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ABSTRACT

The development of innovative test item types that use multimedia technology to improve item authenticity and interaction and allow for objective scoring through partial-credit scoring methodologies was studied. Science test items were developed for community college developmental students using "Authorware 3.0," an instructional compact disc. The items used graphics and animation for the presentation of stimulus materials, the presentation of hints, and for item response alternatives. Forty-one students completed the test items and a questionnaire about their responses to the test items. Students had not received instruction in the concepts tested, and scores were about as high as could be expected, although an apparent error in the programming of the scoring may have further reduced scores. Overall, items were received positively. Students seemed to like the innovative format, and it is thought that the partial-credit scoring could easily to transferred to other subject matter. Future studies are planned that will embed assessments in the instructional materials. Appendix A presents the feedback questionnaire, and appendixes B through E present student responses to particular test items. (Contains seven figures and eight references.) (SLD)

Using Multimedia Technology to Create Innovative Items

Ann French and Janet Godwin

American College Testing

Introduction

For decades, teachers and administrators have criticized traditional, paper-and-pencil multiple-choice tests for their product-oriented approach to assessment. The argument is that because multiple-choice tests require students to select correct responses from a predetermined list of alternatives, the tests measure recall and recognition of verbal information rather than the higher-order skills of generative problem solving, evaluation, and synthesis. In addition, the limitations of multiple-choice tests are often amplified due to the presentation of unrealistic and decontextualized stimulus materials and texts. Given the growing emphasis in today's schools on process-oriented critical thinking in authentic learning environments, many educators feel that traditional multiple-choice tests simply cannot keep pace with instruction.

In response to the growing criticisms against multiple-choice, paper-and-pencil assessments, many educators have turned to performance assessments as a better means of measuring process and thinking. Considerable progress has been made in the development of valid and reliable portfolio assessments and performance-based measures such as direct writing samples and laboratory assessments in science. The goals of these assessments are to measure the thinking and problem-solving skills students use while engaged in relevant and realistic activities. The focus here is on process rather than product, evaluation and synthesis rather than recall of verbal knowledge. While the theory behind performance assessment is sound, many teachers and researchers have discovered the practical limitations to such tests. They are expensive to administer and score, they are extremely time consuming, they cannot broadly sample the content domain, they are difficult to validate, and they often produce unreliable scores (Kumar et al, 1994, Carver et al, 1994). Teachers don't always have the time, money, or expertise to develop rubrics or train raters for the valid and reliable process of evaluating student performance.

Because of the practical limitations of performance-based assessment, many researchers have turned to computers with the hopes that computers and multimedia technologies will be able to couple authentic assessment situations with reliable and objective scoring methodologies that provide information about students' thinking processes. Shavelson et al (1992) note that the closest approximation to hands-on performance evaluation that can be group administered comes from interactive computer simulations. Kumar et al (1994) suggest that computers could not only provide a rich avenue for developing alternative forms of assessment but could also serve as research tools for understanding human cognition. Shore (1993) notes that the best advances in providing realistic problem-solving situations are in the area of computer-administered tests. Advents in computer-adaptive testing techniques and the development of instructional computer-based programs that can track student progress, alter instruction according to students' responses, and provide information about student decision points have provided fertile new areas for research into alternative forms of assessment. Design strategies behind computer-based microworlds, hypermedia-multimedia learning environments, simulations, and intelligent tutoring systems are examples of the kinds of computer environments that could potentially provide avenues for the development of alternative testing techniques that measure more accurately than multiple-choice tests the cognitive processes students engage when solving authentic, task-based problems.

To answer this call for computer-based assessments that measure process and thinking in authentic, performance-based environments while avoiding undue costs in time, budgets, and reliability, a number of researchers have developed prototype computer-based tests to learn more about the possibilities in this area (Singley and Taft, 1995; Baxter, 1995; Kumar, Helgeson, and White, 1994; Kumar, 1994; Young & Kulikowich, 1992). In general, these studies have shown that computers can in fact present more realistic contexts for assessment and allow for more student interaction leading to active problem-solving than can traditional multiple-choice tests. Students perform as well or better on computer-based assessments than on parallel paper-and-pencil tests (Kumar et al, 1994), and the assessment is better linked to instruction thus improving student learning and transfer (Young & Kulikowich, 1992). Not only does the computer collect information about whether or not students correctly solved a problem, the computer also collects information about students' decisions during the assessment activity. Examples of the kinds of information a computer can store that could lead to inferences about students' thinking processes are the following: 1) whether or not students ask to see an answer or hint, 2) whether or not or how many times students refer back to the stimulus materials, 3) how long students spend on one activity, or 4) how many times students change their responses.

While researchers found that the information linked to students' thinking processes is extremely valuable, they also found that interpreting it takes a good amount of time. Data on latency, number of tries per item, choices and decisions in interactions are typically stored in lengthy audit trails, and interpreting these lines of numbers to reconstruct student activity is daunting. Computers are able to provide more information about student thinking, but the information as it has been typically stored is difficult to use.

While it is necessary for the scoring methodology to be defined in relation to the construct or skill of interest, there are a number of potential approaches for scoring student activities or interactions with computer-based performance items that might lead to collecting more accessible information about students' thinking processes during a performance test. One possible approach for measuring the quality and kind of student performance would be to provide partial credit depending on the completeness of student responses. Another would be to judge and quantify decisions students make in a series of interconnected or branching questions. Finally, another approach might track and score the way in which students' complete performance questions. These scoring approaches have been used, when appropriate, with scoring rubrics for noncomputer-based performance assessments. The difference here is that the computer would be able to objectively quantify the quality of student performance.

Given the capability of computers and multimedia technology to provide authentic performance-based activities and the computer's ability to objectively score student performance, computer-based assessment may be able to respond to the dilemma between reliable yet inauthentic multiple-choice assessment and authentic but often unreliable performance assessment. The purpose of this study, therefore, was to begin investigating the development of innovative item types that utilize multimedia technology for improving item authenticity and interactivity and that may also be objectively scored using partial-credit scoring methodologies.

Method

Research Questions

This study grew out of a project to develop different types of items in many subject areas to determine the utility of multimedia technologies in creating computerized assessments. One of the originally developed item sets was in the area of science, and this set was expanded as part of the present study. The decision to expand the science item set was based on three assumptions: 1) multimedia technology presents many advantages in the assessment of science skills; 2) partial-credit scoring methodologies work well with process-level assessments; and 3) science curricula favor process-level instruction and multimedia technologies can more readily elicit process-level interactions than can traditional paper-pencil approaches.

The science item set included the use of graphics and animation for the presentation of stimulus materials, the presentation of hints, and for item response alternatives. One major goal in developing the science item set was to determine whether computer-delivery allowed for more innovative item response interactions than the traditional selection-type item.

The main focus in developing and pretesting the set of science items was to answer the following research questions:

1) Do students find this type of assessment item easier to manage than paper-and-pencil items?
2) Do students like the multimedia presentation?
3 How easy or difficult do students find the format of the assessment?
4) Specifically, what do students like about these types of items?
5) Specifically, what do students dislike about these types of items?
6) Do students like the use of hint buttons, which contain pertinent information for answering the question without making the item too easy?
7) How well do the partial-credit items work for students? Would they be as effective as multiple-choice items?

Item Development

Items were developed using Authorware 3.0, an instructional CD called *Electricity and Magnetism,* and Corel Draw. The intended audience was developmental students from community colleges who had recently completed a unit on electricity and magnetism in a general science course. Our intent was to use multimedia technology to build items that were more realistic than standard paper-and-pencil items and therefore more valid, especially for this student population. The items were based on hands-on lab work that students completing this type of unit would be expected to complete.

Items were written in three areas--magnetism, lightning, and circuitry. The magnetism items were developed to test students' basic conceptual knowledge of attraction and repulsion. The items were developed with a partial-credit methodology, the rationale for which follows: students must first understand a magnet's underlying polarity (i.e., each magnet has a north and south pole) in order to understand the concepts of attraction and repulsion. Students were presented with a 3-D depiction of two magnets, with N and S symbols below the magnets. Students were asked to use the mouse to drag the symbols onto the magnets to demonstrate attraction, then to repeat the process (using identical magnets and polarity symbols) to demonstrate repulsion. Each item was worth two points; students were awarded one point if they demonstrated correct polarity within the magnets but incorrect polarity between the magnets and two points if they demonstrated correct polarity both within the magnets and between magnets.

Two items were developed to assess students' concepts about the charges involved with lightning. In the first item, students were shown an animation of lightning hitting and breaking apart a battlement of a castle and asked a multiple-choice question about the flow of electrons in the lightning. Students were provided with a hint button to find out what symbolized protons and electrons because the animation had been reduced in size from its original and the symbols were no longer clear. The second item showed the same battlement with a lightning rod, and again students were asked a multiple-choice question about the flow of electrons. The same hint button that was provided for the first item was also provided for the second item.

Finally, two items were constructed to test students' knowledge of circuitry concepts. Students were provided with a framework for building either a parallel or a sequential circuit using objects representing resistors, a battery, and a glow lamp. In the first item, they were asked to build a parallel circuit; in the second, they were asked to build a sequential circuit. Students were graded on a partial-credit basis, as with the magnetism items. If students understood the basic concepts of building a circuit, regardless of the type of circuit they built, they were awarded one point. Further, if they could successfully build a parallel or sequential circuit, they were awarded two points.

The four partial-credit items (two magnet items and two circuitry items) were scored by building in hot spots that recognized and scored the placement of symbols in both the magnet and circuit items. The magnet items utilized four hot spots (one on each end of two magnets) and the circuitry items utilized six hot spots. Every possible combination of the hot spots was programmed into the items with associated scores; 0, 1, or 2. The multiple-choice lightning items were dichotomously scored and were worth one point each.

Pretesting

Developmental students at a local community college were selected for pretesting. Unfortunately, we were not able to find students that had just completed a unit on magnetism and electricity; instead we simply sampled from students that used a developmental lab at the community college. Items were arranged in the following way: students were given general directions for the test and were provided a menu from which they could select items in the three content areas (magnetism, lightning, and circuitry) in any order they wished. An end-of-test button was provided for students to indicate when they were finished. As students selected different areas and answered questions, their answers were recorded. They could go back as often as they wished to answer questions. The last response students made was the one that was saved. We did not use a stopping rule to prevent students from going back to previously answered questions because we wanted to see if students used the test-taking strategy of returning to items to revise their responses.

The item sets were loaded onto eight computers in the developmental center of the community college. Students who were regularly scheduled for time in the center were asked to participate in the study by their teachers. Students took the item sets over a two-day period; the average test-taking time was roughly 10 minutes. Responses were stored in data files, one file for each student. A paper-and-pencil questionnaire was designed to allow students to give their reactions to the item sets. In the interest of getting as much information as possible from the students, we asked as many questions as possible on a single sheet of paper, with the idea of keeping students' interest. Questionnaire items generally were of a multiple-choice nature, using Likert-type scales to gauge students' reactions to various aspects of the item set. There were some short-answer questions as well. A copy of the questionnaire is included in Appendix A. The questionnaire took students an average of 15 minutes to complete.

Results

Items

A total of 43 students took the item sets. Each student's data was stored in a separate file on the computer on which they took the items. Each data set was downloaded onto a diskette, and answers were transferred into a larger file for descriptive analyses. Histograms of the distribution of scores on each of the items, as well as a distribution of total scores, can be found in Figures 1 and 2. Two students' total scores were thrown out because of a programming error in calculating scores on the lightning items.

Students did as well as could be expected without instruction on the concepts of magnetism, lightning, and circuitry. On the first magnet item, 70% of students scored at least partial credit, while 79% scored at least partial credit on the second magnet item. Eighty-three percent of the students got at least one of the lightning items correct. Only 23% of students got at least partial credit on the first circuit item, and 37% of students got at least partial credit on the second circuit item. It is assumed that students did poorly on the circuit items for two reasons: 1) circuits are less generalizable to most students' everyday lives than magnets or lightning, and 2) when observing the students taking the items, one of the authors noticed a flaw in the programming of the scoring of these items, which she believes led to spuriously low scores for many of the students. The average total score across items on all three concepts was just over 4.5 out of a possible 10 points.

Students' opinions as expressed on the questionnaire revealed some interesting findings. Forty-one of the 43 students that took the item sets turned in a questionnaire, for a response rate of just over 95%. Responding to question 1, 41% of students felt that the test would be more difficult as a paper-and-pencil exercise, while 46% felt that the test would have been about the same difficulty as a paper-and-pencil exercise. Students were asked why they responded as they did on question 1. If students felt that the test would be harder as paper-and-pencil (n=17), they responded most frequently that the reason they felt that way is because of the computer graphics (n=6), that the computerized test was easier and/or faster (n=3), and that the computerized test offered "demos" (n=2). If students felt that the test would be about the same as paper-and-pencil (n=19), they responded most frequently that the reason they felt that way is because it would be the same material (n=6) or that they didn't know the subject matter (n=4). If students felt that the test would be easier as paper-and-pencil (n=4), students most frequently responded that the test would be easier to check if it were paper-and-pencil (n=2). All short answers to this question can be found in Appendix B. A frequency distribution of this item can be found in Figure 3.

Students did not tend to think they did very well on the items; roughly 10% felt that they did very well on the item set, and 49% felt that they did okay on the test. However, 58% felt that the test would have been easy had they just completed a unit on the topic, and 32% felt that the test would have been just about right had they just completed a unit on the topic. A frequency distribution of these items can be found in Figure 3.

Students came from a large variety of academic backgrounds; a listing of their majors can be found in Appendix C. Students' ages also varied widely; 27.5% had been out of high school 2 years or less, 22.5% were out of high school between 3 and 5 years, 7.5% were out of high school between 6 and 10 years, and 42.5% of students were out of high school more than 10 years. Students overwhelmingly felt that they were familiar with computers; 39% felt that they were very familiar with computers and 49% felt that they were somewhat familiar with computers. Frequency distribution of these two items can be found in Figure 4.

Opinion items relating to different aspects of the test yielded some interesting results. Survey research indicates that respondents tend to rate favorably if they do not have a strong opinion about an item; therefore, one would expect the distribution of responses to be skewed in the direction of the positive responses. With that information in mind, the examinees certainly seemed to find some aspects of the test more favorable than others. Eighty-five percent of respondents agreed or strongly agreed with the statement that the instructions were easy to follow. Sixty-three percent agreed or strongly agreed with the statement that they understood what they were expected to do throughout the test. Ninety percent agreed or strongly agreed with the statement that the screens were easy to read. Eighty-five percent agreed or strongly agreed with the statement that they liked the use of color throughout the test. Frequency distributions of these items can be found in Figure 5.

When asked more specific questions about respondents' opinions about understanding what to do for the various items, it soon became clear why there was a lower percentage that agreed to the general item regarding understanding what was expected for the items. Roughly 59% of respondents agreed or strongly agreed with the statement that they understood what to do for the magnet items, 32% agreed or strongly agreed with the statement that they understood what to do for the circuit items, and 59% agreed or strongly agreed with the statement that they understood what to do for the lightning items. Frequency distributions of these items can be found in Figure 6.

Students appeared to like the various innovative formats of the items. Seventy-one percent agreed or strongly agreed with the statement that they liked the format of the magnet items, 56% agreed or strongly agreed with the statement that they liked the format of the circuit items, and 73% agreed or strongly agreed with the statement that they liked the format of the lightning items. Finally, students appeared to like the use of hint buttons; 76% agreed or strongly agreed with the statement that they liked the buttons for the lightning and circuit items. Frequency distributions of these items can be found in Figure 7.

When asked in a short-answer format what students *liked* about the test (n=36), students most frequently commented that they liked the use of graphics (n=13), that the test was easy (n=6), that they liked using the computer (n=4), and that they liked using the mouse (n=3). A list of the comments for this item can be found in Appendix D.

When asked in a short-answer format what students *disliked* about the test (n=33), students most frequently commented that they didn't know the material (n=13), that there was nothing they disliked about the test (n=5), that they needed more instructions (n=5), and that they disliked everything about the test (n=3). A list of the comments for this item can be found in Appendix E.

Finally, students were asked to add their comments at the end of the questionnaire (n=15). A list of these general comments can be found in Appendix F. Most students said that it was a good test or that they liked the test (n=7), but a few also had negative comments. The most helpful comments were the ones that gave suggestions for improvement (n=4), including that more feedback about responses would have been helpful, and that the N and S in the magnet items needed to be explained. The use of a hint button here would have been helpful.

Conclusions

We would like to note here that this is very much a work in progress; we do not presume to say that we have any definitive results. We were more interested in getting a feel for the types of items, the scoring of the items, and student reactions to the items than in getting hard data on reliability and validity of items. We don't have many hard statistics to answer our research questions; instead we took a more qualitative approach.

Overall, it seems that the items were received positively. Students seem to like the innovative item format. It would be interesting to see how students did on such items, and how they liked the items, right after they had completed a unit on the subject matter. Importantly, we feel that this type of partial-credit item is easily transferrable to other subject matter.

There are several things about the test that we would like to change. First, the programming of the partial-credit rubrics for the circuit items needs to be redone to get rid of the bug that emerged in pretesting. Second, since this test is for use with developmental students, the font of parts of the circuit item and of the questionnaire needs to be larger, so that they are easier to read. Third, we would like to introduce feedback in the form of animation into the items; for example, if the students get the attraction magnet item correct, the magnets would move together. Creating this feedback would necessitate that students not be allowed to return to parts of the test once they have answered the questions in that section. Providing corrective feedback in the form of animation would also necessitate closer scrutiny of the items to avoid undue item dependence.

In future studies, we would like to embed assessments in instructional materials. Further, we would like to create a larger test, so that we could collect reliability and validity data on student's responses and scores.

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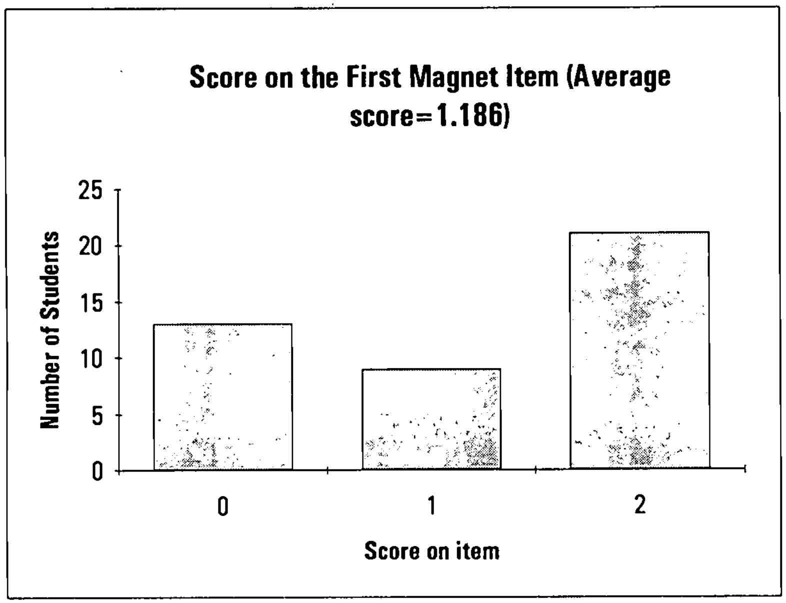
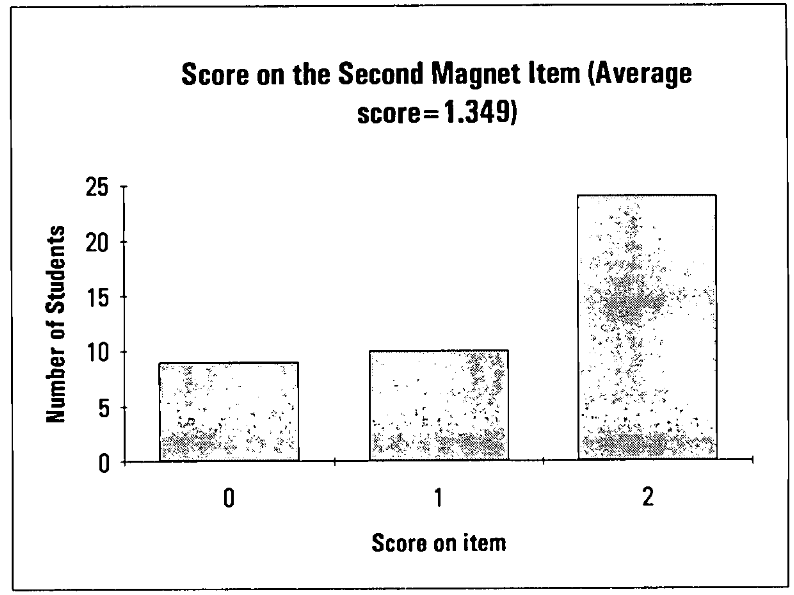
Figure 1: Frequency Distributions of Scores on Magnet and Lightning Items





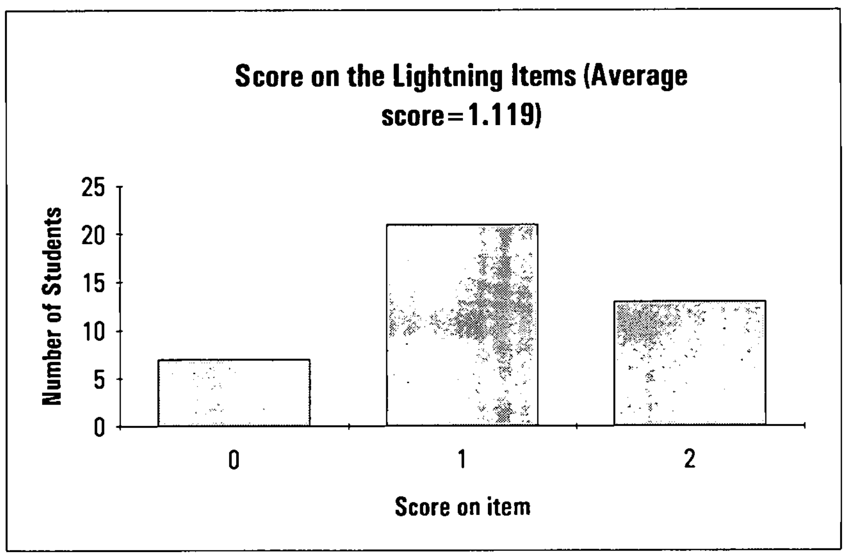
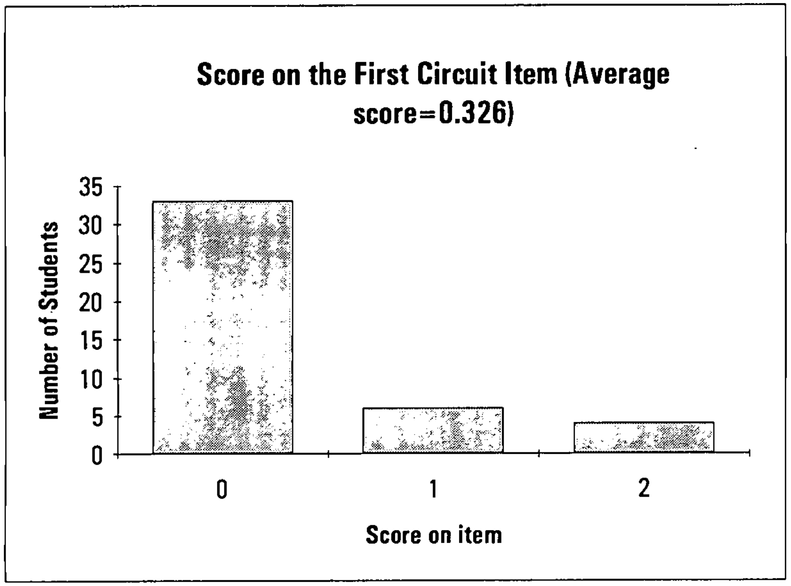
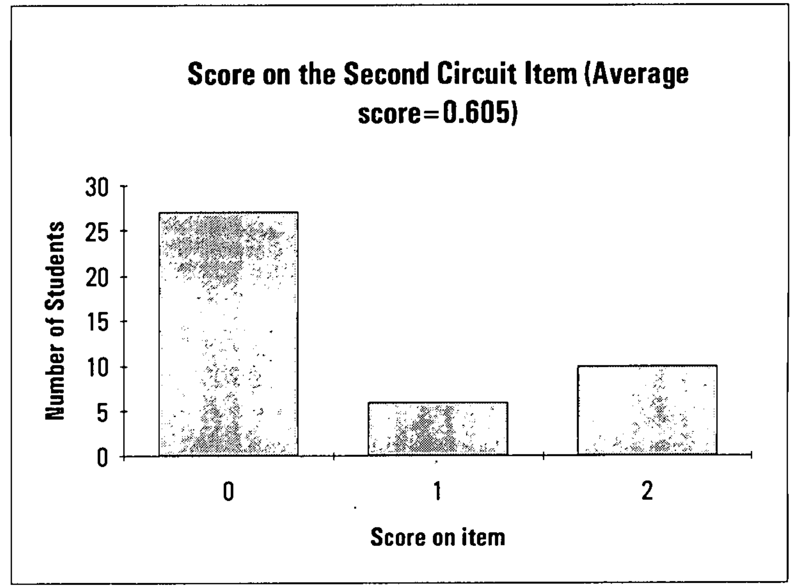


Figure 2: Frequency Distributions of Scores on Circuit Items and Total Test





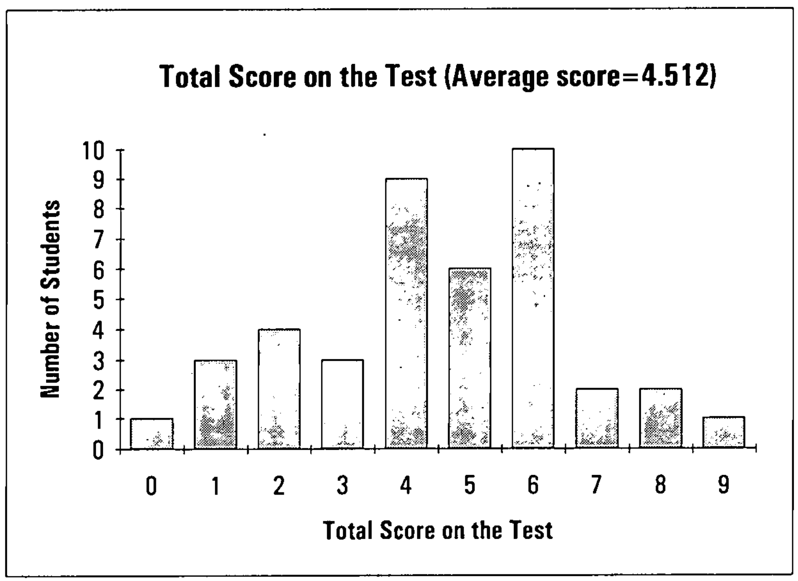
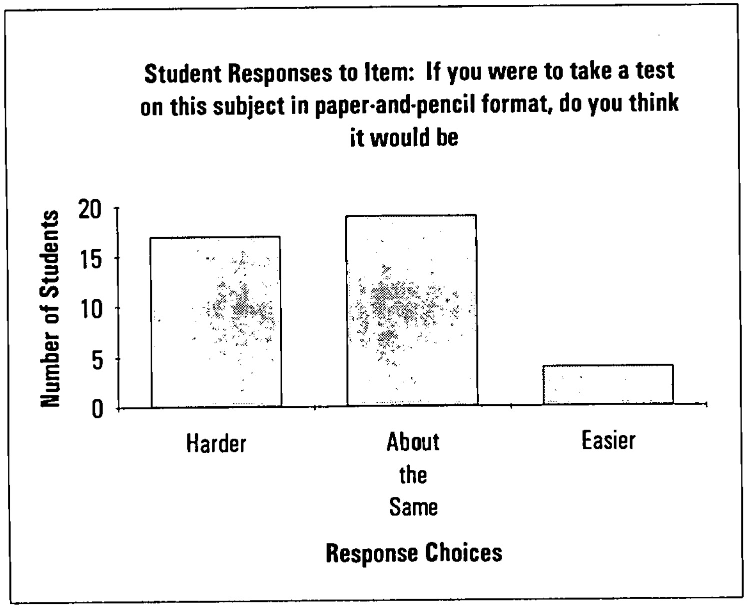
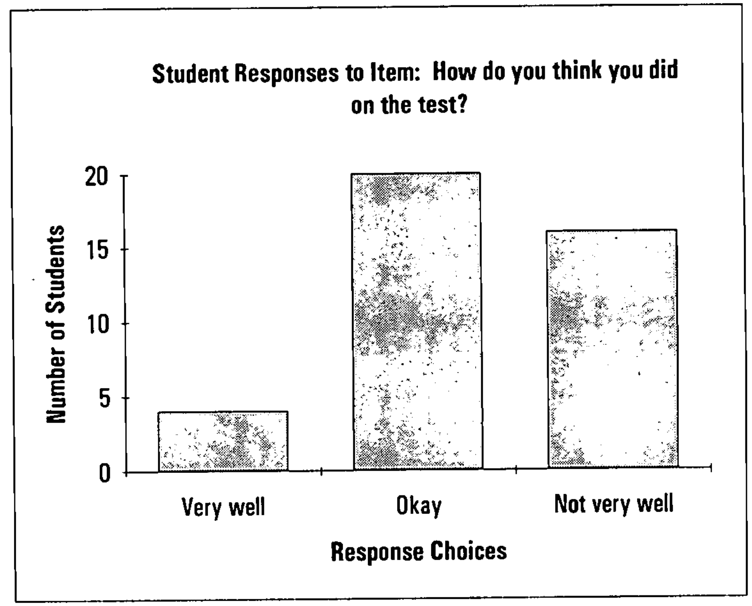


Figure 3: Frequency Distributions of Responses to Questionnaire Items





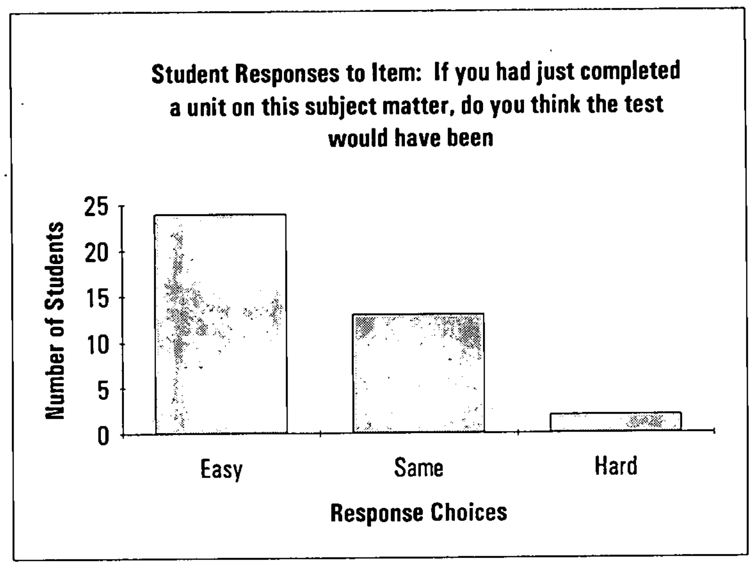
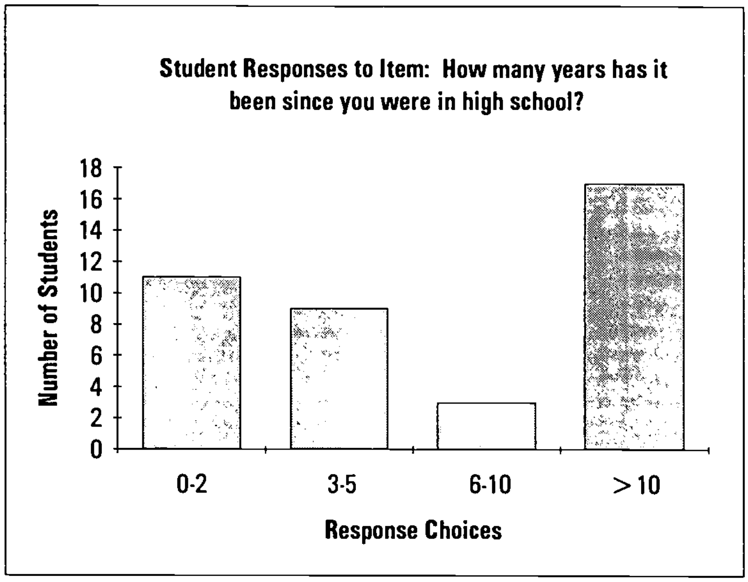


Figure 4: Frequency Distributions of Responses to Questionnaire Items



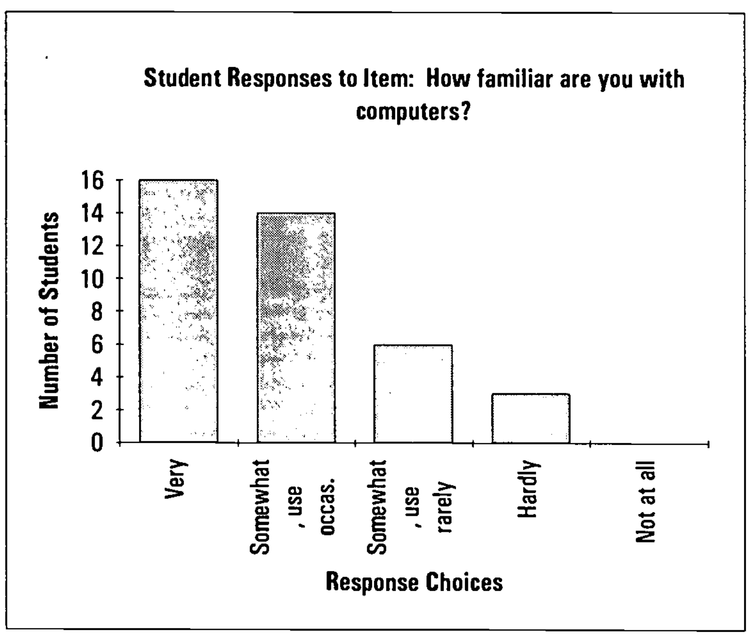
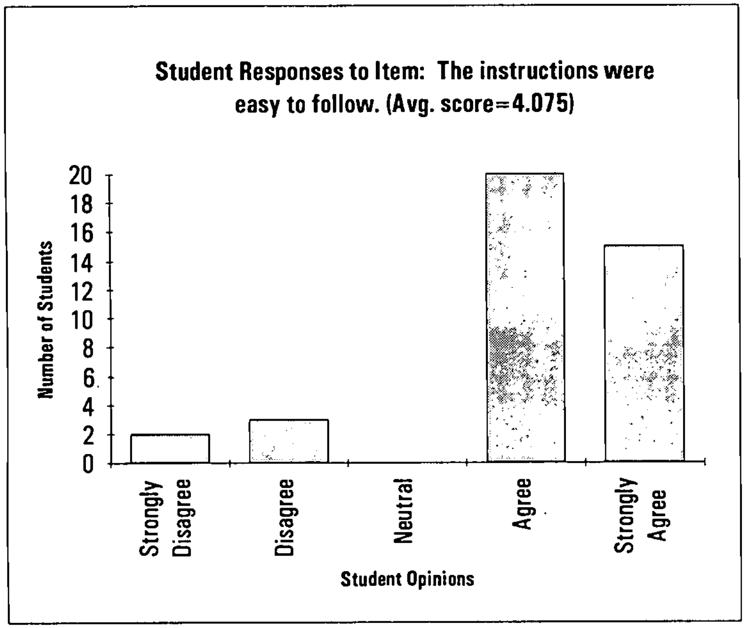
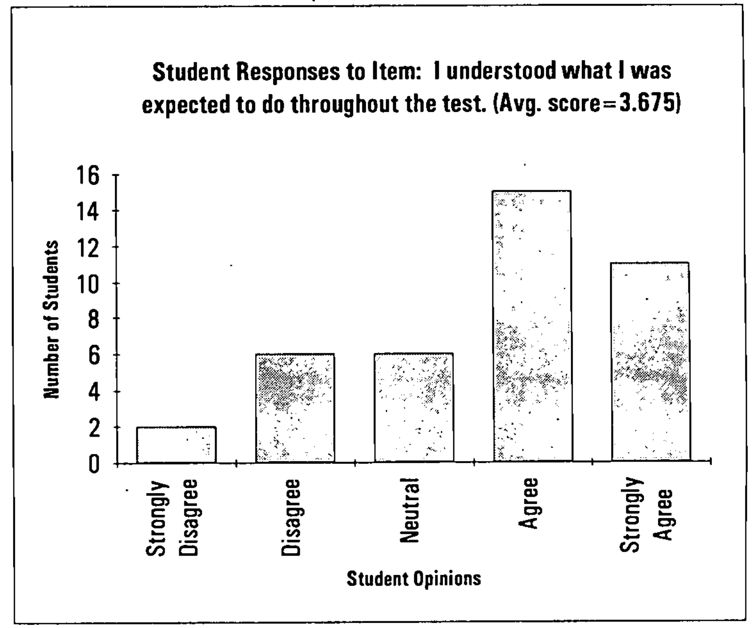
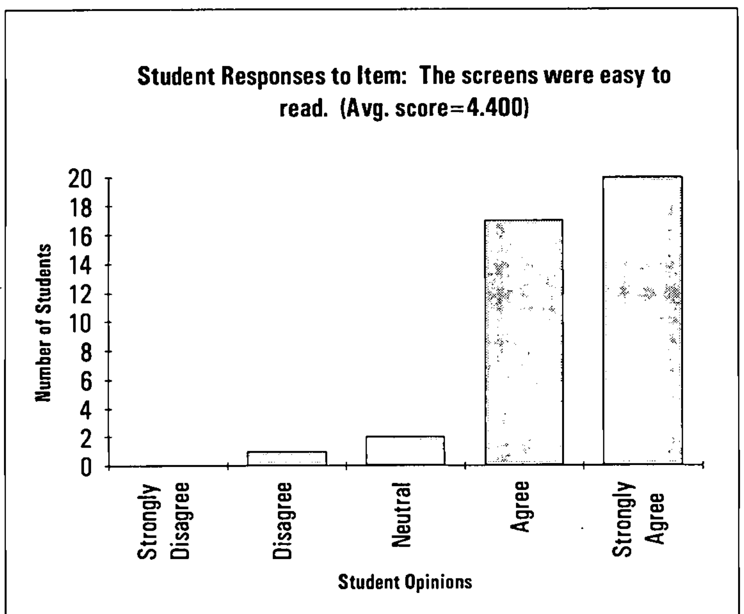


Figure 5: Frequency Distributions of Responses to Questionnnaire Items







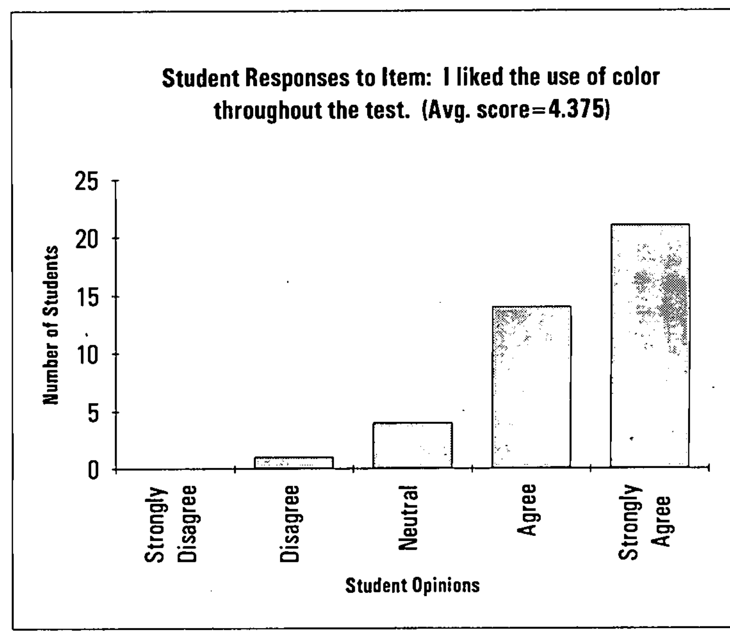
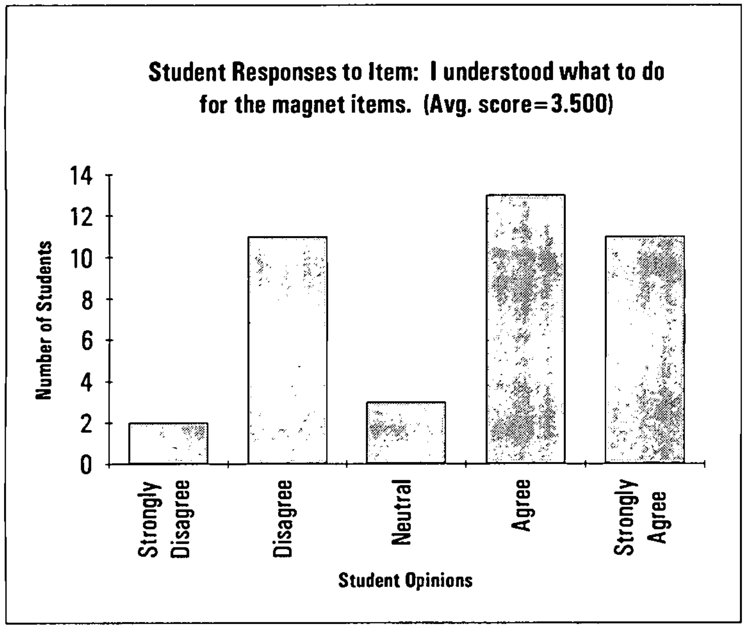
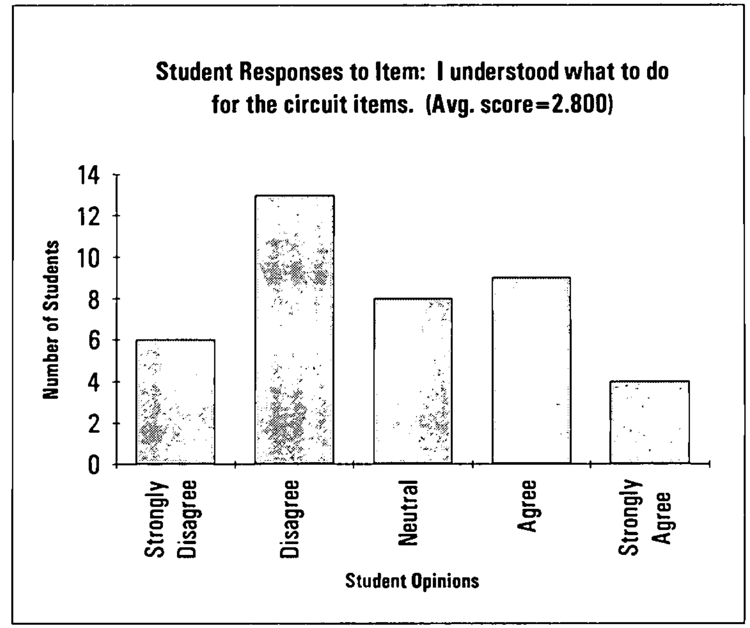


Figure 6: Frequency Distributions of Responses to Questionnaire Items





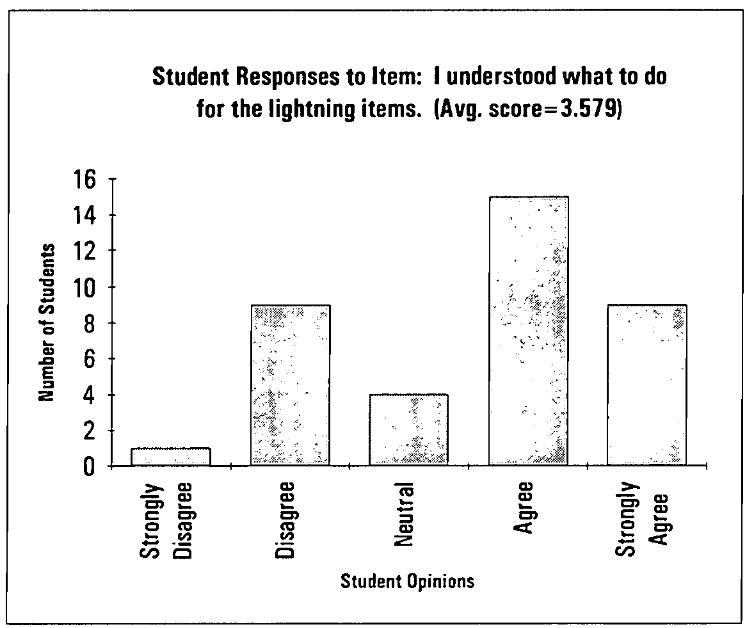
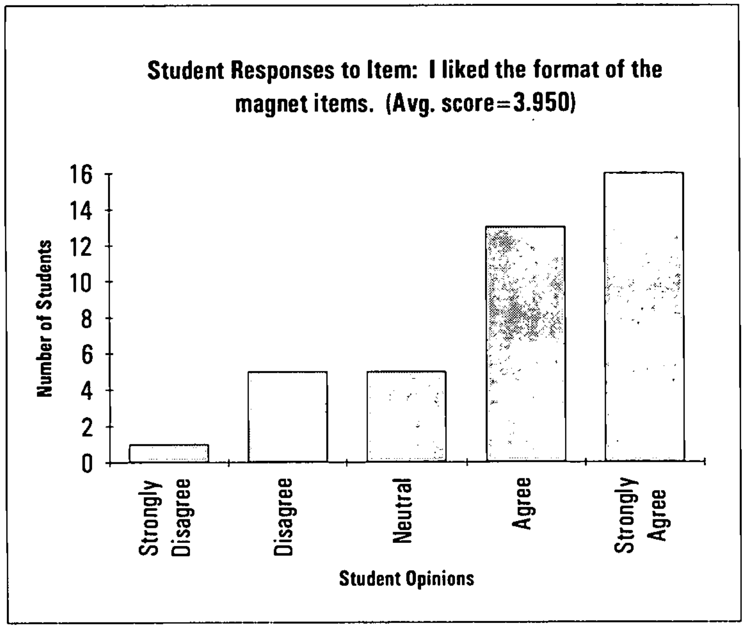
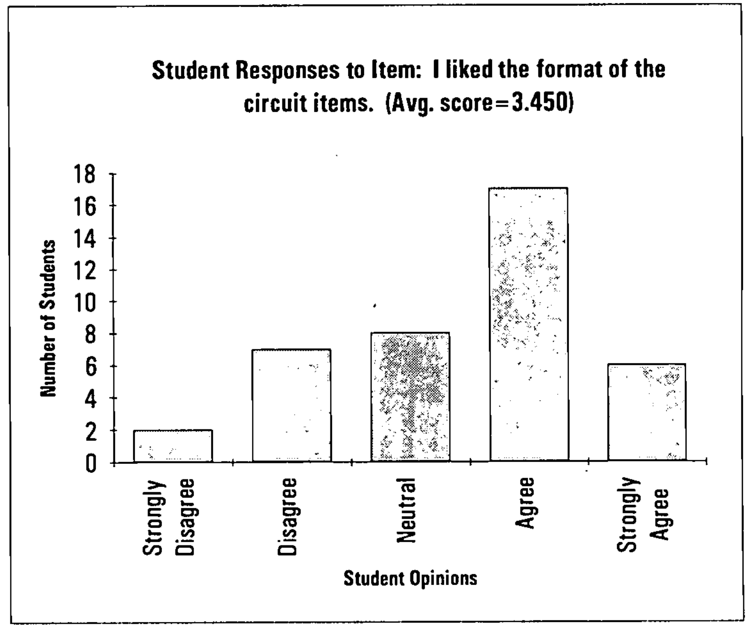
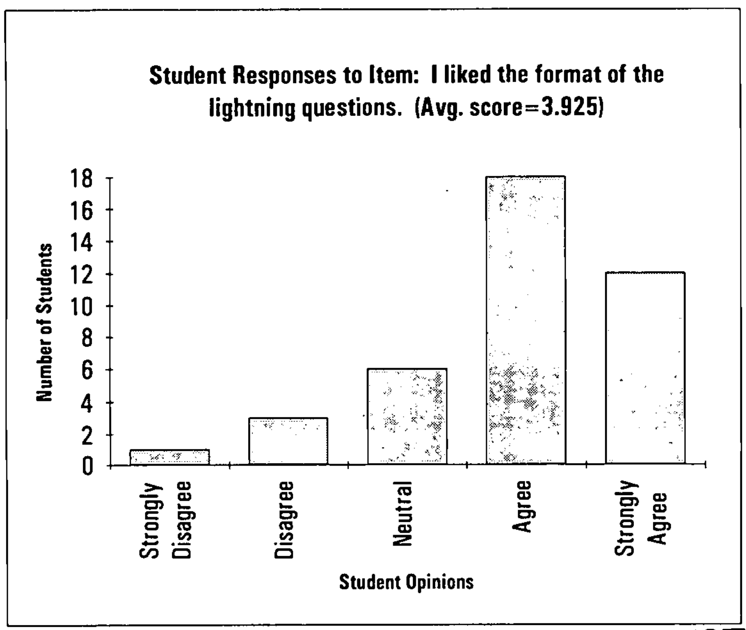
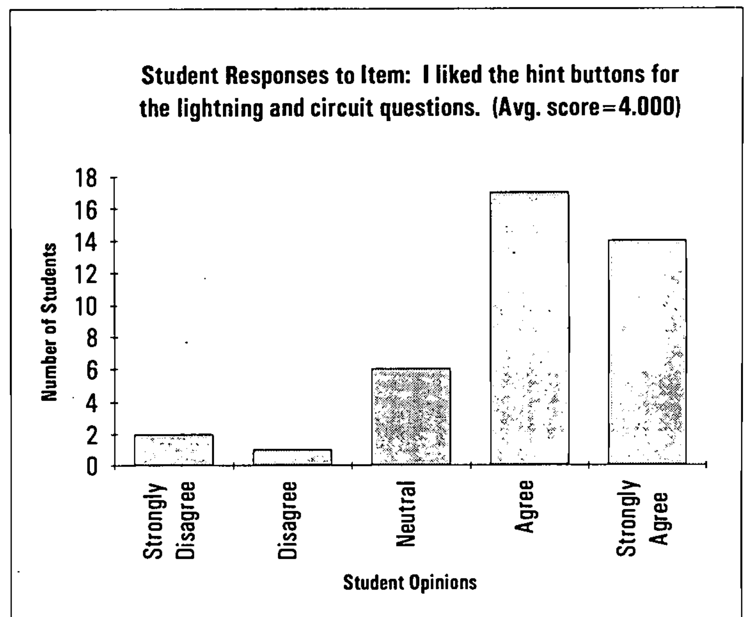


Figure 7: Frequency Distributions of Responses to Questionnaire Items









Appendix A
Feedback Questionnaire

FEEDBACK QUESTIONNAIRE

We are interested in your opinions regarding the computerized test questions you just examined. We are interested in your opinions about the types of questions we asked you, the way the screen looked to you, and how easy it was for you to understand how the test worked, for example. Please take a few minutes to fill out the questionnaire. Your answers will be strictly confidential; your individual responses will not be able to be identified. We will be using all responses in combination in order to make these types of questions and tests better for students in the future. Please circle the response that comes closest to your opinion for each item. There are also some short answer items.

1. If you were to take a test on this subject in paper-and-pencil format, do you think it would it be
   a) easier b) harder c) about the same

   Why?____

2. How do you think you did on the test?
   a) very well b) okay c) not very well

3. If you had just completed a unit on this subject matter, do you think the test would have been:
   a) easy b) just about right c) hard

Please answer the next questions about the format of the test using the following scale. Circle the letter(s) that come closest to your opinion about each statement:

strongly agree(SA) agree(A) neither agree nor disagree(N) disagree(D) strongly disagree(SD)

4.	SA	A	N	D	SD	The instructions were easy to follow.
5.	SA	A	N	D	SD	I understood what I was expected to do throughout the test.
6.	SA	A	N	D	SD	The screens were easy to read.
7.	SA	A	N	D	SD	I liked the use of color throughout the test.
8.	SA	A	N	D	SD	I understood what to do for the magnet items.
9.	SA	A	N	D	SD	I understood what to do for the circuit items.
10.	SA	A	N	D	SD	I understood what to do for the lightning items.
11.	SA	A	N	D	SD	I liked the format of the magnet items.
12.	SA	A	N	D	SD	I liked the format of the circuit items.
13.	SA	A	N	D	SD	I liked the format of the lightning questions.
14.	SA	A	N	D	SD	I liked the hint buttons for the lightning and circuit questions.

15. My major is ____________________________

16. How many years has it been since you were in high school?
    a) 0-2 b) 3-5 c) 6-10 d) >10

17. How familiar are you with computers?
    a) very, I use them all the time.
    b) somewhat, I use them occasionally
    c) somewhat, I use them rarely
    d) hardly, I almost never use them
    e) not at all

18. What did you like about this test?

19. What did you dislike about this test?

20. Comments:

THANK YOU FOR YOUR PARTICIPATION!!!

Appendix B
Short-Answer Responses to Questionnaire Item 1

Respondents that indicated that a paper-and-pencil test would be **harder**:

There would be no graphics (n=6)
There would be no demonstrations (n=2)
The computer is easier and faster (n=3)
Because you need to go between screens if you have questions which take time
Because you would need more time to think about each problem
There would be no moving parts and no way of knowing if it is right
Because I didn't understand
Because some I didn't know

Respondents that indicated that a paper-and-pencil test would be **about the same**:

The material would be the same either way (n=6)
I don't know the subject matter (n=4)
Because you have to read and write except with a computer you can use the mouse
(General knowledge after studying) except for the lightning test part. Graphics.
The computer holds my interest

Respondents that indicated that a paper-and-pencil test would be **easier**:

It's easier to check on paper-and-pencil
I remember really good about diagrams so it wouldn't be that hard to remember which goes with which.
I'm not that good at a computer

Appendix C
Responses to Questionnaire Item 15

Item 15: My major is:

accounting
art
auto mechanics
business (n=2)
communications/public relations
computer science (n=3)
disabilities services (n=2)
education (n=2)
engineering (n=2)
history
human services
IMT
industrial maintenance
legal assistance, paralegal
liberal arts (n=7)
nursing (n=3)
psychology (n=2)
undecided/no response (n=6)
vet tech program (n=2)

Appendix D
Comments on Questionnaire Item 18

Item 18: What did you **like** about this test?

I wasn't graded (n=2)
It was short
It was easy to do (n=6)
I liked using the mouse (n=3)
I liked the graphics (n=13)
I liked using the computer (n=4)
I like tests (n=2)
I liked nothing about the test (n=2)
ok
the two right answers
I thought it was fun

Appendix E
Comments on Questionnaire Item 19

Item 19: What did you **dislike** about this test?

I didn't know the test material (n=13)
There was nothing I didn't like (n=5)
I didn't like everything (n=3)
The test needs more instructions (n=5)
that I didn't do as well as I'd like
the wrong answers
the subject of the test
It would be very easy for someone to read your answers off of your screen or scores being seen.
It was kind of hard
symbols of events (battery, resistor)
The magnitude of the questions

Appendix F
Comments on Questionnaire Item 20

Item 20: Comments:

- I think this would be good for every subject because I think you would be able to learn a lot more on a computer than in a classroom
- These kinds of tests are more fun.
- Going from one screen to the next may cause a person to forget why they needed to go to the other screen
- I think it's a waste of tax money.
- I don't know very much about electricity
- I enjoyed taking the test. Thanks
- Good test overall
- I like always to be tested so that I may know how much knowledge I have
- The test would be easy for students but limit the writing down which could be bad.
- I think on the magnet you should show arrows - was a little confused by the way you wanted them to show attraction. I was a little confused on how you wanted N and S represented (picture drawn)
- Good test - maybe more graphics, make your students think they are playing a game and not a test
- I like to do my work on the computers, as I have one at home.
- If you know the subject I would have done better
- I didn't like the tests
- Would have been helpful at end of test to find out which ones you missed and why. Also would have been helpful to know what N and S were on the magnet items

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