Effectiveness of a computer-based tutorial for teaching how to make a blood smear

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Abstract

Background: Computer-aided instruction (CAI) was developed to teach veterinary students how to make blood smears. This instruction was intended to replace the traditional instructional method in order to promote efficient use of faculty resources while maintaining learning outcomes and student satisfaction. **Objectives:** We evaluated the new instructional method to determine its effect on (a) instructor time, (b) students' ability to make smears and (c) students' ability to recognize smear quality. **Methods:** Three traditionally-taught classes were the control group and four classes taught with the CAI were the experimental group. Students in the control group received a short demonstration and lecture by the instructor at the beginning of the laboratory and then were allowed to perform blood smears. Students in the experimental group received their instruction through a self-paced, multimedia auto-tutorial on a laptop computer and then they too practiced making blood smears. Data came from observation, interviews, questionnaires and smears made by students. **Results:** Students using the CAI made better smears and were better able to recognize smear quality. The average time the instructor spent in the room was not significantly different between treatments, but the quality of the instructor time increased with the experimental instruction. **Conclusions:** The tutorial implementation successfully provided students and instructors with a superior teaching and learning experience to the traditional method of instruction. Using CAI is a viable method of teaching students to make blood smears.

Key words: Computer-aided Instruction, Tutorial, Blood Smear, Psychomotor Skill, Teaching

A new instructional method was implemented in a one-week veterinary clinical pathology course at Iowa State University. In VPTH 457, a required laboratory rotation for senior veterinary students, the students learn several clinical pathology related topics and skills. Although students value the class, it has placed a significant demand on resources, primarily faculty and staff time. Thus the Pathology Department commissioned a small instructional design team to automate some aspects of the course that were particularly time consuming for instructors. This team converted several lecture portions of the course to a self-paced tutorial system with the goal of maintaining existing learning outcomes, while freeing instructors from repetitive lecture and demonstration. The tutorial discussed herein teaches students how to make blood smears.

Studies examining the use of computer-aided-instruction (CAI) have provided a mixed picture [1, 2, 3] of CAI effectiveness as an instructional method. There are various reasons for this. Often methodological differences in instructional approach and study design affect outcomes. Furthermore, CAI studies often compare the effectiveness of two different instructional designs to accomplish the same learning goal. Outcomes frequently have less to do with the medium ("computer" or "face-to-face") than with the way the medium is used. Because CAI is a different information presentation method than face-to-face instruction, optimal CAI design may result in instruction that looks very different from its face-to-face counterpart. Alternatively, CAI may be designed to mimic face-to-face instruction rather than to maximize the strengths of that media, or CAI may be carefully designed whereas the comparison face-to-face instruction may be haphazard. In all such cases, comparative studies weigh poor instruction against effective instruction rather than comparing two different methods of instruction of equal quality. In this paper, therefore, we take care to describe both instructional methods in sufficient detail for the readers to determine differences due to approach vs. differences due to media.

Because our target skill (making a blood smear) was a psychomotor skill, we also examined the literature to determine what is known about using CAI to teach psychomotor skills in health sciences education. Few appear to have examined CAI for psychomotor skill learning in medical fields; however, existing studies suggest that CAI can effectively address psychomotor learning [4, 5].

Since the goal of this particular instructional intervention was to teach how to make a blood smear while saving instructor time, we addressed the following questions:

1. Did the manner of instruction affect the amount of time the instructor spent with the course?
2. Did the manner of instruction affect the quality of the time the instructor spent with the course?
3. Did the manner of instruction affect the quality of the smears the students produced?
4. Did the manner of instruction affect the students' ability to recognize errors and self-correct?
5. Did the instructional intervention affect learning efficiency (i.e., the amount of student effort and time needed to learn the task, and the ease with which the student can perform the task)?
6. Did the manner of instruction affect students' attitudes about smear-making and the laboratory class in general?
7. Does previous experience making slides affect students' perception of the instructional intervention?

Across all questions we hypothesized that the tutorial would result in equivalent or superior learning and attitude outcomes when compared to the traditional method.

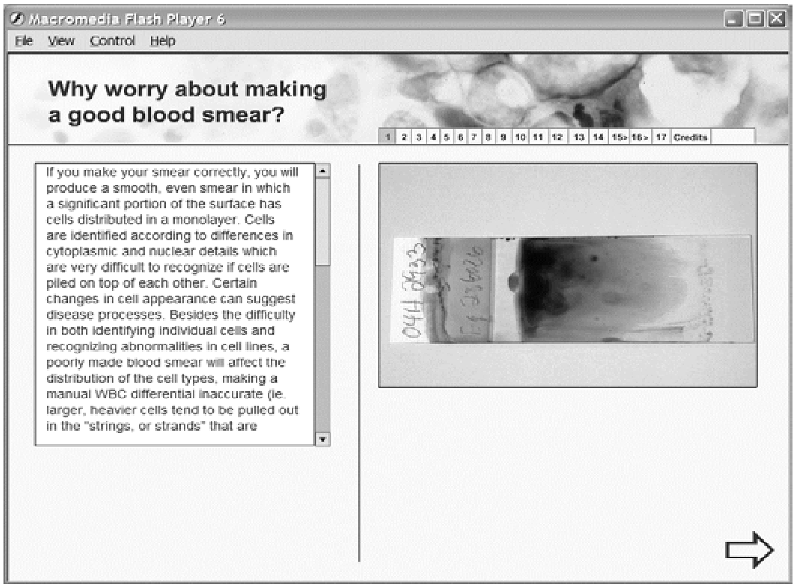
II. Materials and Methods

A. Instructional Materials

The tutorial consists of 17 data presentation slides containing text, illustrations, video, and audio, and 21 interactive question slides.

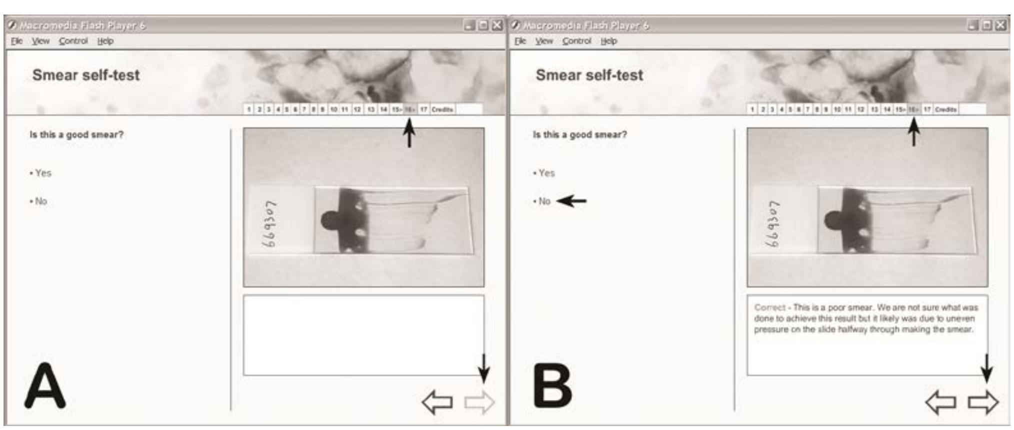
The content of the tutorial was derived primarily from instructional materials produced by subject matter experts (clinical pathologists, residents and clinical pathology laboratory technologists). The instructional presentation and interactions were designed according to commonly accepted instructional design principles to promote a high level of motivation, recall and comprehension [6, 7, 8]. The tutorial's instructional strategy, 1. emphasizes the relevance of the concepts being taught, 2. uses multiple formats (text, video, and graphics) to demonstrate the smear-making procedure, 3. provides multiple examples of good and bad smears and describes the processes that most likely produced each result, 4. provides extensive practice identifying good and bad smears, and choosing the most likely cause for smears' appearance, and 5. requires practice making smears.

The visual design was intended to ensure a pleasing experience for the tutorial users and to maximize the effectiveness of message delivery [9] (Figure 1). We used a simple, clean arrangement of content elements and a color scheme of dark blue Ariel text on a light background. We maintained the navigation and content areas in the same location on each screen. We minimized the need for scrolling by limiting the text per screen.



[Figure 1]

The tutorial was designed to be used primarily in a linear fashion. There are two dark blue arrows in the bottom right-hand corner of the screen. Clicking the right- or left-facing blue arrow moves the tutorial in a forward or backward direction respectively. When the right arrow is present and blue, it is possible to move forward by clicking on it. However, this arrow will become gray and non-clickable at each question slide (Figure 2-A). Once the correct answer is chosen, such as “no” in Figure 2-B, the right arrow becomes blue and clickable. This feature discourages the students from moving forward until they select the correct answer, thus reinforcing the proper response. The program also provides immediate feedback for each answer in the box above the arrows.



[Figure 2]

A clickable menu is available as part of the main title bar across the top of the page. This menu permits users to skip to a selected page. This function prevents a user from becoming “stuck” on a certain screen, and it allows students to move directly to a certain area of the tutorial to retrieve information rapidly. This menu also indicates the user’s current location within the tutorial by graying out the screen’s corresponding slide number in the menu bar. As seen in Figure 1, the box containing the number 1 is grayed for the first screen, and in Figure 2 the box containing the number 16 is grayed for the “yes-no” questions on the 16th screen.

The final version of the tutorial was reviewed for accuracy by two laboratory technicians and three clinical pathologists. During tutorial development, we ensured software usability with a process [10, 11] which involves recording usability problems as target users interact with the software.

The instructional materials also included three items that eliminated the need for an instructor to present didactic information at the beginning of the lab. First, the hand-out found in Figure 3 described the entire laboratory procedure to the students. The handout found in Figure 4 (linked from Figure 3 via hypertext), explained to students how to stain their smears. Finally, the movie illustrated by Figure 5 showed students how to perform the reticulocyte smear. Using

Instructions for Blood Smear Laboratory

In this laboratory you will:
* Learn how to make a good blood smear
* Learn some common errors in making blood smears
* Learn how to make a reticulocyte smear
* Learn how to stain a slide
* Practice making blood smears
* Practice performing differential counts and identifying reticulocytes

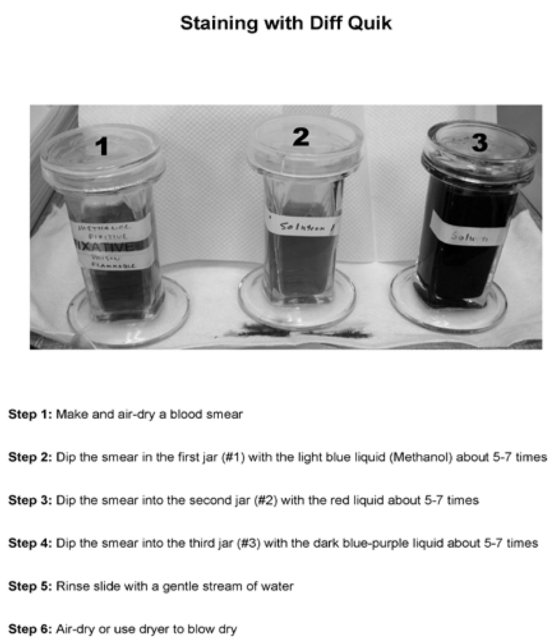
Directions:

To open underlined files, hold the control key while clicking the text with the left mouse button

1. Work through the Blood Smear Tutorial (bloodsmear tutorial)
2. View video and read instructions on making reticulocyte smears
a. Video demonstration (file named MakingReticulocyteSmear3.MOV on Desktop)
b. Text instructions (Reticulocyte-Smear-Instructions.doc)
3. Notify the instructor when the first person done with the tutorial is beginning to move on to making smears.
4. Practice making blood smears until you have made two good smears
a. The materials are in the back of the room
b. Make note of the medical record number of the blood you choose
c. Show your smears to an instructor if you have any question about their quality
5. Stain at least one good smear
a. Use Diff-Quik stain in the three jars next to the sink
b. The instructions for staining are found next to the stain and in the file (Staining-with-Diff-Quik.doc) on the computer
6. Perform a differential count on the Diff-Quick stained smear
a. Sheets with data printed out from the hematologic analyzer are present on the back table.
b. Use the sheets to verify your counts
7. Make a reticulocyte smear
a. The materials are present in the back of the room
b. Refer to the instructions or seek assistance of the instructor as needed
8. Examine the reticulocyte smear and identify a reticulocyte

[Figure 3]

these three resources and the tutorial, students were able to complete the blood smear section without any involvement from the instructor.



[Figure 4, (Left)];
[Figure 5, (Below)]

B. Procedure

Ten sections of 10 to 12 students (senior veterinary students and a few foreign-trained veterinarians) enrolled in the core clinical pathology rotation between 2004 and 2005. A new section was offered approximately every other week during the fall and spring semesters. This study focused on a two-hour session of the rotation that teaches slide-making methods followed by an opportunity to make and stain blood smears.

Group Selection and Assignment:

Seven sections of no more than 12 students (70 students total) participated in the study. Students were randomly assigned to sections through the college's administrative process. The three sections which occurred first received the control treatment, and the remaining four sections received the experimental treatment.

Instructional methods:

Control instruction: In the traditional teaching method the instructor, a medical technologist, explained and performed live demonstrations of smear-making techniques while the students observed. The instructor also explained some principles of staining, methods of ensuring good smears and how to make reticulocyte smears. After the demonstration, the students would collect some of the available materials and begin making smears. While teaching the course, the instructor was also responsible for laboratory duties. Therefore, she would leave the class after the demonstration and then reenter periodically to answer questions and assist students.

Experimental instruction: A notebook computer was made available to each student. The students were told to access a document which explained the laboratory's purpose and activities (Figure 3). These instructions contained links to the Blood Smear Tutorial, a movie demonstrating the reticulocyte smear (Figure 5), and a document describing how to stain smears (Figure 4). The students completed the tutorial and began to make their blood smears using the materials provided. The instructor would enter the classroom periodically to assist students if needed but provided no didactic instruction. In summary, the experimental instruction was the same as the control instruction, except that the demonstration and lecture parts of the control instruction were replaced by the self-paced, computer-based tutorial and accompanying laboratory instructions.

C. Data collection

Two researchers (vp and mb) observed each class and recorded the amount of time that the instructor spent in the classroom and what the instructor and students did. As they made each smear, students noted the smear quality and the time at which the smear was made. All blood smears were then collected.

After the laboratory, students completed a questionnaire in which they expressed their feelings about the instruction on a 5-point scale (Table 1) ranging from *completely agree* to *completely disagree*. At the end of the study, the instructor also completed a questionnaire with a similar 5-point scale. Additionally, one researcher (vp) interviewed the instructor after each laboratory using a semi-structured interview protocol to obtain her perspective on the class.

Instruments:

a. Surveys

Participants completed a survey containing 21 Likert-type items and 6 open-ended questions. We calculated mean responses to Likert items (Table 1). Responses to the open-ended questions were not formally analyzed. Student surveys were validated using focus groups to ensure that item meanings were interpreted by the participants as intended. The survey used for the control group was modified slightly between the administration to the first group and to the subsequent two groups; as a result, data were only available for two control groups for Questions 20 and 21. The instructor completed a similar survey at the end of the experiment.

b. Smear Scoring Rubric

Two expert raters used a rubric to determine the quality of each smear. Inter-rater reliability refers to "the level of agreement between a particular set of judges on a particular instrument at a particular time." [12] Raters used a 4-point scale (Excellent-3, Adequate-2, Marginal-1, Non-diagnostic-0) to score 22 glass slides. The scores were also converted to a dichotomy (diagnostic or non-diagnostic) by categorizing excellent and adequate scores as diagnostic and categorizing marginal and non-diagnostic scores as non-diagnostic. Rater agreement was 95%, with a Cronbach's Alpha of 0.95. Consensus estimates of quality inter-rater reliability should generally be 70% or greater, [12] and a Cronbach's Alpha value of 0.7 or higher is commonly thought to indicate good consistency.[13] Therefore, we determined that the reliability of our raters/rubric was sufficient to pursue the full study.

Since the rubric was to be used to promote consistent scoring of blood smears between judges and because the smear quality gold standard is the approval of an expert, we felt that high inter-rater reliability also would ensure the validity of the blood smear quality assessment.

Data Analysis:

An ANOVA was used to compare treatments in terms of instructor time dedicated to each activity, smear quality, degree to which students agreed with the expert, and student responses to the Likert items.

a. Analysis of smear quality

Each participant's slide quality score was calculated by taking the mean rater score for all of the participant's smears. Thus, each participant received a smear quality score between 1 (all smears are non-diagnostic) and 2 (all smears are diagnostic) regardless of the number of smears he or she submitted.

b. Analysis of student/expert agreement

The degree to which students accurately estimated the quality of their smears was determined by comparing the student quality score with the expert quality score for each smear. When the student quality score for a smear agreed with the score of one or both experts, the student was given an agreement score of 2 for that smear. When the student quality score was different from the score of both experts, the student was given an agreement score of 1. An overall student-rater agreement score was determined for each student by calculating the mean "agreement" among all smears submitted; thus a student's score could range from 1 (complete disagreement) to 2 (complete agreement).

c. Analysis of student attitudes by experience level

We performed a multifactorial ANOVA with experience (4 levels) as one factor, and group (control or tutorial) as the other to determine if students' attitudes towards the instructional interventions varied by their prior experience making blood smears.

III. Results

Questions 1 and 2: Did the manner of instruction affect the amount and/or quality of time the instructor spent with the course?

Table 2 shows the amount of time the instructor spent in the classroom by treatment group and activity (demonstration or interaction). An ANOVA revealed no significant difference between control or tutorial groups for the total amount of time the instructor spent in the room ($F_{(1, 5)} = 0.813$, p = 0.409, power = 0.072). Because homogeneity of variances could not be assumed, this finding was confirmed using a non-parametric (Mann-Whitney) test (U = 4.000, $N_1 = 3$, $N_2 = 4$, $p = 0.629$, two-tailed).

The instructor spent almost no time performing demonstrations or lecturing in the tutorial groups, which was significantly less than the amount of time spent doing these activities with the control groups ($F_{(1, 5)} = 13.391$, p = 0.015, power = 0.387). She spent 6.7 more minutes interacting with the tutorial groups, though this difference was not statistically significant ($F_{(1, 5)} = 0.993$, p = 0.365, power = 0.127).

After teaching all control and tutorial groups, the instructor completely agreed that using the tutorial made instructing the class easier and helped decrease teaching time. She also indicated that the tutorial made instructing the class more enjoyable, made the content more organized, and helped focus some students. The instructor was concerned that the tutorials might discourage some students from approaching her for help when needed. However, the tutorial students themselves indicated that they required less assistance from the instructor than the control students, both in response to question 16 (Table 1, $F_{(1, 68)} = 7.962$, $p = 0.006$), and in response to open-ended questions. Similarly, 8 of 31 control group students (25%) specifically mentioned wanting more interaction with an instructor, whereas only 4 of 39 tutorial group students (10%) mentioned wanting more instructor interaction.

Question 3: Did the manner of instruction affect the quality of the smears the students produced?

Rater agreement on scoring all slides as either diagnostic or non-diagnostic was good (Chronbach's alpha = 0.87).

There were a small but significantly greater number of diagnostic slides in the tutorial group than in the control group (Table 3, $F_{(1, 70)} = 4.118$, $p < 0.05$). Students in both groups agreed equally that the training improved their ability to create blood smears (Table 1, Question 6). However, as seen in Table 1, Question 20, the tutorial students felt more confident than the control students that they could make good blood smears following the training ($F_{(1, 57)} = 7.059$, $p = 0.010$).

Question 4: Did the manner of instruction affect the students' ability to recognize errors and self-correct?

Tutorial group students rated their smear quality more accurately than control group students (Table 4, $F_{(1, 66)} = 6.108$, $p = 0.016$). This result was partially reflected in survey data. While there was no significant difference between groups' beliefs about their ability to identify good and bad smears after the training (Table 1 Question 5: $F_{(1,68)} = 0.303$, $p = 0.584$), tutorial students were more likely to feel that they knew what they did wrong when they made bad smears (Question 15: $F_{(1, 68)} = 6.454$, $p = 0.013$). The instructor indicated that "the students who used the tutorial were more aware of what bad slides look like and recognized that they needed more practice."

Question 5: Did the instructional intervention affect learning efficiency (i.e. the ease of learning the task and the amount of time needed to learn the task)?

There was no significant difference between experimental and control groups' responses to questions 12, 13 and 14 (Table 1), which were intended to indicate the efficiency of the learning. Both groups agreed that the training made it easy to understand how to make a smear, and that they were able to move quickly through the lesson and make good smears with fewer attempts after the training.

Question 6: Did the manner of instruction affect students' attitudes about smear-making and the laboratory class in general?

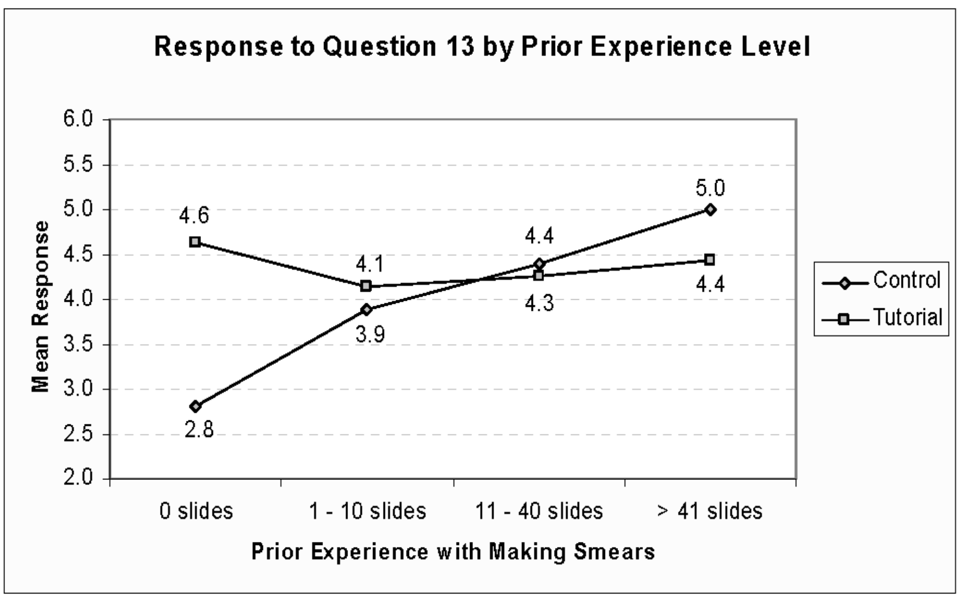
Survey questions 4, 7, 8 and 9 (Table 1) were intended to indicate the students' attitudes about the course and about smear-making in general. There was no significant difference between groups' feelings about the relevance of making and interpreting blood smears (questions 7 and 8) or about the importance of making good smears (question 9). Nor was there a significant difference between groups' feelings about the importance of submitting blood smears for a complete blood count (question 4).

In contrast, the instructor perceived an improvement in the students' attitudes towards making smears when they used the tutorial. She felt that the students using the tutorial were "more concentrated on technique as they started to make the slides, " and that, compared with the students in the control group, those using the tutorial were more positive towards the experience and less likely to give up right away.

Question 7: Does previous experience making slides affect students' perception of the instructional intervention?

The multifactorial ANOVA revealed a significant interaction (Figure 6) between student experience level and instructional intervention for survey question 13 ($F_{(3, 51)} = 3.219$ $p = 0.03$). Subsequent analysis (ANOVA) showed a significant difference between instructional interventions for those who had made 0 slides previously. The least experienced students using the tutorial reported that they could move more quickly through the instruction than the least experienced students in the face-to-face sections ($F_{(1,11)} = 12.995$, $p = 0.004$).

V. Discussion



[Figure 6]

The findings support the idea that a simple psychomotor task such as making a blood smear can be learned as readily through computer aided instruction (with supporting instructor interaction) as through face-to-face demonstration. Furthermore, CAI improved the experience for the instructor.

Effect on Instructor

There was no measured difference in instructor's time with each group; however, the instructor preferred the tutorial experience. Why? Perhaps, by eliminating the demonstration/lecture portion of the laboratory, the tutorial allowed the instructor to conduct only the part of the class she most enjoyed. Also, given the low power of this comparison, it is likely that we are committing a Type II error in not finding significance in total time between groups. Regardless, the 6 minute difference (Table 2) was likely meaningful to the instructor who was trying to conduct a class and to manage her laboratory duties at the same time.

Effect on Learning Outcomes

The tutorial was instructionally effective. Students in the experimental group produced a greater percentage of diagnostic smears and were more likely to accurately assess smear quality than students in the control group. This probably occurred because of specific features of the tutorial's instructional design, such as providing multiple examples of good and poor smears, requiring students to identify smear quality, and providing multiple video and graphical illustrations of how smears are made.

An unintended outcome was that the tutorial students were more confident in their ability to work independently than the students in the control group. Why? The tutorial might have been a more complete or effective form of instruction. If so the tutorial students would not need as much help as the control students. Also, the tutorial was available to the tutorial students for reference after having completed the initial instruction, whereas, the control groups had only the materials that they brought with them and any notes they may have taken.

Experience and Speed

Why did the least experienced students in the tutorial group feel that they could move more quickly through the lab than the least experienced students in the control group? The response level of those who used the tutorial seems to remain fairly stable among experience levels (Figure 6). On the other hand, the score of the control students increased as the level of experience increased. Thus, it appears that the effect is primarily found within the control group and that students differ by prior experience within the control treatment but not the experimental treatment. One possible explanation is that the experienced students, being already familiar with the procedure, saw the demonstration by the instructor as a quick reminder and were able to get started right away. The inexperienced control students, however, may have been struggling to understand what to do and how to do it and thus took more time to orient themselves in the laboratory once they were on their own. The tutorial program may have provided inexperienced students a more comprehensive orientation to the procedure thus helping them start more quickly once they were on their own.

Potentially Confounding Factors

Since the data obtained for each treatment group were derived from a series of laboratory sessions with different participants at different points in time, it is possible that there were some influences on the results not directly related to the instructional interventions. Factors such as time, increasing experience of students, exhaustion, level of training, and class demographics might have affected the outcome, but we have no specific reasons to believe this was the case.

V. Conclusion

The tutorial implementation was successful in providing students and instructors with an effective teaching and learning experience. Both subjective and objective measures indicated that the satisfaction level and post-instruction skills of tutorial students were equivalent to or greater than those of the control students. The instructor spent significantly less time performing lectures and demonstrations in class, and she felt that using the tutorial made the class easier and more enjoyable to teach. Thus, the experimental instruction was a viable method of teaching students to make blood smears.

VI. Acknowledgments

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Figure Legend

Figure 1: Introduction screen of the Blood Smear Tutorial

Figure 2: Interactive questions about smear quality

Figure 3: Electronic document explaining the laboratory procedures

Figure 4: Electronic document (Staining-with-Diff-Quik.doc) on staining referred to in laboratory instruction document

Figure 5: Reticulocyte movie (MakingAReticulocyteSmear3.mov) referred to in the instruction document

Figure 6: Experience/Speed Interaction for Question 13

Table 1: Student survey questions with mean values and association to research question

Tutorial Group		Control Group		
Question	Mean	Question	Mean	Research Question
1. I feel comfortable when I use this tutorial.	4.62	I feel comfortable in this blood smear laboratory.	4.10	General
2. Using this tutorial was easy.	4.56			General
3. Navigating through the tutorial is clear.	4.54			General
4. After using this tutorial, I am more likely to submit blood smears with the anticoagulated blood for a complete blood count.	4.13	After this lab, I am more likely to submit blood smears along with the anticoagulated blood I send for a complete blood count.	4.06	6
5. As a result of using this tutorial I can identify good and bad blood smears better than before.	4.10	After participating in this lab I can identify good and bad blood smears better than before.	3.97	4
6. As a result of using this tutorial I am able to create blood smears better than before.	3.97	After participating in this lab I am able to create blood smears better than before.	4.13	3

7. Making a good blood smear is relevant to my personal and professional goals.	4.67	Making a good blood smear is relevant to my personal and professional goals.	4.35	6
8. Interpreting a blood smear is relevant to my personal and professional goals.	4.69	Interpreting a blood smear is relevant to my personal and professional goals.	4.39	6
9. I feel that it is important that I am able to make a good blood smear.	4.69	I feel that it is important that I am able to make a good blood smear.	4.52	6
10. I enjoyed using the tutorial	3.79	I enjoyed participating in this blood smear laboratory.	4.16	General
11. Technical problems were not an issue when using the tutorial.	3.41			General
12.The tutorial makes understanding how to make a good blood smear easy.	4.10	The instructor makes understanding how to make a good blood smear easy.	4.19	5
13. I was able to quickly move through the lesson.	4.33	I was able to quickly move through the lesson.	3.90	5
14. As a result of using this tutorial, I am able to make a good blood smear with fewer	3.85	After participating in this lab, I am able to make a good blood smear in fewer attempts than before.	3.71	5

attempts than before.				
15. If I make a bad smear, I know what I did wrong.	4.31	If I make a bad smear, I know what I did wrong.	3.74	4
16. I required no assistance from the instructor to understand the material or make a blood smear.	4.03	I required no assistance from the instructor to understand the material or make a blood smear.	3.26	1
17. I like being able to learn how to make blood smears on a computer.	3.67			General
18. I feel comfortable reading from a computer screen	4.18	I feel comfortable reading from a computer screen	4.39	General
19. I feel comfortable using computers	4.18	I feel comfortable using computers	4.26	General
20. I feel confident I can make a good blood smear.	4.23	I feel confident I can make a good blood smear.	3.75	3
21. The number of blood smears I have made before this class falls within the following range:	2.46	The number of blood smears I have made before this class falls within the following range:	2.20	Experience

Note. Scale for Question 21: 1 = no prior experience, 2 = 1-10 smears previous, 3 = 11-40 smears previous, 4 = >41 smears made previously; Scale for all other questions: 1 = Completely disagree, 2 = Generally disagree, 3 = Neutral, 4 = Generally agree, 5 = Completely agree. The furthest-right column shows the research question that each survey item was intended to address.

Table 2: Time the instructor spent in the room by experimental group

Instructor Time	Group	N	Mean*	Std. Dev.
Demonstration	Control	3	11.5	5.0
	Tutorial	4	1.3	2.5
	Total	7	5.6	6.4
Interaction with students	Control	3	19.2	13.3
	Tutorial	4	25.9	3.5
	Total	7	23.0	8.8
Total in the room	Control	3	33.2	13.6
	Tutorial	4	27.1	2.3
	Total	7	29.7	8.6

* Average minutes

Table 3: Smear quality scores assigned by raters

Group	N	Mean*	Std. Dev.
Control	31	1.47	0.32
Tutorial	41	1.61	0.29
Total	72	1.55	0.31

The score for each student is the average quality of the individual’s submitted slides. These scores are averaged across each treatment group to achieve the mean.
* Rater Scores: OK = 2, Non-diagnostic = 1

Table 4: Agreement about smear quality between students and raters

Group	N	Mean*	Std. Dev.
Control	30	1.71	0.31
Tutorial	38	1.86	0.18
Total	68	1.79	0.26

* Agreement = 2, Disagreement = 1