Student attitude toward science and the issue of content relevance in introductory earth science courses

by

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CHAPTER 1. GENERAL INTRODUCTION AND LITERATURE REVIEW

The Science Literacy Debate

The National Science Education Standards (NSES) define science literacy as several things, including a person who can "ask, find, or determine answers to questions derived from curiosity about everyday experiences" (NRC, 1996: 2). It is also defined as "being able to read, with understanding, articles about science in the popular press and to engage in social conversation about the validity of the conclusions" (NRC, 1996: 2). This broad-based definition of science literacy will change over time. In fact, the definition, much like an individual's view of science, "has different degrees and forms; it expands and deepens over a lifetime, not just during the years in school" (NRC, 1996). Even though the definition of science literacy is always changing, it has implications for every branch of science. Indeed, the whole nature of science and scientific thought is in constant flux. This limits the definition of science literacy and, therefore, the path of science literacy, to the preference of an individual, school or government. Presently, the plan for achieving science literacy as stated in the NSES involves an overhaul of the current educational system. Emphases are being shifted in content standards including a new emphasis on "integrating all aspects of scientific content" instead of on "separating science knowledge and science process". Integrating the sciences and scientific content is among a list of new emphases for achieving science literacy. This is where the earth sciences become an important aspect, and ultimately a vehicle, for achieving scientific literacy because it incorporates aspects of physics, biology, and chemistry into its study. Although the definition from NSES places a

rather large responsibility on individuals to take control of their own science literacy, school is where this development begins to take place.

Where should science literacy reform start?

The goal of creating a population that understands and can explain scientific ideas should start as early as primary school. The NSES are aimed at the K-12 levels and do not consider how reform may be achieved at the university level. Tobias (1992) claims that most reforms for science education focus on the elementary- and high-school levels where change is most difficult to make. She also claims that the government and universities fall short of their responsibility to promote science at the college introductory level, where the effectiveness of reform is greatly increased. As a result, students entering high school and college lack the skills and knowledge they need to function in a science class and are deemed scientifically illiterate (Lagowski, 1987). In addition to the problem of scientific illiteracy, there is a general trend for students to avoid choosing science as a major and to leave the science field even after they have completed their degree (Evans, 1985; National Science Board, 1986; Tobias, 1990).

The agreement on the need for improvement in college level introductory science courses is prevalent (Brunkhorst, 1991; Hazen & Trefil, 1991; Palmer, 1991; Short, 1990; Tobias, 1992). In the broadest sense, a curriculum based on science literacy, its ideals, and goals, should fix the problem and create well-rounded citizens who can deal with scientific matters as they are presented in the "real-world". On the other hand, Shamos (1996) has suggested that our current idea of scientific literacy is a “meaningless goal" and that the "practical goal of producing future

scientist must (and does) come first". So, achievement of science literacy for every citizen is either a great idea or the nation is heading for widespread failure. Obviously, the need for a plan that will enable each person to attain his or her own science literacy is crucial. This is where the government steps in with standards and attempts to solve the problem. Whether or not the standards are working is still to be established but along the way, geoscientists are heard raising their voices about the subject. They are advocating the use of the geosciences or earth sciences for the promotion of science literacy. In some cases they promote the addition of geology or earth science to the general curricula (Bezzi, 1999) because it is not included in the curriculum at all. In others, they propose a complete revision of the college science requirements (Short, 1990). In either case, it is hard to deny that increasing numbers of educators, at both college and pre-college level, are acknowledging the value of geoscience in their curriculums. This integration of the sciences will play an increasingly vital role in the future of science literacy.

Using geosciences to achieve science literacy

Science literacy can be achieved through geosciences because geoscientists draw their knowledge from other scientific disciplines to make observations and conduct experiments. For example, a geologist may study earthquakes using concepts from physics or may use chemistry to study groundwater. Often though, other sciences fail to incorporate some aspects of the geosciences that are useful in science literacy such as the context of historical perspective for research, deep and relative time, and descriptive methodologies (Brunkhorst, 1991). The premise of integrating the sciences and spreading out learning in pre-college systems has been

addressed by the American Association for the Advancement of Science (AAAS) and by the National Science Teachers Association (NSTA) as found in the Scope, Sequence and Coordination (SSC) approach (Palmer, 1991). This integration must be accompanied by the realization that a shift from current curricula will be required. The NSES support the organization of earth science content using an earth System as a conceptual basis, which is really a view that science is a study of the earth and its environs. Basic physical, chemical, and biological concepts can therefore be learned in a meaningful context of the student's habitat (Mayer, 1997). Hazen and Trefil (1991) advocate the idea that to be scientifically literate students must be presented with a variety of knowledge bridging all fields of science. Zen (1990) believes that earth science has a pivotal part to play and that it is up to the earth scientists and earth-science educators to teach science literacy. Palmer (1991) believes it is also up to the geoscientists to ask the question "What should my neighbor know about the geosciences?" to establish the criteria for science literacy. Bezzi (1999) states that it is "evident that a more complete public understanding of science requires studying the processes of science, not just the content" and that "simply teaching geology does not change students' images of the geosciences". Physics, biology, or chemistry could easily substitute for the word geology in that statement. In summary, many believe that geosciences are beneficial to increasing science literacy, useful as the starting point to get students interested in science and most assuredly the best science to use as a framework for science literacy. Science literacy is seen in a different way through the eyes of a geologist and an earth science teacher. As a geologist, one is constantly reminded of the failure by the

education system to create geologically, much less scientifically, literate people. This is evident when people build homes on unconsolidated deposits near the San Andreas Fault or on cliff sides over the ocean, or believe that earthquakes will occur on a predicted date. But recently the geosciences have become recognized by education reforms and in some cases have been leading the other sciences in implementing these reforms (Brunkhorst, 2002).

Teaching/Learning approaches in the introductory earth science course

For years university level science courses have relied upon lecture as the main method of teaching. In the lecture-centered method the instructor acts as a disseminator of information and the students as empty vessels to be filled with knowledge gained by listening and taking notes. Recently there has been a movement toward a more student or learning-centered teaching approach in the introductory science class. Among other benefits, actively learning material improves student comprehension and promotes deeper learning of the material (Allen, 1996; Ebert-May, 1997; Klinowsky, 2001). Lecture-centered courses do not focus on such deeper learning because it invokes a different approach to learning. Mc Manus (2001) defines this difference in several characteristics of the Teaching-Centered and Learning-Centered methods or "paradigms". For example, the Teaching-Centered paradigm includes educational goals like "instructor transfers information to students" while Learning-Centered paradigm has educational goals such as "instructor creates a learning environment".

Science literacy through increased relevance and improved student attitudes

Specific solutions to the science literacy problem at the university level include improving student attitudes toward science and increasing the relevance of the content for the students. While these solutions may seem straightforward in purpose, their methods are not fully developed and there are numerous opinions on achieving each.

Attitude Assessment

Research conducted on attitudes in science has yielded many suggestions for improving negative attitudes, but there has been no single answer for improving all students' attitude in all science classes (Libarkin, 2001; McEneaney & Radeloff, 2000). Despite the obstacles involved in attitude assessment, it is most important to determine what factors most likely cause change in attitude. Methods used for assessment of attitudes in science education are not agreed upon, and solutions for addressing these problems are found on a case-by-case basis. The researcher must ask what the specific research question is, who will be assessed, and what kinds of resources are available. Studies addressing the issue of uncertainty in attitude change assessments point out several factors that could be influencing the attitude changes, either positive or negative (Gogolin, 1992; Ramsden, 1998). These factors can include teacher characteristics, previous experiences, and gender.

Changing one or more aspects of the course content is a method used to determine if attitude changes when *what* is taught changes. Often content is selected by instructors of introductory earth science courses based on what they

think the students should know and is held to be primary to the course (McManus, 2001). Course content usually relies upon a predictable presentation of textbook chapters and compartmentalized ideas in introductory science classes. This manner of selecting content is sufficient for a teacher- or lecture-centered course but is not comprehensive enough for a student- or learning-centered course. Deeper understanding by the student and a feeling of being part of a community of learners is difficult to achieve when instructors rely solely upon the lecture method. Changing content to include issues that pertain to students on a personal and social level can be a tool for improving attitudes as well as interest toward science. This insight demands a new look at what is being taught and how the content can be objectively chosen.

Relevance

Assessing the content and effectiveness of introductory earth science courses requires a quantitative investigation of earth science topics and their relevance to current issues and concerns. This can be done by analyzing introductory earth science syllabi and textbook content. How students view the content of the course can affect how they feel about the class and thus, how they perceive science. By introducing topics that are relevant to the students' lives, it is possible that a deeper understanding of the subject matter will evolve. As put forth in the NSES, college science faculty need to "address problems, issues, events, and topics that are important to science, the community, and teachers" (NSES 1996:61). Subjects that matter to these groups, including students, are most often issues of a political and

social nature. Newspapers, radio, and television broadcasts discuss these issues because they are deemed relevant enough to be introduced to the general public.

Although there must be a link between what happens in an introductory earth science class and how the student's attitude and performance are affected, the connection is not clear enough to say if a certain teaching style improves attitude or performance. Research done by the NRC (1997:200) finds that lecture-centered methods are less effective in helping students learn scientific concepts (McManus, 2001) but more research is needed to clarify why one method is more effective than another. Each student population is so different from the next that it is nearly impossible to isolate the many variables that could go into each improvement. The difficulty of educational reform stems from the fact that there is no one solution to the problem. Reform is a series of experiments based on prior knowledge of what didn't work before, and changes made must be evaluated again and again for success. When considering changes in course curricula and pedagogy, the relevance of introductory earth science course content and current real-world issues to student attitudes is a crucial factor

Working toward student-centered large introductory earth science classes

To address the problems found in large introductory earth science classes, one can focus on the method and theory of teaching. Student-centered teaching is a working technique used to engage students and increase learning even when the students outnumber the teacher two hundred to one. Establishing a theoretical base is important before attempting a student-centered teaching method, but not necessary. Thus, the instructor needs to explore his or her own epistemological and

theoretical beliefs in order to effectively understand and manage a student-centered course. The epistemological views of teachers and students are centered on their understandings of the nature of knowledge and the nature of knowing (Hand et al., 1999). While epistemological beliefs may not be the main focus when considering change in the introductory science class, it is important for instructors to realize where they stand epistemologically in order to effectively direct the students', and their own, understanding. Four ways of changing a large introductory earth science course based upon student-centered learning theory are discussed below with advantages and disadvantages considered in each case.

Cooperative Group Work

Lecture halls in colleges usually have fixed-seating for 250 to sometimes 500 students. One obvious concern is how to overcome the roadblock of forming cooperative groups. Sharma *et al.* (1999) used cooperative groups in a large introductory physics class. These groups were formed by the students with no input from the instructor and no requirements as far as gender or performance. The students could change teams at will. Likewise, Klionsky (2001) used groups formed by people sitting next to each other in the lecture hall to address conceptual questions and allow for discussion between the students. Both of these studies as well as others (Tobias, 1990; Allen, 1996; Ebert-May, 1997; Lord, 1997; Scott, 1997; Chapman, 2001) overwhelmingly indicate that group work can have a profound influence in the success of the course. Each of these studies found the advantages of group work to include enhanced student achievement, team building skills, better retention of women and minorities in science, and increased intellectual

independence. Some disadvantages were also noted, the most apparent one being complications with different students' learning styles. Some students tended to dislike the groups or decide they were disruptive to learning because one or two students dominated everyone else or because they liked to learn by themselves. Finding a balance between lecturing and group work in the large classroom can be the base for a successful student-centered course (Airasian and Walsh, 1997).

Content

Another aspect involved with the implementation of student-centered learning is decreasing or changing the amount of content presented and how it is presented. Time and manpower are a big consideration in this area. Deciding how much time will be spent lecturing and how much will be spent with the students in small or large group discussion depends on course objectives and student attitudes, among other factors (Allen, 1996). When "factual material was presented in the context of the main theories", students were able to see the relative importance of the major concepts instead of memorizing detail without meaning (Chapman, 2001). While exchanging content for depth may seem like a tradeoff, the goal of student-centered learning is not to leave most areas of content uncovered while delving into just a few concepts. With the big ideas in place, it is the goal of student-centered learning to fill details without the rote memorization required in traditional classes. "By eliminating superfluous and repetitious content, such student-focused group activities as analyzing charts and graphs, constructing concept maps, and interpreting scenarios can be included in a lesson without serious consequence" (Lord, 1997). Teachers who desire a student-centered classroom need to realize that getting through the

entire textbook by the end of the semester should not be the primary goal. The inability to rely heavily on the textbook initially seems to be a hindrance until one manages to break free of preconceived notions. Not having a book guide the class and instead having the learners chart their own course for learning creates a class more relevant and specific for the students. Having a strong theoretical and conceptual framework concerning student-centered learning as described above, will help teachers accomplish this goal with less fear about relinquishing control of learning to the learner.

Class Format

The format of the class will be affected as a consequence of the previous activities. A class that includes basic changes to the amount of lecturing and activities will have a format that emphasizes the learner's questions and discussion. Depending on the type and level of class being taught, the format may be adjusted for the difficulty of the concepts. For example, different amounts of student group work, discussion, and experiments as compared to lectures, Socratic discussions, and demonstrations were used in introductory biology, physics and chemistry courses (Allen, 1996). This revision of class format requires extra effort from the teacher and a deep understanding of the subject so as to be ready if the class goes in a direction that was not foreseen. Deeper understanding of the subject will also enable the teacher to have better questioning skills that focus not on right or wrong answers but on how and why that answer was given. The main advantage of this change is the passing of power from the teacher to the student; this is also the main disadvantage to the teachers who see it as their duty to "give" knowledge away.

Thus, a teacher with epistemological and theoretical preparedness will be more able to handle this restructuring than one without.

Assessment

The methods and goals of student assessment in a student-centered classroom are different from traditional methods of assessment both on the surface and on a deeper level. Student assessment reflects directly on everything else being implemented in the student-centered classroom. "Assessments that focus on the processes as well as on the products of learning and that involve students as participants in determining criteria of excellence for the work" are as "rich (complex) and interpretive (potentially subjective) as the learning activities themselves" (Windschitl, 2002). Typical tests given in large science classes involve elements of the same scheme: multiple choice, low-order thinking questions that generate anxiety and competition for grades among students. Instead of this situation, in which students are treated as "vessels" to be "filled" with information, a situation should be created in which students are considered independent thinkers capable of demonstrating knowledge in a variety of different ways. Practical difficulties are faced when assessing a large number of students and can be worked through in different ways. Group quizzes, in-class writing exercises and essay questions on the exams can be an alternative ways of assessing student performance (Ebert-May, 1997; Sharma *et al.*, 1999). The teacher of a large science class needs to come to an agreement with themselves on what they *want* the students to learn and what the students *might* actually learn in the course, and how to assess both. Making this distinction can be seen as a major disadvantage when compared with

traditional methods of assessment where the student is expected to know only specific content given out either by the teacher or a textbook. Regurgitation of facts and low-level thinking questions are easy to incorporate into large class assessment but only serve to reinforce the students' roles as passive learners who absorb concepts and facts just long enough to get through the next test (NRC, 1996b). When this is considered, the challenges faced by the teacher when implementing ideas in a student-centered course take on new significance.

Looking at the Future of Large Student-Centered Science Classes

The reality faced by most teachers and learners in large science classes at the university level is in stark contrast to what the education community is trying to advocate. While it is likely that most introductory science instructors still rely on the "sage on the stage" approach, a teacher presenting content as a lecture with no other interaction with students, such as discussion or group work, leaves the students unaffected and bored. Although there are some students who can "learn" in this environment, student comprehension is undoubtedly enhanced by student-centered pedagogy and active learning (Harris, 2002; McManus, 2000). From a science education perspective, the real problem is that science literacy being force-fed through the K-12 curricula steeply declines when undergraduate education starts. Reforming the large introductory science class is a step in the right direction for science literacy. This involves a look at what is being taught and how, and also requires teachers to consider the deeper meaning behind teaching and learning. Real-world situations never look as neat and clean as theory, which is why it takes time to change in a system with so many factors. Meeting the challenge of today's

science education in universities will take the entire education community beyond theories and put them in the hands of reality.

Conclusion

Science literacy is a large objective for educators to handle and is not without detractors. "The science education movement has failed to penetrate the consciousness of the American public in a manner that even borders on what might be considered 'science literacy'" (Shamos, 1996). Shamos also claims that science literacy should be considered "an impossible task and [we should] get on with the normal business of science education". This kind of detraction and pessimism is what created the problem in the first place. To achieve science literacy, we must not let semantic debate overshadow the larger picture. There are many words to describe, define and explain science literacy, but this does not mean it is not a real problem or does not affect a large population. More likely we should agree with E-an Zen's (1990) view of science literacy: "During the time we sit here to discuss science education, it is likely that another species will have become extinct somewhere because of man's arrogance, complacency, and ignorance. That's certainly one argument for enhancing the general level of science literacy". Reality has awakened our government to action and created a new awareness that most people are not ready to deal with scientific issues on their own. Standards were created to help guide educators in the important aspects of science education and to remediate the problem of scientifically illiterate citizens. Proponents of integrating the sciences call for an earth science framework for the goals of science literacy to be organized around. Geosciences are an obvious starting point for this framework

because they utilize other sciences to answer questions and find solutions using the entire earth system for reference. Coordinating ideas for reform in a practical, useful manner is a complicated task and it may be years before any methods can be completely measured and classified as to what works and what doesn't.

Thesis Organization

Two papers are included in this thesis, which are intended for publication. These papers comprise Chapters 2 and 3. In addition there is the general introduction (all of the above) and a general conclusion chapter.

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CHAPTER 2. MEASURING THE ATTITUDE TOWARD LEARNING SCIENCE OF STUDENTS IN INTRODUCTORY GEOLOGY COURSES

A paper to be submitted to *Teaching Earth Sciences*

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Abstract

Research into attitudes in science focuses largely on determining if certain instruction methods affect student attitude and there is a broad range of opinions as to what attitude means and how to study it. We have analyzed the attitude of students enrolled into two introductory geology classes with the goal to test if demographic factors and success in the class play a significant role in determining students attitude towards science and learning science. A pre-test and a post-test Likert-type attitude questionnaire were administered to two introductory Geology classes at Iowa State University during the Fall semester 2002. Results were analyzed for statistically significant relationships between attitude, gender, major and final grade. The results show that male students, science, math and technology majors, and students who successfully passed the class have a better attitude towards learning science.

Introduction

Attitudes in science have been researched since the 1930s, but it has always been difficult for researchers to come to an agreement on certain key issues. What should be studied and why? What is exactly meant by "attitude"? How should attitude be measured? Studies, such as those done by Munby (1980, 1983, 1990), established methods and terminology that are still used today as a guide for attitude research. The critical difference between early studies and current ones is a new

focus on how student attitudes are connected to science literacy. This connection is important but is not completely understood yet and, therefore, its implications are not fully realized. Importance is placed upon ties between science, society, and technology with a strong drive for every student to be a scientifically literate citizen. National standards include the idea that "attitudes and values established toward science in the early years will shape a person's development of scientific literacy as an adult" (National Science Education Standards, National Research Council, p.2, 1996). This statement underlines the importance of science literacy development in students as a means to aid them in making informed decisions about science and technology issues.

Most attitude research has been concentrated in four geographic areas: the United States, Great Britain, Australia and Israel (Haladyna, Olsen, and Shaughnessy, 1982). A connection between positive student attitude and improved understanding of concepts has been shown, as has the reinforcement of attitudes on performance in science and vice versa (Gogolin, 1992; Jovanovic and Dreves, 1998; Papanastasiou, 2002). In addition, relevance has also been shown to improve student attitudes (Byrne and Johnstone, 1988; Singh, 1999; Bicak and Bicak, 1990). When a science course is relevant to students on a personal and societal level, they tend to have a better attitude toward the course and toward science in general. A positive attitude provides a student with greater possibilities including increased learning of concepts.

Past research that has focused on student attitudes toward science has shown that little progress has been made to improve those attitudes (Morrell &

Lederman, 1998). One reason for this could be that the definition of attitude is different depending on the type of research being done and the goals of the researcher. The definition of attitude encompasses many psychological and behavioral concepts and its context spans affective and cognitive scales making the term hard to classify. In some cases it is an opinion or belief, while in others it is a cognitive state of the mind with no relationship to feeling. Shrigley et al. (1988) define attitude as a trio of concepts:

> "The three-parts of the attitude trilogy (affection, cognition, and conation) are no longer equal partners. Each element is related to the definition of attitude but in varying degrees. Affection is equivalent to evaluative quality. When translated as beliefs, cognition is a backdrop to attitude. Behavioral intention may replace conation."

Defining attitude is an integral part of defining the boundaries for attitude research. Much effort has focused on defining attitude and describing how or why it is formed, however it is still important to consider the different variables that play a role in students' attitude in the science classroom. "The lack of integrative findings has created a situation where not much is known of the possible determinants of attitudes toward the school subject of science" (Haladyna et al., 1982). The relationships between instruction, attitude and achievement hold importance in the field of attitude research because "qualitative and quantitative studies [...] show how particular and contained instances of instruction related to students' views of themselves interacting with specific science activities (classroom or otherwise)" (Munby, 1990). Relating attitude, specifically attitude toward science, to a specific instruction type or instance is one of the few ways to find a cause-effect relationship between attitude and some treatment.

A study conducted by Libarkin (2001) at the University of Arizona indicated that student attitudes towards science and towards learning science were not affected by type of instruction, whether traditional or student centered. So, what type of pedagogy, if any, will affect and improve students' attitude toward science?

Attitude toward a science course is a conglomerate of many components including self-image, peer influence, parental influence, and classroom environment. Attitudes are developed over the course of a person's life and tend to change with cognitive states.

This study is intended to demonstrate that attitude assessment can be a valuable tool in the science classroom especially when there is an established style of instruction and a desire for improvement. The most convenient way of assessing attitude change is the pre/post test method where a survey is given at the beginning of the instruction segment and at the end of the segment. One-time assessment of attitude can be used when one assignment or activity is the focus, but repeat assessment gives the instructor and the students a chance to see how and if the treatment affected student attitudes over time. Within the test is the possibility for error because, although methods for assessing attitude and attitude change are well established, questions still remain about the reliability and validity of each method. One must determine which method will best fit the study considering the main objectives, number of students, and type of attitude being measured.

Methods of attitude measurement

Several types of attitude measurement are available to researchers. Some of the more common types are Likert-type scales, Thurstone-type scales and semantic

differential scales (Aiken, 2003). These attitude scales are designed to assess a number of variables from political to occupational attitudes and may be standardized instruments available from commercial test publishers or may have been designed for a particular research investigation or application. Method of scoring, conditions of administration, and number of response categories can all affect the reliability of an attitude survey (Aiken, 2003).

Other issues may influence the type of method being used, which depends on the goals of the study. First, disparity commonly exists between the respondent's and the researcher's viewpoint of the question and of the study. Lack of understanding can cause complications in scoring the attitude assessment (Munby, 1980; Ramsden, 1998). This is especially a problem when a researcher is developing an original assessment tool for a specific purpose. Second, attitudes are not stable and change with cognitive states (Munby, 1990). In light of wanting students to change cognitive states from passive to active learners, this issue with attitude assessment must be carefully considered when studying attitude change. Last is the definition of attitude. There is a difference between the terms "scientific attitude" and "attitude toward science", which can translate into a difference in the researcher's goals. Gardner (1975) describes *attitudes towards science* as 'interest in science', 'attitudes towards scientists', 'attitudes toward social responsibility in science' and *scientific attitudes* as 'open-mindedness', 'honesty', and 'skepticism'. This study focuses on attitude toward science or the "views and images young people develop about science as a result of the influences and experiences in a variety of different situations" (Gardner, 1975; Ramsden, 1998). Positive change in

student attitude can mean positive gains in understanding and science literacy, thus research on attitude assessment and improvement mostly concerns the attitude toward science.

Methods: Attitude assessment in Geology 100, Iowa State University

Libarkin's (2001) research was used as a model for this study done at Iowa State University during the Fall semester in 2002. Student attitudes were assessed using a Likert-type scale attitude survey at the start of the course and again at the end of the course with the goal of examining any attitude change over the semester. The courses assessed for this study were two sections of a three-credit introductory geology class with no lab or recitation and a total enrollment of about 460 students, taught by the same instructor (Cervato). Since the treatment for the students in this study was the instruction of the geology course, establishing the teaching method is important. The instruction style was a combination of lecture, classroom demonstrations, and occasional work in small groups. Assessment of students' learning consisted of on-line and essay-style homework assignments in addition to short in class assignments (5-10 min) that, in total, accounted for 40% of the grade. The remaining 60% was derived from traditional multiple-choice and short answer tests covering content from the lectures. Students were also allowed to gain extra credit by completing additional homework assignments and a diagnostic test (up to an additional 11%). Based on the continuum of teacher-centered versus learner-centered, the instruction style of this course fell towards the middle with a tendency towards learner-centered teaching.

Student makeup

Typically, students enroll in introductory science courses to meet a science requirement set by the college or university. Gogolin and Swartz (1992) found a significant difference between non-science, math or technology students (non-SMT) and science, math and technology students (SMT) in their pre-test attitudes toward science. Also, they found that only one half of the class had taken more than one year of science in high school and that this can influence how a student feels about science in their postsecondary education (Gogolin and Swartz, 1992). In the course researched for this study about three-fourths of the students raised their hands when asked on the first day of class who was taking this class to meet a science requirement and about 80% of the 460 students enrolled in the two sections were non- science-math-technology (SMT) majors (**Figure 1**). The final letter grade (A-D are passing grades, F is the failing grade), gender, and year in school were also recorded for each student and used to determine if there were factors outside of the specific treatment that could affect a student's attitude. Specifically, gender is one of the most studied variables in attitude toward learning science and it has been shown in many studies that male students tend to have a more positive attitude toward science than female students (Jovanovic and Dreves, 1998; McEneaney and Radeloff, 2000). This has significant implications and it has been shown that women hold non-tenure track positions more often than men in the geosciences and occupy fewer geoscience positions in the U.S. and Canada (Coultish, 2002; DeWet, Ashley, and Degel, 2002; Macfarlane and Luzzader, 1998; Libarkin and Kurdziel, 2003).

The final grade obtained by the students was factored in the analysis to test the hypothesis that it may affect the student attitude at the end of the course. The survey was given a few days before the final exam, but students could keep track of their performance since the grading scale and exam, quiz, and homework scores are accessible to them through the course's WebCT page.

The attitude survey

The attitude survey consisted of a pre-test (26 questions) and a post-test (31 questions). The post-test included five additional questions on peer and familial influences (**Table 1**). The ability of a student to cope with the different demands of postsecondary science classes may factor into their attitude toward science, and this ability to cope may have developed in high school. For this reason, a question was added on the post-test asking how many science classes the respondent took during high school.

Most academic attitude scales yield one score that represents attitude in general and this means that the variables that affect attitude cannot be distinguished from one another (Gogolin & Swartz, 1992). The 26 questions of the survey were divided into three groups based on what they specifically addressed: Attitude toward Learning Science (ALS - 7 questions), Attitude toward Science (AS - 5 questions), and Conception of Science (CS - 14 questions). Dividing attitude into distinctive scales can give a researcher the ability to specifically determine how attitudes are formed and how they change. Sources for the survey items are given in Libarkin (2001).

Statistical analysis method

The statistical software packages SAS™ v. 8.2 and SPSS v. 10.0 were used for analyzing the results of the survey. The results obtained from the survey when the students started the class were statistically compared with the results obtained at the end of the semester taking into account the variables gender, year in college, major, and final course grade. An analysis of variance (ANOVA) was run to test for differences between freshmen and more advanced students. Independent t-tests were run to compare scores of male vs. female students, non-SMT majors vs. SMT majors, and freshman vs. other years. Paired t-test analysis was done to compare Pre-test and Post-test scores of unsuccessful students (final grade: D+ or lower) to successful students (final grade: C- or higher).

The Cronbach alpha statistic is used to determine internal reliability and is useful for survey analyses because it standardizes the reliability and validity of surveys that are used by researchers. Reliability is the proportion of variability in a measured score that is due to the true score. For example, a reliability of 0.9 means that 90% of the variability in the observed score is true and 10% is due to error. The Cronbach alpha statistic can range from 0-1, with 1 representing perfect reliability or an observed value that is exactly equal to the true value (Libarkin, 2001). A reliability of 0.80 is recommended for group means and a reliability of 0.90 is recommended for individuals (Gardner, 1975).

Content validity of the original survey (Libarkin, 2001) was established by asking faculty to comment on the relevance of each test item and by testing undergraduate and graduate students as a control group. Typically, a control group

is a randomly selected group of participants from the original test population. The term "control group" as used in this study refers to a specific population chosen for their assumed positive attitude to science in each scale of the survey. For comparison purposes, a control group similar to the one selected by Libarkin's (2001) and consisting of 27 undergraduate majors in geology, graduate students and faculty members at Iowa State University was also given the survey.

Results

The means and standard deviations for attitude towards learning science, attitude toward science, and conception of science of the control group from Iowa State University were 0.66±0.14, 0.66±0.16, and 0.66±0.13 respectively. The means and standard deviations of the control group from the University of Arizona for ALS, AS and CS were 0.93±0.06, 0.86±0.10, and 0.80±0.10 respectively. Although no suitable explanation can be given to explain the low scores of Iowa State University's control group, the scores of the control group are needed as reference point for pre- and post-test comparisons and should be measurably different from the mean scores from the test population. Since this is not the case when comparing ISU control group and student results and the survey administered at ISU was identical to the one used at the University of Arizona, we have chosen to use the control group scores from the University of Arizona as standard scores for a group with a positive attitude.

Acceptable student scores on the attitude scales are set at two standard deviations below the University of Arizona control group mean. Thus, for students to be considered as having a positive attitude, they must score at or above 0.81 on the

ALS scale, 0.66 on the AS scale, and 0.60 on the CS scale. This ensures that all variability associated with testing individuals is accounted for (Libarkin, 2001).

Pre-test means for the student population were 0.49±0.12, 0.60±0.10 and 0.55±0.80 for ALS, AS, and CS respectively. Post-test means for the student population were 0.58±0.16, 0.58±0.12, and 0.55±0.09 for ALS, AS, and CS respectively. All attitude scales show improvement from Pre- to Post-test. Attitude means reported for the Post-test show that the students' attitudes are not acceptable based upon the standard deviations set by Libarkin (2001). The means from the Pre-test, Post-test, and both control groups (Iowa State University and University of Arizona) are compared in **Figure 2.** A t-test or other statistical analysis that compares means across these groups would not be useful because the groups were so different from each other in sample size and in respondent makeup. Comparing the means of two groups with a two-tailed paired t-test is most useful and reliable when using matched data, as in the student population pre-test and post-test. However, the means compared in Figure 2 are a generic way to gauge if the groups are comparable to one another.

The Pre-test and Post-test Cronbach alpha scores for the students are compared in **Table 2**. The Post-test Cronbach alpha scores for the ALS, AS, and CS scales for the study group were 0.81, 0.74 and 0.80 respectively. All attitude scales improved their Cronbach alpha scores from Pre-test to Post-test. Since the Cronbach alpha measures reliability, this means that the scores are more reliable for the Post-test than they are for the Pre-test. The attitude toward science scale

consists of only 5 questions and has a lower Cronbach alpha than the other two scales, which means interpretations based on the AS scale are not as reliable.

A survey question regarding the number of science classes taken in high school was included on the Post-test questionnaire for this study (Question #27 in Table 1). Most students (about 55%) said that they completed between 3 and 6 science classes in high school (**Figure 3**).

SMT majors have overall a more positive attitude than non-SMT majors on all scales (**Table 3**). This is true both for Pre-test and Post-test. Their attitude toward learning science improved at the end of course, while their attitude towards science slightly decreased. Pre- and post-test scores do not vary substantially in non-SMT majors.

Plots of attitude scale values versus final grade expressed as a percentage (out of a possible total of 111%) show random patterns with no strong correlations (**Fig. 4**, **Fig. 5**, **Fig. 6**). To test the hypothesis that success in class and positive attitude are related (i.e. students who had more positive attitudes received a higher final grade or students who had higher final grades displayed a more positive attitude at the end of the semester), the students were divided into groups based on their final grades with the line between successful/unsuccessful being moved to encompasses fewer and fewer students in the successful group. This was done to even out the sample sizes for analysis and to determine if, as the final grade improved, attitude improved as well. The terms "successful" or "unsuccessful" are useful in this study when considering groups of students and their final grades, but do not consider actual learning or retention of material.

Unsuccessful students showed no significant difference between their Pre- and Post-test scores only when D+ to F was considered unsuccessful. There was a significant increase in the students' ALS from Pre- to Post-test for all but the D+ to F unsuccessful students as shown in the paired t-test scores (Table 4). On the other hand, the students who were successful had a significant increase in their ALS in *all* group divisions and a significant decrease in their AS for all except the A to B group. The change in CS was not significant in any of the successful groups. To determine if there were any other significant differences between unsuccessful and successful students, an independent sample t-test was also run for each of the four divisions of grades. It showed that with fewer students in the successful group (the A to B group) there were more significantly positive attitudes than when more students with lower grades were included. So, in other words, the more successful the students were, the more of their attitude scales showed a significantly positive result. This could also be a result of student views on what grade they consider successful and what grade they consider unsuccessful. The D+ to F category of unsuccessful had no significantly positive attitudes but contains the university approved passing grade of D+. This could mean that, even though the student received a passing grade, the grade was considered as unsuccessful by the student. More likely is that most students view a successful grade different than the university because of the expected easiness of an introductory class.

The independent sample t-tests also showed that the Pre-test scores of successful students were consistently more positive than the Pre-test scores of unsuccessful students, although not significant in all cases. As described above the

more successful the group, the more the results became significant. (Results from independent t-test can be found in an online appendix at http://www.ge-at.iastate.edu/people/faculty/cervato/publications.html.) These results suggest that students who are successful in the class may have more positive attitudes toward learning science, which may help them in the learning process. However, since the sample sizes of the successful and the unsuccessful groups were so different in all of the divisions, it is difficult to say if attitude affects the final grade of a student, or if the final grade is a factor in student attitude.

The independent sample t-tests for attitude and gender showed statistically significant results. The Pre-test scores indicate that male students had a significantly higher ALS than female students ($t=2.695$, $p=0.008$) and female students had a significantly higher AS than male students ($t=-2.121$, $p=0.035$) (**Table 5**). The CS was not significantly different between male students and female students for their Pre-tests, although results show that male students had a slightly more positive CS than female students. The Post-test scores indicated that the male students still had a significantly higher ALS than the female students ($t=3.185$, $p=0.002$) while the female students had higher AS and CS scores than the male students, but not at a significant level (**Table 6**).

The students' class rank did not show any significant results when compared with their attitude. **Table 7** shows results from independent sample t-tests comparing freshmen with all other years. The hypothesis was that freshmen would have a different attitude as compared with the attitude of students who had already been in the university at least a year and may have already taken a science class.

Freshmen attending university for the first time are often overloaded with the demands required of large introductory courses and may not have the same attitude as other students who had already adjusted to the routine of classes, studying and homework. In Table 7 it is shown that there are no significant differences between the attitudes of freshmen students and the attitudes of sophomore, junior, and senior students. An ANOVA (analysis of variance) was also done to determine if there was a difference in freshmen students and upper level student attitudes. This yielded no significant results just as the independent sample t-test, showing that when upper level students are grouped together or looked at independently and compared to the freshmen, there still is no significant difference in attitude.

Interpretation

Interpretations of the results of the comparison between attitude versus final grade and attitude versus major should be considered with caution due to the difference in sample sizes. The statistical results of the comparison between gender and attitude are more reliable due to the similarity of sample size between the two groups.

Based on previous studies found in the literature (e.g., McEneaney and Radeloff, 2000) and on results from questions added to the Post-test about peer and family influence, we had expected male students to have a more positive attitude than female students in all scales. A question on the Post-test revealed that male students from the student population had taken more science classes in high school than female students (**Fig. 3**). There were about 10% more male students than female students who took 6 to 9 science classes in high school (17.7% male and

7.9% female) and about 4% more male students than female students who took more than 9 science classes in high school (6.2% male and 2.0% female). Also, when asked if the student would do well if they decided to major in science, 17% more male students than female students replied "yes" (57.0% male and 39.4% female). As for family influence, the results indicated that while neither male nor female students had a high attendance at science fairs and museums (4.5% for males and 4.1% for females in the category of "quite often"), the male students had 4% more "occasional" attendance than the female students to these types of events (34.2% male and 30.6% female). Results from the Post-test questions supported the hypothesis that male students had more previous experiences in science and prior positive attitudes that would predispose them to doing better in a post-high school setting.

The results from the independent sample t-tests showed that male students had only a significantly better attitude toward learning science in both Pre- and Post-test scores. Female students showed a more positive attitude toward science but not at a statistically significant level. The attitude toward learning science improved in the post-test in both groups, while the attitude towards science and conception of science scores decreased slightly or remained constant in both groups. Male students may be more positive towards learning science from the onset because of past experiences (e.g., encouragement from family and teachers and competition among peers for high scores in science and math, McEneaney and Radeloff, 2000). The increased ALS score in the post-test scores of both groups possibly suggests that the teaching style and/or classroom environment made the students like the

class and encouraged them to learn. These factors may not have affected the attitude towards science and the conception of science as strongly because these attitudes encompass broader areas including societal opinions, ethics, and religion. Also, Results from the AS scale are not as reliable as the results on the other scales due to the fact that it is determined using only 5 questions.

The SMT students had significantly more positive scores than the non-SMT students for the ALS and CS on the Pre-test. The SMT students also had a higher ALS and CS for the Post-test but it was not statistically significant. Both groups show an improved attitude toward learning science at the end of the course, while AS and CS scores slightly decreased. These results were expected since the SMT majors would probably have had previous experiences with science that predisposed them to a more positive attitude toward learning science and a more positive conception of science. But, the non-SMT students showed the same or slightly more positive attitude toward science. This result is probably due to the smaller number of questions related to AS in the survey.

The students who successfully passed the class showed a significant increase in their ALS, which could suggest that their attitude was positively influenced by the expectation of a good grade in the class. None of the tests run (ANOVA or independent sample t-test) indicated a difference between freshmen and second through fourth year students. Most freshmen students have not completed a university level science class before attending university, thus their attitude toward science and learning science must have been formed at some previous time. The attitudes of students other than freshmen may or may not have been formed from

previous university level science courses. Although, the attitudes of freshmen are most likely formed from experiences in high school. The results for year in school suggest that being a freshman or upper classman does not affect attitude significantly. Further examination of large groups of students in the same science course from each year in school would determine if there is a significant difference in attitude. These results do not indicate if students that have had more science classes have a more positive or more negative attitude.

Conclusions

There is a general consensus in the science education literature that instruction and attitude are closely linked (Haladyna, Olsen, and Shaughnessy, 1982; Munby, 1990; Gogolin and Swartz, 1992; Osborne, Driver and Simon, 1998). These studies suggest that good or quality instruction is essential to improve student attitude. Gardner (1975) suggests that the teachers associated with positive student attitudes are well organized, achievement motivating, and enthusiastic.

This study represents a view into student attitude toward science in two introductory geology classes using a survey specifically designed to test the attitudes of students in earth science classes.

From this study it can be concluded that there is a relationship between attitude toward learning science and gender, success in the class, and major. Overall male students, successful students, and SMT majors have a more positive attitude toward learning science. The relationship between these factors and the attitude toward science and the conception of science is more ambiguous. There seems to be no relationship between the year in school, freshman through senior,

and attitude but these results are still unclear because of sample size. Overall students showed a more positive attitude toward learning science at the end of the course. While exogenous variables such as gender, socioeconomic status, and family mobility are not under the direct influence of the school or instructor (Haladyna, Olsen, and Shaughnessy, 1982), a teaching environment that attempts to actively engage students and involve them in the learning process such as the one used in the classes surveyed for this study, can improve student attitudes.

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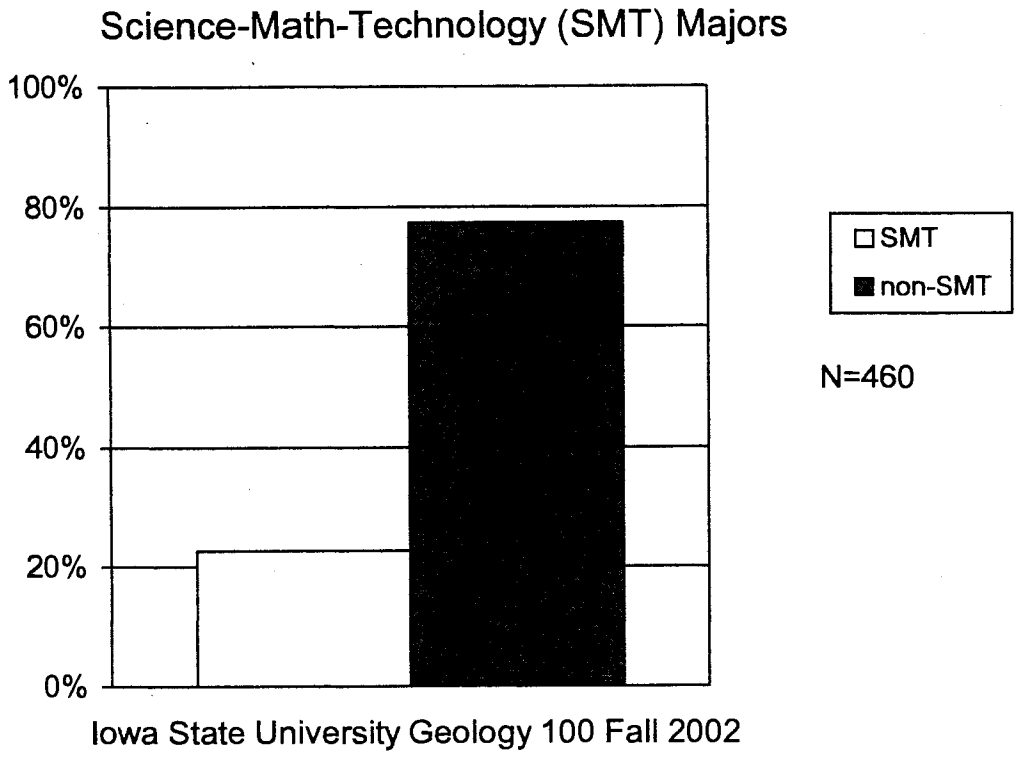


Figure 1. Distribution of students in an introductory Geology course at Iowa State University.

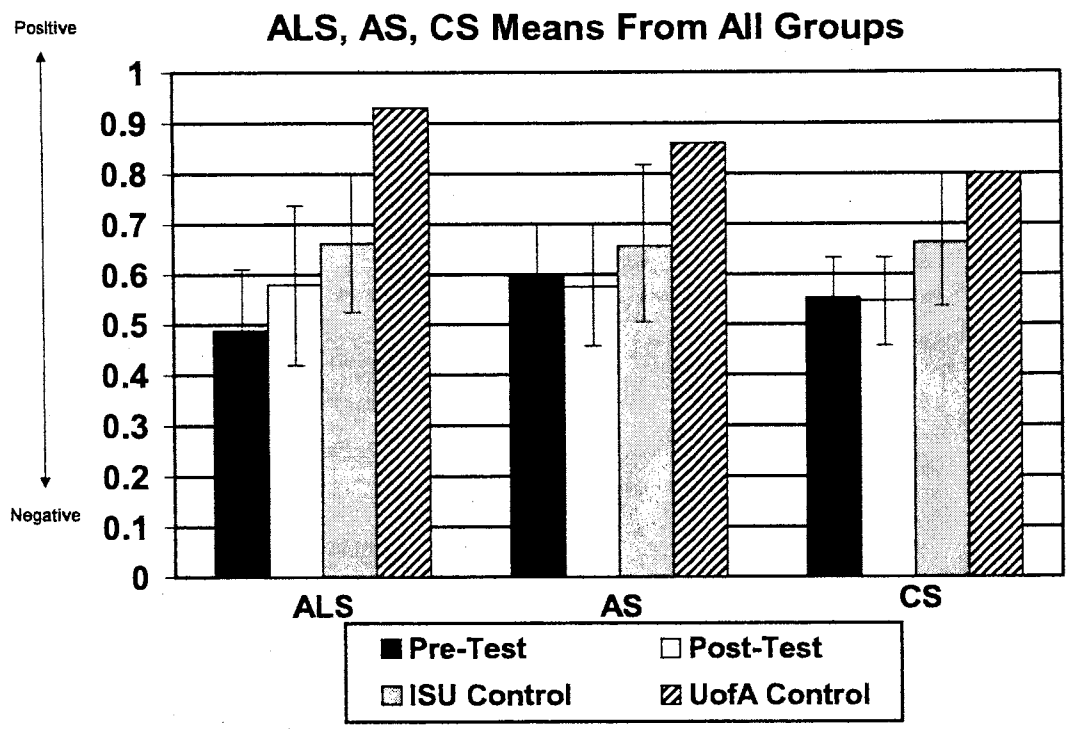


Figure 2. Means of the Pre-test and Post-test scores for the student group from this study (N=221), of the Iowa State University control group (N=27) and the University of Arizona control group (N=31). No standard deviation was available for the University of Arizona control group (Libarkin, 2001).

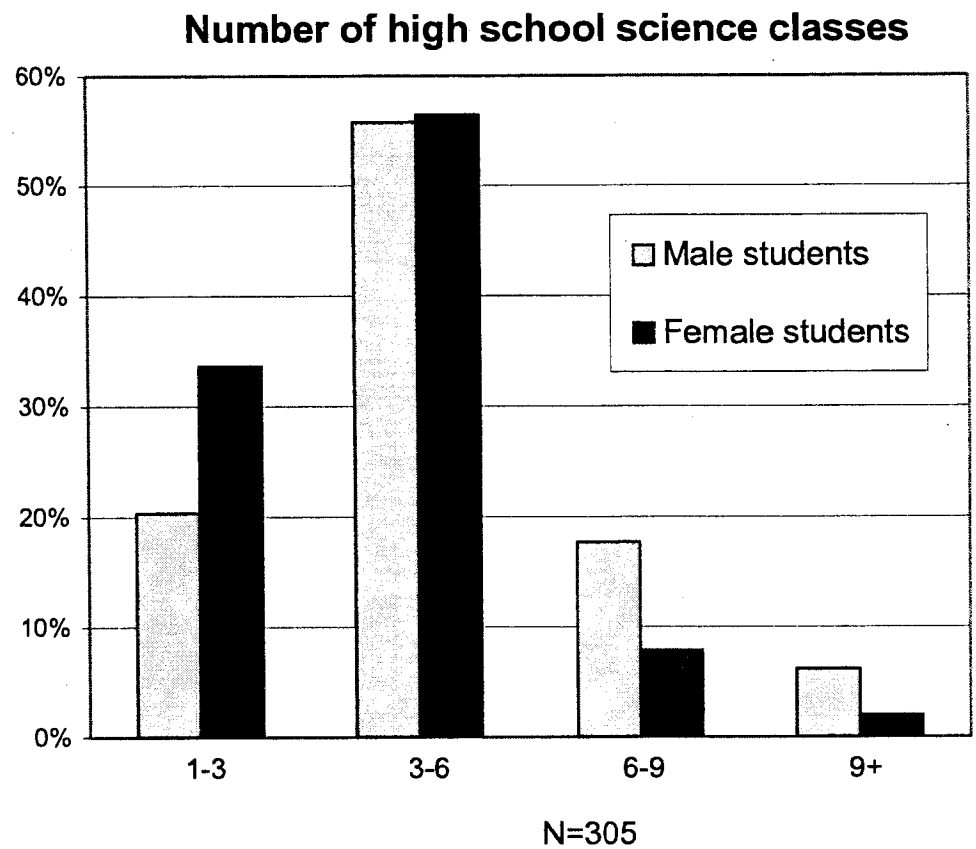


Figure 3. Number of high school classes that the surveyed students declared to have taken.

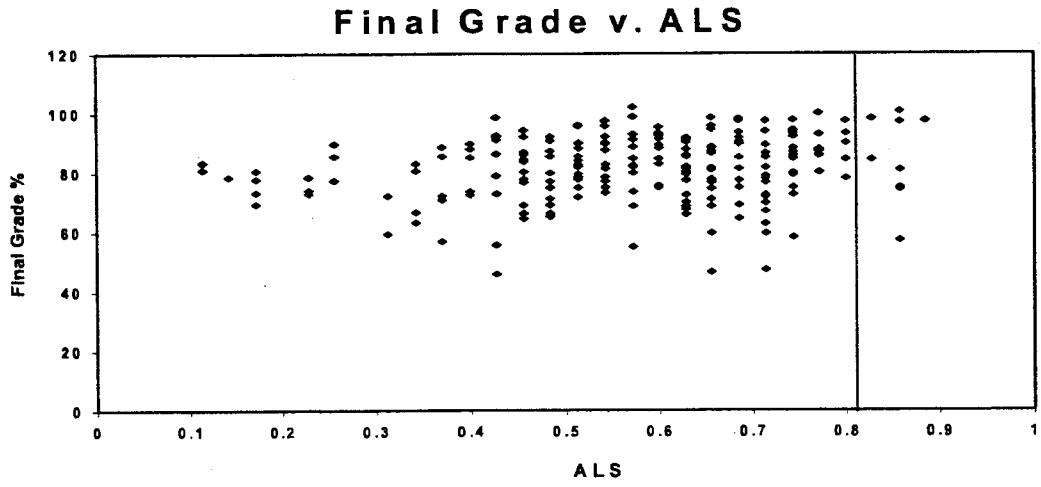
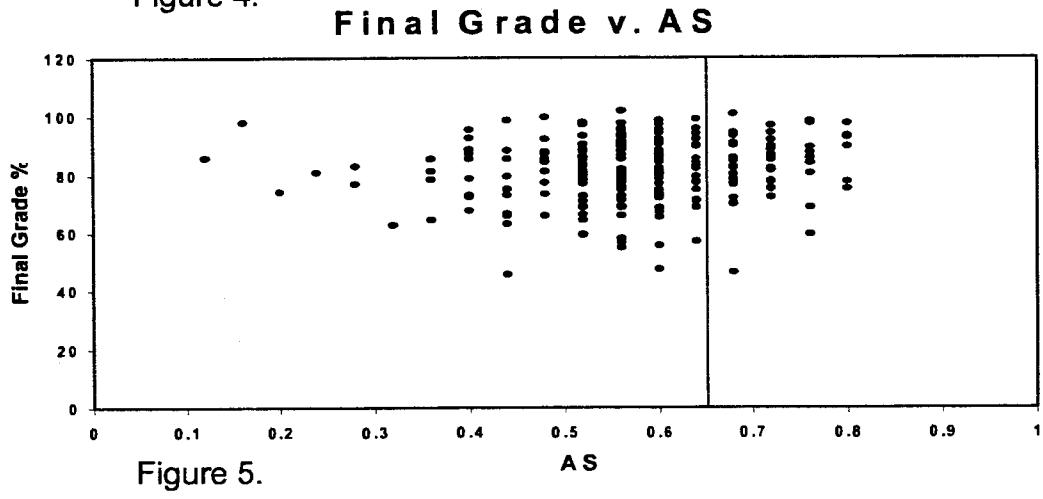


Figure 4.



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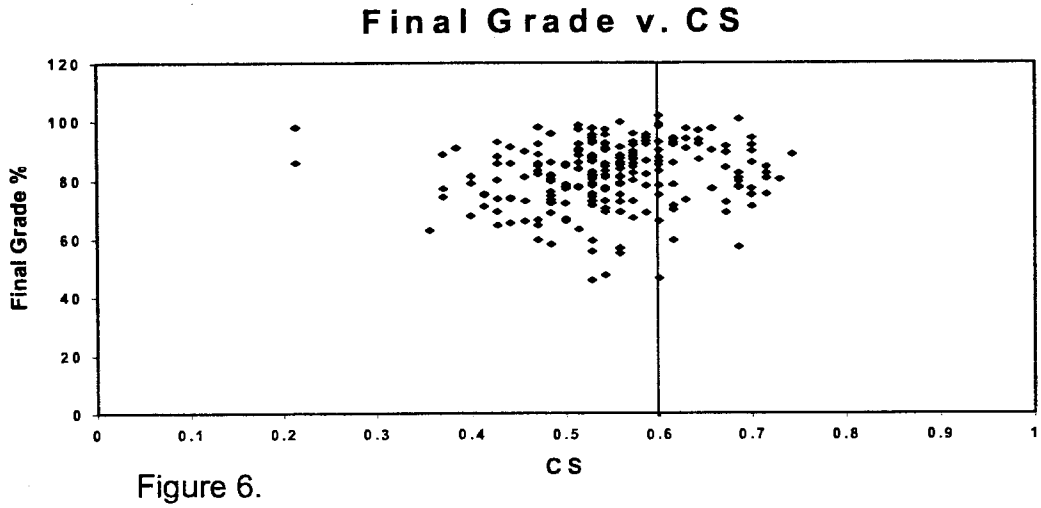

Figure 6.

Figures 4-6. Plots of Final Grade of student population against each attitude scale.

Table1. Attitude survey used in the Fall 2002 Geology 100 course. Questions 1-26 from Libarkin (2001); questions 27-31 adapted from Gogolin and Swartz (1992).

1. I like to read about new scientific discoveries.
2. I like learning about the Earth and how it works.
3. I often wonder why the Earth looks the way it does.
4. I like science because it challenges me.
5. I think science is interesting and would like to learn more.
6. Science classes are boring.
7. I like to talk about interesting classes with my friends.
8. Nothing interesting can be learned from rocks.
9. Geologic discoveries made today are important for the future.
10. Geologists are not as scientific as other scientists.
11. I think that science has done more harm than good.
12. People with poor social skills tend to become scientists.
13. Scientific beliefs do not change over time.
14. Scientists believe that we will one day know everything there is to know about the universe.
15. Scientists will accept scientific information even if test results are now consistent.
16. The evidence for scientific information does not have to be repeatable.
17. The laws, theories, and concepts of all areas of science are not connected.
18. The truth of all scientific knowledge is beyond question.
19. When scientific investigations are done correctly, scientists gather information that will not change in future years.
20. When scientists classify something in nature, they are classifying nature this way because that is the way nature is; any other way would be incorrect.
21. Even when scientific investigations are done correctly, the information that scientist discover may change in the future.
22. The laws, theories, and concepts of all areas of science are related.
23. Scientific laws, theories, and concepts are tested against reliable observations.
24. Scientists classify nature through schemes which were originally created by another scientist; there could be other ways to classify nature.
25. Scientists reject the idea that we will one day know everything about the universe.
26. Today's scientific laws, theories, and concepts may have to be changed in the face of new evidence.
27. How many science classes did you take during high school? A.0-3 B.3-6 C.6-9 D.9 or more
28. Were there science labs in your high school? A. Yes B. No
29. How many *college* level science classes have you taken? A.0-3 B.3-6 C.6-9 D.9 or more
30. Would you do well in science if you tried to major in it? A. Yes B. No
31. Did your family attend things such as science fairs or science museums when you were growing up? A.Never B.Rarely C.Occasionally D.Quite often

Table 2. The Chronbach alpha reliability coefficient for all three attitude scales of the student study group. Pre-test and Post-test scores for reliability show an improvement for all scales.

Chronbach alpha for the Three Scales of the ACS*

Scale	Pre-test	Post-test
Attitude toward Learning Science	0.76	0.81
Attitude toward Science	0.66	0.74
Conception of Science	0.78	0.80

*Combined SMT and non-SMTscores (n=221)

Table 3. Pre-test and Post-test scores for the three scales of the attitude separated into science, math and technology (SMT) majors and non-SMT majors.

SMT majors (n=44)				Non-SMT majors (n=177)			
	ALS	AS	CS		ALS	AS	CS
Pre-test mean	0.53	0.60	0.58	Pre-test mean	0.48	0.60	0.55
Pre-test SD	0.12	0.11	0.09	Pre-test SD	0.11	0.10	0.08
Post-test mean	0.61	0.56	0.56	Post-test mean	0.57	0.58	0.54
Post-test SD	0.13	0.14	0.10	Post-test SD	0.17	0.11	0.08

Table 4. Paired t-test scores for Pre- to Post-test change in attitude for successful and unsuccessful students with different divisions of unsuccessful and successful based on student final grade.

Successful	**t**	**Sig.(2-tailed)**		
A to B	-5.858	0.000**	ALS	N=158
	1.953	0.053	AS	
	0.633	0.528	CS	
A to B-	-5.857	0.000**	ALS	N=174
	2.192	0.03*	AS	
	0.884	0.378	CS	
A to C+	-5.774	0.000**	ALS	N=189
	2.029	0.044*	AS	
	0.703	0.483	CS	
A to C-	-8.486	0.000**	ALS	N=211
	2.924	0.004*	AS	
	1.061	0.290	CS	
Unsuccessful	**t**	**Sig.(2-tailed)**		
B- to F	-3.490	0.001**	ALS	N=63
	1.127	0.264	AS	
	0.515	0.069	CS	
C+ to F	-3.537	0.001**	ALS	N=47
	0.643	0.524	AS	
	0.000	1.000	CS	
C to F	-4.183	0.000**	ALS	N=32
	1.052	0.301	AS	
	0.433	0.668	CS	
D+ to F	-1.809	0.101	ALS	N=11
	-0.357	0.728	AS	
	-0.117	0.909	CS	

*=<.05 **=<.01

Table 5. Independent sample t-test scores for the Pre-test and Post-test for Male vs. Female students.

Pre-test

	Male Students (N=115)	Female Students (N=106)	t	Sig. (2-tailed)
ALS	0.51	0.47	2.695	0.008**
AS	0.59	0.61	-2.121	0.035*
CS	0.55	0.55	0.247	0.805

Post-test

	Male Students (N=115)	Female Students (N=106)	t	Sig. (2-tailed)
ALS	0.61	0.54	3.185	0.002**
AS	0.56	0.59	-1.476	0.141
CS	0.54	0.55	-1.180	0.239

*=<.05 **=<.01

Table 6. Independent sample t-test scores for the Pre-test and Post-test for non- SMT majors vs. SMT students.

Pre-test

	non-SMT (N=177)	SMT (N=44)	t	Sig. (2-tailed)
ALS	0.48	0.53	-2.341	0.022*
AS	0.60	0.60	0.076	0.940
CS	0.55	0.58	-2.314	0.024*

Post-test

	non-SMT (N=177)	SMT (N=44)	t	Sig. (2-tailed)
ALS	0.57	0.61	-1.893	0.062
AS	0.58	0.56	0.660	0.512
CS	0.54	0.56	-0.643	0.523

*=<.05 **=<.01

Table 7. Independent sample t-test comparing freshmen and all other years in school for each attitude scale for the Pre-test and the Post-test. Freshmen (N=83) and all other years (N=138).

	Pre-test			Post-test	
ALS	**t**	**Sig.(2-tailed)**	**ALS**	**t**	**Sig.(2-tailed)**
	0.253	0.800		-0.361	0.718
AS	**t**	**Sig.(2-tailed)**	**AS**	**t**	**Sig.(2-tailed)**
	0.865	0.388		-0.405	0.686
CS	**t**	**Sig.(2-tailed)**	**CS**	**t**	**Sig.(2-tailed)**
	-0.799	0.425		-1.623	0.107

CHAPTER 3. USING NEWS MEDIA DATABASES TO ESTABLISH RELEVANCE IN INTRODUCTORY EARTH SCIENCE COURSE CONTENT

A paper to be submitted to *Eos*

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Abstract

Content selection for introductory earth science courses tends to focus on the textbook or what the instructor believes from experience is important for students to know. Non-science majors are often the majority in introductory science classes and their needs are inherently different from those of science majors. Identifying topics and fundamental understandings that are relevant to students provides a framework for the course, and an instructional approach that can improve both student attitude and concept understanding. Working from a base of public literacy, Earth science topics covered in the news media provide unique opportunities for establishing relevance to science and non-science majors. This study explores content selection based upon scientific literacy and discipline relevance for an introductory, undergraduate geoscience course. Topics presented in the public news media and their relative occurrence, collected from the LexisNexis™ Academic Universe, are contrasted to content coverage of thirteen introductory earth science textbooks and to findings from a survey of 36 colleges and universities across the United States. The results show that topics related to climate, geologic time, hydrologic cycle and surface processes, and rocks and minerals occur much more frequently in the news media than in textbooks and in the content of introductory geoscience classes.

Keywords: content selection, relevance (education), non-science majors, mass media, textbook content, scientific literacy, science and society

Introduction

Each year, geoscientists teach introductory earth science courses to approximately 350,000 undergraduate students in the U.S. and Canada. The vast majority of these students are not science majors, and the course often represents the only college-level science these undergraduates will ever encounter. The methods that instructors use for choosing content for these courses vary widely. A common method is selecting a textbook and using it, in whole or in part, as an outline for the course (Chiappetta et al., 1991). Using textbooks as content selection tools provides a straight forward, easy to follow, content-directed course outline. In spite of what is promoted by their title, introductory texts, and introductory science courses, have the objective of presenting small amounts of information on all sub-disciplines of the science. Therefore, most introductory textbooks cover a large number of topics and background content (Chapman, 2001). The instructor may modify the textbook content selection approach to include content drawn from other sources such as major national and global research, current events in science, the Internet, or from their own individual areas of research. Whatever the means of selection, content is chosen, more often than not, at the discretion of the instructor with little selection basis other than what the individual believes to be appropriate to add to the class (McManus, 2002).

The educational process demands both development of scientific literacy and the acquisition and integration of specialized knowledge. Scientific literacy is required for personal decision-making and for participation in civic and cultural affairs. Being scientifically literate means that a person is able to read, with

understanding, articles about science in the popular press and engage in social conversation about the validity of the conclusions (National Science Education Standards –National Resource Council, 1996). Scientific literacy involves more than reading about science and understanding, it involves the daily interactions and decision-making that the general population is faced with. To be scientifically literate one needs to be able to have a conversation, make an informed decision or write a letter to the editor using knowledge based in science. Instructors are working to move from the convention of trying to teach as much as possible in a course, to what every student should be expected to know to be scientifically literate.

Contemporary science research illustrates how an earth system approach provides scientific context for enhanced understanding of important relationships between processes, features and phenomena. Although earth system science is touted as the instructional approach of choice (Shaping the Future of Undergraduate Earth Science Education, 1996), in the educational arena it has been more difficult to accomplish. Trained in specialized subjects, most instructors have little preparation or experience teaching with an integrated approach. In spite of attempts by publishers and authors to incorporate a systems approach, most introductory textbooks retain a remarkably consistent, content-based, topical approach. A systems approach is typically presented by way of vignettes or case study inserts, rather than by central chapter theme or story line. Introductory courses and associated instructional materials could benefit from a larger contribution of collective, professional development. It is not just a matter of having lots of good

material to choose from, but rather a rational construct for why various activities modules or investigations are deserving of instructional implementation.

Content relevance has long been shown to improve science literacy, attitude and interest toward science, an interest that extends over a student's entire life (e.g., Byrne and Johnstone, 1988; Bicak and Bicak, 1990; Singh, 1999). Since the implications of student learning are far-reaching and long-lasting, content selection in introductory science courses must be seen in a larger context and carefully planned. Many curricular components, including historical development and ways of knowing unique to a particular science are important elements. Yet, at the core of course objectives lies development of scientific literacy. All recent curriculum reform efforts, including the National Science Education Standards, are premised upon the goal of enhanced scientific literacy. In a world filled with the products, contributions and concerns of scientific inquiry, scientific literacy enables people to use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society (National Science Education Standards, 1996). Having a rationale for the selection of topics in an introductory geoscience course can best enhance scientific literacy and is an important first step when developing curriculum.

Curriculum development is affected by establishing relevance for the student. Not only are instructors of introductory courses intensifying their efforts to make clear their goals and the significance of what is being taught, but they are also engaging students in direct research investigations and assigning investigations that make use of Internet accessed, authentic data. Content is scrutinized for its

currency, validity in terms of changing conditions, and interest. In discipline-oriented curricula the organizing center or relevant topic is frequently being defined as a problem or issue. But the question remains, what are the objective, independent ways to establish the appropriate discipline-based issues or problems? Finding what is relevant to students in introductory earth science classes can begin by asking a few questions. Is this content related to something relevant to regional or national events (i.e. beach erosion, earthquakes, oil shortages)? How does the student become aware of such issues (i.e., discussion with peers and teachers, school, newspaper, TV, radio)? While improving the scientific literacy of students cannot be achieved by one approach alone, a systematic assessment of media-based coverage of earth science topics provides a useful approach for establishing relevance and identifying needed content understandings that contribute to scientific literacy.

Methods

Two sources for content assessment were used in this study, the LexisNexis™ Academic Universe (http://web.lexis-nexis.com/universe) and introductory earth science course materials, including textbooks and syllabi. The objective was to compare the content taught in introductory earth science courses to earth science topics found in the news and accessed through the LexisNexis™ Academic Universe database. By comparing what is carried by the news media to what is taught in introductory earth science classes, a topic occurrence method for determining relevancy was established.

1. LexisNexis™: Earth science in the news

There are several versions of LexisNexis™ available for academic or corporate use (http://www.lexisnexis.com). The academic version of LexisNexis™ was used in this study. The text of each news report or article is indexed daily by type of source, geographic location, and date, with the ability to search the articles using one or a combination of indexed categories.

A user is presented initially with two choices: "Quick News Search" and "Guided New Search". The "Guided News Search" gives more options for specific dates, sources and geographic areas than the "Quick News Search". 204 earth science words were chosen from the indices of several introductory earth science textbooks to give a broad and as comprehensive as possible representation of earth science topics and keywords. One very commonly used earth science term, weather, was left out of this study because the context in which it appears daily in newspapers (as 'weather forecast') returned a very high score that would overshadow the occurrence of other terms more specifically relevant for this study (e.g., greenhouse effect, hurricane).

These terms were searched in the "Guided News Search". Articles are grouped into twelve news categories with options such as "General News", "Today's News", and "Non-English Language News". Since this study focused on the United States and U.S. News, a search for each word in the "U.S. News" and "News Transcripts" (from radio and TV reports) category was conducted. Each news category has a selection of news sources. For this study five news sources for "U.S. News" were selected (Midwest, Northeast, Southeast, Western, Iowa), and one source was selected for "News Transcripts" (All Transcripts). The search was done

in "Full Text" of the article to maximize the chance of finding one of the relevant words. Searches were conducted for the past 5 and 10 years respectively. Combining all search parameters with all of the words searched yielded 2448 numbers, each number representing the number of hits for the earth science word searched.

Since time frames and geographic areas studied for this project were large, in some cases it was found that LexisNexis™ limited the number of occurrences of a term. When a search term occurs in more than 1,000 articles, LexisNexis™ does not give a specific number but simply states, "more than 1000 hits". In these cases, the occurrence is recorded in our data charts as 1,000 when in reality this is a minimum. The list of terms searched, the number of occurrences in LexisNexis™ as well as a list of sources (i.e., newspapers, textbooks, television and radio stations) is available as an electronic appendix (http://www.ge-at.iastate.edu/people/faculty/cervato/publications.html). Based on the number of occurrences of the terms, we grouped them into eight major categories: plate tectonics (including earthquakes, volcanoes, earth's interior), glaciers, minerals and rocks, hydrologic cycle/surface environments (including streams, flooding, oceans), geologic time, mass wasting, energy and natural resources, and climate (including greenhouse effect, global warming, weather phenomena). These categories were selected because they coincide with major categories discussed in the majority of earth science textbooks.

The data for 'glaciers' in the U.S. printed news for the last 5 and 10 years are represented in **Table 1** as an example of how topic occurrences were calculated.

There are seven words within the topic of glaciers—alluvium, clays, glacial, glacial till, glacier, loess, and moraine. For each word we obtained the occurrence in a geographical area. For example, the word 'alluvium' has an occurrence of 25 hits in the Midwest (MW) printed news over the last 5 years. Adding all of the found occurrences of each word within a topic in the four main geographic regions (Midwest, Northeast, Southeast, Western) to obtain a national value, and expressing them as a percentage of the occurrence of all earth science topics allows us to normalize the individual results and make comparisons between different major topics and sources. In Table 1, the major topic 'glaciers' is expressed as 4% over the last 5 years and 4% over the last 10 years. This approach was used for the eight major topics.

Figure 1 shows the results for all eight groups of words searched in the U.S. printed news (all geographical areas averaged together) for the last 5 and 10 years. There are four topics that occur more often than the others: climate, geologic time, hydrologic cycle and surface environments, and minerals and rocks. **Figure 2** and **Figure 3** show the same eight topics and their occurrences in the regional geographical areas (West, South East, North East, and Mid West) for the last 5 and 10 years, respectively. In both 5 and 10 year results, there are differences in the occurrences of topics. The topics of plate tectonics, geologic time and hydrologic cycle/surface environments occur more in printed news in the West than anywhere else. The topic of glaciers occurs more often in the printed news in the Mid West. Also, hydrologic cycle/surface environments occurs more in the South East. Mass wasting, energy & natural resources, and climate were about the same in all of the

regional areas. These differences are consistent whether looking at the 5 or 10 year results showing a consistent pattern through time. The results from the U.S. printed news are similar to the occurrence data from Iowa printed news for the last 5 and 10 years with the exception of geologic time, which has a lower occurrence in Iowa news than in US news (**Fig. 4**). In the U.S. news transcripts (TV and radio transcripts, **Fig. 5**), the occurrences are very similar to the U.S. printed news. In this study we have used Iowa as an example of a narrower geographical region, but this type of analysis could be done for any U.S. state or region (MW, NE, SE, W). When comparing the three graphs, one can see that Iowa printed news have a different focus than the U.S. printed news and news transcripts. In the Iowa printed news, climate news jump to more than 25% occurrence and minerals and rocks occur in over 20%.

2. Introductory earth science course content

The eight topics used in the LexisNexis™ searches were also used in an analysis of introductory earth science course content. For this, syllabi from a random sample of colleges and universities and textbooks used for introductory earth science classes around the United States were analyzed. Since a comprehensive examination of all introductory earth science courses taught across the nation was unrealistic, a randomly selected representative subset of schools was chosen for this study using the protocol commonly used by the American Geological Institute for their surveys (Christopher Keane, personal communication, 2002) and a list compiled by AGI of the schools that either have a geology department that teach an introductory course or a faculty member who teaches an introductory geology

course. We divided the nation into six geographic regions using the regional sections of the Geological Society of America (Cordilleran, Rocky Mountain, Northeastern, North-Central, South-Central, and Southeastern States that are part of each region are described at http://www.geosociety.org/sectdiv/sections.htm) to select a representative subset of colleges and universities. . We then randomly selected one community college, one four-year college or university offering only Bachelor's degrees, and one university offering graduate and undergraduate degrees from either type of setting given in the list (rural or urban). This yielded a list of 36 schools. We contacted instructors at each of these schools who, in turn, provided us with course textbook titles and detailed syllabi for their courses. From the information provided by the instructor, an approximate number of class terms that each instructor spends on each of the eight main topics searched in the LexisNexis™ database was obtained. By dividing the time spent on specific topics by the total time spent in class, a percentage was calculated for each topic to be used in a comparison with topics in other sources such as textbooks and news. A table of these data is also included in the electronic appendix.

3. Content in Textbooks

Textbooks are often the main source of written scientific information provided to students and they have the capacity to influence how students and to a lesser extent instructors view science. **Figure 6** shows which textbooks were used in the examined courses. In the 36 colleges and universities surveyed, a total of 14 textbooks or text resources are used in introductory geology classes. One course used a custom text created by the instructor and another course did not require a

textbook but instead used various readings from texts on hold in the library. The tables of contents of the thirteen introductory earth science textbooks (including physical and environmental geology, and earth systems science) were canvassed to determine the number of pages used to cover each of the eight main topics used in this study. This number was then expressed as a percentage of the total length of the book (**Figure 7**). Plate tectonics accounts for about 30% of introductory earth science books while climate change accounts for about 10%.

Results and discussion

The results of this study show that four of the eight broad earth science topics that we have identified (i.e., climate, geologic time, rocks and minerals, and hydrologic cycle and surface environments) have dominated the news coverage of earth science topics over the last 10 years, both nationwide and in the four main geographical areas studied. There is no significant difference between the occurrence of the groups of topics in printed news and news transcript for the last 5 years and the last 10 years (Figure 1 and 3). Terms related to climate have been slightly more common in the last 5 years and plate tectonic terms occurred slightly more frequently in the last 10 years of news.

Thirteen textbooks are used in the introductory earth science classes that were surveyed. They represent an almost complete list of introductory geology textbooks that are currently available on the market and cover a broad spectrum from more traditional geology books, to environmental geology, to earth system science. Most textbooks are used by more than one instructor and one (Press and Siever, 2001) is used in seven of the 36 classes surveyed (Figure 4). We have only

considered the occurrences in the news during the last 5 years for our comparison between news and textbook content, since textbooks tend to undergo major revisions approximately every five years. The difference between these two sources is shown in **Figure 8**. It shows that topics related to plate tectonics and hydrologic cycle and surface environments occur between 7 and 17% more often in textbooks than in the news, while topics related to minerals and rocks, geologic time, and climate occur 4-11% more often in the news than in the textbooks. Mass wasting and energy and natural resources are only 2% more common in textbooks and news, respectively. These results suggest that there is a strong imbalance between textbook and news coverage for climate and plate tectonics. Part of this is probably due to the available textbooks. Nine textbooks can be considered 'traditional' physical geology textbooks and only four are more slanted towards environmental geology and earth systems science (**Figure 4**).

The dominance of one group of topics either in the news or in textbooks is not consistent with what was found in the course content analysis. There was far more variability in the time dedicated to cover the topics in the 36 selected schools. Comparing course content information from the 36 schools and the means, medians and standard deviations from each topic reveal large discrepancies in coverage between schools (**Table 2**). Plate tectonics is the only topic consistently taught in all classes, independently from course title or textbook adopted. This is in line with the trend followed by many instructors to use plate tectonics as the most fundamental unifying concept for the earth sciences. However, different instructors spend widely varying amounts of class time discussing all topics, with the highest variability

observed for plate tectonics, minerals and rocks, hydrology and surface environments, and climate. This results lead to the question: Why do some instructors spend no class time on a topic while others may spend as much as one-third of class time on the same topic? Evidently instructors focus their teaching on different aspects of geology, some possibly presenting content in accordance with the goals of science literacy while others might teach in the same way they were taught, thus propagating a method of content selection that relies on familiarity.

There is a relationship between what is taught in the subset of introductory earth science classes around the United States and textbook content (**Figure 9**), suggesting that instructors tend to teach what is covered in the textbook, although with varying emphasis. However, the fact that some instructors spend considerable time on topics that are not covered at all in other schools suggests that an alternative method of content selection may be in place. On the other hand, there is a substantial difference, sometimes as great as 20%, between course content and what is covered in the news media, suggesting that relevant topics from the news are not given due time in introductory earth science courses. This is particularly true for climate (on average covering 5% of course content, 9% of a textbook, and 20% of the news), plate tectonics (25% of course content, 31% of textbook, and 11% in the news) and geologic time (6% of course content, ~10% of a textbook, and ~14% of the news). The difference between the news and course content or textbooks for the other topics is less than 5%.

The four topics that have occurred more often in the printed news during the last five years are climate (20%), minerals and rocks (~20%), hydrologic cycle and

surface environments (15%), and geologic time (14%). For comparison these topics together make up about 56% of introductory textbooks and about 45% of introductory course content.

It was surprising to see how infrequently words related to energy occur in the news (8%) relative to other topics. If we consider that these words include "oil", "petroleum", "hydrocarbons", "fossil fuels", it would be expected that, since these topics are discussed in a variety of contexts of national and international relevance, from economy, to finances, to world politics, their occurrence would be higher than the 8% found. This may be explained by the fact that five of the ten words occur more than 1000 times and, therefore, the total occurrence is an artifact of the query results of LexisNexis™ and probably is much higher than what described here. This artifact can also be used to explain the fact that the score for climate-related topics in the news (with 12 of the 23 terms with more than 1000 hits) is the same as the one of topics related to minerals and rocks (with only 11 out of 33 terms with more than 1000 hits). While the textbooks and course content match the relative occurrence of minerals and rocks in the news, they do not match the occurrence of climate.

The importance of topics such as global warming and severe weather is reflected in the news in the high occurrence of words related to climate and ought to be a topic that is covered in introductory earth science courses. Yet, 19 out of 36 instructors surveyed spent no time on climate. For comparison, only three out of 36 instructors spent no class time on minerals and rocks.

Content selection should be based ultimately on the goal of science literacy for every student but can also be based categorically on relevance of topics for students. This study shows that the use of a news media database such as LexisNexis™ allows a regional to local analysis of earth science topics that can be used to direct course content selection. Also, choosing a textbook that focuses on relevant topics would support and/or guide the content selection. Findings from this study indicate that there is a wide range of topic coverage in introductory earth science courses, yet did not reveal how instructors chose their course content or why, although the close relationship between course and textbook content suggests that the textbook is probably used as basis for content selection.

Conclusions

Byrne and Johnstone (1988) offer general implications of relevance for learning and examples of appropriate learning materials. One of their main points is that "almost all attempts to make science relevant are *concerned with attitude change* as well as cognitive gain." Thus far, there are no clear criteria for establishing what topics are relevant for students. This study attempted to address this issue.

Overcoming negative student attitude and low science literacy is a daunting task for any instructor, but content selection can go a long way in setting the stage for achieving improvements in both attitudes and literacy. This study shows a novel approach to a more objective selection of what to teach. News media coverage of earth science topics is dominated by the 'hot' topic of climate, followed closely by topics like minerals, rocks, hydrology, surface environments, and geologic time that

might be perceived as more 'traditional' by instructors and that are in some cases left out of their syllabi altogether. The results of this study that compares computer-based media information with course content show that we could do a better job at putting our instructional focus on the very important objective of furthering scientific literacy.

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US Printed News 5yr						US Printed News 10yr					
MW 5	NE 5	SE 5	W 5			MW 5	NE 5	SE 5	W 5		
25	13	38	66			32	21	47	95	ALLUVIUM	
1000	1000	1000	1000			1000	1000	1000	1000	CLAYS	
1000	1000	1000	1000			1000	1000	1000	1000	GLACIAL	
33	46	2	34			59	72	4	49	GLACIAL TILL	
1000	1000	1000	1000			1000	1000	1000	1000	GLACIER	
652	16	64	31			887	23	98	40	LOESS	
1000	656	244	385			1000	1000	388	607	MORAINE	
4710	3731	3348	3516	15305	55%	4978	4116	3537	3791	16422	59%
					4%						4%

GLACIERS

Table 1 Example of word occurrence within a topic. Words on the right side of graph have certain occurrences for each geographical area and time period.

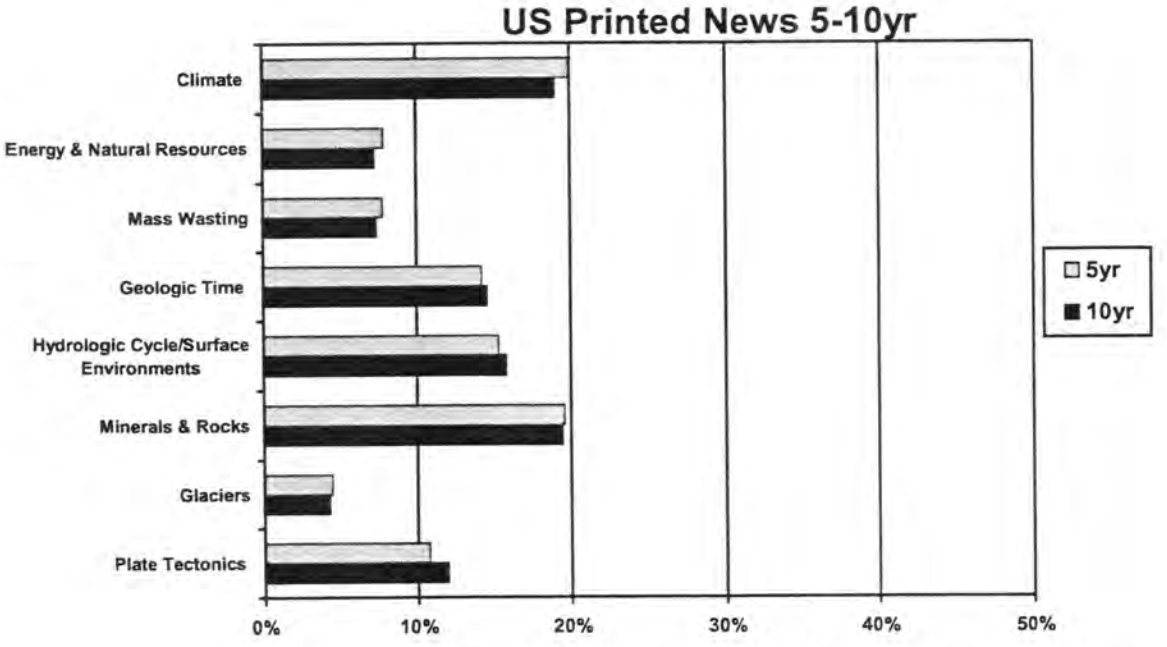

Figure 1 Occurrences of topics in the U.S. printed news for the last 5 and 10 years.

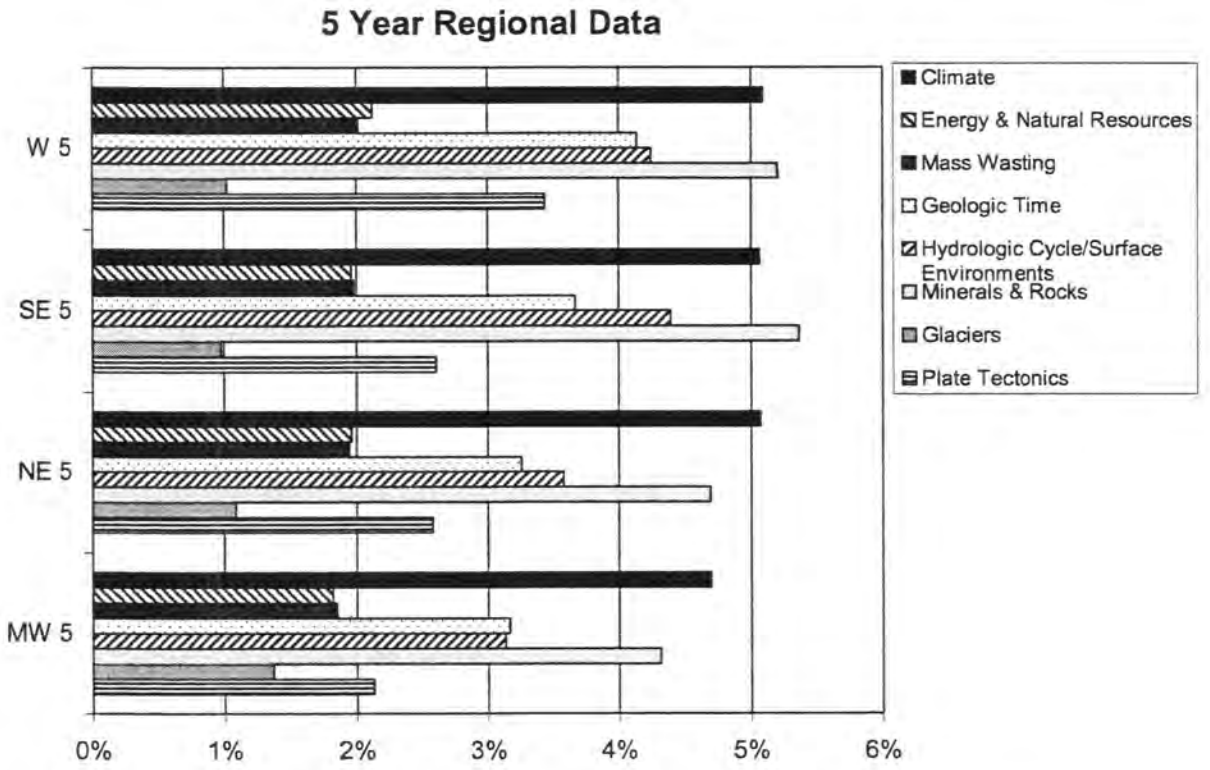

Figure 2 Regional data for the last 5 years of printed news in each of the eight topics. Occurrences are plotted for each of the four geographical areas (W=West, SE=South East, NE=North East, MW=Mid West) as percentages of all words from the topic in the last 5 years.

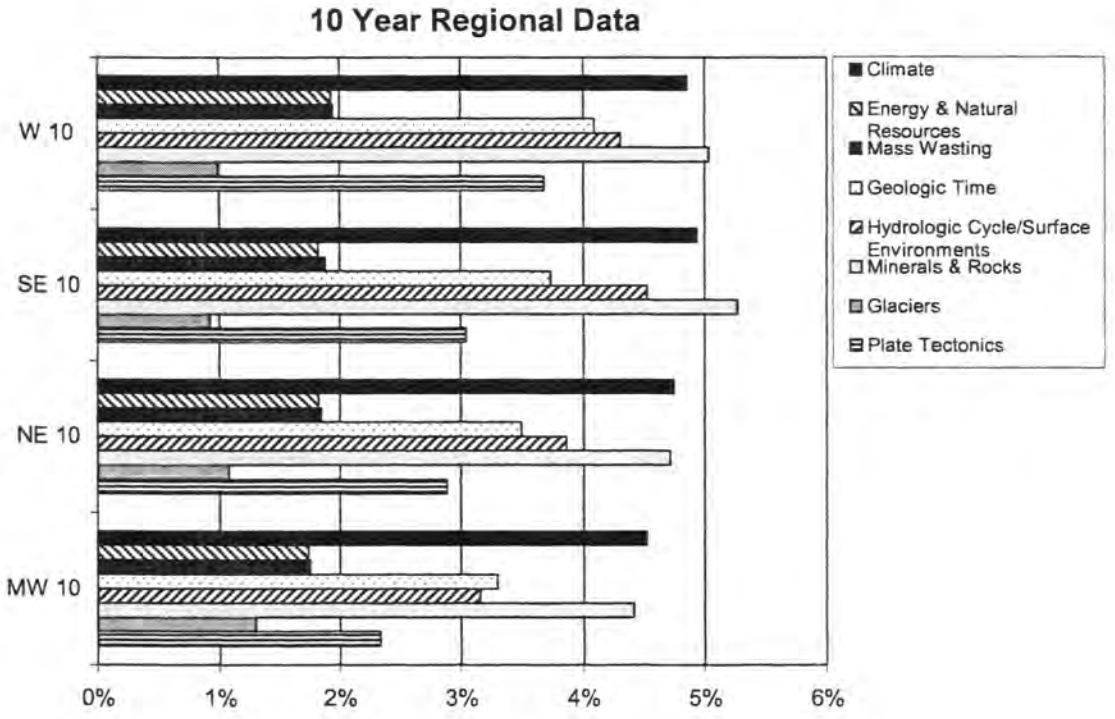

Figure 3 Regional data for the last 10 years of printed news in each of the eight topics. Occurrences are plotted for each of the four geographical areas (W=West, SE=South East, NE=North East, MW=Mid West) as percentages of all words from the topic in the last 10 years.

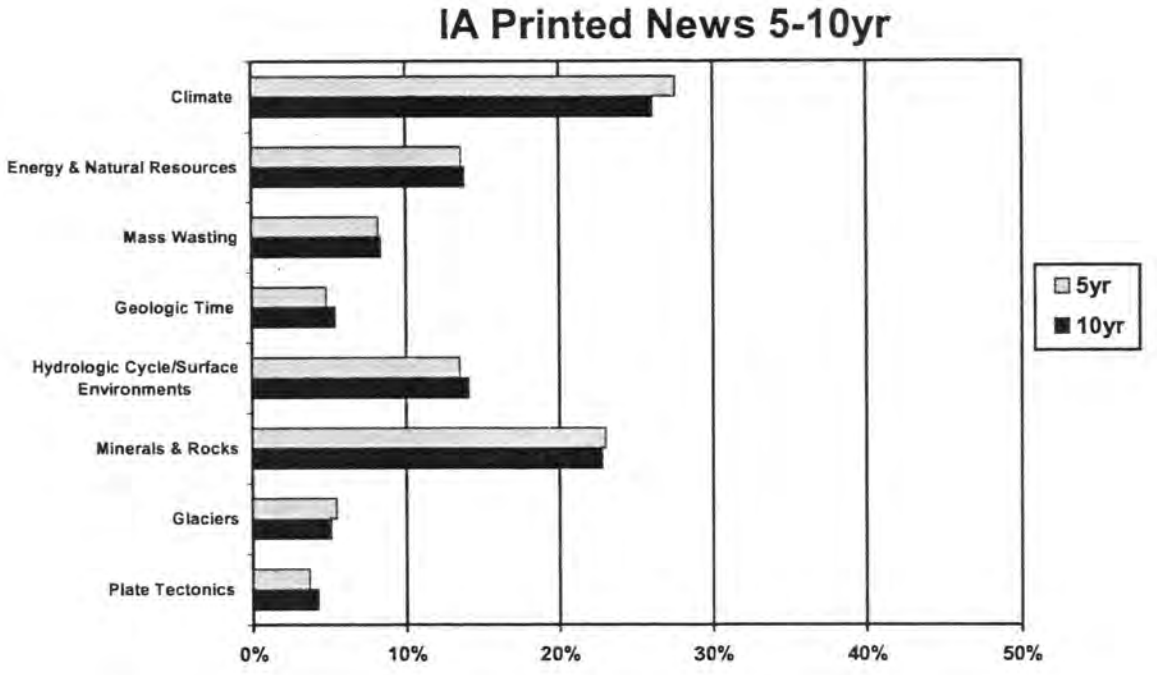

Figure 4 Occurrences of topics in Iowa printed news for the last 5 and 10 years.

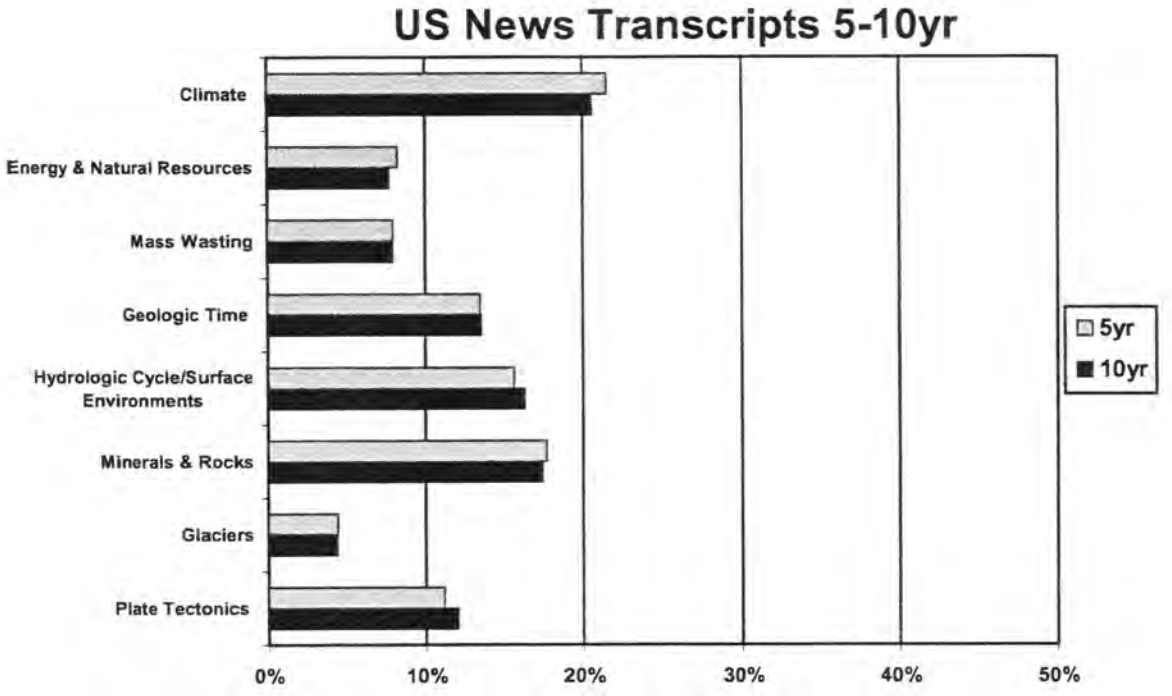

Figure 5 Occurrences of topics in U.S. TV and radio news transcripts for the last 5 and 10 years.

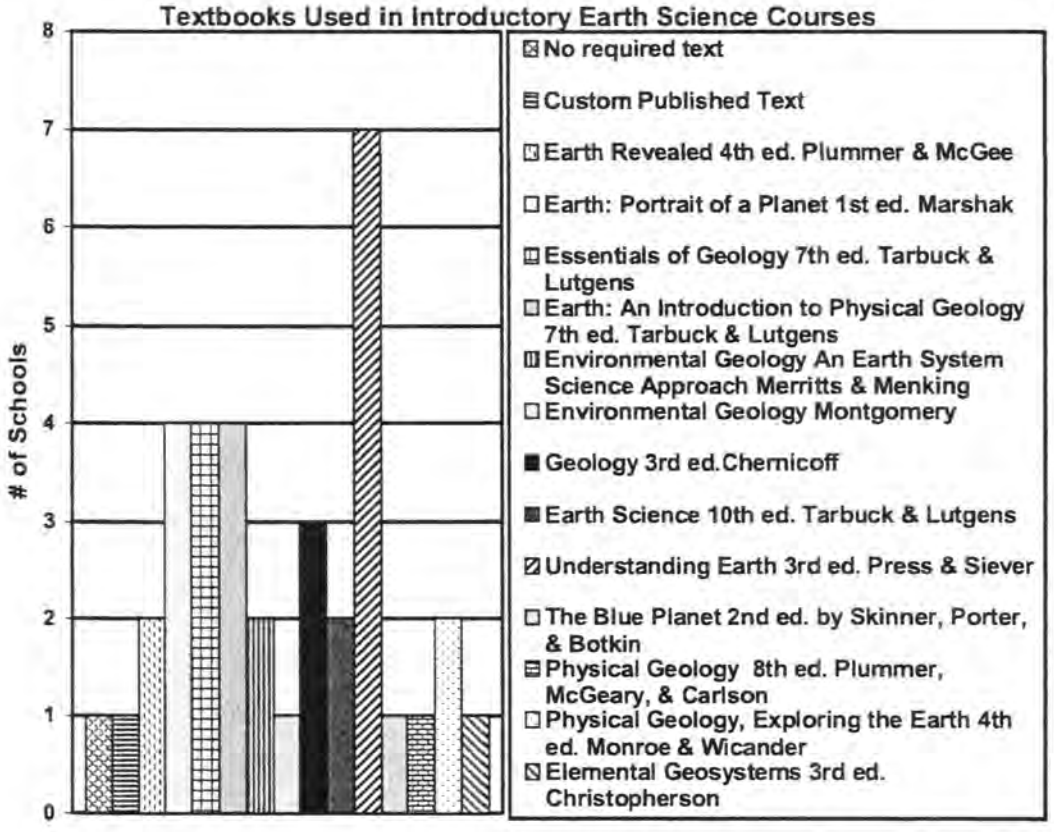

Figure 6 Textbooks used in the 36 colleges and universities surveyed. *Understanding the Earth* by Press and Siever was the most popular textbook. The selection of textbooks includes earth systems science books as well as several environmental geology books.

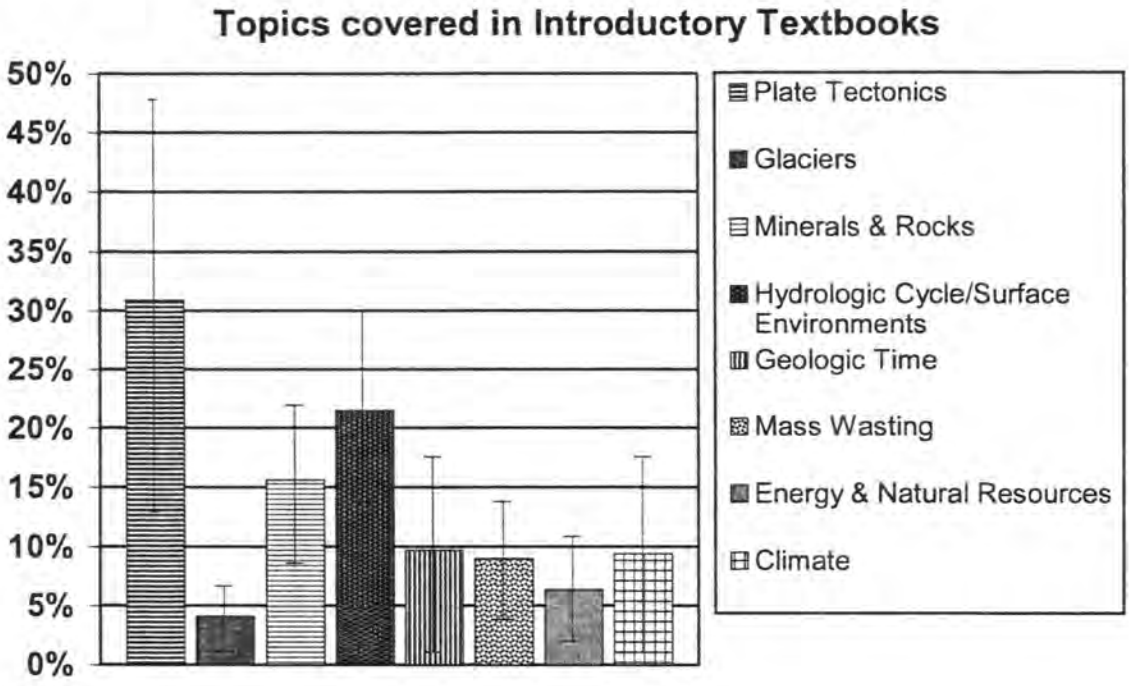

Figure 7 Topics that are covered in the surveyed introductory earth science textbooks. The values represent averages from 13 textbooks.

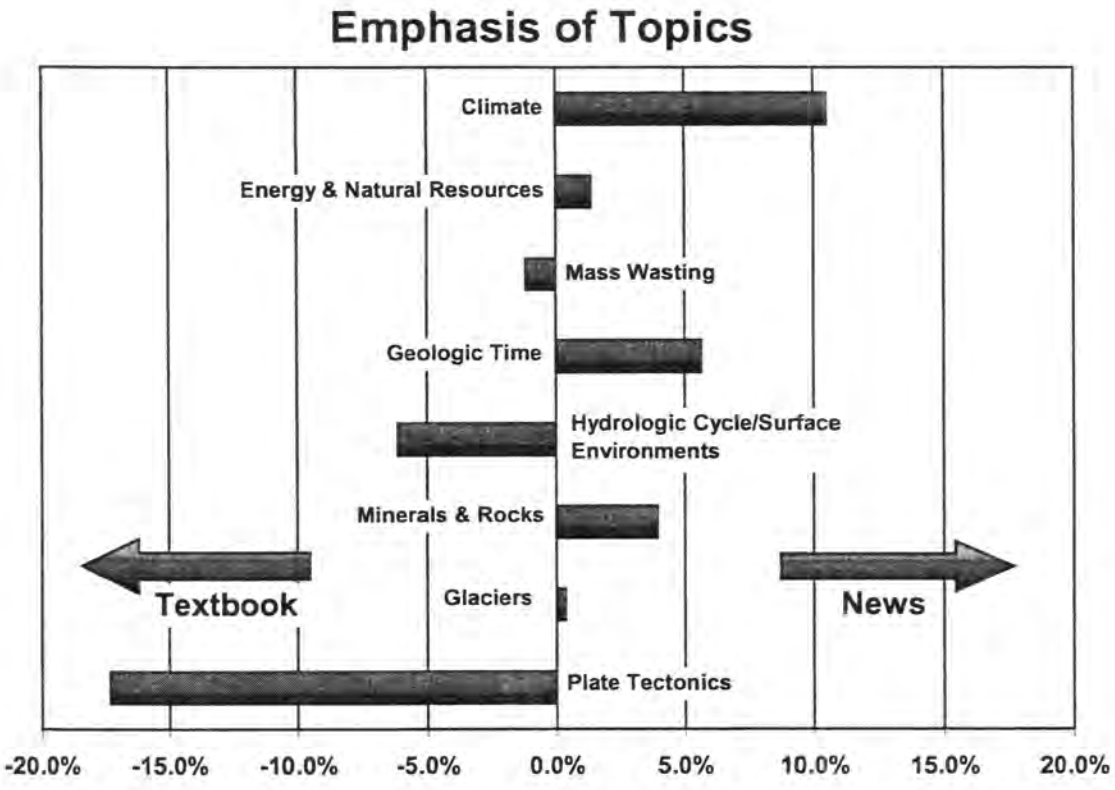

Figure 8 Data in this figure was calculated by subtracting percentages of topic occurrences in the textbook from the occurrences in the news. A topic with the same emphasis in both sources will have zero as its value.

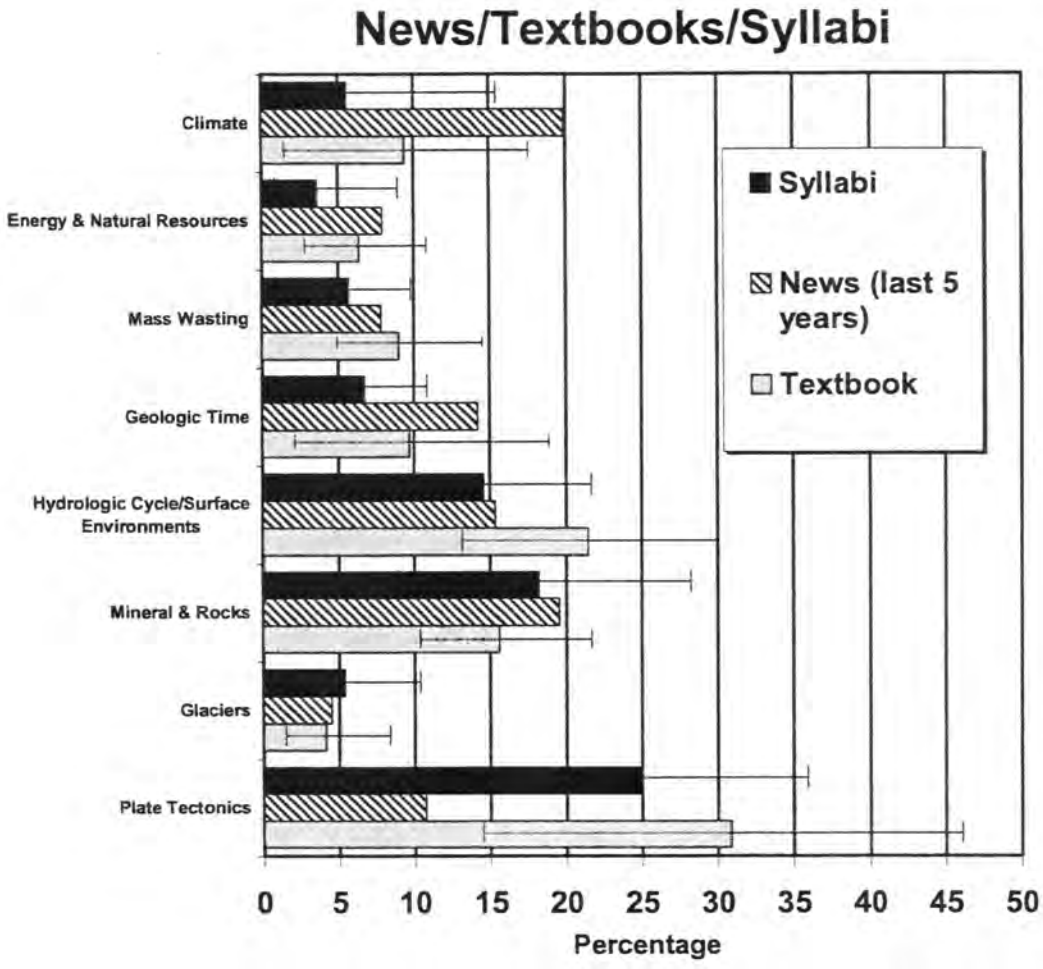

Figure 9 Comparison across the three sources used for the analysis of earth science terms.

Table 2 Statistical evaluation for course content of introductory earth science classes taught in the selected colleges and universities in the U.S. Data were compiled by examining the syllabi of introductory earth science courses.

	Mean	Median	Standard Deviation	Range
Plate Tectonics	25.0%	23.2%	11.5%	7-67%
Glaciers	5.4%	6.0%	4.6%	0-21%
Minerals & Rocks	18.2%	18.3%	10.1%	0-44%
Hydrologic Cycle/Surface Environments	14.6%	14.3%	7.5%	0-33%
Geologic Time	6.7%	6.7%	4.1%	0-17%
Mass Wasting	5.7%	6.5%	3.3%	0-11%
Energy & Natural Resources	3.6%	0.0%	4.5%	0-18%
Climate	5.6%	0.0%	9.5%	0-33%

CHAPTER 4. GENERAL CONCLUSIONS

The relationship between student attitude and demographic factors was investigated as part of this study. We also studied what is taught in introductory science courses and compared it with what occurs in the news following the assumption that what is covered by the media can be deemed 'relevant' and therefore can be used to achieve science literacy.

Instructors usually chose the content for their course based upon a "what worked for me" approach or a textbook-based approach. The amount of content usually covered in introductory science classes combined with the typical lecture style of teaching leaves many students out of the learning process by not accommodating their prior knowledge or learning style. The demands of teaching an introductory course to undergraduate non-science majors are sizeable: 15/16 weeks to cover a significant amount of content. Students who have never taken a university level science course may be unable to cope with the content, vocabulary, and format that are standard in introductory science classes. This inability to cope may cause students to develop, or strengthen, negative attitudes towards science. Previous studies have shown that there is a measurable difference in attitude between non-science and science majors (Gogolin and Swartz, 1992; Sadava, 1976) and between male and female students (McEneaney and Radeloff, 2000). This difference has been ascribed to many factors including secondary education experiences, instructor characteristics, and class environment. Analyzing the attitudes of non-science majors in introductory science courses is important for two

reasons. First, if a difference between the learning criteria of non-science and science majors is to be established, then the attitude toward science must be analyzed for both groups and compared. Attitudes toward science and toward learning science can give direction to instructors and administrators when choosing course content and creating standards. Second, non-science majors are usually the majority of the students in introductory science classes. There are innumerable factors that affect students when they take a course that are uncontrollable and unknown. For example students may have issues other than school affecting their general attitude toward life such as personal problems. Other factors that could affect students in any number of ways could be as big as world events (e.g. September 11th) or as small as something in the classroom (e.g. students talking etc.). These factors contribute to students' attitudes toward science in ways that cannot be measured completely or accurately by any attitude instrument. This study explores the possibility of addressing the issue of student attitude toward science by looking at changing *what* is taught in introductory science courses, as opposed to focusing on *how* the course is taught.

The occurrence of earth science topics in news media such as newspapers, TV and radio was analyzed and compared with what is currently taught in a selection of universities and colleges around the country. We started from the assumption that teaching relevant issues and events, and using them to present content in a 'relevant' context, could have a positive effect on student attitude and ultimately improve science literacy. A genuine effort to take material from class and relate it to issues and topics that the students find personally relevant may help improve

understanding and attitude toward learning science (Byrne and Johnstone, 1988; Singh, 1999).

This study established that a representative subset of 36 randomly selected colleges and universities across the United States, the only earth science topic covered consistently in every school was plate tectonics. While most of the topics considered in this study were covered in the syllabi, there was at least one school which spent no time discussing climate change. Overall the results suggest that content selection by the instructors in the selected schools was, for the most part, similar. This study, however, did not inquire with the instructor about the process of content selection that was used.

The National Science Education Standards encourage teachers, administrators, parents, and students to strive towards scientific literacy and outlines how to achieve it. Student attitude toward science is not specifically mentioned in the NSES but is implied when the standards discuss the nature of science and student inquiry. The results from the attitude study and the study on relevance are important when put into the context of science literacy. Implications of changing course content and focusing on attitudes toward science include better understanding, improved science literacy and a more positive attitude toward science and learning science. It is important that instructors and administrators take into consideration new research, such as been done here, to develop their teaching skills and to access their methods and goals. It is especially important for instructors of introductory science classes to find new and better ways of engaging students

and encouraging a positive attitude toward science because these students will become the next generation of voters and decision makers.

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