside of class (preparation, execution, and reporting), and had incorporated too little chemistry in it to suit some instructors. Teachers found that the Vitamin C (titrations) and the penny (spectrophotometric instrumentation) exercises integrated into the curriculum well. Unfortunately, there was little or no interchange other than the ICN sessions for the students. The teachers also communicated less than in past years, other than scheduling. It was suggested that there should be an attempt to integrate more communication during Phase VII, if the ICEA Project was continued.

F. Phase VII?

Would the ICEA Project continue into its seventh year? Supportive teachers had that discussion late in the Spring semester of 2002 during Phase VI. Until then, school administrators had wholeheartedly supported the Project after Department of Education Star Schools funding was no longer available. The Adel-Desoto-Minburn district willingly conducted the billing processes necessary to "pay for" interactive Iowa Communications Network sessions. During each ICN billing period, ADM paid for the ICN costs and in turn invoiced the other participating school districts. There were few problems with this system.

Perry High School students were scheduled to move into a new facility in the Fall of 2002. That facility did not have an ICN classroom. Because the former building that DID have an ICN classroom was not too far away, the question became whether students could be transported from the new facility to the former location. This was a valid concern to the instructor, due to the time factor. Because it would not be a daily undertaking, he was willing to consider it.

Two of the most enthusiastic proponents of the ICEA Project had just facilitated classes for groups of relatively unmotivated students. One confided,

"I've got a different group of kids this year. It is extremely difficult to interest them in anything; if it isn't 'Star Wars' or 'Rambo', it's booooooooring. They've been unwilling to do much, they're not a group of scholars over-all. Somewhat of a frustrating year for me in that respect. I hope this isn't the rule for the rest of my career!!!!!", (Bolluyt, private communication, 2002).

1. Phase VII—a go!

Phase VII of the ICEA Project was organized by a small circle of interested and motivated ICEA teachers. Participating high schools included Adel-DeSoto-Minburn, Hamburg, Johnston (on block schedule), and Perry. Fall semester 2002, teachers scheduled the same units that had been used for the past several years: Introductions (ICN presentations October 21/25), Soda Pop Density (ICN presentations November 11), and Favorite Chemicals (ICN presentations December 17). All the lab units were done at each of the individual schools, following the procedures prescribed in advance by the teachers.

To help students become familiar and comfortable with the ICN system, for the Introductions, students were paired in the local classrooms, exchanged personal information, and then introduced one another to students at the remote schools. Although *all* students interacted in the local classroom, due to time constraints, not all students presented via the ICN. For those who did, the 2-5 minutes of time allotted to each pair helped the entire group to get a feel for the ICN—protocol, technology, and interactive capabilities. Those who did not were also able to get a feel for how it was done.

First semester, no data was interchanged via the ICN. Instead, each class created an individual database of all the soda pop data. Density information was exchanged via electronic mail. The research question for the groups was whether or not there was a statistically significant difference between the densities of diet and regular pop. Because of a substantial overlap of values, students found no statistically significant difference, but the means *were* different. Admittedly, this group was not nearly as careful a group of experimentalists as some groups had been in the past. "Close enough is good enough for this group," (Bolluyt, private communication, 2003).

Student groups presented via the ICN. "All of the ICN sessions went well, " (Paper, private communication, 2003). At Adel, each student was responsible for one individual component of the presentation. Most of the participating classes included the same requirements of two visuals per presentation. Presentations were limited to 2-4 minutes in length.

Second semester, teachers intended to undertake the spectrophotometric analysis of the U.S. penny, and Vitamin C in fruit juices, but not to incorporate an ICN component due to anticipated scheduling difficulties. Teachers proposed they should agree on deadlines, complete lab units by those agreed-upon dates, and then exchange data via electronic mail. In that way, class period coordination would be immaterial, and all classes could use all of the data. Initially, they discussed various experimental scenarios for determining Vitamin C content. It was suggested that teachers have each class as a whole prepare a PowerPoint presentation, then exchange and share them via an attachment to electronic mail. The ICN component of the Project did not exist the second semester. There were too few schools to be able to schedule together.

One class had no other classes with which to pair. Another teacher offered to move his class to a different time to accommodate a peer group for the ICN presentation days, but that was not an option for the first class. It was suggested that the group conduct the second semester entirely via the Internet and e-mail. That did not happen either. Instead, teachers modified ICEA units and integrated them into their existing curriculum. Students did not have "partners" at distant school locations.

Teachers noted that their students had always enjoyed the supplemental study units. They did not want to abandon using them, even if they did not implement the Iowa Communications Network as part of their interaction. One teacher scheduled a modified forensics unit. As a part of the activities, his students used the SEM (Scanning Electron Microscope) at Iowa State University. Students in the class actually controlled the SEM over the Internet (this has been described earlier in Chapter 6). Students found this to be an intriguing experience.

G. Phase VIII

Teachers hoped to organize again for the academic year 2003-2004 and keep the ICEA Project going both semesters. Much depended on the number of students who registered for classes at the different schools, when the classes were scheduled, and whether the scheduled classes could coordinate overlapping periods of time when students would be able to interact via the ICN. It was evident that these teachers valued the ICEA Project as a good part of their teaching experience for themselves and for their students. However, as earnest as their intents were, Phase VIII of the ICEA Project did not materialize. There were too many obstacles to overcome.

IX. CHAPTER 9. THE IOWA CHEMISTRY EDUCATION ALLIANCE—LONGITUDINAL SUMMARY, OBSERVATIONS, AND REFLECTIONS

As the ICEA Project manager, certain observations could be made over the four-year Star Schools funded period as well as beyond. Several themes can be recognized and their importance to successful continuity of the ICEA Project highlighted.

A. Original Project Development.

The idea of the *product* and *process* of the Iowa Chemistry Education Alliance was a good one. The Iowa State faculty who drafted the preliminary grant plan crafted their strategies well. Their choices for the master teachers who would put together the modules and associated curriculum were excellent. Without the energy, enthusiasm, drive, determination, and dedication of the original four teachers, the "Right Chemistry" of the entire ICEA Project would not have evolved. The professional development package offered to the original drafters of the ICEA materials created the dynamic and aggressive approach adopted by the Phase I teachers.

Teachers in Phases II, III, IV, and beyond had tremendous respect for the work of the Phase I teachers, their collaborators, and the curriculum they developed. They believed that without the original four people's work in module development and the belief that distance learning could revolutionize the way chemistry could be made real, the ICEA Project would not have been the success it had been. They valued the United States Department of Education Star Schools funding that made it possible for the four lead teachers and ISU support staff to draft, implement, and modify the ICEA Project materials. Renewed granting supported the Project for three more years.

The design of the Project was sound, doable, and interesting. It was well organized by motivated high school chemistry teachers using state of the art technology such as the ICN, electronic mail, CUSeeMe cameras, the Internet, and laboratory and graphic software programs. It was well-designed for chemistry teachers at *any* level of teaching expertise. This reflected the tremendous insight of the ICEA Principal Investigators in selecting the original ICEA Phase I teachers. They were recognized among peers as being dynamic and innovative—exactly the "Right Chemistry" for the ICEA Project.

B. Project Evolution

The ICEA Project was an exceptional one—a hallmark It was no wonder the DOE overseers requested a description of the ICEA Model. One phase of the Project transitioned to another relatively seamlessly. The teachers worked hard to make this happen. The ICEA Project was a delight to watch as it evolved. Facilitation of that process was not an overwhelming challenge, but rather, a privilege.

Principal Investigators for the ICEA Project demonstrated a particular insight in their strategies from the outset. Familiar with a number of Iowa's more talented and dynamic high school chemistry teachers, they approached four of the finest with the idea of the Iowa Chemistry Education Alliance.

1. The four teachers would draft a series of modules that would meet the National Science Education Standards (1996) and that could be incorporated into any existing high school chemistry curriculum without needing to modify either the curriculum or the modular materials. Module topics would be left to the teachers.

2. Activities would be hands-on, collaborative, real world, and motivating for students.

3. Students and teachers would collaborate on-site as well as across a distance via the Iowa Communications Network, electronic mail, the Internet, and CUSeeMe cameras.

4. Teachers would be provided a planning/professional development workshop during the summer prior to implementation of the ICEA Project. Project funds would purchase one period of the teachers' contracted time with their school for one entire academic year to allow work on the Project.

The four teachers were close colleagues prior to the Project. Little effort was needed to facilitate their working together efficiently. By the end of a three-week summer workshop, the teachers had prepared a skeletal outline of a series of eight learning modules, had prepared three of the eight modules, accompanying assessment rubrics, and were in the midst of drafting a fourth. Two teachers undertook primary responsibility for each module from design through implementation.

1. Phase I

As the first semester of the academic year progressed, students enthusiastically embraced the ICEA learning modules along with the opportunity to interact via the ICN. Teachers facilitated these modules along with their continued work on drafting four more modules and accompanying assessment rubrics to be implemented during the second semester. Weekly ICN "staff" meetings with ISU support personnel provided an avenue of communication wherein ideas were exchanged, strategies coordinated, and plans made for the upcoming week, the upcoming month, and the rest of the semester. These four teachers had tremendous vision—the ability to plan ahead as they dealt with the challenges of the present. Student focus groups at the end of the year were extremely positive in their overwhelming support for the ICEA Project and recommendation that it be continued. Teacher interviews also favored continuing the Project. Teachers revised curricular materials and assessment rubrics early in the summer following the first academic year. Edited materials were compiled into a notebook format. Three accompanying videotapes were created. The *product* and *process* of the ICEA had been devised. The ICEA Project, Phase I, had been a success. The Phase I teachers recommended that only four of the eight modules should be implemented in any given academic year. Integrating all eight of the modules had been too stressful and time-consuming for them and for their students. Incorporating four should accommodate and complement the existing curriculum better.

2. Phase II

Project Principal Investigators applied for Star Schools funding to continue the ICEA Project for a second year. To be successful, it was stipulated that the teacher pool be expanded, with a goal to include another eight instructors, some of whom should be from outside the central Iowa area. The four original teachers would mentor novice teachers, providing them with professional development opportunities in the use of the supplemental curriculum modules, use of the ICN technology, and any other useful guidance.

Because Phase II funding was not procured until November of that year, ICEA teacher "training" and ICEA ICN session scheduling could not begin until December, module implementation could not begin until January, after the end of first semester.

Four modules were implemented during the second semester. Students had enjoyed using the ICN, but Project personnel observed that students felt their activities were "add-ons" to the curriculum rather than a part of it, that they did not coincide with the material they were studying "in the book", and that they were moving at too fast a pace. Teachers agreed with this observation that the pace was too accelerated. They themselves wished that they had had more time prior to beginning ICEA work for learning about the modules and technology. Although the Phase I teachers were excellent mentors, Phase II teachers felt rushed and unprepared.

3. Lessons learned from Phases I and II

Lessons learned from Phases I and II included:

1. Start the ICEA Project at the beginning of the academic year in order to validate its integration into the existing curriculum. Have a plan in place for professional development for teachers, ICN scheduling for the schools, and funding to support these activities. Then it appears to be a part of the "regular" course.

2. Integrate two modules per semester to achieve the best "fit" in the existing curriculum.

3. Provide as much interactive ICN time for students as possible. Make groups at different schools interdependent on one another.

4. Phase III

The ICEA Project Phase III included an expansion to twenty-five schools with the addition of 13 more teachers to the Project. Phase III took all the successful aspects of Phases I and II, creating the overall "best" phase of the Project in terms of comfort level for both students and teachers. Funding for Phase III was available in time to incorporate a two-day opportunity for professional development for the teachers along with ICN planning time prior to the beginning of the academic year. Teachers became acquainted with one another. Experienced instructors mentored novices. Novice teachers completed experimental work for each of the modules in order to be familiar with the work their students would do. The ICEA Project "team" had gelled well prior to beginning the academic year. Modules were integrated into the curriculum in a timely fashion and implemented at a rate of two per semester. Students found the units to be motivating, relevant, and fun. Teachers as well as students felt comfortable with the pace.

5. Phase IV

The ICEA teachers and Project personnel were convinced that Phase III has most effectively achieved the Project goals of statewide dissemination and interactive implementation. Because Phase III of the ICEA Project was resoundingly successful, the teachers anticipated further expansion in Phase IV. Rather than extend the number of instructors, school sites, and students, Department of Education personnel requested a focus on impact rather than further dissemination. It was found that the ICEA Project helped students to learn (as supported by preliminary ICEA Diagnostic results), but the way in which teachers facilitated ICEA modules did not appear to differ from their approach to similar non-ICEA lessons. Although instructors perceived they had tried to create a more student-centered classroom environment, outside observation by a science educator did not support this perception.

6. After funding—Phase V and beyond

With minimal ISU personnel support available, ICEA teachers interested in continuing the ICEA Project garnered assistance from local administrators to continue the two-way interactive ICN student sessions. There was such strong support among administrators that no teacher who asked for financial aid was denied. Teacher belief in and student enthusiasm for the ICEA Project modules led to continued implementation long past the "official" grant period.

D. Professional Development

The ICEA Project provided an excellent opportunity for professional growth in many respects. As already noted, novices learned from mentors, and mentors learned from novices. On-site meetings at Iowa State University were organized to promote positive interdependence among the student groups and their teachers. Training to use technology or to integrate aspects of learning modules and their supporting videotapes was valued by teachers from all four phases of the Project. Processing time and discussions with the other teachers were invaluable. Opportunities to share experiences and Project success at meetings of the Iowa Science Teachers Association, the Iowa Academy of Sciences, National Science Teachers Association, American Chemical Society, and the Biennial Conferences on Chemical Education were useful experiences for presenters as well as excellent opportunities for promoting the Project to new audiences.

E. Networking

Teachers appreciated the opportunity to interact cooperatively with colleagues around the state. They cited several aspects of this component of the Project. Above all, the ICEA Project fostered camaraderie and respect among the participating teachers. By way of frequent communication and sharing of ideas (via the ICN, CUSeeMe, electronic mail, personal conversations, or on-site meetings), they admired one another's professionalism, commitment to the Project, and dedication to their students. Although Project novices were convinced that they especially benefited from the experiences of their mentors, experienced teachers appreciated the enthusiasm and fresh approaches introduced by newer teachers. They highly regarded the ability of the organization to evolve and change.

The ICEA Project served as an ongoing alternative to more formal professional development experiences. Each of the teachers learned as they progressed in the Project. All valued the ICEA Project for the opportunity to interact with two dozen dynamic, enthusiastic, energetic, knowledgeable colleagues. Communication was not limited to Project topics. Teachers constantly exchanged many ideas about explaining somewhat complex chemistry concepts or conducting exciting demonstrations, dealing with student and administrative challenges, and coping with their everyday workload.

F. Technology and Presentation Software

Teachers appreciated the opportunity have access to and to learn to use state of the art technologies (the Iowa Communications Network, electronic mail, CUSeeMe video cameras, and the Scanning Electron Microscope) to implement the curriculum. For the ICEA teachers, the typical ICN room was a technological work of art. Anyone using the room had access to front, rear, and overhead display cameras, a video cassette recorder, a computer, a slide projector, and a FAX machine.

Teachers felt that their students were advantaged by the availability of the technology. The integration of technology was enjoyable and rewarding for students. It expanded and improved their communication skills. They quickly learned to control all cameras, and took pride in switching seamlessly from the overhead display camera to the computer, to front and rear cameras. They projected a more poised and mature presence to peers.

For many, the Project was a first exposure to the use of the ICN. Teachers learned along with their students. They had had enough faculty development practice (via on-site training at Iowa State University) prior to the beginning of the term to appear to know what they were doing. Only they knew that they were just one step ahead of their quicker students! Frequently, the teachers became the first in their building to actively and regularly utilize the ICN room and all related technologies, providing an avenue for professional growth. Some became the resident "expert" in their building, some for their entire district. This was a source of pride for teachers and their students.

Students who learned to use the ICN classroom technologies and presentation software packages were given an advantage over peers in other classes who did not have the same opportunities. Certain students grew to be more competent at employing these technologies than some teachers in their own school building. In addition, the ability to use the ICN and presentation software tools were an asset to students in their outside work environment.

Development of the ICEA web site for getting background information and collecting data provided an option that had not been present in a more traditional curricular format. For some students (as well as teachers), this was a first experience of using any reference materials like the ICEA databases.

G. Teaching Materials

Teachers believed that the Iowa Chemistry Education Alliance Project was a good idea to begin with. It was not just a project for the sake of being a project. It had important and useful goals. The ICEA was a real life project that integrated interesting hands-on learning modules and different from traditional curricular materials to keep students interested (with the added benefit of retaining faculty interest).

There were good materials—the modules and accompanying videotapes that composed the ICEA Product were well designed. The quality of the activities was obvious. Modules could be integrated into any existing curriculum without disruption.

Even when not facilitating an ICEA module, teachers tried to use additional visual aids and tried to make laboratory activities increasingly more open-ended and student-directed across the curriculum than before the ICEA Project. This was a greater motivation for students and engaged them to a greater extent in the learning process.

H. Teaching and Learning Paradigm Shift

Instructors realized from the outset that the ICEA Project would not recreate the traditional teacher-centered classroom. Their charge was relinquishing control of student learning without compromising the quality of classroom activities nor straying too far afield from the "expected" curriculum. Chemistry topics were presented in a broader form. Although teachers may have been frustrated at times with being unable to "cover" a topic more quickly, the benefit of integrating technology with communication and science learning made the ICEA Project an outstanding contribution to student growth.

Student collaboration and communication skills were developed using higher order reasoning in a TEAM format, making science (chemistry) a real world experience. Students were accountable for preparing presentations and being a part of a group. They taught their peers. One anonymous student reflected on the benefits of that responsibility: "You retain 90% of what you teach."

The challenge of doing an experiment when the final answer was not immediately known was intriguing to teachers and broadened the curriculum. Students who were confronted by there not being one single "right" answer for the first time in their science careers found it disequilibrating.

I. Communication

Numerous interactions between ISU staff and teachers and among teachers (ICN "staff" meetings in conjunction with on-site summer and winter meetings, electronic mail messages, etc.) were critical to Project success. In the opinion of the Phase I teachers, the importance of the ICN to the ICEA Project cannot be emphasized enough! Without the availability of weekly ICN "staff" meetings and e-mail back-up, the Project would have struggled through Phase I. No avenue of communication was left unopened. Teachers shared teaching strategies about *all* topics in chemistry, not just ICEA modules. Teachers whose students continued to advanced placement or second year chemistry courses reported that those students recalled information previously encountered during their ICEA chemistry experiences and were able to make connections to what they were learning at the time.

J. Student Benefits

The use of the ICN was a motivating factor for students. They were excited to communicate with distant classmates. Teachers observed that ICN presentation days were eagerly anticipated by their students. They dressed more formally, they prepared more effectively. Their school was "on display" for the state to observe—they wanted to make a good impression.

Students became accountable for their own learning, that of their group mates, and that of students at a distance. They were responsible for doing presentations and being a part of a group. They learned to negotiate meaning in a social sense as well as to collaborate with peers, both local and distant. Many demonstrated an increased degree of poise and self confidence.

One teacher observed an "incredible" desire among her students to not let their peers, their teacher, or their school down. She did not believe there could be another, more compelling way to encourage the students to do their best. She noted that there were students who were in her classroom during days off, who e-mailed her at home, searching for ways to improve, because they were motivated to excel. By observing a variety of peer presentations and interactions, students evaluated what they found to be good and what they thought could be changed to improve them. During this process they became more mature in their outlook and more poised and sophisticated communicators and presenters.

Many ICEA classrooms expanded from their original size of ten or fewer students to include much larger classrooms of distant students. Students enjoyed seeing new faces and getting to share results with people other than their local classmates. Students enjoyed the fact that they could get away from a "normal" chemistry class routine and do different things with different schools and students. This was a desirable experience for students and teachers in more remote rural locations. Students liked the idea of being able to communicate with peers from different schools with whom they might not get to interact any other time outside sporting events. The students seemed to enjoy getting opinions from people other than those in their own classroom.

The students were intrigued by getting to use the ICN room to communicate with the other schools and students. They noted that using the ICN was a different learning environment and was something new that they found to be enjoyable. The new equipment made the learning process more interesting. Students understood that they would need to be familiar with using technology for their future careers and recognized that the ICEA Project allowed them the chance to become familiar with it. It was getting out of the normal lab and learning different things. They were motivated by using technology to learn and not just a book.

Students welcomed the opportunity to compare and share results. Also presenting to other schools was very interesting and exciting for the majority of the students. The idea that they could actually talk with and present to people in a different part of the state was another facet of this same theme. Students were able to see other students doing the same kinds of things they themselves were doing. It seemed surprising to some that students across the state were learning about the same kinds of chemistry concepts, doing the same homework assignments, and encountering the same kinds of problems and challenges. This developed mutual respect and support among the groups. Instructors appreciated the ability for certain quieter students to shine when some of their more popular or smarter peers floundered or stepped into the background.

Across the years of the ICEA Project, the forensics lab seemed to be the favorite ICEA learning module for the majority of the students. It brought real life applications of chemistry into the classroom. Students relished working together in their own classrooms as well as collaborating with distant classmates order to solve the "crime". In addition, students appreciated the variety of guest speakers volunteering to talk to them about the way in which forensic chemistry fits into their jobs. They recognized that they were seeing how chemistry could be applied in real job situations as an important idea of the module. Teachers observed that the forensics unit encouraged critical thinking skills more than any of the other modules. There was a notable increase in the amount of questioning between the students at distant schools, wondering how things were done, why things were asked, etc.

Student input was used to guide the evolution of the ICEA Project over time. The majority of feedback dealt with students wanting to schedule more time on the ICN either to talk to other students (i.e., socializing in order to develop a greater comfort level with distant classmates) or to make presentations. This dealt in part with disparate bell schedules across the state. Students correctly observed that schools on the same bell schedule could more efficiently plan meeting times via the ICN. Students also wanted to do more in-depth activities using the ICN, especially concentrating on interactive exercises rather than just sharing of similar information (data) so that they would be learning about *new* or *different* material. Finally, they believed that involving more students would be interesting.

K. ICEA Project Support Staff

Drafters of the ICEA Project determined that there would need to be a support staff at Iowa State University upon whom the ICEA teachers could depend for resources of all kinds. Administrative support actually had several components: personnel at Iowa State University, Iowa Public Television, the Iowa Communications Network, Area Education Agency 11, and administrators at the various individual schools. Coordination provided by the Iowa State University team facilitated the efforts of all of these support groups. United States Department of Education Star Schools funding provided financial support for Iowa State University staff, ICN air time, continued module revisions, meetings (ICN and on-site at Iowa State University), and teacher stipends.

The Iowa State University support team consisted of the Principal Investigators for the Project (Drs. Downs, Simonson, Greenbowe, and Phye) and the Project Managers (Charlie Schlosser and Kathy Burke) and team (the secretarial staff, and graduate and undergraduate student helpers). The four Phase I master teachers (Richard Ehlers, Ken Hartman, Jeff Hepburn, and Don Murphy) were also recognized as ISU support personnel in the role of peer mentors.

Teachers realized the insight of planners in organizing this infrastructure. The ICEA Project Manager (ICEA-PM) was readily accessible via electronic mail or telephone as were the Project's PIs. The ICEA-PM's team coordinated details of ICN scheduling, the planning and hosting of meetings, data collection and analysis, equipment procurement (instrumentation, hardware, and software), equipment coordination (lending and exchange when necessary), and technical and subject matter support. Having the ICEA-PM staff housed at Iowa State University provided a centralized location and ready access. By undertaking all of the responsibilities of facilitating the ICEA Project, support staff at ISU was tremendously useful to the Project. Without a single group available to coordinate their efforts, ICEA Project teachers from all phases did not think that the ICEA Project would have been as successful.

Electronic mail lists to allow frequent, immediate conversations were available to all participants. Assistance from the organizers who created the Project was available for its integration into the existing curricula around the state. The mentoring hierarchy made it possible for novices to understand how to comfortably incorporate ICEA modules in their curriculum via the advice received from their more experienced mentors. Advice about the order in which to implement certain learning strategies was tremendously useful to first-time adapters. There were many instances of instructors sharing simple stories of "here's what I did that worked..."

Teachers viewed the commitment of the leadership team (the first four Phase I teachers and ISU support staff) to see the program grow and be successful to be a key feature of the

Project. Without the genuine interest and support of the "founders", newer teachers felt there would have been a much more confusing and frustrating period of adjustment for them.

What was the most important aspect of the ICEA Project? There was no one single *most* important aspect. The vision and creativity of the Iowa State University educators who formulated the Project and the critical choice of the four original teachers who had the tenacity, creativity, and talent to develop and implement the content modules were fundamental to the Project. The ICEA Project was and continues to be both a dynamic and evolving *product* and *process* held together by the "Right Chemistry" of teacher and student enthusiasm and teacher motivation to "make it happen".

X. CHAPTER 10. THE IOWA CHEMISTRY EDUCATION ALLIANCE CONCLUSIONS

A. The Role of the ICN in the ICEA Project

The Iowa Chemistry Education Alliance Project probably did a better sales job for the use of the Iowa Communications Network than any prepared publication or brochure could ever do. News of the Project reached the target audience of high school chemistry teachers by way of word of mouth and local, state, national, and international meetings. Enthusiastic teachers from Phase I encouraged motivated colleagues to join them in Phases II through IV. Even after the ICEA Project was no longer sponsored by funding from the United States Department of Education, a feature article describing the ICEA curriculum (Myers, 2001) was included in *Fiber Optic Lines*, an Iowa Communications Network publication, in June 2001.

Student motivation produced quality ICN interactions across the state of Iowa. After the novelty of use of the ICN wore off, implementation of ICN technology became second nature to the students and their teachers. The ICN was just another educational tool, used specifically for communication. Expanding their classroom to include students at a distance DID, however, continue to motivate students.

The ICEA Project was the largest statewide interactive collaborative venture of its kind. For each new group who learned about the ICEA Project, it was a testimony to the successful integration of communications technologies into the classroom. Parents appreciated and approved of the opportunities experienced by their children as they participated in the ICEA Project. Some parents observed their own high school chemistry experiences would have been heightened by an ICEA-type program. In addition, there were numerous instances in which human interest stories about student involvement in the ICEA Forensics module appeared in local newspapers.

In addition, guest speakers came to appreciate the flexibility and usefulness of the ICN system for interactive sharing sessions conducted among distant sites. Student interest and preparedness for these sessions exceeded guests' (and teachers') expectations. Their self-imposed accountability was imperative to student productivity and success.

Guests found it rewarding to interact with students and motivating to interact with other scheduled guests during ICN sharing sessions. This created dynamic interchanges among sites. Students highly valued the opportunity to learn about real-world applications of chemistry via these guest interviews.

B. The ICEA Model

The ICEA Model provides a framework on which any discipline could build. One well-documented factor in the successful integration of the ICN into the classroom is a matter of instructor comfort and familiarity with the technology. A participating group of teachers who wish to pursue an ICEA-type of project must be provided an opportunity to successfully interact with each other and with the ICN room equipment prior to commencement of the project with students. These faculty development sessions make the difference between project success or failure, collaborative enthusiasm or mediocrity.

The instructor's seamless use of ICN technology provides students with a role model from whom to acquire a proficiency and respect for the use of the ICN. Without this outlook, students are not engaged in the success of the project. With this view, students easily implement the technology in the spirit of school and personal academic pride.

C. Future ICEA Work

1. New subject matter

The ICEA Model is flexible enough that it can easily be adapted to other areas outside of chemistry. This was seen to be true during Phase IV of the ICEA Project when the ICEA Model was successfully implemented in a ninth grade physical science course (previously described in Chapter 6).

At one time, there was an effort made to determine whether a group of physics teachers with the same drive and motivation exhibited by the Phase I teachers could be enticed to undertake creating and implementing student-centered physics learning modules with a focus on real-world problems. Although nothing concrete materialized, the proposed project generated genuine interest among Iowa high school physics teachers, including more than one of the ICEA Project chemistry teachers who also taught physics.

2. Elementary science

A move could be made away from the secondary and post-secondary school students to the elementary level. ICEA Project organizers could identify appropriately interested and motivated candidates among Iowa's elementary school science teachers. These teachers would need to have access to ICN equipment and electronic mail communication.

Using the ICEA "training" model, some of the ICEA high school chemistry teachers could be selected to be mentors and subject matter and content experts for a group of elementary teachers. The elementary teachers would be charged with the task of drafting some appropriate level-specific science modules that they could then implement in their own classrooms with the intent of sharing information and activities with students in distant classrooms. One important factor to consider is the lack of ICN classrooms in many of Iowa's elementary schools. More classrooms are now found in institutions at the secondary and post-secondary levels than at the elementary level. Another factor is the need for positive interdependence and a high level of interactivity. Elementary students would not tolerate "talking head" syndrome very well.

3. Use of the Internet

Much of the ICEA Project relied on the use of the ICN and electronic mail for communication. A more deliberate dedicated use of the Internet (e.g., a web-based discussion forum) could expand that tremendously. However, it should be noted that the two way audio-video capability of the ICN provided the spark to ignite student enthusiasm to interact with peers. Putting faces and voices with identities was a definite benefit that the faceless, voiceless medium of Internet or electronic mail communication could not achieve. In addition, the synchronous time factor of face-to-face two-way interactive ICN communication was invaluable in the progressive design, implementation, and modification of the ICEA curricular materials. Concerted use of CUSeeMe or i-Chat technology could make a significant contribution along with integrated use of the Internet in an ICEA expansion effort (Liu, Walter, and Brooks, 1998).

4. Move outside the state of Iowa

a. A FIPSE proposal for national expansion

At one time, ICEA teachers and ISU support personnel discussed inviting high schools in the states bordering Iowa to join the Project. Although cost concerns about technology were a matter of some importance, enthusiasm was still high. A high school chemistry teacher in Texas had heard about the ICEA Project and expressed an interest in networking and collaborating with the group. A proposal was submitted to the Funds for the Improvement of Post-Secondary Education in and attempt to create an interstate networking opportunity. The proposal received a lukewarm review and was not funded.

b. 18th Biennial Conference on Chemical Education workshop

Phase I teachers Ken Hartman and Don Murphy (now retired) and Richard Ehlers and Jeff Hepburn (currently teaching), presented a workshop about the ICEA at the 18th Biennial Conference on Chemical Education, which was held at Iowa State University in Ames, Iowa, July 18-22, 2004. They were joined by Phase II teacher Mary Fedderson. Twenty participants attended from sixteen states across the country (Arkansas, California, Colorado, Connecticut, Iowa, Kansas, Kentucky, Massachusetts, Michigan, Minnesota, Missouri, New York, Pennsylvania, Texas, Washington, and Wisconsin). The great majority of attendees were high school instructors.

The ICEA colleagues presented the ICEA philosophy and distributed module notebooks and the accompanying support videotapes to interested participants. They also showed the ICEA videotape "the Right Chemistry". They attempted to organize a group of teachers nationwide who would be interested in integrating the ICEA materials into their existing curricula. Student interaction could be organized nationwide via the Internet, probably using electronic mail exchanges.

Ken Hartman was enthusiastic and hoped to generate enough interest to develop a nationwide outreach project in. However, given the opportunity to organize some formal effort, the members of the group remained neutral. After the workshop, they did not interact with facilitators nor with each other. Ken believes they intended to integrate materials into their classes as they saw fit, but desired no networking options with others. "Although my thoughts were to get some continuity and possible connections, I didn't get the sense that there was much interest. Several did mention that they thought they could use some of the activities in their classrooms. Realistically, I don't expect this to go any further. In retrospect, I think we emphasized the ICN too much. Certainly (the videotape) 'The Right Stuff' really focused on it." He had hoped to report on the outcome of this work at the ChemEd meeting in Vancouver, B.C. in July 2005. That did not happen.

5. Evaluation

Most of the evaluation of the ICEA Project was qualitative in nature. A more quantitative study could be designed to track the performance of student participants from the ICEA Project versus the general student population for success in freshman chemistry classes at Iowa's three state institutions. Overtures were made to conduct such a study during Phase IV of the ICEA Project. Privacy issues were a concern. Because there was a plethora of red tape to overcome to obtain permission from the high schools to access student records to make the necessary correlations, the study was not undertaken. Permission would need to be secured from parents prior to their child's involvement and a plan outlined in order to collect baseline data, as well as to conduct a longitudinal study.

D. Reflections

From its inception to the present, creators and users of the ICEA materials have been among its most staunchly loyal supporters. A kernel of an idea in 1995 grew to a Project involving 1600 students and their teachers in 25 schools across the state of Iowa in just three years. The idea was sound, the strategies to implement it were well-grounded. Teachers watched students become more motivated, more independent, better critical thinkers. They became more confident, mature, and poised in their social interactions. That is why the ICEA Project was still in use in Iowa high school chemistry classes several years after federal funding ended. Aspects of the Project can be observed in today's classroom.

"I think that the network of teachers that you and the other ISU people put together for the ICEA Project was great. I still see many teachers and have received e-mails from others. I will always remember the ICEA as a good part of my teaching experience" (unidentified ICEA Project instructor, Spring 2003).

Epilogue

This goal of writing this dissertation was to document the dynamic process and product called the Iowa Chemistry Education Alliance. Most of the ICEA story is a success. Drs. Gary Downs (Professor of Curriculum and Instruction), Tom Greenbowe (Professor of Chemistry), and Mike Simonson (Professor of Curriculum and Instructional Technology) at Iowa State University suggested that Iowa high school chemistry students could engage in collaborative interactive telesessions using the Iowa Communications Network. Familiar with Iowa's high school chemistry teacher cadre, they invited Richard Ehlers (Perry High School), Ken Hartman (Ames High School), Jeff Hepburn (Dowling High School), and Don Murphy (Hoover High School) to formulate the process and create the product of the Iowa Chemistry Education Alliance. The four teachers were an excellent choice. Each espoused an enthusiastic and focused work ethic.

These four teachers created the *product* of the ICEA modules and accompanying videotapes. Along with the teachers, Iowa State support personnel played a role in creating the ICEA *process*—designing and implementing strategies for welcoming, preparing, and mentoring the teachers who would participate in the ICEA Project. These two groups worked seamlessly in tandem. This was Phase I.

Through three more years, the Project grew to 1600 students in 25 schools across the state or 4000 students at 25 schools over four years. Each year, novice teachers were mentored by previously experienced teachers. Students enthusiastically engaged in hands-on active learning chemistry exercises, using the ICN to collaborate and interact.

Although federal funding for the ICEA Project was terminated, the ICEA success story did not end. Teachers continued to implement the ICEA Model, expanding high school chemistry classrooms and broadening student active learning experiences statewide by opening their individual microcosms to the world of distant colleagues and peers.

APPENDIX A
ICEA TIMELINE OF ACTIVITIES
PHASE I - PHASE IV

Appendix A
ICEA Timeline of Activities 1995-1997
Phase I

December 1995

Four master teachers met at Iowa State University to provide input to drafting the Star Schools Iowa Chemistry Education Alliance proposal.

January -May 1996

Iowa State University personnel arranged summer workshop for the ICEA teachers

June-July 1996

Four teachers convene at Iowa State University for pre-service training

1. Distance learning
2. Cooperative learning
3. Learning Styles

Four teachers and project personnel draft an outline of supplemental high school chemistry curricular materials

Four teachers work to create first four modules, tentatively draft second four

Four teachers return to their own schools to continue fine-tuning the modules

August 1996

Students at four high schools introduced to ICN classroom technologies

Students practice using ICN equipment, not live

Students interview distant classmates via e-mail or FAX to prepare introductions to be delivered via the ICN

Teachers meet weekly with each other and ISU project personnel via the ICN to continue to touch base and plan for future in-class, laboratory, and ICN work

September 1996

Students make introductions of distant peers via the ICN

Students present report about favorite element/chemical via the ICN using video technologies, presentation software, and visual media

Weekly ICN "staff meeting" between teachers and ISU project personnel to continue to touch base and plan for future in-class, laboratory, and ICN work

October 1996

Four ICEA Phase I teachers took hands-on PowerPoint workshop

Four ICEA Phase I teachers presented synopsis of ICEA planned activities at Iowa Science Teachers Association Meeting

Four ICEA Phase I teachers taught PowerPoint to their own students

Students worked on Module 2:

Ken Hartman taught lesson on Statistical Analysis

Students did experimental analysis to determine densities of diet and regular varieties of different brands of sodas

Students shared results via e-mail and ICN presentation

Weekly ICN "staff meetings" between teachers and ISU project personnel continued

November 1996

Module 3—Students were given 5-component mixture to analyze

Students collaborated on-site to propose method of separation

Students collaborated via the ICN to discuss their proposed method of separation with a group of distant peers charged with the same task

Students collaborate on-site to execute the actual separation

Weekly ICN "staff meetings" between teachers and ISU project personnel continued

December 1996

Weekly ICN "staff meetings" between teachers and ISU project personnel continued

Teachers facilitate Module 4 (Forensics) with students at their individual schools

Students interview guest forensic experts during an ICN meeting

Students share results of forensics investigation via ICN meeting

January 1997

Teachers facilitate Module 5 (Instrumentation/copper coins) with students at their individual schools

Students share results via ICN meetings

February 1997

Teachers facilitate Module 6, Analysis of Vitamin C

Students at different schools compare different kinds of juices

Students do Web search about Vitamin C

Sharing results of vitamin C Web search and experimental results

Teachers identified topics of interest for students to select for reporting

Iowa Distance Learning Association meeting, Ames

March 1997

Teachers facilitate Module 7 (Student Reports)

Students share results via ICN meetings

April 1997

Teachers facilitate Module 8 (Water Analysis) with students at their individual schools

Students collect water samples at locations around the city, from water fountains, and from the school swimming pool

Students run five or more tests on water samples with Hach kits

Students share results of water investigations via ICN meeting

Iowa Academy of Sciences meeting, Dubuque

May 1997

Post-project demographic survey of students administered

Student focus groups conducted at all four schools

Statewide informational ICEA ICN dissemination meeting

IP-TV and Iowa State Department of Education send out ICEA brochure to state high school chemistry teachers

June-August 1997

On-site (ISU, Ames) meeting of ICEA teachers to debrief about Phase I

Post-project PORGI (Perceived Innovativeness of the Organization) survey and Post-personal Innovativeness Survey administered to teachers

Focus group conducted

Module modifications incorporated and modules reproduced for dissemination

Draft of ICEA Phase I final report

September 1997

Submit ICEA Phase I final report

Appendix A
ICEA Timeline of Activities 1997-1998
Phase II

October 1997

Four ICEA Phase I teachers present synopsis of ICEA activities 1996-7 at Iowa Science Teachers Association Meeting

November 1997

Star Schools moneys awarded for ICEA Phase II

Eight new teachers identified and contacted to participate in ICEA Phase II

December 1997

Twelve teachers meet, train, schedule ICN sessions

Teachers split themselves into two organizational groups, the A and B groups

Pre-project PORGI (Perceived Innovativeness of the Organization) survey and Pre-personal Innovativeness Survey administered to teachers

January 1998

Pre-project demographic survey of students

Twelve-teacher "staff" meeting—scheduling of periodic subgroup "staff" meetings for the A and B groups

February 1998

Teachers facilitate Modules 1 (Introductions) and 2 (Data Analysis) with students at their individual schools

Students interact via ICN meetings

ICN introductions of partners at paired schools

Favorite element/chemical presentation

Sharing results of statistical analysis of soda

Iowa Distance Learning Association meeting, Ames

March 1998

Teachers facilitate Module 3 (Instrumentation) with students at their individual schools

Students share results via ICN meetings

April 1998

Teachers facilitate Module 4 (Forensics) with students at their individual schools

Students interview guest forensic experts during an ICN meeting

Students share results of forensics investigation via ICN meeting

Iowa Academy of Sciences meeting, Mason City

May 1998

Post-project demographic survey of students administered

Student focus groups conducted at Adel, Ames, Dowling, Hoover, Perry, and Valley High Schools

Statewide informational ICEA ICN dissemination meeting

IP-TV and Iowa State Department of Education send out ICEA brochure to state high school chemistry teachers

June 1998

On-site (ISU, Ames) meeting of ICEA teachers to debrief about Phase II

Post-project PORGI (Perceived Innovativeness of the Organization) survey and Post-personal Innovativeness Survey administered to teachers

Two faculty focus groups conducted: Phase I and Phase II teachers interviewed separately

Draft of ICEA Phase II Final Report

July 1998

Submit draft ICEA Phase II final report

August 1998

Preliminary preparation workshop for ICEA Phase III

September 1998

Delivery of ICEA modular materials to IP-TV for dissemination to Iowa high school teachers

Submit ICEA Phase II final report

Appendix A
ICEA Timeline of Activities 1998-1999
Phase III

August 1998

Preliminary preparation workshop for ICEA Phase III

Twenty-three teachers meet, train, schedule ICN sessions

Teachers split themselves into six organizational groups, the Red, Orange, Yellow, Green, Blue, and Tan groups

Pre-project PORGI (Perceived Innovativeness of the Organization) survey and Pre-personal Innovativeness Survey administered to teachers

Pre-project demographic survey of students

September 1998

Delivery of ICEA modular materials to IP-TV for dissemination to Iowa high school teachers

Submit ICEA Phase II final report

October-November 1998

Teachers facilitate Modules 1 (Introductions) and 2 (Data Analysis) with students at their individual schools

Students interact via ICN meetings—2000 Iowa high school chemistry students share lab data and results via the ICN

ICN introductions of partners at paired schools

Favorite element/chemical presentation

Sharing results of statistical analysis of soda

27 Iowa high school chemistry teachers conduct bi-monthly "staff" meetings via the ICN

December 1998

ICEA tri-fold brochure designed

Phase III teachers meet, debrief about 1st semester

Teachers work through two modules scheduled for Spring Semester 1999

Teachers arrange equipment sharing pool for Module 3, Instrumentation, and evidence packages for Module 4, Forensics

January 1999

Twenty seven teachers meet in pre-scheduled "staff" meetings for the Red-Tan groups

February 1999

Meet with IP-TV/Iowa Department of Education liaison, Joen Rottler—broadening the horizons of ICEA

ICEA brochure delivered

Teachers facilitate Module 3 (Instrumentation) with students at their individual schools

March 1999

Teachers facilitate Module 3 (Instrumentation) with students at their individual schools

Students share results via ICN meetings

April 1999

Teachers facilitate Module 4 (Forensics) with students at their individual schools

Students interview guest forensic experts during an ICN meeting

Students share results of forensics investigation via ICN meeting

Iowa Academy of Sciences meeting, Ames

May 1999

Post-project demographic survey of students administered

Student focus groups conducted at Adel, Ames, Dowling, Hoover, Perry, and Valley High Schools, DSM East

Statewide informational ICEA ICN dissemination meeting (May 20, 1999)

June 1999

On-site (ISU, Ames) meeting of ICEA teachers to debrief about Phase III

Post-project PORGI (Perceived Innovativeness of the Organization) survey and Post-personal Innovativeness Survey administered to teachers

Three faculty focus groups conducted: Phase I, II, and III teachers interviewed separately

Draft of ICEA Phase III final report

July 1999

Submit draft ICEA Phase III final report

August 1999

Preliminary preparation workshop for ICEA Phase IV

September 1999

Submit ICEA Phase III Final Report

Appendix A
ICEA Timeline of Activities 1999-2000
Phase IV

August 1999

Preliminary preparation workshop for ICEA Phase IV

Twenty-three teachers meet, train, schedule ICN sessions

Teachers split themselves into six organizational groups: Einsteinium, Gold, Platinum, Plutonium, Silver, Titanium

Pre-project PORGI (Perceived Innovativeness of the Organization) survey and Pre-personal Innovativeness Survey administered to teachers

Pre-project demographic survey of students administered

ICEA Diagnostic drafted

Submit ICEA Phase III final report

Dr. Downs surveyed ICEA teachers to obtain their input concerning the ICEA Model (Appendix D).

September 1999

Pre-ICEA Diagnostic administered

ICEA Module 1 activities begin

October-November 1999

Teachers facilitate Modules 1 (Introductions) and 2 (Data Analysis) with students at their individual schools

Students interact via ICN meetings—2000 Iowa high school chemistry students share lab data and results via the ICN

ICN introductions of partners at paired schools

Favorite element/chemical presentation

Sharing results of statistical analysis of soda

October-November 1999 (cont'd)

27 Iowa high school chemistry teachers conduct bi-monthly "staff" meetings via the ICN

ICEA Presentation at Iowa Science Teachers Association Meeting, Des Moines Convention Center

ICEA Video completed

ICEA ICN Presentation at Grant Wood Technology Fair, Prairie HS, Cedar Rapids

December 1999

Phase IV teachers meet, debrief about 1st semester

Dr. Downs prepared focus group questions to administer to ICEA teachers attending the December ICEA Teachers Meeting to obtain their input concerning the ICEA Model

Teachers talk about and modify two modules scheduled for Spring Semester 1999

Teachers arrange equipment sharing pool for Module 3, Instrumentation, and evidence packages for Module 4, Forensics

Teachers learn about Web CT

Teachers learn about Scanning Electron Microscope features

January 2000

Twenty seven teachers meet in pre-scheduled “staff” meetings for the Einsteinium, Gold, Platinum, Plutonium, Silver, and Titanium groups

Working with teacher input provided by the Teacher Survey and Focus Group feedback, Dr. Downs drafts and refines the ICEA Model document

Working with teacher input provided by the participating schools, Dr. Greenbowe works to track ICEA students who have matriculated to Iowa State University, the University of Iowa, and the University of Northern Iowa

February 2000

Teachers facilitate Module 3 (Instrumentation) with students at their individual schools

March 2000

Teachers facilitate Module 3 (Instrumentation) with students at their individual schools

Students share results via ICN meetings

April 2000

Teachers facilitate Module 4 (Forensics) with students at their individual schools

Students interview guest forensic experts during an ICN meeting

Students share results of forensics investigation via ICN meeting

Iowa Academy of Sciences meeting, ???

May 2000

Post-project demographic survey of students administered

Post-project ICEA Diagnostic Exam

June 2000

On-site (ISU, Ames) meeting of ICEA teachers to debrief about Phase IV

Post-project PORGI (Perceived Innovativeness of the Organization) survey and Post-personal Innovativeness Survey administered to teachers

Three faculty focus groups conducted: Phase I, II, and III teachers interviewed separately

Draft of ICEA Phase IV final report

July 2000

Submit draft ICEA Phase IV final report

Copies of the ICEA Model document will be made available to ICEA participants and staff.

August 2000

Preliminary preparation workshop for ICEA Phase V?

September 2000

Submit ICEA Phase IV final report

APPENDIX B
ICN PROTOCOL AGREEMENT

APPENDIX B
ICEA ICN Protocol Agreement
Fall 1999

The Iowa Chemistry Education Alliance is a model program for the state of Iowa and the rest of the nation. Educators from other sites will be monitoring our ICN sessions either live or by tape; it is imperative that we set a good example.

We ask that students conduct themselves in a manner that will reflect the best of the ICEA, your school, your state, and your family. Please refrain from derogatory remarks, improper language, improper dress, or misuse of electronic mail. Remember that we are guests in someone else's classroom.

Enjoy the opportunity that we have to learn, be innovative, and be a part of a pioneering program.

APPENDIX C
DEPARTMENT OF EDUCATION CONTENT STANDARDS AS MATCHED TO THE IOWA CHEMISTRY EDUCATION ALLIANCE SUPPLEMENTAL INSTRUCTIONAL MATERIALS

Appendix C
DEPARTMENT OF EDUCATION CONTENT STANDARDS
as Matched to the
Iowa Chemistry Education Alliance Supplemental Instructional Materials

The ICEA Supplemental Instructional Materials include:

Written Modules

1. Communication Tools and Protocols
2. Data Analysis
3. Laboratory Separations
4. Forensics
5. Instrumentation
6. Vitamin C Analysis
7. Research Reports
8. Water Analysis

Videos

Iowa Communications Network
Statistics
Department of Criminal Investigation

Science as Inquiry:

Content Standard A:

As a result of activities in grades 9-12, all students should develop

- *abilities necessary to do scientific inquiry*
- *understandings about scientific inquiry*

Guide to the content standard

Fundamental abilities and concepts that underlie this standard include:

- Abilities necessary to do scientific inquiry
  - Identify questions and concepts that guide scientific investigations
    —Modules 2, 3, 4, 5, 6, 8
  - Design and conduct scientific investigations
    —Modules 2, 3, 4, 5, 6, 8
  - Use technology and mathematics to improve investigations and communications
    —Modules 1, 2, 3, 4, 5, 6, 7, 8; Videos: ICN, Stat, DCI
  - Formulate and revise scientific explanations and models using logic and evidence
    —Modules 2, 3, 4, 5, 6, 8; DCI Video
  - Recognize and analyze alternative explanations and models
    —Modules 3, 4; DCI Video
  - Communicate and defend a scientific argument
    —Modules 1, 2, 3, 4, 5, 6, 7, 8; ICN Video
- Understandings about scientific inquiry
  - Scientists rely on technology to enhance the gathering and manipulation of data
    —Modules 2, 3, 4, 5, 6, 8; Videos: ICN, Stat, DCI
  - Mathematics is essential in scientific inquiry
    —Modules 2, 4, 5, 6, 8; Stat Video

Scientific explanations must adhere to criteria such as: proposed explanation must be logically consistent, abide by the rules of evidence open to questions and possible modification, based on historical and current scientific knowledge
—Module 4; DCI Video
Results of scientific inquiry—new knowledge and methods—emerge from different types of investigations and public communication among scientists
—Modules 2, 3, 4, 5, 6, 8; DCI Video
Developing Student Understanding
—Modules 1, 2, 3, 4, 5, 6, 7, 8; Videos: ICN, Stat, DCI

Physical Science:

Content Standard B

As a result of activities in grades 9-12, all students should develop an understanding of

- *chemical reactions*

Guide to the content standard
Fundamental concepts and principles that underlie this standard:

- Chemical Reactions
  A large number of important reactions involve the transfer of either electrons or hydrogen ions
  —Modules 5, 6

Science and Technology

Content Standard E:

As a result of activities in grades 9-12, all students should develop

- *abilities of technological design*
- *understandings about science and technology*

Guide to the content standard
Fundamental abilities and concepts that underlie this standard include:

- Abilities of technological design
  Propose designs and choose between alternative solutions
  —Modules 4, 5, 6
  Evaluate the Solution and Its Consequences
  —Modules 4, 5, 6
  Communicate the problem, process, and solution
  —Modules 1, 2, 3, 4, 5, 6, 7, 8; Videos: ICN, Stat, DCI
- Understandings about science and technology
  Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence
  —Modules 4, 5, 6, 7, 8; DCI Video
  New technologies extend the current levels of scientific understanding and introduce new areas of research
  —Modules 4, 5; DCI Video
  Creativity, imagination, and a good knowledge base are all required in the work of science and engineering
  —Modules 2, 4, 5; Videos: Stat, DCI

Science in Personal and Social Perspectives

Content Standard F

As a result of activities in grades 9-12, all students should develop understanding of

- *personal and community health*

Guide to the content standard

Fundamental concepts and principles that underlie this standard include:

- Personal and community health

  Selection of foods and eating patterns determine nutritional balance; personal and social factors—such as habits family income, ethnic heritage, body size, advertising, and peer pressure—influence nutritional choices

  —Modules 6

History and Nature of Science

Content Standard G:

As a result of activities in grades 9-12, all students should develop an understanding of

- *Science as human endeavor*
- *Nature of scientific knowledge*

Guide to the content standard

Fundamental abilities and concepts that underlie this standard include:

- Science as human endeavor

  Individuals and teams have contributed and will continue to contribute to the scientific enterprise

  —Modules 2, 4, 5, 6; Videos: Stat, DCI

- Nature of scientific knowledge

  Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, striving for the best possible explanations about the natural world

  —Modules 2, 3, 4; Videos: Stat, DCI

  Scientific explanations must be consistent with experimental and systems; they should be logical, respect the rule of evidence, be open to criticism, report methods and procedures, and make knowledge public

  —Modules 2-6; Videos: Stat, DCI

APPENDIX D
THE IOWA CHEMISTRY EDUCATION ALLIANCE MODEL PROCESS AND PRODUCT

Appendix D
The Iowa Chemistry Education Alliance Model
Process and Product

The Iowa Chemistry Education Alliance. The Iowa Chemistry Education Alliance has been a unique and valuable Project for Iowa high school chemistry teachers and their classes. In the seven years of its existence, the ICEA has impacted twenty-nine teachers and over 4,500 high school chemistry students. It has allowed students and teachers alike to step out of the confines of their individual classrooms and to share information via cutting edge technologies including interactive television, electronic mail, and the Internet. Collaborative activities engage students in cooperative on-site investigation of a problem, assessment of problem-solving strategies, evaluation of results, and ensuing intra- and inter-classroom discussions. Students talk with others in their own work group, classroom colleagues, and peers at distant schools linked via either Internet or Iowa Communications Network teleconferencing. Teachers network with colleagues across the state to promote student-centered learning opportunities as well as engender professional development via collaboration, discussion, and information exchange.

How was the ICEA Project developed? In the Fall of 1995, Iowa high school chemistry teachers were surveyed by the Iowa Chemistry Education Alliance to determine their needs for and attitudes toward technology, communication, and collaborative activities (Schlosser, 1997). It was found that:

a. Iowa's high school chemistry teachers had had little opportunity for communication with other chemistry teachers around the state, but believed that it was important that they increase communication with their peers.

b. Iowa high school chemistry teachers wanted to increase student-centered cooperative and discussion-type activities in their classroom and de-emphasize the traditional lecture mode.

c. Iowa high school chemistry teachers were not using the Iowa Communications Network, ICN, Iowa's two-way interactive fiber optic communication system, but believed that it was "somewhat important" that they use the ICN at least on occasion.

In December 1995, four exemplary high school teachers were asked to participate in the drafting of a Star School grant proposal that would focus on the Product and Process of the ICEA

. **The Product.** The ***product*** would include the features listed below.

1. *A series of varied supplemental chemistry modules would be created that could be integrated into the traditional curriculum.* These would be print materials. They would be based on the National Science Education Standards (1996). The traditional teacher-directed "lecture" would be replaced with student-directed learning modules (Cyrs, 1997).

2. *These modules would incorporate active learning methods and collaborative exchanges among students within a school classroom and across a distance by using the Internet and the Iowa Communications Network.* Why use the ICN? It would provide students at a distance with the same learning opportunities as the students on site (Cyrs, 1997; Simonson, Zvacek, Smaldino, and Albright, 2000). Learning via interactive distance education would favor the student-centered classroom as opposed to the teacher-centered classroom (Cyrs). Students would become more active and cooperative in the learning process in interactive television sessions (Cyrs).

One aspect of distance education involves the delivery of materials at the same time in different locations. Students receive materials synchronously and are able to interact with each other and their instructors in real time. There has, therefore, been a paradigm shift in the ICEA Project away form the same-time, same-place traditional classroom learning environment (Simonson et al., 2000). Students are able to learn at the same time in a variety of different locations using one or more technologies (the ICN, the Internet, and CUSeeMe). Herring (1997) states, "Due to the interactive character of distance learning technologies, students and instructors alike have access to tools that are adaptable, investigative, and open to a myriad of uses, both academic and nonacademic (social) in nature. Their availability for use in life contexts can change the way students and teachers operate, think, perform, and acquire," p. 57.

Studies looking at the learning outcomes of students in conventional and television classes have found that the students in televised classrooms had no significant differences in learning outcomes. Television is a delivery system that provides the opportunity to deliver material to more than one location without changing it an any fashion. There is no influence on the quality of instruction by the technology employed to deliver it. It provides students at a distance with the same learning opportunities as the students on site (Cyrs, 1997; Simonson et al., 2000).

The proximity of the instructor does not influence the outcome of learning. Students learn from a well-designed curriculum that is facilitated well. Simonson and Schlosser (1995) confirm that students learning at a distance achieve at an equivalent level to those learning on site in the more traditional setting with instructor on site. Simonson and Schlosser and Simonson et al. (2000) note that students engaged in distance learning sessions have shown even a higher level of knowledge of the subject following instruction than do their local counterparts (on-site learners).

3. *Supporting videotapes would be designed to accompany the printed materials.* In order to facilitate student-centered learning, a series of videotapes designed to provide an overview of distance learning concepts, the ICN, the ICN classroom, and related technologies, as well as relevant topical materials were developed. These included three videotapes: *"Foundations and Applications of Distance Education", "Data Analysis and Basic Statistics",* and *"Tour of the Iowa Division of Criminal Investigation Criminalistics Laboratory".*

The Process. The ICEA design ***process*** could become a model for the development of supplemental curricula in any discipline. In order to put together an endeavor like the ICEA Project, there were certain considerations to bear in mind. Most had to do with assuring the comfort level of the teachers who would participate in using new teaching tools and developing a new teaching paradigm.

“Ultimately, it is the opportunity for meaningful involvement, professional development, and institutional support that are the key factors in promoting faculty receptivity and significant contributions to distance education programs" (Merkley, Bozik, and Oakland, 1997, p. 39). Teachers needed to assume some degree of ownership of the ICN to be comfortable with its use as a communication tool.

Teachers profited from interaction with colleagues as they grappled with learning about the teaching environment of distance education. Bringing together a group of neophytes to engage them in the formative process was beneficial to all involved. Bigilaki, (1997) had found that neither participants’ years of experience nor educational level has an effect on their beliefs as to whether curriculum competencies can be taught via an interactive teleteaching classroom. Therefore, the audience was receptive to whatever could be learned. Additionally, it was found that participants’ years of experience as an instructor does not affect knowledge, ability, interest, and feelings as related to interactive teleteaching techniques (Bigilaki).

In any telelearning environment, it is the teacher who determines whether or not the technology is used effectively to enhance student outcomes, so the teachers needed to be completely comfortable with and knowledgeable of the ICN fiber optic system and its capabilities. Teachers of science, especially, face obstacles unique to them when trying to design materials that allow the incorporation of the laboratory experience into a distance learning environment. This factor alone may make science the most challenging subject to be taught at a distance (Tillotson and Henriques, 1997). This is why planning and support staff who designed the ICEA formative sessions provided the teachers with as broad an exposure to as many separate but intertwined ideas for paradigm change as possible. It is also why the ICEA master teachers designed their materials to use the ICN as a communication tool to be used for discussion of real-world hands-on collaborative laboratory activities, rather than as a traditional "talking head" telling mechanism. Telling *IS NOT* teaching. Sharing information with peers *may* evoke a learning event if the distant and local learners can be motivated to become *engaged* in the process.

Cyrs (1997) and Simonson et al. (2000) summarize principles of effective teleteaching and telelearning. A series of their recommendations follow.

1. *Teachers and learning materials should encourage active learning by creating an active teleclassroom that gets students involved in their own learning.* The ICEA Project provides students with real-world hands-on learning activities that lead them to interactive discussions and exercises via the ICN.

Activities must be relevant, meaningful, and doable. Students must be engaged in the learning process. The focus is on higher level application and critical thinking skills. To keep their attention, students should be involved in activities and exercises between 30-50% of the time.

Students must learn through discovery and exploration. The teacher must be the guide who facilitates this process.

Activities must be prepared to allow the students to have fun as they learn so that they want to pursue the topic(s). This is the challenge to developers of instructional materials.

2. *Teachers communicate high expectations that students perceive as achievable.*

Cyrs (1997) recommends that the students be convinced that they can succeed in the modular learning activities and can use what they have learned. This is the reason real world tasks have been designed for the ICEA Project.

3. *Teachers emphasize time on learning tasks.*

For the more open-ended design of the ICEA learning modules, students must learn to manage their time appropriately. Airtime is also limited, so that the students must prepare well to efficiently utilize the time allotted to them. If they spend part of their time organizing in front of the camera, their distant classmates will be bored and less apt to pay attention to them when they start their presentation or to take seriously the material being presented.

4. *The teachers respect diversity in the classroom and different ways of learning.*

Teachers model appropriate behaviors in the ICN classroom. They discourage any snide remarks, criticisms, sarcasm, or any type of remark or behavior that might embarrass any student. Respect for ethnic and popular beliefs is fostered. The push to talk microphones may not pick up harsh comments but the teacher microphone could. The ICEA teachers agreed upon a code of behavior to be read to all participants prior to their first on-air session (see Appendix B of the dissertation).

5. *Teachers encourage student and instructor contact before and after class.*

The teacher must remember that her or his impact on the students is greater before and after class than it is *during* class. During class, she or he merely facilitates a student-centered atmosphere.

6. *Teachers promote cooperative learning among students.*

The thrust of the ICEA Project is to promote student-student and student-teacher interaction and learning. The premise of cooperative learning is that knowledge is socially constructed. No *one* individual on the team contributes more than the team as a whole. The strength of the team is the sum of its parts. Critical thinking is fostered by teamwork. Evaluation has a two-fold emphasis: the group project provides a common grade for each team member and the individual is assessed regarding her or his contribution to the group effort by instructor and peer appraisal.

7. Teachers provide prompt feedback to students on learning achievement.

Cyrs (1997) recommends positive timely input from instructors to their students. In addition, Cyrs encourages instructors to solicit feedback on how the class is going for the students.

8. *Teachers communicate and connect teaching and learning goals and objectives in ways that students understand them.*

In order for student-centered learning to be effective, students should have some idea of their own learning goals. The object of each ICEA module should be made clear to them so that they are working toward an understanding of a concept.

9. *Teachers connect new information to prior knowledge.*

Teachers in the ICEA Project have designed successive lessons to build on earlier ones. Students should build their *new* knowledge on the scaffold of *prior* understanding.
Using their real world module experiences to make the connection between past knowledge and new information will make the students into more independent, self-reliant learners.

10. *Teachers organize information in personally meaningful ways in the telecourse and lecture organization, syllabus design, and handouts to show the content structure.*

Anything that classmates can do to help one another to organize their learning experiences in a better way is beneficial to the success of learner outcomes.

11. *Teachers provide appropriate practice for transfer and application of skills.*

A student might know facts, but not know how to apply what she or he knows. For this reason, the real-world applications of chemistry concepts and principles as illustrated by the ICEA learning modules are useful in the transfer or application of chemistry knowledge.

12. *Teachers motivate students any way possible: They tell them why they should learn something, the benefits to them if they learn it, and how they will be able to apply the skill or data immediately.*

If teachers model enthusiasm for learning, students will benefit from their example. Televised sharing sessions via the ICN by guests who are experts in the field of forensics have been extremely popular with students and teachers alike. Guests have been so motivated by student questions that they have extended the duration of the time spent visiting with students. Students have been so enthusiastic about guest sharing sessions that they have generated a number of spontaneous questions to supplant the "canned" questions previously drafted for the session. Guests have returned to the school on their own time to continue working with students.

13. *Teachers promote high levels of learning by designing tests, questions, activities, and exercises that are based on high-level learning performance objectives since students learn in the way in which they are assessed.*

Students who are assessed on the basis of higher order critical thinking skills and application of concepts are apt to recall more than those tested over memory recall alone.

14. *Teachers visualize key concepts and ideas and communicate that visual picture.*

Students "play" with technology every day. They are comfortable "Internet surfing". They play video games and computer games. They communicate via electronic mail. They have been used to being videotaped for posterity since infancy. It is, however, somewhat novel to them to apply these technologies to their schoolwork. Teachers should capitalize on this familiarity to encourage them to utilize as many of these technologies as they are able to prepare collaborative lessons for ICN presentation. Students have a marvelous ability to create presentations that their instructors could not even imagine.

15. *Teachers articulate their philosophy and model of teaching and learning.*

By undertaking the collaborative ICEA modular learning units, teachers validate their belief in the student-centered classroom. They relinquish "control" so that the students design and modify their own learning. Teachers serve as resource personnel as the students become accountable for their learning. The more the teachers model good practices of facilitating and mentoring, the more seriously students will take the responsibility of learning on their own.

16. *Teachers know who they are as a teacher and they know the priority of teaching in their career.*

Skills for teaching at a distance can be more important in that venue than in a traditional classroom. The ICEA Project activities were designed to avoid the "talking head" syndrome that has become associated with televised delivery systems. Communication among students at various sites was made to be more interactive and less "delivery"-oriented.

17. *Teachers are provided training.*

Because lack of training is the largest single problem of teleteaching, it was one of the first considerations in the preparation of the four master teachers for participation in the ICEA. To hone their communication skills, they were provided with training in cooperative learning, learning styles, and distance teaching and learning techniques. With this background, they were able to incorporate lessons and exercises to accompany the ICEA modules they designed with the express purpose of training their students to collaborate interactively using ICN technology.

18. *Teachers are provided support.*

The second most important facet of the ICEA Project was the support provided to the ICEA teachers by faculty and staff at Iowa State University. This assistance was crucial to the success of the Project (Ehlers, Hartman, Hepburn, Murphy, personal communication, June, 1997).

19. *Teachers provide guidance to students in the preparation of their materials.*

Materials needed to be prepared in a more detailed way for students struggling to understand the approach that they needed to take to communicate effectively via two-way interactive technology systems (Cyrs, 1997). They were encouraged to refine their presentation skills, prepare more visually appealing graphics, in order to engage their distant classmates. Scribbling figures at the last minute on a piece of notebook paper may work in the local classroom, but does not serve to enhance a telelesson.

Students found that the traditional preparation of presentation materials fell short of meeting the needs of distant learners. As a result, presentation materials were designed to follow a 3 X 4 aspect ratio with a minimum of six words per line and six lines per slide or overhead transparency; fonts (sans-serif) were at least 24 point for ease of legibility (Lochte, 1993; Schlosser, personal communication, August, 1994; Graf, personal communication, September, 1995; Simonson, 1995; Smaldino, personal communication, October, 1996). Students were disappointed to find that the scraps of notebook paper on which they made notes did not serve them well as overhead display materials. Nor did students benefit from trying to present their laboratory data and results on large pieces of posterboard. Neither the "teacher" camera, nor the overhead display camera could capture the entire piece of work on a posterboard for display to distant classmates. Students learned that the use of PowerPoint Presentation software allowed them to easily prepare a legible professional delivery of their ideas.

Interactive handouts distributed during collaborative telesessions provided direction and structure (Cyrs, 1997) as well as kept students engaged and on task while others were presenting.

20. *Teachers modeled appropriate comportment and dress for telelearning sessions.*

Because television is a visual medium, teachers and student presenters were especially aware of the role of physical movement, dress, body language, facial expression, enthusiasm, and self confidence in how their presentation came across (Cyrs, 1997). Teachers observed that their students seemed to dress better on ICN presentation days. They also were more aware of how they came across to distant classmates. They tried to make their presentations as high a quality as they could. They became somewhat competitive in their attempts to outshine distant classmates.

Teachers involved in the ICEA looked for important factors in staff development opportunities. To want to participate in the ICEA and ICEA preparation, they needed to perceive the benefits to themselves and to their teaching situation. To satisfy these criteria, Merkley et al. (1997) found that ICN staff development must include:

a. Methods to establish and maintain *effective* communication between interacting sites;

b. Methods to *increase* interaction;

c. Strategies for encouraging motivation among presenters and receivers;

d. Techniques for planning and managing organizational details, etc.;

e. Awareness of the time demands of distance delivered courses.

Project modules had to be designed and modified for implementation under the conditions of synchronous interactive cooperative ICN sessions. Of major concern to the teachers was devising lessons that would foster site to site interaction, interdependence, accountability, and student-centered learning. Instructional materials and techniques were designed in such a way that the learning experience for both the distant and local learners would be as equivalent as possible (Simonson et al., 2000). Some concerns mentioned by the four master teachers as well as others who have planned similar lessons (Lochte, 1993; Tillotson and Henriques, 1997) include some philosophical questions:

1. How does interactive television affect the ability to establish a rapport between the teacher and students in the originating classroom with teachers and students at distant sites? There should be more than "talking head" interactions. Does the technology interfere, or is it possible to make its presence transparent enough that students feel that they are communicating directly with peers without the intervention of a camera?

2. Can participants at one site still "read the faces" of the distant students? Are all members of the overall "class" as separate and unique as they would be in the traditional classroom? Can local students empathize or relate with distant peers?

3. Using the ICN, can the course still have a feeling of informality? Is there still the relaxed attitude of the traditional classroom? Or is there a constant awareness of and nervousness about "being on the ICN"?

The goal of the ICEA modular units was to provide Iowa high school chemistry students with real world experiences to help to motivate them to make connections between their experiences and learning, between real life and chemistry concepts. Cyrs (1997) notes that when students become motivated, information will be acquired, internalized, and applied. Making real world connections promotes learning.

An example of this is in Module 2, Statistical Analysis of Data, the students analyzed the density of several brands of diet and regular soda pop. Based on laboratory analyses, students found that there was no statistically significant difference in the densities of diet and regular soda. This was wrong. There should be a significant difference. Students realized that their results were anomalous. They speculated that they had found a case of insufficient monitoring of end products by the quality control division at a particular bottling plant (please see Appendix F of dissertation). This sparked an electronic mail "conversation" between Project personnel and personnel at the corporate offices of the Coca Cola Corporation in Atlanta. A chemist at Coca Cola Corporate assured them that there was indeed a statistically significant difference between the two densities. He assessed and processed the student data that was available to him via their student database on the World Wide Web. He assured them and their teachers that their conclusions were correct for the data they were using. But, he was able to evaluate their data and suggested that their scientific technique might need some practice. He indicated that there was not appropriate agreement between their mass data and their volume data. He recommended that they practice the techniques of using a pipette until they were more proficient and encouraged them to repeat their experimental work. He felt that they would achieve the results they desired and would prove to themselves that there is a difference between the density of diet Coke and that of regular Coke.

In addition to discussing the specifics of this particular analysis, more aspects affecting soda densities were discussed. Teachers and students were interested to learn that diet and regular sodas go through different processes of carbonation and contain varying amounts of carbonation. Additionally, non-cola beverages (such as "white" sodas, carbonated juice drinks, and carbonated flavored beverages (orange, etc.) require different amounts of carbonation. The official from Coca Cola Corporate even recommended a quick chemical method of degassing the beverages used for ICEA analysis. Teachers followed a procedure of pouring the beverages into large wide-mouthed containers two to three days prior to doing the experiment in order to allow all of the carbon dioxide to escape. Diet and regular sodas decarbonate at different rates.

This has made an impression not only on the students who performed the experiments and reported the results, but also on distant classmates hearing about the discrepancy, and on all of the teachers involved. Everyone realized that the students had stumbled upon an anomaly in the real world that they had discovered using their understanding of the concept of density. That firmly cemented the density concept in their minds. There is no doubt that the concept of density has been acquired, internalized, and applied. It would have been difficult for the instructor to answer the usual student questions: "Why do I need to know about density? When will I ever use it?" But, students retrospectively would be able to reflect on usefulness and importance after having experienced the lesson, applying the concept of density to a real world problem.

Cooperative projects get students actively involved in their learning. They are able to achieve at higher levels if activities challenge their critical thinking skills (Cyrs, 1997). When moving beyond the traditional classroom walls using the ICN, new, non-traditional problems were encountered. One of the most noteworthy problems for anyone using the ICN is the problem of differing bell schedules and different academic calendars across the state of Iowa (Sorenson, 1997). To work around this was a challenge, as the teachers and ISU support staff came to find. It was the single largest problem facing Project planners during the design and implementation of the modules the first year. To provide all four schools with the opportunity to interact with each other as much as possible, there were only 20 minutes of common class time out of every hour. However, disparate bell schedules continued to plague planners throughout the Project lifetime. This problem was not unique to the ICEA Project.

A teacher comment made during a focus group reflected on this issue of time and scheduling common ICN sessions: "I don't see that getting easier as time goes on, because if you take a look at a lot of those ICN rooms and I'll throw this out as my observation, they don't get used very much. They get used for the "talking heads" type of thing. But getting the kids involved I think makes our Project unique in that respect with the ICN. And I hope they're ready and flexible enough in their scheduling that they can handle that kind of thing and don't squelch it, because that's really what it's all about. The kids. That's what the ICN should be all about. Giving an education to them."

Putting Together the ICEA Project. Here is the suggested list of ideas used to guide the ICEA Project development. This outline evolved out of the three-week planning and development sequence drafted by the ICEA ISU support staff and personnel for the four master teachers as well as the succeeding ICEA Phases II, III, and IV teacher preparation workshops. It is supported by the literature (Crowther, 1993; Felder, 1993; McNeal, 1998; Nurrenbern, Mickiewicz, and Francisco, 1999; Bullard and Felder, 2003; Oliver-Hoyo, Allen, and Anderson, 2004).

1. Team building exercises were necessary to encourage the teachers to work together as a group rather than as separate individuals.

McNeal (1998) observes that most instructors do not adopt new teaching strategies by simply learning about them—they need to experience being taught in these ways. They should practice, get feedback and receive support from their colleagues. They work together while learning.

a. "Icebreaker" activities could help a group of participants to get to know one another. Good icebreakers use previous knowledge and skills in some way. Active, hands-on exercises and reflection are useful to engage participants (McNeal, 1998).

b. Activities that could build trust among members would fortify the bonds among group members. Those that encourage positive interaction increase faculty motivation to incorporate similar exercises themselves. Setting the tone of collaborative problem solving from the outset engages novice teachers and prepares them to continue using the same strategies as they involve their students.

c. Discussions about subject matter could serve the purpose of ice-breaking and trust-building activities for those previously well acquainted.

Although the original four teachers had known each other for years when the grant planning began, they very much recognized their need to "gel" as a team.

"We had to develop as a team also."

"Yeah. We had to get comfortable with each other."

"We knew each other quite well, but we had to adjust to each other."

"Yeah, if we had not, well if we had not known each other. If it had been other than these three, I would have been very reluctant to participate in the Project. I'm speaking for myself, because I knew what kind of support system I would have, because I knew the three. If you just threw four people together, who didn't know each other really much at all, this thing would never have gone. Never, ever have gone. And I only reflect comparing with the success, overall success, I think of the DaVinci Project (a multimedia art and science design project [Schlosser, 1997]) compared to this.

"One of the problems (with the DaVinci Project) is that you had too large a group."

"Too large a group I think."

"Too large a group and too diverse a group of people, who really didn't know each other very well. Even on the science side, separate from the complexity of the two disciplines (art and science), but even within the science group, other than the four of us, we didn't know the others real well. And so I think there was not as much of a community. I didn't feel as much of a community as I already have with these three. So I don't think I would try this with other people in this locale. There are some other people around the country, I might have done it with, because I feel fairly... And I've worked with them before in summer institutes and so forth. But not here. "From my perspective I got the best three I could have."

As is obvious from the teacher comments, the four original teachers trusted one another implicitly. They had an open and cordial relationship, able to joke with and cajole one another while at the same time being able to critique lesson plans and make suggestions for changes.

Succeeding training meetings always included a period of socializing to allow the teachers to talk with each other prior to beginning formal sessions. This seemed to promote the necessary "bonding" among the group members. As more teachers joined the Project, they were provided with appropriate team-building exercises. Personalities "clicked". The new groups "gelled" based on their observation of the closeness of the first group. Working at a greater distance, weekly ICN "staff" meetings provided needed moral support as the new teachers "learned the ropes". Each ensuing "generation" of ICEA teachers were mentored by the previous group. The single most noticeable factor in each group's success was the complementary nature of their personalities. Any difficulties with student lesson planning and delivery could be accommodated due to the respect and trust developed by the ICEA teacher colleagues.

2. Distance education training and practice with the equipment are designed to maximize the teachers' comfort level.

Project personnel assessed teacher-training needs when the sessions began. If a group was familiar with the ICN equipment and procedures and with principles and practices of distance education using the ICN, the preparation was different from a group of teachers who had had no exposure to the ICN.

Teachers could view a series of videotapes designed to provide an overview of the ICN and how it is used. In addition, Project personnel personally showed them how to use the different components of an ICN room. For the teachers in Phase I, there was an opportunity to attend college-level class sessions about distance education. For Phases II, III, and IV teacher training, participants could view the videotape segments as well as practice using the ICN equipment while being mentored by ICEA teachers already trained in use of distance education equipment.

The ICN is an integral part of the Project for students and teachers alike.

For Students. "We're not teaching over the ICN. We're using the ICN to help in the classroom, but we're not *teaching* over the ICN."

"Students are interacting with other classes."

"We're using the ICN as a good communications tool. Not as an instructional content delivery system."

"We tried to use the ICN for educational purposes with the students. We talked about the student presentations and that may be one of the things we're most proud of—is about how well the students did do their presentations and how accountable they were. But we tried to do different things each time and some things worked better than others and we had ways to improve those things that didn't work as well as they should have. But the use of experts was really kind of a cornerstone of the Project."

For Teachers. "If we never did a lot of student ICN things, because I think that's a good thing to keep in there...The ICN that we used for weekly, or regular conferencing and for teacher planning and teacher development. I think probably was, for me and as far as the Project, was a more important aspect of ICN use. Because we're pretty used to it now that's just, for me at least, I guess I can only speak for myself, to me it's no different to meet there than it is to sit in a face-to-face meeting all at the same site."

"We (Phase I teachers) did meet weekly from 3:00 to 4:30 p.m. every Thursday all year long over the ICN and it was very valuable for coordination of the Project."

"I don't think the Project could have gone without it."

"We were writing those last five modules, the clarification, the corrections, what was going well with the module we were on, what was going wrong, what kind of ideas you had. Even entrepreneurial ideas were all fair game during those sessions. Plus just administrative things that had to happen."

"Without the ICN and those meetings, it wouldn't have worked as well. Without the Internet, the e-mail, sending documents back and forth..."

ICN Guests. "And the experts didn't come in and deliver some speech of sorts. They came in and they were *consulted* by the kids."

"They had to be there to answer questions and it really got some good things going. The forensics—they bounced things back and forth *between experts* (at different sites) and the kids could see them in action. And I think that was great."

"It's the kind of thing you could have done in your classroom, but I never would have done in my classroom because I don't think I could have gotten any of those people to come to just my classroom."

"And as an expert, I'm sure they would rather come and talk to 400 students than they would to 30."

3. Training in cooperative learning and assessment, multiple intelligences, and creative thinking provided the teachers with a broad spectrum of tools for ensuring successful engagement of students in their own learning.

Teachers learned about and modeled practices they would later use in their classes. Iowa State University staff worked with the teachers to guarantee they had acceptable exposure to all of the ideas that were deemed necessary for successfully moderating student-centered learning sessions geared to encourage the students to become responsible for their own knowledge acquisition. It underlined the possibility and often very real necessity of trying multiple real-world approaches to appeal to different student learning styles.

4. Drafting content modules provided the teachers with the needed ownership of the Project.

Teachers were forced to undertake consideration of principles of visual thinking, student involvement, use of interactive study guides, presentation skills, telecourse organization and planning, and technical skills essential for developing two-way interactive modules and ICN sessions (Cyrs, 1997).

Training sessions for this purpose should preferably occur during a summer workshop meeting, when the pressures of the academic year are lessened. A generous amount of time should be allocated to the process. The amount of time devoted to planning and reorganizing traditional curriculum to adapt it to a two-way interactive distance learning environment affects both the quality of the ensuing telesessions and how well students learn (Cyrs, 1997).

New skills and an emphasis on other teaching skills different from the traditional course are required (Cyrs, 1997).

Some keys to successful design of materials as outlined by Cyrs (1997) include:

a. Modifying an existing curriculum for delivery at a distance through audio (ICN), video (ICN and CUSeeMe), computing (Internet and electronic mail), print, and combinations of these media.

b. Thinking visually about lesson design and presentation (leading to the use of presentation software packages such as PowerPoint).

c. Describing how to identify and develop interactive activities and exercises for use on site and in remote ICN classrooms.

d. Analyzing how presenters look, sound, and move on television. Practicing use of the ICN technology prior to actual airtime to relieve tensions about "being on television" as well as getting related occasions of horse play out of the way prior to an interactive session with distant classmates.

e. Explaining administrative and disciplinary policies that support distance-learning programs.

The Phase I teachers outlined a series of chemistry topics around which a set of supplemental learning modules could be designed to coordinate with the existing curriculum in all schools. They then investigated the kinds of hands-on activities that could be related to the chemistry topics being considered. Because they worked as a team, they proposed a number of ideas to consider. Their greatest difficulty was culling those most likely to be of greatest interest and of academic value to their students.

Their research helped them to decide which of several topics to pursue for each module. Working as pairs, the teachers drafted the skeleton of what was to become the different supplemental learning modules. Basing their work on the National Science Education Standards (1996), they designed introductory materials or activities (and eventually, in some instances, supplementary support videotapes to accompany materials), the actual hands-on laboratory experiences, accompanying report procedures, assessment rubrics, and coordinating Internet research exercises.

Designers of the ICEA learning modules could envision the possibility of where the strategies they provided students might take them. Only by living the experience, could they observe how one set of students interacted. Another group with dissimilar personalities, backgrounds, and learning styles would interact differently.

Later, they could share these experiences and related advice as they mentored novice ICEA teachers (Felder, 1993; Crowther, 1999; and Bullard and Felder, 2003). However, as a group, the teachers soon proposed that future "classes" of novice teachers should actually be placed in the student role and should complete entire learning unit. By experiencing firsthand some of the same challenges, surprises, and satisfaction that their students would encounter, the teachers became better strategists and more able to anticipate the direction their students might pursue in the course of constructive problem solving (McNeal, 1998 and Nurrenbern, Mickiewicz, and Francisco, 1999). The novice instructors recognized the practical benefit of the rehearsal exercises. These experiential sessions were then followed by the actual implementation of the module units when the novices depended on further mentoring from the experienced teachers.

5. Implementation and modification of content modules enabled the teachers to observe first-hand student involvement and investment in their own learning.

The process, in the words of one of the creators of the module units, is one of "a strategy for teaching teachers how to take existing curricula and develop a product. We don't make the modules for them (the students), but (we) guide the strategies. Build the model that allows them to take the existing stuff...how do we go about taking what we do and designing and developing. Because I think that we've gone through the process." As an added benefit, work on the design and implementation of materials for a two-way interactive distance education session leads to the continued advancement of teacher performance in traditional classrooms, as well as improvement of teacher communication with students and colleagues (Cyrs, 1997).

6. Support.

Support personnel and guidance were necessary to provide instructors with the time to modify traditional materials and to develop new materials designed to capitalize on the flexibilities of two-way interactive ICN technologies. The four Phase I teachers credited support and mentoring from personnel at ISU as being partially responsible for the Project's success (Ehlers, R; Hartman, K.; Hepburn, J.; and Murphy, D., personal communication, May, 1997). Assistance from a strong support network was critical at the beginning when the teachers were training with the ICN equipment. "The day to day, week to week support that we've gotten has been really, really outstanding. The strong support staff enabled us to get things (accomplished). Whenever we've needed it , we've asked for it and they've helped us get that done. I think it's really good. It's been a good team," (unidentified Phase I focus group participant, June 1997).

Teachers cite the organizational role played by Project staff as being highly instrumental in the success and smooth day-to-day operation of the Project. Organizational meetings for ICN group scheduling, electronic mail memos, deadline reminders, and funding for activities, supplies, data analysis, on-site meeting, and travel mileage were valued by participants. All of the factors contributed to the steady progress made by the Project.

In addition, the teachers credited the Project PIs with a supportive yet hands-off approach to Project facilitation. "They have not dictated, contrary to other projects...They have not dictated predetermined outcomes. This has been our Project and they have recognized that as such and have been enablers for us," (unidentified Phase I focus group participant, June 1997).

"And, it does follow the National Science Education Standards (1996)...I think that the analysis and the synthesis and higher order thinking skills are there (as well as) the use of technology..." (focus group comment, 2000).

ICEA Phase I, II, and III Teachers Focus Group and Survey Comments: Assessment of the Development of the ICEA Project

Teacher focus group comments (Dave Bolluyt, Sara Coleman, Ted Crow, Richard Ehlers, Mary Feddersen, Terry Frisch, Ken Hartman, Jeff Hepburn, Sherri Huff, Amy Jabens, Roger Kuhlmann, Maureen Mays, Don Murphy, Ron Newland, Marty Paper, Larry Schwinger, Barb Taylor, Rick Wells, John Wozniak, 2000) and comments made on surveys about the ICEA preparatory workshops, have indicated that the teachers believe there are several considerations about their training and what is necessary for those contemplating starting such an undertaking as the ICEA Project. These include the ideas of participating teachers from Phases I-III. No Phase IV teacher attended the focus group meeting nor returned the survey.

1. Face-to-face workshops to set up the collaborative process and ICN training.

Teachers felt the training sessions were valuable and inclusive. Videotapes provided an overview of the ICN system and equipment. Practice sessions using the ICN equipment allowed teachers to familiarize themselves with what was available as well as to achieve a certain comfort level. It was important for teachers to be comfortable with the equipment before standing in front of students in the classroom. Teacher comfort level in turn minimized student apprehension and nervousness about using the ICN. Mentoring teachers helped to direct novice teachers as they worked through the ICEA laboratory exercises that their students would later do. Although the opportunity to actually work through the ICEA materials in the classroom was the best experience, teachers valued the ICEA hands-on training experience for its thorough attention to detail.

2. Electronic mail and technology to maintain the collaborative process. Electronic mail exchanges and CUSeeMe exchanges allowed communication among teachers between ICN "staff" meeting times. Teachers believed they had ample opportunity to communicate. One teacher commented that he had had three hundred ICEA-related e-mail exchanges during one semester. He noted that without the ICEA Project, he would never have collaborated with colleagues to that same degree.

3. Mentoring.

Mentors provide the support network that novices required at the outset of undertaking a different instructional approach. A person cannot become comfortable with an alternate approach to instruction during a one semester course, let alone a three-day (or less) training workshop (Felder, 1993b). Mentors helped novices find an individual approach suited to their own teaching strengths, personalities, student populations, and school and district administrative constraints.

The ICEA mentoring system was designed so that the seasoned teachers could help the novice teachers in all respects. Communication was appropriately frequent and directed to provide a well-rounded experience for the novices. Mentors had had past experiences and could help novice teachers to anticipate difficulties, challenges, or procedures that might require an exorbitant amount of time. Collaboration between experienced and novice teachers saw the evolution of new, improved ideas, techniques, and procedures as modifications were made and implemented. This mentoring relationship was very effective and was highly valued and, for teachers, remains one of the primary success features of the ICEA.

Bullard and Felder (2003) list several benefits to mentoring. The mentee:

a. Receives frequent demonstrations of good teaching practices and has the opportunity to implement them;

b. Derives effective feedback on her or his performance;

c. Has some relief from the responsibility of developing content materials from scratch;

d. Does not feel the same fear of "going it alone";

e. Finds a sounding board for new ideas;

f. Acquires help with questions and problems;

g. Is able to teach at a higher level the first time;

h. Finds a colleague with her or his best interest at heart;

i. May offer the mentor new ideas from the novice perspective.

4. Familiarity with modules—What was the purpose of the modules? How were they set up? What was expected? Were there any helpful hints about them?

Mentoring teachers took it upon themselves to prepare helpful overviews of the ICEA modules in order to make it easier for the novice teachers. Having been involved in the design and implementation of the original materials, seasoned veterans provided novices with a clearer understanding of how and why instructional materials were designed the way they were. The novices were able to view the modules with a fresh outlook. They contributed ideas for useful modifications. The teachers who had designed the original materials readily welcomed suggested changes. Some current ICEA modular procedures show little resemblance to the original materials.

5. Teacher ICN meetings prior to presentations.

There were regularly scheduled ICEA teachers' meetings held via the ICN. During those meetings, a substantial volume of work could be accomplished in a short period of time.

Teachers held preparatory discussions via electronic mail or telephone to set the groundwork for their "staff" meetings. Because ICN time was limited, prior organization provided them with the opportunity to use the apportioned airtime to their best advantage. On-air "staff" meetings included discussion about how to best conduct student presentations sessions and module modifications. In addition, teachers used their sessions to network, discussing teaching issues, students successes and problems, administrative challenges, and the like. The teachers realized the importance of these sessions. Even more important to them were the on-site sessions held at Iowa State University three times during each academic year. When teachers gathered on site, they invariably accomplished a phenomenal amount of work, but also forged the strong personal and professional bonds that have characterized the ICEA Project.

6. Related technology training.

A teacher must first have the necessary technology (an operating ICN classroom and Internet access) and the desire to learn how to use it.

There was a substantial variability in teacher use of and exposure to use of technology in teaching. Prior to the Project, no Phase I teacher had used the ICN for classroom teaching. Few used computers, the Internet, or electronic mail to communicate. Out of necessity, teachers became frequent and positive users of electronic mail. As detailed above, they became weekly (or, later in the Project, biweekly) users of the ICN for "staff" meetings. What is more interesting are two related phenomena. Teachers who used communication technologies for the ICEA Project went further. Some worked together on a U.S. West Grant to develop an ICEA data base and a series of supporting web pages for Module 5, Chemical Instrumentation—Spectrophotometry. As a test for that project, teachers designed a statewide database for the analysis of the density of soda pop. Some other teachers designed their own chemistry course web sites.

Another interesting outgrowth of the Project concerned teachers being looked upon and consulted as ICN and distance education experts. Colleagues wanting or needing to learn or know about use of their school's ICN room consulted with the ICEA teachers. Administration members did the same. This resulted in high profile publicity for the teachers, their departments, and the ICEA Project.

Solely as an outgrowth of participating in the ICEA Project, one teacher at an urban Des Moines high school saw her classroom evolve from being technology-impoverished to technology-rich. During the first year that her class participated in the Project, her ICN room was primitive. The only camera in the room had to be manually turned to focus on the teacher or the class. There were no controls. Her district was given a grant by the Sony Corporation to remodel her ICN room. State of the art improvements created a model classroom in her district. This remodeling was followed by a second grant providing her with 21 new computers and a networked printer. Her classroom evolved from being the most underprivileged of the district to the most technologically advanced. District administrators were regular visitors to her campus to see her classroom. She attributed her students' good fortune to the ICEA Project. Her own enthusiastic motivation played a crucial role.

7. Running through the laboratory exercises. Work through student modules to be certain that each aspect is completely discussed and understood.

The most efficient teacher preparation was providing novices with the opportunity to have their own hands-on experience with the laboratory activities that their students would eventually perform. They collected and analyzed data in exactly the same manner their students would. Experienced teachers mentored them, giving teaching tips along the way, and sharing their own experiences from past years. These laboratory sessions were followed by "live" ICN sharing sessions between sites. These strategies were designed to enable the teachers to participate in the full spectrum of ICEA experiences.

8. To be a comfortable participant, an ICEA teacher must be:

a. Flexible. She or he needs to break away from the routine of the traditional classroom, letting students take more responsibility for their own learning. She/he must coach and guide, not dictate.

b. Innovative. Because she or he is doing new lessons, the teacher must be prepared to implement different instructional strategies, recognizing that there are a variety of learning styles.

c. Willing to spend extra time on the Project. This is an important consideration. Student ICEA activities take no more time in the lab than any other traditional experiences would. But, preparing for them might require additional time. In addition, she or he must sacrifice class time to allow the student the opportunity to prepare for their ICN presentations.

9. Teacher networking was a benefit.

This was a fine example of how interaction between teachers of various districts formed a strong web of support, not only just for the ICEA Project but other innovations in chemistry. It was important to remember, "No man is an island, entirely to himself." To work together strengthened all.

Teachers gathered together to make one another's acquaintance and discuss teaching philosophies. This provided them initially with an opportunity to get to know one other. To know the people with whom they were working was a definite benefit. After they were acquainted, the ICN "staff" meetings provided them with the opportunity to network with other ICEA teachers who were having the same experiences as they were. Some had more background than they had and could counsel them as mentors. The teachers knew they had a valuable support system—support from peers and support from Iowa State University personnel.

Getting together with the other teachers to exchange ideas and philosophies about the direction of the Project seemed especially important to the teachers, specifically those who had participated in the Project for a full year. They valued the free reign they were given to direct the course of the Project in a way that best accommodated the needs of the majority.

The teachers had a firm understanding that they were working with other teachers and students who were also under time restrictions, so good communication was important. Teachers who on occasion had other commitments that prevented their attending face-to-face ICEA teacher meetings realized they were missing the opportunity to interact and share ideas with their colleagues. They were unwilling to miss these meetings unless absolutely prevented from attending.

12. ISU support staff was needed.

Communication from ISU staff was timely and useful, and addressed problems quickly and efficiently. Until the teachers had experienced at least two years of the Project working in tandem with Iowa State University support personnel, they would not have been able to work independently. During Phase III, the teachers realized they were capable of drafting a mentoring network, conducting training of novice teachers, planning module units, devising ICN network schedules, and organizing staff meeting. Project support personnel continued to prove useful to the smooth operation of the Project.

13. What more could have been done.

a. In making suggestions for changes to what had been done for ICEA teacher preparation, the group strongly suggested that more time be devoted to module work. They thought that working completely through each module was imperative. With more training on modules prior to student use, teachers felt they would be more relaxed in the classroom. Teachers also wanted the group to explore using modules other than the four that had become the foundation for the ICEA "curriculum". Another thoughtful proposal was the suggestion to invite teachers who might be interested in participating in the ICEA to observe the modules in action in the classroom.

b. Teachers would be more comfortable with additional modeling of ICN interactions. From the point of view of the teacher moderator, more training was wanted. Newer participants especially felt inadequate in the face of equipment failure.

c. Prior to the beginning of an academic year, novice teachers wanted to see examples of student work and students reporting on the ICN. Because ICN preparations and presentations are time consuming, both students and teachers wanted to observe "the right way" to conduct an ICN presentation. Teachers also wanted videotaped models of appropriate student comportment during ICN sessions.

d. Learning to encourage efficient group work is a goal teachers outlined. To achieve that goal, they believed that training sessions were necessary to explore techniques for cooperative learning and getting students to work well in groups .

e. Teachers requested more opportunities for communication. In addition to face-to-face training meetings, they wanted more frequent interactions. This underlined the importance that networking had for them. It also highlighted the fact that distance technologies (the ICN and electronic mail) did not provide the same satisfaction as personal face-to-face discussion could.

f. Some teachers felt ill prepared to use the software programs their students were encouraged to use. For example, not all teachers were familiar with using PowerPoint. They requested training sessions to learn before being asked for help by their students.

g. In order to cope with increasing scheduling problems with the ICN, teachers suggested that there should be a central coordinator for the ICN to keep all students and teachers on task. This could be one goal of future funding efforts—the appointment of a knowledgeable participant to serve as ICN scheduling coordinator. If stipends were available for future ICEA teachers, the ICN scheduler should be given additional compensation commensurate with the amount of work she or he would be asked to undertake.

ICEA Phase I Teachers Focus Group Comments: Overview of the Development of the ICEA Project by Relevant Topic

The following discussion is developed via direct quotations from the ICEA teacher focus group conducted following Phase I. Quotation marks are used to differentiate comments from the teachers. These comments further illustrate the impact of formative evaluation (via teacher feedback) on the development of the ICEA Project.

Technology for Teachers. "I just had changes in, changes, heck, massive increases in uses of technology in the classroom...by myself and by my students. At the beginning of the year we didn't use computers at all and by the end of the year students were doing PowerPoint presentations with great ease. We were using CUSeeMe cameras in the classroom and even from the very beginning the students were easily using the equipment in the ICN room. And showing very creative ways to use that equipment."

"All the technology that you're using technology more, your students are using technology more, students had to be more accountable for the work that they were doing, the support that you've developed within your group that's allowed you to share ideas and, as another teacher said, to take risks that you maybe wouldn't have been able to take on your own for a variety of reasons. And all the quality curriculum that you've developed—that you have a really good product, really good work to show for your effort."

Changes in Teaching. "I think all of us have changed the way we do some of our teaching and will probably not go back even if the Project isn't funded to specifically do this again, but all of the spin-offs in terms of using collaborative models with students, the use of the technologies in the classrooms, putting those resources in the hands of kids and letting them use those, integrating that...giving students alternate ways of expressing their learning and understanding other than the pencil and paper."

"We did a lot more open-ended things with our students than I normally would ever do. And students normally want to know what the right answer is and for a lot of our activities there was no right answer. It was particularly true of the last module we did with water quality and I think it was a very good experience for the students, knowing that they're the ones who actually have the answer and know whether or not the answer they got is accurate."

"We've done some change in teaching style from more of a teacher as a fountain of knowledge to a facilitator."

Teacher Growth. "It's been a good experience and it's been a growing experience. What was I doing with the computer—with Internet, and World Wide Web—even a year ago, at this time? I didn't know what to do. Or PowerPoint. Remember we worried about PowerPoint?"

"I don't realize how much I've grown, until I really sit back and reflect on it."

"And digital imaging."

"Yeah, I mean just all that stuff I'm now taking for granted and I think in some cases, 'Well, anybody can do that. Everybody's doing that.' When indeed they aren't. You know, but because the four of us all know how to do it, you kind of think, 'Gee, those are skills everybody has.' I've developed a lot of good skills and I'm still learning.""

"It just drives me nuts, when I go to our technology support people in our school and they just don't even have a clue about what we're doing on a daily basis with kids. Unfortunately, the kids are picking that up in my classroom. That my students almost make fun of our media center technology services because they are doing so much more in our class, in what we're doing than anybody else even can talk about to an extent in there (the media center)...Like another teacher said, we kind of take it for granted, but in fact, we're doing some things that are not common among the average school, the average classrooms, irrespective of being chemistry classrooms, any classrooms."

Changes in Student Learning. "I would comment that I think I've observed and what I've heard from the others during the Project is students really tend to have more of a responsibility and ownership for their learning and they're more accountable because they have to do presentation types of things. They have to be accountable for the results they show to their peers in the classroom, and, the other students in the other schools. I think those have been side benefits that perhaps we didn't, I didn't think of initially.""

"I think they gained skills and different concepts that they probably wouldn't have seen in a normal chemistry course. I think those skills sometimes maybe are more important—communication skills, the technology skills that they've picked up—than if I had just been teaching a regular course."

"We come from an area where it was pretty much teacher-centered and we've gone to a situation where it's getting more and more student-centered. With which I have no problems, that's the way it should be. But it's a change and later in life, sometimes that change is a little harder to do than it is if you've come out of a university or college with those skills already developed."

"It's more time-consuming and more difficult to plan for students... It's a positive experience, but is more difficult as a teacher than to kind of have total 'do-your-thing'. There's a lot more detailed planning that has to go into that (student-centered classroom)...and to structure that, than if you're just 'song-and-dancing'. I think so anyway."

"I had better student action in the classroom I think this year, than I've had before. And I attribute part of that, a great deal of it, to the experiences they had. The repetitive experience of the students managing their own activities and the one that really hit me was the forensics module, with the class manager concept and that sort of thing. That was a lot of work getting it ready, but the class day, I thought, was a snap. I mean, it was easy. I felt pretty good by the end of the day because the workload for me almost felt like I could go out for a cup of coffee. I could sit over there for 20 minutes easily and absolutely do nothing except watch them do their thing, because they had adapted themselves so well and taken the leadership responsibility. Not every class but at least a couple of my classes, particularly, had the natural leadership—students who were willing to bite the bullet. That they were no longer coming to me to ask for things, they were going to each other and taking care of a lot of that themselves. To me that's fun. It's fun to teach when they've been able to do this. It's also easier to teach."

"You're less of a fountain of knowledge and more of a facilitator."

"Once you get set up, they even help facilitate each other."

"That structure that you guys developed with the team leaders and the class managers and stuff—I think that is unique; probably it's been done elsewhere. I guess I haven't seen it that much, but I think that's something that could be promoted—taken out of this thing as a teaching design and perhaps sold a little bit."

"Class manager. I think that's a tremendous way for giving students accountability and responsibility. They do like it. I never had a lack of students to volunteer to do it or if I ask people who I knew would be able to do it say, "No, I won't do that." They were generally pleased to have those responsibilities."

"Some students who were reserved and quiet and if you asked them, they wouldn't volunteer, but if you asked them to assume a position, they did."

"I had some kids that I would not have expected to have done things. Boy, they came through, took leadership."

Student Accountability. "One of the things we didn't talk about—and I'm not sure it's one of my favorite things—is that part of giving students more accountability—we gave them more freedom. And I wasn't really comfortable with that. I did it and it kind of increased my stress level this year, because I was always concerned about it. And for the most part they responded in a very admirable way to it. But if you're going to demand they do something and hold them accountable for it, I guess you have to give them the freedom to do it the way they want to do it. And I did that and that's not the way I'm used to teaching. And I'm sure that if I have reinforcement of the Project again next year, I'll continue to do it the new way. If not, I will probably back-slide into taking control of my class again."

Student Flexibility. "And I think that got passed on to the students, too. They were seeing us being flexible in handling situations and so I think some of them became more flexible."

The Teacher Team. "When the four of us got together there's an awful lot of good, positive chemistry going on. We were always excited. We really fed on each other. And teaching chemistry by myself—it's kind of neat to get together with these guys, and be it on lessons, or be it just talking about chemical concepts of some sort. It's always fun to do and I enjoyed that very much."

"We were trying to pattern it after the new science standards (National Science Education Standards, 1996), and so that's, I think, why the modules had gotten longer than we originally intended. I agree with an earlier comment that I didn't think they'd be that long. But we were able to get some quality projects with students doing a lot of the ideas that are being recommended by the Standards."

Teacher and Student Adjustments to the ICEA Method. "Just because of my experience not only in teaching, but also in chemistry. I think the experience really helps work with that NSES model."

"You've been in laboratory situations enough where that's more of a situation like this and so you've had the experience and you're able to connect and compare."

"If they have had an opportunity to examine and work in these kinds of flexible models, they're probably more ready to do it."

"A little experience and knowing that things don't always work right the first time is good...which we're used to. Even though there's a little frustration there, it's less than for that first year person who expects the answer book to be followed and all the tests come out the way the author said they would."

"I thought considering the number of things we did that we have never done before or had never done them this way before, and the number of chances for things to go wrong, things went very smoothly and even when they went wrong there was somebody who was ahead of the rest of us who caught it and told everybody to watch out for that part. That was very helpful. The activities did go, just astoundingly smooth."

"Students had recognized that there were going to be little minor problems and they'd seen enough little, minor problems. So they were able to adjust I think."

"I think this shows the characteristic of the group though. We're all pretty flexible and if something goes down we don't get all upset. We just do what we can."

"And try and get it solved and worked out. I think it takes a unique individual to do that. I guess we are rather unique as a group anyway, but I think that's an important component. We were talking about that. We talked about the kind of teacher that would do this. I think it has to be one that's flexible. When you talk about the ICN, the ICN did cause us some problems from time to time, but we were able to adjust."

Teacher and Student Networking. "Are there other ways that we haven't talked about yet that this Project has changed your teaching?"

"In a more of a global aspect. I mean, for my students and for me, we had a larger support where I was able to realize there were three other chemistry teachers out there that I could talk to. And then the students were also able to realize that they weren't in this isolated chemistry class by themselves. There were other chemistry students out there that were experiencing the same problems, same joys, or whatever. And so I think it added more of a global aspect."

"And I think another thing that is interesting, is the kids have certain stereotypes of what students were like in other schools. And I think they found out, 'Hey, they're not all that different. We're not all that much different...from each other than we thought we were.' 'They're good kids and they have the same problems and they don't understand the same things that we don't.' So I think getting those walls broken down I guess was—of course that's what distance learning is supposed to be all about anyway. It was nice to see that."

Scheduling Problems. "Scheduling was a big problem."

"It got ugly."

"I don't see that getting easier as time goes on, because if you take a look at a lot of those ICN rooms, and I'll throw this out as my observation, they don't get used very much. They get used for the "talking-head" type of thing. But getting the *kids* involved I think makes our Project unique in that respect with the ICN. And I hope they're ready and flexible enough in their scheduling that ICN administrators can handle that kind of thing and don't squelch it, because that's really what it's all about. The kids. That's what the ICN should be all about. Giving an education to them."

"The four of us went to the annual National Science Teachers' Association meeting in New Orleans during the middle of the spring semester. It was the worst day for us, but I think in some ways, it went much better than I had anticipated it would, given that we left undone work in the hands of students. I think that activity, what I saw done by my students and the others students when we got back really speaks to the fact that they did assume...I think a little more responsibility because they knew there was no one to help them or bail them out. They had to do it on their own and do it themselves and they did. And came up with some nice stuff. And so in some ways, although it was uncomfortable for us because we wanted to be there to guide everybody every step of the way, maybe, in a way, it was good that we were gone for those four days. Walk back in with an ICN presentation and they had to have done everything between gathering data to getting ready and do it in presentation mode. And for the most part, they did it."

Lack of Support in Home School District. "But since nobody has ever done this before, you have to deal with the inertia that is there (in the school district). If you need anything, you have to go through all the layers to get it. To explain what it is and why you need it and what you're going to use it for. And they're all very supportive, but it's just not things they've ever thought of before and so they have to go through the thinking process. And so, we've kind of blazed a trail. For the next teacher in my system who wants something like that, it'll be easier for them. Or it will already be in place, and that may have raised the stress level this year as well, having to deal with the inertia in your own school system towards this kind of thing. But I've had nothing but very good support, it's just been slow."

"It's not that they didn't care, but I think you're right. There's some unawareness inertia type of thing that you need a long cable to hook to an external monitor, a camera so you can fit it onto your video input. They don't even have a 20-foot RCA cable for video to hook up a simple composite video signal. It's just really frustrating to deal with. You just go out and buy your own stuff, you know, like teachers do all the time."

"When they should be encouraging and having the resources to strengthen that, they don't seem to be aware of it, so you have to do the teaching to the administration."

"I guess I'm thinking of my ICN room in terms of, you know, I had no knowledge about what it was until I guess I walked into the one at Iowa State and realized what a real ICN room was like in terms of size. And that I think I would have liked to be set down with somebody that had some responsibility over that in the district and gotten the equipment there prior to when it did come. That's the negative downside. Now on the positive side of that, I think equipment appeared in that room that probably would never have appeared had it not been for the ICEA Project. I mean, there were students saying, 'Everybody else has this. Why don't we have this?' 'Well, maybe we can get that for you.' And it came. And, so, slowly and steadily things came in. We still have a physical problem. You know, I had no overhead camera and I improvised. And again that takes a certain amount of creativity and I kind of enjoy Rube Goldberg types of arrangements of things. But it's nice to have the real thing there too and when it did come it was a lot easier to teach with."

"Thank goodness for the Canon camera because that was your overhead camera."

"Yes it was. If it hadn't been for that, we'd be holding sheets of paper up in front of the other student camera."

The ICEA Modules. "I think the fact that we did these together we generated so many more options for each of the modules. Even what we have here is really in most cases a dramatic reduction in all the possibilities that we had for any one module. We had to start limiting. Sometimes limiting I found to be the hardest part."

"I think maybe if you added four more modules to the package, you virtually have an entire course. You could almost do an entire course with another four or five modules on top of the eight here. If they were selected carefully and with a little rearranging I think you could build a whole course around it."

Integrating the ICEA Modules into the Existing Curriculum. "We need to do less modules with the existing curriculum."

"They weren't as tight as they could have been. And so we can focus them more. We've been working on doing some of that this summer. We've had to narrow down what we did just because it fit in the time frame. And we have some other things we think are probably even better than what we did. And so, we can modify to incorporate some of that in the modules. But definitely not eight modules."

Putting the ICEA Team and Module Package Together. "Start earlier in the summer."

"We just didn't have enough time last summer to actually do the basic writing on, so we were doing all that, along with conducting classes. We were always writing some, while we were trying to plan some, and that's where I think the heavy load and the stress level tended to get higher, because of that. Now, we had a "goodly" amount of time last summer, but a lot of that was just in terms of deciding what would work, what couldn't, what modules, how should we structure this? You know, there was a lot of just preliminary planning to kind of get the whole sense of where we were going. Had that been done, we could have spent the whole five weeks just writing. I think we would have had most of that done and that would have taken a little of the load off."

"We had to develop as a team also."

"Yeah. We had to get comfortable with each other."

"We knew each other quite well, but we had to adjust to each other."

Using the ICN as a Communication Mechanism.

"For students: Students are interacting with other classes. We're using the ICN as a good communications tool. Not as an instructional content delivery system."

"For teachers: The ICN that we used for weekly, or regular conferencing and for teacher planning and teacher development, I think probably was, for me and as far as the Project, was a more important aspect of that."

"...Morning, afternoon, daily basis. It wouldn't have worked without the CUSeeMe in the case of our problems with the orange juice lab, where we actually, within an hour period via e-mail and camera were able to debug an experiment and correct it for the students within about an hour period in our classrooms. It wouldn't have worked as well. So it's not one of these things that's made this a successful Project, it's a combination of the totality of using all of the communication, interactive resources that are at our disposal and using them for the things they do the best. I think we've used the ICN for what it does the best and not made it the sole delivery mechanism for chemistry."

"We should use the laboratory for what it does the best, student investigation. We've used the e-mail for what it does the best. We've sent print matter quickly back and forth to each other by attaching the files. I mean, a lot of stuff we were getting in the morning, copying, and going to the laboratory with the guides for the students. And you couldn't have done that without that fast way of passing documentation back and forth. The visual video face-to-face planning weekly, without it, I don't think we could have been successful. So we used the things that work the best for what they're designed for and not tried to stake the whole Project on one of these technologies. That's my feeling about it."

ISU Support Staff. "We haven't really talked about the crew that we worked with at Iowa State University. Which I appreciate."

"I know e-mailing our grad assistant in particular. Our grad assistant always had something very positive to say after everything. She congratulated us and I enjoyed this. There were positive times there when things maybe didn't go as well. It was nice to have a good report. Everybody's cooperated fairly well. We've had some problems of getting some things taken care of, but I think all in all..."

"That goes with the territory."

"All in all fairly well."

"Yeah, I would like to echo that too. I think we've had... I think the PI's have been very supportive, Tom and Gary, but they also have let this be our Project."

"Yeah, never been domineering."

"One graduate student bore the brunt of the scheduling."

"Because he had to battle the...bureaucracy..."

"Saved a lot of the frustration for us, even if we did have some of our own."

Thoughts and Outcomes of the ICEA Project. "Real world applications...I think I've put perhaps a little more emphasis on applications of chemistry, because we've used it in our modules. Even in the general content that I've taught, I think I used more illustrations of how the chemistry is applied to things they interact with day to day. Although we did a little bit before...but I think I'm becoming more sensitive to trying to help them see the reason why chemistry is important because of how it applies to commercial advertising and so forth. This is not just a laboratory science only. It has some real impact on them in their lives."

Teacher Reflections on the ICEA Project. "You've been talking about is how you've developed this group, this network amongst yourselves of four chemistry teachers and your classrooms, in terms of the support, the camaraderie that has developed among you. What are other ways that this Project has affected feelings of isolation that you may have had before? Or perhaps you didn't feel isolated before?"

"We're feeling a little more isolated now because we're not getting the large number of e-mails that we were sending between each other. And so that's isolating us."

"I talked with my ICEA teaching colleague during the day (via CUSeeMe) more than I talked with the chemistry teachers next door, across the hall, because he was there. He was in my classroom. As opposed to having to leave the classroom to go talk to somebody."

"We turned CUSeeMe cameras on at 7:30 in the morning when we got to school and we could leave them on all day until we left at night. And in addition to that, I've discovered that my colleague does his e-mailing between 8:00 and 8:30 in the morning usually."

Unexpected Outcomes of the Original ICEA Project Grant Moneys. "How has this Project affected you in terms of turning you into chemistry entrepreneurs (Kodak, VR, and VisCam)?"

"We were able to get $20,000 in equipment and it's because of the ICEA grant."

"I think... we had....the ICEA grant provided a framework upon which people were interested in providing equipment to support that framework. And they were entrepreneurs in and of themselves."

Other Influences on the ICEA Project. "How has this Project influenced you, in other ways, going out and getting these things that are perhaps not directly related to ICEA?"

"It's made us more open to doing that I think. More willing to take a chance."

"Yeah, and we could see that we are bringing other kinds of technology, not just technologies, but anything that helps support students, piques students' interest (or impacts) student investment in their learning. Variety, multiple intelligences, our Area Education Agency advisor had gotten this lady to come and talk about multiple intelligences. Although we didn't specifically document that, I think it really helped for things like this because it sensitized me to try and to get students more different ways of being interested in the chemistry and ways of expressing their learning and understanding and tap into their interests. The DaVinci Project has helped a little bit including the same kind of a thing. Any time we can tie in so the visual imaging is there. Had we not thought about this, we probably wouldn't have, at least I wouldn't have been tempted to go after that kind of stuff."

What Are the Implications of this Project? "I wonder if you could talk just a little bit, what implications do you think this Project has, which has been very good, for what we ought to be doing in schools in terms of curriculum, technology, teaching, collaboration? Doing all these things we talk about trying to do in schools? That it sounds like you have been doing successfully?"

"I hope we're kind of a beacon for others to follow, in a sense."

"A lighthouse project."

"We need to get into it for a second year to work out some of the bugs just to improve the system and to get a better feel for it."

"We are not at the end. We're merely evolving. We've only taken one step. And so we're doing things that other teachers aren't doing in their classrooms, but five years from now they're going to be doing what we're doing now. And what we have done and the kind of things we've done will work just as well in social studies classes and English classes as they worked in chemistry classes. It's just our focus was in chemistry, but they work in other things."

"And I'm sure that they will come up with better ways to do it than we did. But we've got a start here and that's all it really is, a start."

"I think it would be too bad if this start isn't continued. Last summer when we were at the 14th Biennial Conference on Chemical Education, talking with several of the people who are into "distance education" in science and chemistry nationally, they readily admitted this is the most unique project that they've seen anybody ever try. No one is doing anything of this order of magnitude. And I think that the opportunity here for real research, unique research in distance education impact is there once you have things in place to do the studies. I can see a lot of people getting degrees and dissertations using this kind of modeling as focus for research and for degrees. It would be kind of a waste to let it go for a few bucks to keep it running. That materials, and ICN time and that kind of support system, because I think there would be hosts of ways people could get a lot of research done in that area."

"So I hope that they can keep it going. In terms of the fact that—and to give a model for others and as was said earlier, in other areas, in other content fields to examine similar types of things. And a much larger impact in terms of the ICN for large numbers of schools and large numbers of students, instead of having 15 kids occupy an ICN room every day of the week. Or four out of a class, or 15 out of five schools, because there's 3 or 4 here and 2 or 3 there, and to block it out for the rest of the school...When you can meet 18 days a year and impact hundreds of kids. And then if you had other kids doing other days of the year, the number of students who would have the experience of using that communication technology would really go up and it does what it does the best, which is quality communication. And let the other types of contact deliveries be done the way they're done the best, which may not be sitting in front of a television set watching somebody else talk."

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APPENDIX E
IOWA CHEMISTRY EDUCATION ALLIANCE DIRECTORY
Phase I - Phase IV

Appendix E
Iowa Chemistry Education Alliance Directory Phase I
ICEA Phase I Chemistry Teachers

1. Richard Ehlers (I)
Perry High School
1200 18th St.
Perry, IA 50220-2311
school code: 9
AEA 11

2. Ken Hartman (I)
Ames High School
1921 Ames High Dr.
Ames, IA 50010
school code: 8
AEA 11

3. Jeff Hepburn (I)
Dowling High School
1400 Buffalo Rd.
West Des Moines, IA 50265
school code: 10
AEA 11

4. Don Murphy (I)
Hoover High School
4800 Aurora Ave.
Des Moines, IA 50310-2999
school code: 3
AEA 11

Iowa State University Support Team
ICEA Phase I
1996-1997

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1608D Gilman Hall or 3051 Gilman Hall
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Iowa Chemistry Education Alliance Directory Phase II
ICEA Phase II Chemistry Teachers
I=teachers 1996-1997; II=teachers joining 1997-1998

1. Dave Bolluyt (II)
A-D-M Senior High School
801 S. 8th
Adel, IA 50003
school code: 4
Tan
AEA 11

2. Sara Coleman (II)
Norwalk Senior High School
1201 North Ave.
Norwalk, IA 50211
school code: 1
Green
AEA 11

3. Richard Ehlers (I)
Perry High School
1200 18th St.
Perry, IA 50220-2311
Yellow
AEA 11

4. Mary Feddersen (II)
East High School
5011 Mayhew Ave.
Sioux City, IA 51106
school code: 11
Red
AEA 12

5. Chris Fink (II)
Abraham Lincoln High School
1205 Bonham Ave.
Council Bluffs, IA 51503
school code: 5
Blue
AEA 13

6. Terry Frisch (II)
Johnston Senior High School
P.O. Box 10
6501 NW 62nd Ave.
Johnston, IA 50131
school code: 2
AEA 11

7. Ken Hartman (I)
Ames High School
1921 Ames High Dr.
Ames, IA 50010
school code: 8
Orange
AEA 11

8. Jeff Hepburn (I)
Dowling High School
1400 Buffalo Rd.
West Des Moines, IA 50265
school code: 10
Yellow
AEA 11

9. Dale Howe
Lincoln High School
2600 SW 9th St.
Des Moines, IA 50315
school code: 7
AEA 11

10. Amy Jabens (II)
Prairie High School
401 76th Ave. S.W.
Cedar Rapids, IA 52404
school code: 12
Red
AEA 10

11. Resa Kelly (II)
Valley High School
1140 35th St.
West Des Moines, IA 50266
school code: 6
Tan
AEA 11

12. Don Murphy (I)
Hoover High School
4800 Aurora Ave.
Des Moines, IA 50310-2999
school code: 3
Orange
AEA 11

13. Ron Newland (II)
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401 76th Ave. S.W.
Cedar Rapids, IA 52404
school code: 12
Green
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ICEA Phase II
1997-1998

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Project Manager
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Iowa Chemistry Education Alliance Director Phase III
I=teachers 1996-1997; II=teachers joining 1997-1998;
III=teachers joining 1998-1999

1. Dave Bolluyt (II)
A-D-M Senior High School
801 S. 8th
Adel, IA 50003
school code: 4
Tan
AEA 11
2. Sara Coleman (II)
Norwalk Senior High School
1201 North Ave.
Norwalk, IA 50211
school code: 1
Green
AEA 11
3. Ted Crow (III)
Lincoln High School
2600 SW 9th St.
Des Moines, IA 50315
school code: 7
Tan
AEA 11
4. Richard Ehlers (I)
Perry High School
1200 18th St.
Perry, IA 50220-2311
school code: 9
Yellow
AEA 11
5. Mary Feddersen (II)
East High School
5011 Mayhew Ave.
Sioux City, IA 51106
school code: 11
Red
AEA 12
6. Chris Fink (II)
Abraham Lincoln High School
1205 Bonham Ave.
Council Bluffs, IA 51503
school code: 5
Blue
AEA 13

7. Terry Frisch (II)
Johnston Senior High School
P.O. Box 10
6501 NW 62nd Ave.
Johnston, IA 50131
school code: 2
AEA 11

8. Kris Groff (III)
Sheldon High School
1700 E 4th St.
Sheldon, IA 51201
school code: 14
Green
AEA 4

9. Ken Hartman (I)
Ames High School
1921 Ames High Dr.
Ames, IA 50010
school code: 8
Orange
AEA 11

10. Jeff Hepburn (I)
Dowling High School
1400 Buffalo Rd.
West Des Moines, IA 50265
school code: 10
Yellow
AEA 11

11. Bernie Hermanson (III)
Harlan High School
2102 Durant St.
Harlan, IA 51537
school code: 15
Red
AEA 13

12. Sherri Huff (III)
Creston High School
601 W. Townline Road
Creston, IA 50801
school code: 16
Yellow
AEA 14

13. Amy Jabens (II)
Prairie High School
401 76th Ave. S.W.
Cedar Rapids, IA 52404
school code: 12
Red
AEA 10

14. Resa Kelly (II)
Valley High School
1140 35th St.
West Des Moines, IA 50266
school code: 6
Tan
AEA 11

15. Roger Kuhlmann (III)
Missouri Valley High School
605 E Lincoln Highway
Missouri, IA 51555
school code: 17
Blue
AEA 13

16. Maureen Mays (III)
East High School
815 E. 13th St.
Des Moines, IA 50316
school code: 31
Orange
AEA 11

17. Kathy McLean (III)
Valley High School
1140 35th St.
West Des Moines, IA 50266
school code: 6
Blue
AEA 11

18. Don Murphy (I)
Hoover High School
4800 Aurora Ave.
Des Moines, IA 50310-2999
school code: 3
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AEA 11

19. Ron Newland (II)
Prairie High School
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school code: 12
Green
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20. Marty Paper (III)
Hamburg High School
105 E Street
Hamburg, IA 51640
Farragut High School
Farragut, IA
school code: 30
Yellow
AEA 13

21. Owen Primavera (III)
Okoboji High School
P.O. Box 147
Milford, IA 51351
school code: 21
Red
AEA 3

22. Larry Schwinger (III)
Stuart-Menlo High School
1023 North Second Street
Stuart, IA 50250
school code: 23
Orange
AEA 11

23. Barb Taylor (III)
Thomas Jefferson High School
1243 20th Street SW
Cedar Rapids, IA 52404-1691
school code: 24
Tan
AEA 10

24. Rick Wells (III)
Davenport Central High School
1120 Main Street
Davenport, IA 52803
school code: 25
Yellow
AEA 9

25. John Wozniak (III)
Fort Dodge High School
819 N 25th Street
Fort Dodge, IA 50501
school code: 26
Blue
AEA 5

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ICEA Phase II
1998-1999

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Iowa Chemistry Education Alliance Directory Phase IV
ICEA Phase IV Chemistry Teachers
I=teachers 1996-1997; II=teachers joining 1997-1998
III=teachers joining 1998-1999; IV=teachers joining 1999-2000

1. Dave Bolluyt (II)
A-D-M Senior High School
801 S. 8th
Adel, IA 50003
school code: 4
Einsteinium
AEA 11

2. Sara Coleman (II)
Norwalk Senior High School
1201 North Ave.
Norwalk, IA 50211
school code: 1
Silver
AEA 11

3. Ted Crow (III)
Lincoln High School
2600 SW 9th St.
Des Moines, IA 50315
school code: 7
Gold and Titanium
AEA 11

4. Richard Ehlers (I)
Perry High School
1200 18th St.
Perry, IA 50220-2311
school code: 9
Titanium
AEA 11

5. Mary Feddersen (II)
East High School
5011 Mayhew Ave.
Sioux City, IA 51106
school code: 11
Plutonium
AEA 12

6. Chris Fink (II)
Abraham Lincoln High School
1205 Bonham Ave.
Council Bluffs, IA 51503
school code: 5
Gold
AEA 13

7. Terry Frisch (II)
Johnston Senior High School
P.O. Box 10
6501 NW 62nd Ave.
Johnston, IA 50131
school code: 2
Titanium
AEA 11

8. Kris Groff (III)
Sheldon High School
1700 E 4th St.
Sheldon, IA 51201
school code: 14
Titanium
AEA 4

9. Ken Hartman (I)
Ames High School
1921 Ames High Dr.
Ames, IA 50010
school code: 8
Titanium
AEA 11

10. Jeff Hepburn (I)
Dowling High School
1400 Buffalo Rd.
West Des Moines, IA 50265
school code: 10
Plutonium
AEA 11

11. Bernie Hermanson (III)
Harlan High School
2102 Durant St.
Harlan, IA 51537
school code: 15
Platinum
AEA 13

12. Sherri Huff (III)
Creston High School
601 W. Townline Road
Creston, IA 50801
school code: 16
Platinum
AEA 14

13. Amy Jabens (II)
Prairie High School
401 76th Ave. S.W.
Cedar Rapids, IA 52404
school code: 34
Einsteinium
AEA 10

14. Resa Kelly (II)
Valley High School
1140 35th St.
West Des Moines, IA 50266
school code: 6
Gold
AEA 11

15. Roger Kuhlmann (III)
Missouri Valley High School
605 E Lincoln Highway
Missouri, IA 51555
school code: 17
Silver
AEA 13

16. Maureen Mays (III)
East High School
815 E. 13th St.
Des Moines, IA 50316
school code: 31
Gold
AEA 11

17. Kevin Mcginity (IV)
Ottumwa High School
501 E. 2nd
Ottumwa, IA 52501
school code: 32
Platinum
AEA 15

18. Don Murphy (I)
Hoover High School
4800 Aurora Ave.
Des Moines, IA 50310-2999
Einsteinium
AEA 11

20. Ron Newland (II)
Prairie High School
401 76th Ave. S.W.
Cedar Rapids, IA 52404
school code: 12
Einsteinium
AEA 10

21. Marty Paper (III)
Hamburg High School
105 E Street
Hamburg, IA 51640
school code: 20
[Farragut High School
Farragut, IA
school code: 30]
Titanium
AEA 13

22. Owen Primavera Jr. (III)
Okoboji High School
P.O. Box 147
Milford, IA 51351
school code: 21
Platinum
AEA 3

23. Mike Rathe (IV)
Ottumwa High School
501 E. 2nd
Ottumwa, IA 52501
school code: 33
Platinum
AEA 15

24. Larry Schwinger (III)
Stuart-Menlo High School
1023 North Second Street
Stuart, IA 50250
school code: 23
Platinum
AEA 11

25. Barb Taylor (III)
Thomas Jefferson High School
1243 20th Street SW
Cedar Rapids, IA 52404-1691
school code: 24
Titanium
AEA 10

26. Rick Wells (III)
Davenport Central High School
1120 Main Street
Davenport, IA 52803
school code: 25
Silver
AEA 9

27. John Wozniak (III)
Fort Dodge High School
819 N 25th Street
Fort Dodge, IA 50501
school code: 26
Silver
AEA 5

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1999-2000

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APPENDIX F
IOWA CHEMISTRY EDUCATION ALLIANCE
CASE STUDIES

Appendix F
ICEA Case Studies
"When Will I Ever Use This Chemistry Stuff?"
Two Anecdotes

The Iowa Chemistry Education Alliance (ICEA) (Burke and Greenbowe, 1998; Burke and Greenbowe, 1999; Simonson *et al.*, 2000) provides Iowa high school teachers with supplemental curricular modules to help answer the traditional student questions: "Why do I need to know this chemistry stuff? When will I ever use it?" These questions are answered in a very non-traditional way. Teachers step out of their conventional role as source of knowledge to act as facilitators to the students who work through a series of real-world hands-on activities to try to answer focused questions applicable to particular chemistry concepts.

Drafted, implemented, and revised over an 18-month period by a team of four master high school chemistry teachers, the ICEA package provides students with real-world laboratory activities which are investigated collaboratively by groups of students at high schools across the state of Iowa. Experimental laboratory results are shared within classrooms on site as well as via statewide databases, CUSeeMe cameras from school to school, or via electronic mail with distant classmates. Further discussions among students at remote sites are held using Iowa's statewide two-way interactive fiber optic television network, the Iowa Communications Network or ICN (Maushak, Simonson, and Wright, 1997: Maushak, 1997; Greenbowe and Burke, 1995, Simonson *et al.*, 2000).

Students present their experimental findings and discuss them with distant learners who are tuned in to an ICN broadcast session at three or four remote sites and who have undertaken the same studies at their own individual schools. Skits, videotapes, and rap songs are some of the creative ways in which groups present their results to distant learners (Burke, 1998; Burke, 1999) thereby avoiding the deadly boring talking head syndrome (Cyrs, 1997).

Students are accountable for presenting their results in a meaningful and informative way. They take this responsibility very seriously. Teachers report that much effort is directed to designing a presentation which is not only creative but also utilizes commercial presentation software so that it is visually on par with the presentations of distant classmates. Students judge themselves and their peers on the sophistication of their use of the cutting-edge technologies available to them. They become adept at using the broad capabilities of the ICN classroom including integrated overhead presentation cameras, cameras which can be focused on either the classroom or the teacher presentation station at the front of the classroom, computers with Internet connections, VCRs, and slide projectors. Some students who have used the ICN equipment during their participation in the ICEA project are more proficient using the apparatus than are teachers at their school who do not regularly use the ICN as a teaching tool. This is a wonderful opportunity for the students and they are well aware of it (Burke, 1998; Burke, 1999).

The ICEA Curriculum Package itself consists of eight learning modules and three supporting videotapes which supplement the traditional high school chemistry curriculum (Burke and Greenbowe, 1998). Teachers find that using two of these supplemental units per semester integrates well into the existing curriculum without disrupting the pace or detracting from traditional chemistry topics.

During the first semester, students will work through the introductory module which introduces them to ICN equipment and how to use it. This lesson culminates in a presentation by a group of three to four students to their on-site and distant classmates. They work together to share information and must use at least three different forms of media to do so. Some of these presentations are highly entertaining.

The second module is a laboratory analysis of the density of name brands and generic brands of diet and regular soda pops. An accompanying videotape provides guidance in statistical calculations as well as evaluation of laboratory data for its validity. Results are entered in a statewide database at

http://205.221.129.250/ICEA/density.htm

During the second semester, students do a spectrophotometric analysis of the copper content of a post-1982 U.S. penny. Results are pooled in a statewide database found at

http://hydrogen.chem.iastate.edu/www/pennies/homepage.html

The final module is a forensics exercise for which students are given evidence packets associated with eight known suspects who are being investigated for their alleged involvement in the perpetration of a crime. Students compare their evidence packets with evidence which has been "found" at the scene of the crime. They evaluate their crime scene evidence, consult distant peers about their investigations of the evidence packets, and try to determine which suspect is the guilty party by process of elimination.

One favorite feature of the unit is an ICN guest experts session. Students prepare a series of questions which are of interest to them about forensics and address the experts with their queries. Experts have been impressed with the thoughtfulness which goes into student question formulation, and students have been duly impressed with the time and attention the experts will devote to the students' understanding of the topic.

Focus group results from students and faculty alike reiterate student enthusiasm for the ICEA project. They appreciate the fact that they are doing something in school which has real world connections. This strongly supports education research which encourages making connections between new concepts with prior, well-grounded knowledge (Cyrs, 1997). They also appreciate the ability to network with distant learning peers. They consistently note three factors which are important to them about ICN sharing sessions (Schlosser, 1997; Burke, 1998; Burke, 1999):

1. There are other students at larger/smaller, rural/suburban/urban schools studying exactly the same material in chemistry class and "going through" some of the same struggles at mastery of the material that they are.

2. Peers at *distant* schools have their own personalities but are not very different in reality from any students in the *local* classroom.

3. Peers who may be competitors on the sporting field can be collaborators in the classroom.

Critical thinking skills are fostered by the active learning which is nurtured by the ICEA modules. Real-world hands-on problem solving reaches outside the confines of the classroom. It is as natural for a student in the ICEA project to exchange information with a distant classmate as it is to turn to a local peer and converse. Students in some classrooms have further explored discoveries made in connection with ICEA labs with interesting results: in one instance, contacting an official in the corporate offices of the Coca Cola Corporation and in another, dialoguing with officials at the Royal Canadian Mint. These are summarized in the two anecdotal reports which follow.

Anecdote 1. ICEA Module 2, Statistical Analysis of Data.

Soda pop seems to have become the beverage of preference for many individuals. Using such a common household product for a laboratory experiment in chemistry class brings chemistry a little closer to real life. The research question: Is there a difference in density between the regular and diet varieties of the same brand of soda pop?

Students across the state determine the density of several brands of diet and regular soda pop. They make repeated measurements of different masses and volumes of soda samples to calculate an average density (the mass of soda per unit volume of soda) for their student group at their own school. They then report that information (in grams of mass per milliliter of volume) by entering it in a statewide database

http://205.221.129.250/ICEA/density.htm

Based on data collected during what they thought were carefully executed laboratory procedures, students have found that there is no statistically significant difference in the densities of diet and regular soda. This cannot be true. There should be a significant difference, because there is a significant amount of sugar (corn syrup) in regular soda which is not present in diet soda.

In a highly visual demonstration, a can of diet soda and a can of regular soda are each introduced into an aquarium in the classroom (or a 3-5 gallon clear glass receptacle if no aquarium is available). Based on their laboratory work and the information they have exchanged with distant classmates, students are asked to make predictions before the soda is actually introduced into the water. They hypothesize that the regular soda will be under the water and that the diet version will be closer to the surface of the water or will float. The regular soda can *does* sink to the bottom while the diet soda can floats at the top. This is a graphic demonstration of the differences in densities of the two types of soda, and holds true no matter what the brand or whether the soda is a name brand soda or a generic variety. The visual impact is something the students remember and will repeat for peers and family members, explaining why the phenomenon occurs. Not only do *they* understand the concept of density, but they can explain it to others.

In the case of the lack of statistical evidence to show there is a difference between the densities of regular soda and diet soda, students suggested that they may have found a case of insufficient monitoring of end products by the quality control division at a particular bottling plant. This issue was raised via electronic mail dialogue with officials at Coca Cola (Dan Quarterone, private communication, January, 2000; Randall Woodbeck, private communication, January, 2000) who explained that there should be a definite difference in densities between the diet and regular varieties of the same brand, that product quality is constantly monitored at the bottling plant, and that they *should* be detectable employing the density procedure and resultant calculations used by the students. For some reason, the amount of variation in the data taken by the students is so large that it cannot be shown that there is any difference between the calculated densities between the two data sets. Dan Quarterone actually accessed the ICEA Soda Pop database and analyzed student numbers. Using his own experience performing the same types of analysis, Quarterone detected discrepancies in student measurement. The speculation is that the students are making errors in their measurements because they are using a new procedure to determine the volume of their samples. They are not as proficient at utilizing this procedure, and, as a result, have calculated a wider range of densities than in past years of running the experiment.

This irregularity has made an impression not only on the students who performed the experiments and reported their anomalous results, but also on their distant classmates who confirmed the discrepancies with them, on all of the teachers involved, and on the parents of the students who reported their results at home. Parents became interested in their child's learning experiences and commented on them during parent-teacher conferences. Everyone realized that the students had stumbled upon what appeared to be anomaly in the real world which they had discovered using their understanding of statistical analysis and density There is no doubt that statistical skills and the concept of density have been acquired, internalized, and applied.

Teachers might not have answered the usual student questions: "Why do I need to know about density? When will I ever use it?" prior to students performing this laboratory exercise, nor had the students understood the relevance of the concept before going into the laboratory. But, it certainly became clear for the students after having done the lesson, shared the information with peers, and discussed its ramifications. Further, careful measurements must be made to obtain valid data.

Anecdote 2. ICEA Module 5, Spectrophotometric Analysis—The Instrumentation Module.

All of us carry pennies in our pockets, leave them tucked away in drawers, or collect them in containers of some kind to eventually take to the bank and have them converted into a larger denomination coin or bill. But, do we really think about the composition of the penny? We have heard the news that there is a copper shortage or that copper is expensive. So, are we hoarding valuable amounts of copper in our pockets or jars? The research question: What is the percent copper in a post-1982 U.S. penny or a newly minted Canadian penny?

In the Instrumentation module, **Module 5**, teachers collaborate to coordinate an equipment exchange in order to provide all of the schools with at least two of the three types of instruments needed to perform spectrophotometric analysis and share their data. This effort enables schools which lack instrumentation to participate in the same way as the institutions which have more sophisticated equipment.

Teachers and students use a web site which was specifically designed to be integrated with this spectroscopy module. Development work was supported by a grant from U.S. West. The URL for this site is:

http://hydrogen.chem.iastate.edu/www/pennies/homepage.html

This site includes an introduction to color, the electromagnetic spectrum, a discussion of color absorption, colorimetry, coin composition, a section of teacher notes, and a glossary of terms. Students are able to keep records of their spectrophotometric results in order to compile and compare data. They can instantly access all data generated by distant classmates.

Prior to laboratory work, students undertake an extensive Internet/World Wide Web investigation of coinage facts. They learn that pennies in the United States and Canada are composed of a zinc slug coated with a thin layer of copper metal somewhat like the popular M&Ms TM—Mars Candy Company candies have a thin colored candy coating on top of a chocolate interior. This background knowledge helps them to better understand the dissolving process they follow in the laboratory.

Students dissolve the entire penny in a strong acid solution which generates a showy brown cloud and leaves a sky-blue solution of dissolved copper and zinc. Spectrophotometric analysis is based on the intensity of the blue color of copper dissolved in the solution.

Students use instruments (spectrophotometers) which pass a certain pre-determined wavelength of light through the solution. Depending upon how intensely the solution is colored, more or less light is able to pass through and be detected by the instrument. The deeper the color, the less the amount of light able to pass and the less light which is detected by the instrument.

Students prepare reference solutions with *known* amounts of copper in them. They then use these solutions and compare the solution in which their penny is dissolved to try to determine the amount of copper contained in their penny solution. Considerable practice as well as more sophisticated laboratory techniques are required of students for this study. But, they appreciate the challenge of performing an experiment similar to a professional analyst in an actual laboratory. Their calculated results are based on their understanding of statistics from their work on the density module.

As a result of discovering a discrepancy in their results for the percentage of copper in a newly-minted Canadian penny compared to the value actually reported by the Canadian mint, a group of students pursued an interesting electronic mail discussion among peers and teachers at several sites in Iowa with analysts at the Canadian mint. Teachers, satisfied with the consistency, reproducibility, and reliability of their students' figures repeated the same experiments to determine where the error might be. Their own careful work produced the same calculated percentages of copper.

Unless there is some element which is interfering with the chemical reactions which were used to dissolve the penny and prepare the system for spectroscopic analysis, ICEA students and teachers have revealed a disparity between the experimental value of the percentage copper in a Canadian penny and that reported by officials at the Canadian mint. Bruce Conard, a corporate executive with International Nickel Corporation and an Iowa State University graduate (chemistry) who has provided Hoover High School in Des Moines with Canadian pennies for analysis, was helpful in guiding students in the proper direction to interact with the appropriate personnel at the Canadian Mint. Don Murphy, the Hoover High School chemistry teacher, helped facilitate student discussions.

Canadian officials speculate that what had been thought to be a pure zinc base must actually be a zinc alloy doped with copper. Therefore, it appears that the student analysis detects the copper coating on the *outside* of the zinc core, as well as copper *in the core itself.* Mystery solved! This definitely required some higher level problem solving among the students, their teachers, Bruce Conard (Bruce Conard, Private communication, April 1999) at International Nickel Corporation, and officials at the Canadian mint. It is another case of critical thinking and problem solving reaching outside the confines of the classroom to make real world connections .

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APPENDIX G
THE IOWA CHEMISTRY EDUCATION ALLIANCE
IOWA COMMUNICATIONS NETWORK MEETING GROUPS
PHASE I — PHASE IV

Appendix G
Iowa Chemistry Education Alliance ICN Meeting Groups
ICEA Phase I

All four schools coordinated times to meet concurrently

Richard Ehlers—Perry High School
Ken Hartman—Ames High School
Jeff Hepburn—Dowling High School
Don Murphy—Hoover High School

Appendix G
Iowa Chemistry Education Alliance ICN Meeting Groups
Phase II
"A" and "B" Groups

"A" Group (NOT on Block Scheduling)
Dave Bolluyt—A-D-M Senior High School
Sara Coleman—Norwalk Senior High School
Richard Ehlers—Perry High School
Mary Feddersen—East High School
Ken Hartman—Ames High School
Jeff Hepburn—Dowling High School
Dale Howe—Lincoln High School, DSM
Amy Jabens—Prairie High School
Resa Kelly—Valley High School
Don Murphy—Hoover High School
Ron Newland—Prairie High School

"B" Group (on Block Scheduling)
Terry Frisch—Johnston Senior High School
Chris Fink—Abraham Lincoln High School

Appendix G
Iowa Chemistry Education Alliance ICN Meeting Groups
Phase III
Color Groups

Red
Fedderson—East.HS Sioux City
Primavera—Okoboji HS
Hermanson—Harlan HS
Jabens—Prairie HS, Cedar Rapids

Orange
Hartman—Ames HS
Murphy—DSM Hoover HS
Mayes—DM East HS
Schwinger—Stuart/Menlo HS

Yellow
Hepburn—Dowling HS
Huff—Creston HS
Ehlers—Perry HS
Paper—Hamburg HS
Paper—Farragut HS
Wells—Davenport Central HS

Green
Coleman—Norwalk HS
Groff—Sheldon HS
Selbher—Mason City HS
Newland—Prairie HS, Cedar Rapids

Blue
Fink—Abraham Lincoln HS, Council Bluffs
Wozniak—Ft. Dodge HS
Kuhlmann—Missouri Valley HS
McLean—West Des Moines Valley HS

Tan
Bolluyt —A-D-M Senior HS
Taylor—Thomas Jefferson HS
Crow—Des Moines Lincoln HS
Kelly—West Des Moines Valley HS

Appendix G
Iowa Chemistry Education Alliance ICN Meeting Groups
Phase IV
Element Groups

Einsteinium
Dave Bolluyt—A-D-M Senior High School
Amy Jabens—Prairie High School
Don Murphy—Hoover High School
Ron Newland—Prairie High School

Gold
Ted Crow—Lincoln High School
Chris Fink—Abraham Lincoln High School
Resa Kelly—Valley High School
Maureen Mays—East High School

Platinum
Bernie Hermanson—Harlan High School
Kevin Mcginity—Ottumwa High School
Owen Primavera Jr.—Okoboji High School
Mike Rathe—Ottumwa High School
Larry Schwinger—Stuart-Menlo High School

Plutonium
Mary Feddersen—East High School
Jeff Hepburn—Dowling High School
Sherri Huff—Creston High School

Silver
Sara Coleman—Norwalk Senior High School
Roger Kuhlmann—Missouri Valley High School
Rick Wells—Davenport Central High School
John Wozniak—Fort Dodge High School

Titanium
Ted Crow—Lincoln High School
Richard Ehlers—Perry High School
Terry Frisch—Johnston Senior High School
Kris Groff—Sheldon High School
Ken Hartman—Ames High School
Marty Paper —Hamburg High School
Barb Taylor—Thomas Jefferson High School

APPENDIX H
IOWA PUBLIC TELEVISION SURVEY
IOWA CHEMISTRY EDUCATION ALLIANCE
MODULAR MATERIALS REVIEW
FEBRUARY 1999

Appendix H
Iowa Public Television Survey
Iowa Chemistry Education Alliance Modular Materials Review
February 1999

Last September you were sent a package from IP-TV containing Iowa Chemistry Education Alliance (ICEA) modular materials and supporting videotapes. We would like to ask you a few questions about your review of these materials. We ask you to complete and return this survey by March 30, 1999.

1. Please indicate which of the following correctly describes what portion of each of the ICEA modules/videotapes you *have reviewed.*

a. 0 % c. 11-20% e. 31-40% g. 51-60% i. 71-80% k. 91-100%
b. 1-10% d. 21-30% f. 41-50% h. 61-70% j. 81-90%

Modules

_____ Module 1 _____ Module 3 _____ Module 5 _____ Module 7
_____ Module 2 _____ Module 4 _____ Module 6 _____ Module 8

Videos

_____ ICN/Distance Education Video _____ Department of Criminal Investigation Video

_____ Statistical Analysis Video

Your comments:

2. Of the materials you *have reviewed*, please indicate which of the following correctly describes your evaluation of their usefulness to you and your curriculum. Please answer only for those modules/videos you have *actually* reviewed.

a. very useful—I would implement most or all of this module/video in my curriculum
b. moderately useful—I would implement a portion of this module/video in my curriculum
c. not useful—I would not implement a portion of this module/video in my curriculum
d. other:

____

Modules

_____ Module 1 _____ Module 3 _____ Module 5 _____ Module 7
_____ Module 2 _____ Module 4 _____ Module 6 _____ Module 8

Videos

_____ ICN/Distance Education Video _____ Department of Criminal Investigation Video

_____ Statistical Analysis Video

Your comments:

3. Please indicate which of the following correctly describes what portion of each of the ICEA modules/videotapes you *have implemented* in your chemistry curriculum this year.

a. 0 %	c. 11-20%	e. 31-40%	g. 51-60%	i. 71-80%	k. 91-100%
b. 1-10%	d. 21-30%	f. 41-50%	h. 61-70%	j. 81-90%	

Modules

_____ Module 1 _____ Module 3 _____ Module 5 _____ Module 7
_____ Module 2 _____ Module 4 _____ Module 6 _____ Module 8

Videos

_____ ICN/Distance Education Video _____ Department of Criminal Investigation Video

_____ Statistical Analysis Video

Your comments:

4. Of the materials you *actually implemented*, please indicate which of the following correctly describes your evaluation of their usefulness to you and your curriculum.

a. very useful—all of the material I implemented this time, I would implement again in my curriculum
b. moderately useful—I would implement a portion of this material again in my curriculum
c. not useful—I would not implement this material again in my curriculum
d. other:

Modules

_____ Module 1 _____ Module 3 _____ Module 5 _____ Module 7
_____ Module 2 _____ Module 4 _____ Module 6 _____ Module 8

Videos

_____ ICN/Distance Education Video _____ Department of Criminal Investigation Video

_____ Statistical Analysis Video

Your comments:

5. **If you have reviewed the ICEA materials and are interested in attending a workshop/in-service presentation to help you learn more about using the material in your curriculum, please indicate this.**

_____ Yes, how can I participate? Please contact me with more information. I have included my address. **Please print:**

Name: ______________________________

School: ______________________________

City, Zip: ______________________________

e-mail address: ______________________________

_____ No, I will contact your offices at some future time if I wish to learn more

6. **Based on your review and/or use of these materials, are you interested in participating in the ICEA project?**

_____ Yes, how can I participate? Please contact me with more information. I have included my address. **Please print:**

Name: ______________________________

School: ______________________________

City, Zip: ______________________________

e-mail address: ______________________________

_____ No, I will contact your offices at some future time if I wish to participate

APPENDIX I
IOWA CHEMISTRY EDUCATION ALLIANCE DIAGNOSTIC EXAMINATION AND ANSWER KEY

ICEA Diagnostic Quiz

Name:________________________

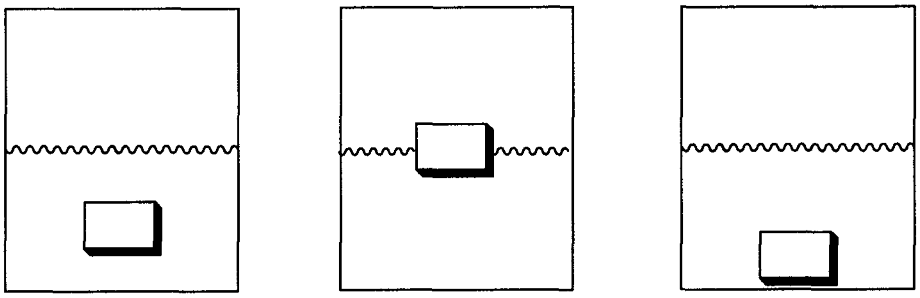
Number:______________________

Density

1. If you are going to calculate the density of a substance, what would be the likely units in which the answer should be reported?

   a. mL/g
   b. m^3
   c. dg
   d. g/cm^3
   e. g H mL

2. To answer this problem, please refer to the diagram below. Which of the objects, A, B, or C, has the greatest density? All objects have been placed in water.



   a. A
   b. B
   c. C
   d. All have the same density.
   e. Cannot tell from the information given.

3. The density of copper is greater than that of aluminum. The density of gold is greater than that of copper. If we have blocks of copper, aluminum, and gold all of which have the SAME VOLUME, which is the heaviest?

   a. Aluminum
   b. Copper
   c. Gold
   d. All have the same mass.
   e. Cannot tell from the information given.

4. You have equal amounts of three solutions of copper (II) sulfate, $CuSO_4$, in similar containers. Solution A is darker than Solution B; Solution B is darker than Solution C.

   a. The concentration of Solution A is greater than that of Solution B and the concentration of Solution B is greater than that of Solution C.
   b. The concentration of Solution C is greater than that of Solution B and the concentration of Solution B is greater than that of Solution A.
   c. The concentrations of all three solutions are the same.
   d. The concentration of Solution B is greater than that of Solution B and the concentration of Solution B is less than that of Solution C.
   e. Cannot tell from the information given.

5. There are four solutions of $CuSO_4$ with concentrations shown; Estimate the concentration of the fifth solution which has been labeled "UNKNOWN".

Solution 1=80% Solution 2=60% Solution 3=40% Solution 4=20% Unknown (UK) Solution

   a. 70%
   b. 50%
   c. 30%
   d. 10%
   e. Cannot tell from information given.

6. If you have 100.0 mL of a 20.0% $CuSO_4$ solution, and you want to make a 5.00% solution of $CuSO_4$, how many mL of the 20.0% solution are needed to make 50.0 mL of a 5.00% solution of $CuSO_4$?

   a. 20.0 mL
   b. 50.0 mL
   c. 25.0 mL
   d. 12.5 mL
   e. 80.0 mL

Spectroscopy

7. A sample holder containing a sample of a colored solution is placed in a spectrophotometer. As the concentration of the colored solution increases, what happens to the intensity of light leaving the tube?

   a. It increases.
   b. It decreases.
   c. It does not change.
   d. It goes to zero.
   e. It increases as the inverse square.

8. If you have a red solution which you wish to analyze using a spectrophotometer, at which wavelength should you set the maximum absorbance of the instrument?

Wavelength in nm	**Color**
430-460	Blue
490-520	Green
575-585	Yellow
725-750	Red

a. 445 nm
b. 505 nm
c. 580 nm
d. 738 nm

Significant Figures

9. Which of the following has four significant figures?
a. 0.004 L
b. 30.020 kg
c. 500 cm
d. 0.1730 mg
e. 9.87 Mm

10. What is the sum of the following three numbers?

20.34 cm + 2.23 cm + 80.0 cm =

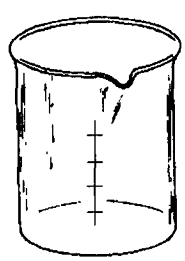
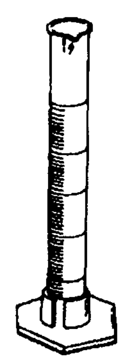
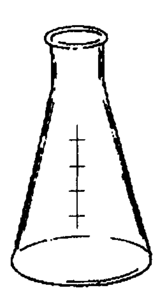
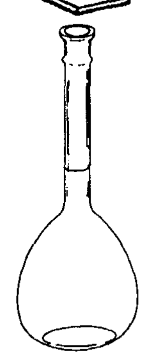
a. 104 cm
b. 104.5 cm
c. 104.6 cm
d. 105 cm
e. 104.57 cm

11. The following experimental measurements were obtained by measuring the mass of the same block of zinc metal six times. Calculate the **mean** and the **median** of the data set.

Data
12.0 g
14.0 g
12.0 g
13.0 g
12. 5g
13. 5g

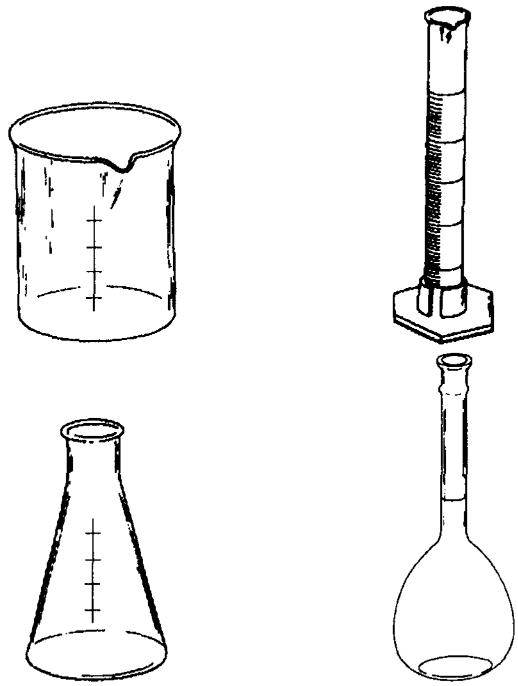
a. 13.0 g; 13.0 g
b. 12.5 g; 13.0 g
c. 13.0 g; 12.5 g
d. 12.0 g; 13.5 g
e. Cannot be determined from data provided.

12. A scientist needs to measure **84.50 mL** of a solution. Which measuring device would be the best to use?

a. 100 mL beaker
b. 100 mL graduated cylinder
c. 100 mL Erlenmeyer flask
d. 100 mL volumetric flask

13. A scientist needs to measure **100.0 mL** of solution; which measuring device would be best to use?



a. 100 mL beaker
b. 100 mL graduated cylinder
c. 100 mL Erlenmeyer flask
d. 100 mL volumetric flask

14. The mass of a block of copper metal was measured using three different balances, doing four separate determinations on each balance. Based on the following results, *which balance is the* **most accurate** and *which balance is the* **most precise**. The true value of the mass of the copper metal is 4.505 g.

Measurement	Balance A	Balance B	Balance C
#1	4.50 g	4.45 g	4.50 g
#2	4.49 g	4.45 g	4.50 g
#3	4.48 g	4.45 g	4.51 g
#4	4.50 g	4.45 g	4.50 g

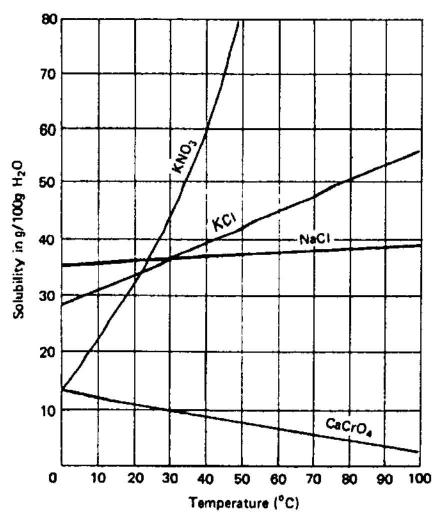
a. Balance A, Balance A
b. Balance A, Balance B
c. Balance B, Balance C
d. Balance C, Balance B
e. Balance A, Balance C

15. A student analyzed a sample known to contain 135 ppm of lead. The student used the same instrument and measured the sample over two days once in the morning and once in the afternoon. The following results were obtained.

Trial	ppm Lead
1 2	169 114
3 4	142 115

a. The data set is both precise and accurate
b. The data set is neither precise not accurate
c. The data set is accurate but not precise
d. The data set is precise but not accurate

Graphs – Please use the following graph to answer Questions 16-18



16. What is the solubility of KNO_3 at 45°C?

a. 30 g KNO_3 / 100 g H_2O
b. 70 g KNO_3 /100 g H_2O
c. 60 g KNO_3 / 100 g H_2O
d. 8.0 g KNO_3 / 100 g H_2O

17. How many grams of KCl will dissolve in 250 grams of H_2O at 60°C?

a. 150 g KCl
b. 95 g KCl
c. 112 g KCl
d. 17.5 g KCl
e. Cannot tell from this graph

18. At what temperature will the same number of grams of KCl and NaCl dissolve in 100 grams of water?

a. 22°C
b. 24°C
c. 30°C
d. 50°C
e. Cannot tell from this graph

Elements, Compounds, Mixtures

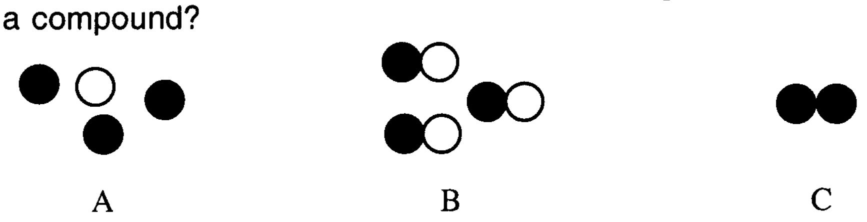
19. Which of the following is a pure substance?

a. Wood
b. Salt water
c. Sugar
d. Steel
e. All of the above

20. Consider a mixture of sand in salt water. This mixture could be separated into its three components (water, sand, and salt) by first ____________________ the mixture and then _________________ the remaining mixture.

a. distilling, distilling
b. distilling, filtering
c. filtering, distilling
d. filtering, filtering
e. none of the above

21. The following diagrams represent a small volume of atoms and/or molecules at the particulate level of matter. Which of the following samples, A, B, or C best depicts a compound?



a. A
b. B
c. C
d. Cannot tell from the information provided.

Classify each of the following as a mixture, a compound, an element, or something else.

22. Pepsi®

a. mixture
b. compound
c. element
d. something else

23. Orange juice

a. mixture
b. compound
c. element
d. something else

24. Table salt

a. mixture
b. compound
c. element
d. something else

25. An iron frying pan

a. mixture
b. compound
c. element
d. something else

26. Air

a. mixture
b. compound
c. element
d. something else

Answer Key for ICEA Diagnostic

1d	14d
2c	15b
3c	16b
4a	17c
5c	18c
6d	19c
7b	20c
8b	21b
9d	22a
10c	23a
11a	24b
12b	25c
13d	26a

APPENDIX J
IOWA CHEMISTRY EDUCATION ALLIANCE
STUDENT SURVEY

Iowa Chemistry Education Alliance Student Survey
Fall Semester, 1996

The information you provide on this survey will be used to assist in the evaluation of the Iowa Chemistry Education Alliance project. ALL information you provide will be kept confidential.

Marking Instructions

•Use a Number 2 pencil only. DO NOT USE INK.

•Mark answers on the answer sheet only.

•Darken only ONE circle for each question.

•Erase cleanly any marks you wish to change.

IMPORTANT DIRECTIONS

On side 1 of the answer sheet, please complete the following information in the section to the left of the heavy vertical bar.

(1) Darken the correct circle in the section labeled "**SEX.**"

(2)In the section labeled **"IDENTIFICATION NUMBER"** start with box "A" and fill in your student identification number.

Please answer the following questions by darkening the appropriate circles on side one of the answer sheet.

1. My grade level is
1=9 *2=10* *3=11* *4=12*

2. My ethnic group is
1=Caucasian *2=African American* *3=Hispanic* *4=Asian* *5=Native American* *6=Other*

3. My approximate class rank in high school is
1=1% to 25% *2=26% to 50%* *3=51% to 75%* *4=76% to 100%*
top quarter *bottom quarter*

4. Which of the following best describes how often you use computers for coursework?
1=Never *2=Once or twice a semester* *3=Monthly* *4=Weekly* *5=Daily*

5. How often have instructors in your previous classes used computers for instruction?
1=Never *2=Once or twice a semester* *3=Monthly* *4=Weekly* *5=Daily*

OVER→

Iowa Chemistry Education Alliance Student Survey
Fall Semester, 1996

6. Which of the following best describes your previous experiences with the ICN/Fiber Optics classroom?

1=Never *2=Once or twice a semester* *3=Monthly* *4=Weekly* *5=Daily*

Mark the frequency of your use of the following distance communications tools.

7.	Electronic mail (e-mail)	*1=Never*	*2=Occasionally*	*3=Regularly*
8.	World Wide Web	*1=Never*	*2=Occasionally*	*3=Regularly*
9.	FAX	*1=Never*	*2=Occasionally*	*3=Regularly*
10.	Video conferencing	*1=Never*	*2=Occasionally*	*3=Regularly*

For items 11 through 21, use the following scale to respond.

1 = strongly disagree	**4 = somewhat agree**
2 = disagree	**5 = agree**
3 = somewhat disagree	**6 = strongly agree**

11. I feel confident about my abilities in science.
12. I feel confident about my knowledge of science.
13. I expect to get a good grade in this course (an "A" or "B").
14. I have a positive attitude toward chemistry.
15. I learn a great deal from visual images.
16. I learn a great deal from hearing explanation by others.
17. I learn a great deal by participating in hands-on classroom activities..
18. My previous experience with science has been positive.
19. I feel my math background is adequate for this science course.
20. I expect this course to be taught primarily using lecture and lab.
21. I believe this course will help me make informed decisions about science issues (environmental, around the home, etc.).

For items 22 through 29, darken the circle that best represents the number of semesters you have had in each subject area. For example, if you have taken one semester of a subject, you would darken the circle containing the number one.

22. High School Biology
23. High School Earth Science
24. High School Physics
25. Any other High School Science
26. High School Algebra I
27. High School Algebra II
28. High School Trigonometry
29. Any other High School Math

APPENDIX K
IOWA CHEMISTRY EDUCATION ALLIANCE VIDEO
"THE RIGHT CHEMISTRY"

Appendix K
The Right Chemistry—The Iowa Chemistry Education Alliance

Chief Investigators: Gary Downs, Tom Greenbowe

Time: 23:02

This video provides a description of the Iowa Chemistry Education Alliance (ICEA) and the interactive modules developed through this Star Schools-funded project. The ICEA materials comprise a product and process designed to supplement traditional teaching in high school chemistry classes, with the intent of increasing the enthusiasm and learning experiences for students. It combines traditional teaching with distance learning and networking to not only help students but also to benefit teachers. The ICEA was started in 1996 with only four central Iowa schools. It has now increased to twenty-five schools from across the state. Using the Iowa Communication Network (ICN), Iowa's two-way interactive audio-video fiber optic network, e-mail, and CUSeeMe, students and teachers collaborate with one another about the results and procedures of four modules which are completed throughout the year. The four modules include 1. Communication Tools & Protocols, 2. Data Analysis, 3. Forensics, and 4. Instrumentation.

Star Schools Grant #R203F5000199
Iowa State University, 1999

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ACKNOWLEDGMENTS

For the opportunity to follow this path and grow as a person and a scholar, I thank God.

With gratitude for guidance and support, I thank my committee members, Tom Greenbowe, Gary Downs, Dennis Johnson, Rex Thomas, and Larry Ebbers.

For your role as mentors, I thank Adolf Voigt and Bill Hutton.

To colleagues at this university, thank you for your contributions to this work.

To the ICEA creators, Dick, Ken, Jeff, and Don, without you, this Project wouldn't not have evolved. To you and the ICEA Phase II, Phase III, Phase IV, Phase V, Phase VI, and Phase VII teachers and students, thank you for your vision, enthusiasm, motivation, and perseverance.

To the members of the 18th Biennial Conference on Chemical Education Committees, we did it thanks to you!

To Sally, I am grateful for advice and help on many levels.

To my family, thank you for support, interest, and caring.