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Classroom Response System Integration in a Distance-Learning Introductory High School Physics Course

Alexander T. Pegram
apegram@utk.edu

Recommended Citation
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To the Graduate Council:

I am submitting herewith a thesis written by Alexander T. Pegram entitled "Classroom Response System Integration in a Distance-Learning Introductory High School Physics Course." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Physics.

Jon C. Levin, Major Professor

We have read this thesis and recommend its acceptance:

Marianne Breinig, Stuart B. Elston

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

Classroom Response System Integration in a Distance-Learning Introductory High School Physics Course

A Thesis Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Alexander T. Pegram
August 2012

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ABSTRACT

Tennessee ranks among the lowest states in terms of high school physics availability. This fact is compounded in rural areas by limited enrollment and a lack of accredited physics teachers. A distance-learning physics course was established between the University of Tennessee Knoxville and Morristown West High School in order to offer an introductory physics course in a school with no accredited physics teacher. Because classroom response systems have been shown to increase interactivity and discussion in physics courses, leading to better learning gains, the course was taught via live video-conferencing with the integration of a classroom response system.

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CHAPTER I
INTRODUCTION AND GENERAL INFORMATION

A physics course was designed to allow a graduate student at the University of Tennessee Knoxville and a teacher at a rural high school to cooperatively teach a class of high school students. The course was taught primarily through remote instruction via a live two-way video stream, with the graduate student teaching from a classroom on the Knoxville campus to the students in a high school classroom in the rural county.

Under the guidance of physics professor Dr. Jon Levin, I worked with a high school teacher, Erik Hutchins, from Morristown West High School in Hamblen County, Tennessee. Mr. Hutchins is a certified physical science teacher who was interested in attaining accreditation in physics. As a result, one goal of this project was to provide a means for Mr. Hutchins to gain a familiarity with the conceptual understanding and problem solving skills necessary to obtain physics accreditation.

The course was taught during the Fall semester of 2011. This coincided with the high school's block scheduling. As requested by the school, the material taught in this semester focused on mechanics.

The class was taught by utilizing a variety of instructional methods, with traditional style lectures being delivered via teleconference and web-based lab activities being provided to further explore the concepts being discussed. Mr. Hutchins was responsible for homework and exams which were primarily assigned and graded via WebAssign. One goal of the project was to also implement and test a Classroom Response System over a long-distance learning environment.

CHAPTER II
MOTIVATION

Physics Availability

A study conducted by the American Institute of Physics in 2008-2009 compared the availability of high school physics courses among states. In the results shown in Figure 1 (source: White, et. al), based upon enrollment factors and proportions of seniors attending public schools, Tennessee was ranked among the lowest states for physics availability. Compounding this fact is evidence that seniors attending small public schools with small senior student populations tend to offer physics less often than the larger, more populated schools.

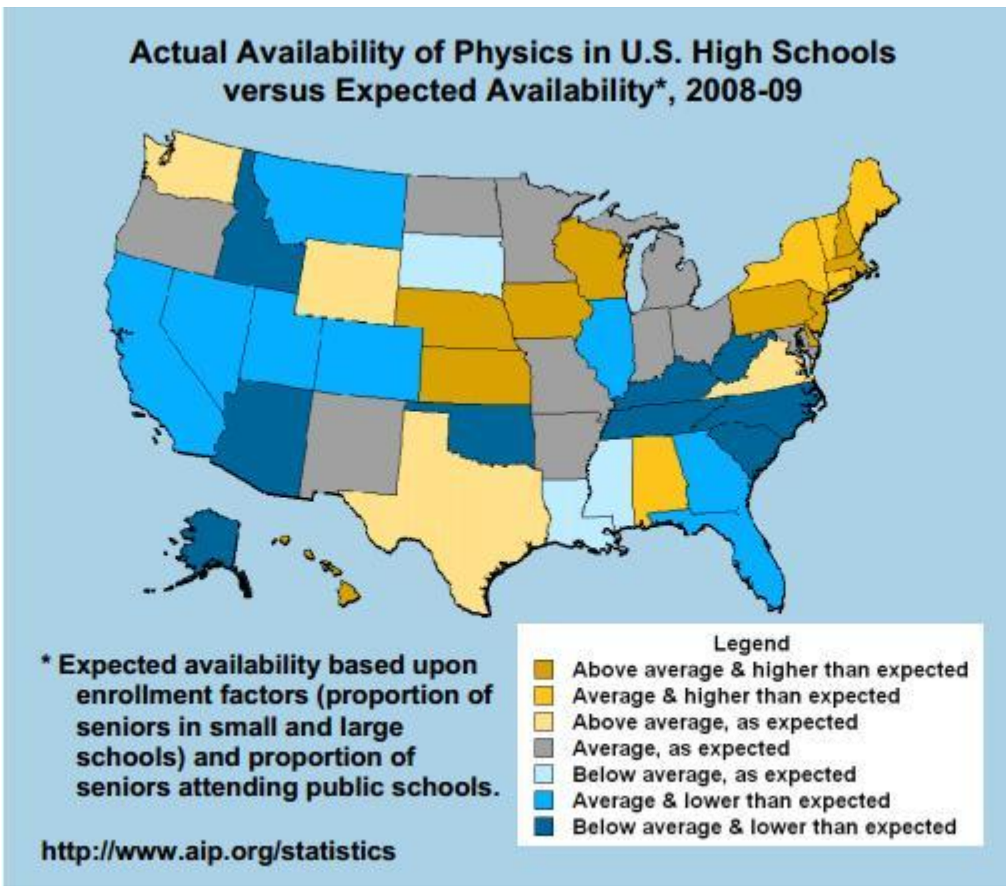

Figure 1. High School Physics availability by state versus Expected Availability.

In connecting with high schools with low physics availability, such as Morristown West High School, one of the goals of this research was to implement a distance-learning physics course in a school where no accredited physics teacher was employed.

Participation and Interactivity

Research suggests that increased classroom participation yields better learning outcomes. Classroom participation includes student discussion and peer instruction. Figure 2 (source: Hake) shows an increase in the normalized learning gains for students enrolled in physics courses with an emphasis on enhanced participation. It has also been shown that peer and group discussions are increased in classroom settings which implement a Classroom Response System (CRS). Additionally, students in CRS classrooms are more likely to respond to other students' comments when compared to a non-CRS setting (Fies, p. 101). As a result, another goal of this research was to successfully implement a Classroom Response System in conjunction with the distance-learning structure in order to increase participation and enhance potential outcomes.

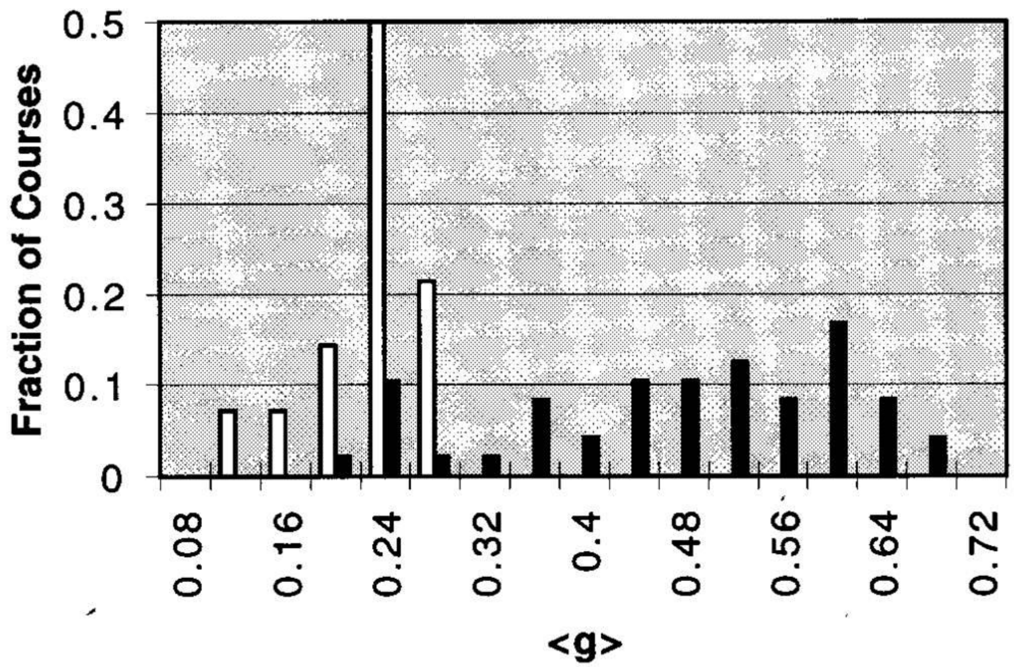

Figure 2. Normalized learning gains, <g>, of traditional (white bars) and enhanced interactivity (black bars) physics courses.

CHAPTER III
METHODS AND MATERIALS

Instructional Method

The textbook supplied by the school was *Physics: Principles with Applications*, 6/E by Douglas C. Giancoli. Although this text often references and utilizes calculus techniques in its derivations, the course itself was intended to be an introductory, algebra-based course. Because the school already had copies of this text, it was impossible to select another text for the purposes of this course. However, understanding and efficiency with calculus was not required for most of the homework problems available in the text, and many of the concepts could be introduced without relying on calculus concepts.
When the university semester started, the high school's classes had already been in session for two weeks. During that time, Mr. Hutchins began teaching the first two chapters of material to the students. These chapters primarily involved understanding of the scientific method, material with which Mr. Hutchins was already familiar teaching in his physical science courses. As a result, the initial lessons taught via long-distance learning were primarily a review and discussion of basic vector properties. Following this initial review, each new lesson followed a similar weekly structure. The following is a typical weekly plan.

Monday: Review and Concept Introduction

Mondays began with a quick review of the previous week's concepts along with help on any particularly troubling homework problems and questions. After addressing any questions or concerns that might have arisen from the previous week's lab and/or problem solving review, I would begin to introduce the new material. This lesson was mostly taught by traditional lecture (see: Attachment 1: Chapter-8-Lecture-Notes.pdf).

On these days, pertinent derivations would be shown and new variables and equations would be introduced. This lesson would usually be conveyed via white-board notes while the students took notes from the video-feed. In order to solidify the concepts, physics demonstrations from the physics department's supply would be shown and discussed when applicable. However, set up and execution of the demonstrations were dependent on the video camera's ability to move and focus at various angles. It was beneficial in many cases to have a table in view of the camera on which to place demonstration materials.

Tuesday: Concept Review

Having introduced the new material on the previous day, Tuesdays would begin with questions relating to the previous day's material. Questions asked on these days were typically conceptual, often coming from the "Questions" section at the end of the textbook chapter preceding the "Problems" section. These questions rely less on mathematical understanding and more on the application of physical laws.

The questions, if open ended, were given to the students to discuss in small groups. The seating arrangement of the high school classroom naturally divided the students into 3 separate groups. Having been posed a question, the students would be given approximately 2-5 minutes of wait-time in order to discuss the question. If the questions were multiple choice, they were utilized in conjunction with the Classroom Response System (see Attachment 2: Chapter-8-Torque.ppt). Due to the quicker response resulting from the CRS, less time was spent waiting for answers. Once the correct answer was revealed, students who correctly answered were then encouraged to discuss their reasoning to the class, while students who responded with incorrect answers were encouraged to ask questions in order to clarify their understanding. As a result, less time was spent discussing concepts that the students were more comfortable with, freeing up more time for discussing the more difficult concepts.

Aside from conceptual questions, relatively simple problems were also presented in order to help familiarize the students with the new variables, equations, and units. Many of these simpler problems came from the textbook's "Problems" section. The classroom response system was implemented in a manner similar to the conceptual questioning described above, with similar emphasis placed on student discussion and clarification.

Wednesday: Problem Solving

Having introduced and used the new concepts and equations, Wednesdays were spent applying the new concepts and equations in the context of real physics problems. Using a combination of PowerPoint presentation and white-board notes, I would begin the day by solving one or two example problems and highlighting key points of the problem solving process. Following examples, both conceptual questions and simpler problems would be given to the class as a whole while the students answered via the Classroom Response System (see Attachment 3: Chapter-8-TorqueContinued.ppt). Due to the simple nature of these earlier problems, the students were given a short time to deliberate and discuss before responding. Again, students who submitted correct answers would be encouraged to explain their reasoning while students who answered incorrectly would be encouraged to ask questions to their classmates or myself.

After this, the students were assigned selected problems to solve together in groups. The students, divided in their 3 groups, would be given approximately 15 to 20 minutes to work together on separate problems selected from the text. These problems were often similar to problems they would be assigned for homework on WebAssign and were moderate in difficulty. After the groups had solved their problem, or made their best effort, we would present and work through each problem as an entire class, with each group leading the discussion about their respective problem. The students would direct me as to what to write on the white-board while explaining their thought processes and reasoning to the other groups. This process was ideally repeated for each group if time permitted. In the event that the all 3 problems were sufficiently discussed, CRS problems would be presented to the class as a whole for extra practice before the end of class.

Thursday: Online Lab Activity

Rather than connecting with the high school, I would send an online lab activity and worksheet via e-mail to Mr. Hutchins for Thursdays. The class had access to a computer lab once a week, and, instead of teleconferencing with me, the students would meet with Mr. Hutchins in the high school's computer lab.

In the online activities, the students would be given a web address to various Flash- or Java-based physics simulations (see Attachment 4: Activity11-TorqueAndInertia.doc). The students would then have an accompanying worksheet that would be used to guide the students to explore and apply the new concepts. Mr. Hutchins would supervise and be expected to assist the students if necessary, allowing him an opportunity to teach the material.

While rare, there were a few occasions wherein my schedule allowed for me to visit the school on Thursdays. On these occasions, I would bring demonstrations to perform in the classroom that I felt did not translate well through video, such as the angular momentum demonstrations which allow the students to actively participate in the demonstration. Classroom visits were also beneficial in helping the students and I overcome the detached feeling associated with long-distance learning.

Friday: Problem Solving and Review with Mr. Hutchins

Fridays were left for Mr. Hutchins to plan. According to Mr. Hutchins, most of these days were spent practicing problem solving techniques and overcoming troubles in the homework assignments. These open-ended days allowed for Mr. Hutchins to work on his own physics problem solving and physics instruction skills. Any particularly difficult or unclear questions would be saved until the following Monday and addressed in the week's initial review.

Classroom Response System

The lectures and presentations also relied on the aforementioned Classroom Response System, or "clickers," by Turning Technologies. This system, fully integrated into the PowerPoint presentations, allowed for real-time feedback by measuring students responses to questions proposed in the presentation. Again, due to network restrictions, it was required that the clicker remotes and all necessary technology be present on the high school's end.

The Classroom Response System yielded many benefits. Being able to gauge in real-time the class understanding of course material made it easier for me to focus on specific problem areas throughout the lesson. The clickers enabled us to view the conceptual questions as a group while still allowing the students to answer independently (See Figures 3, 4). However, in the long-distance learning scenario, the clickers yielded another benefit.

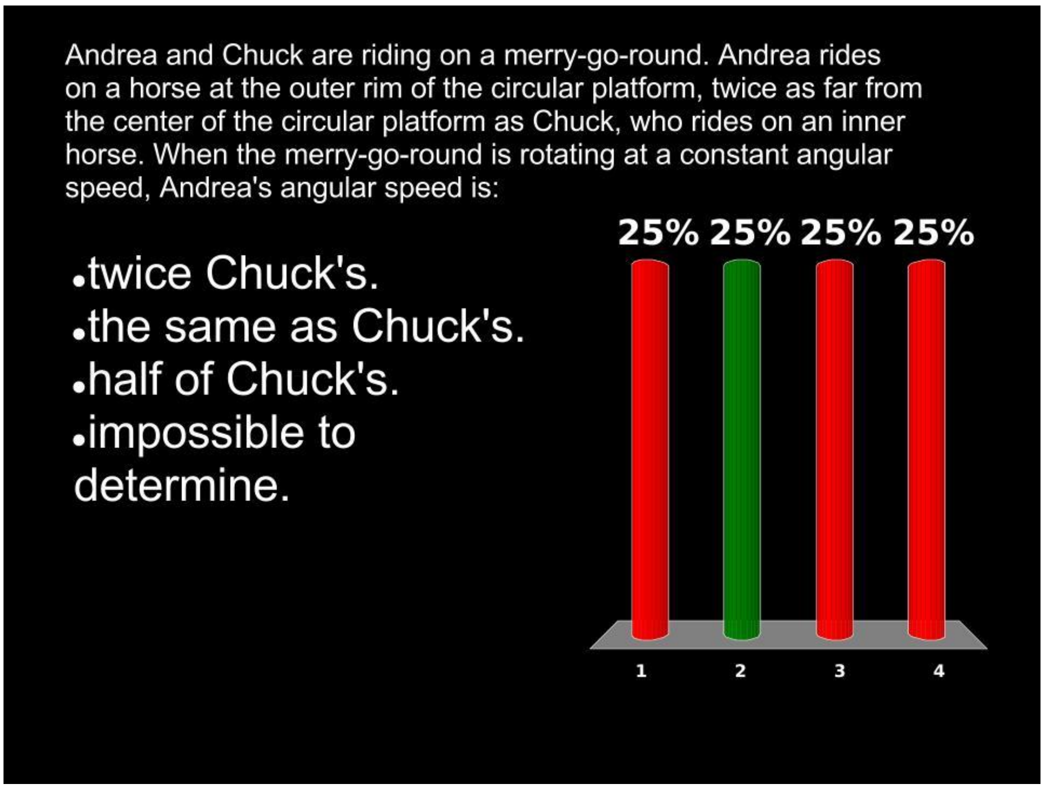

Figure 3. Example conceptual question with example response rates.

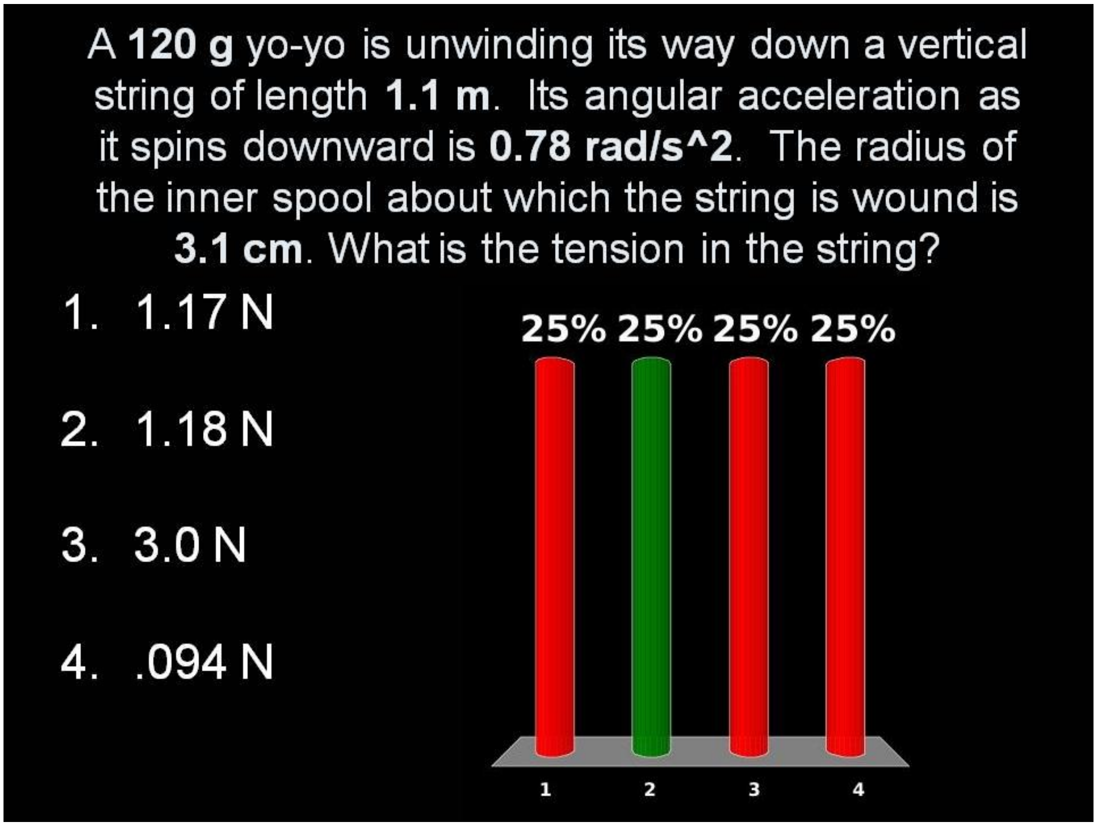

Figure 4. Example problem question with example response rates.

Early in the semester, before full clicker integration, it was often difficult to get students to volunteer answers to questions. As is typically the case in many classrooms, shyness and uncertainty often prevent students from answering questions. This problem was exacerbated by the long-distance learning setup, wherein the students also had to struggle with the unfamiliar scenario of talking to a person on a television screen. The clickers remedied this problem by allowing the students to silently submit answers which, in turn, allowed clearer, quicker responses to proposed questions or problems.

After all students had submitted their answers and the correct answer was revealed, students were then more willing to discuss their answers. Students who submitted correct answers now had confidence to explain their thought processes in front of other students, and students who submitted incorrect answers were given an opportunity to ask questions to help clarify misunderstandings. As a result, the clickers helped the students to gain a familiarity with open, group discussion in the classroom and through the video feed. The open discussion increased student involvement and interactivity and provided insight into students' understanding or misconceptions, allowing me the chance to immediately target problematic concepts while relying on the already established strengths of the students.

Specific Setup Notes

The traditional lecture methods implemented in the first days of each week were performed with a combination of white-board notes and PowerPoint presentations. I was able to control the video camera's ability to pan and zoom, allowing me to write on the white-board comfortably without sacrificing legibility. Due to the restrictions of the school's network security, I was unable to directly control PowerPoint presentations via remote desktop as initially intended. Instead, the presentations were e-mailed in advance to Mr. Hutchins, and he controlled the progress of the presentation on the high school's end. While not necessarily ideal, this setup had the unintended consequence of giving the classroom teacher a slightly more engaged role on the days involving lectures.

In the university room that I taught from, the camera and screen faced the white-board, allowing me to face the camera while also viewing the high school classroom on screen. In the high school classroom, two televisions were present on two adjacent walls displaying the video-feed from the university, however only one camera above one of the televisions was used to view the classroom. Opposite the classroom camera, and thus visible to me, was a projector and projector screen that displayed the PowerPoint presentations. In order for me to see the current slide displayed, the presentations were made with dark backgrounds and bright text so as to appear more legibly on my end of the connection.

CHAPTER IV
RESULTS AND DISCUSSION

At the conclusion of the semester, the students were given a multiple choice Force and Motion Diagnostic Survey consisting of conceptual questions. This survey is often used to gauge student understanding. Because the high school students were not given a pre-class survey, the results are compared with pre-class results of a university, non-calculus based course at the University of Tennessee-Knoxville in Figure 5.

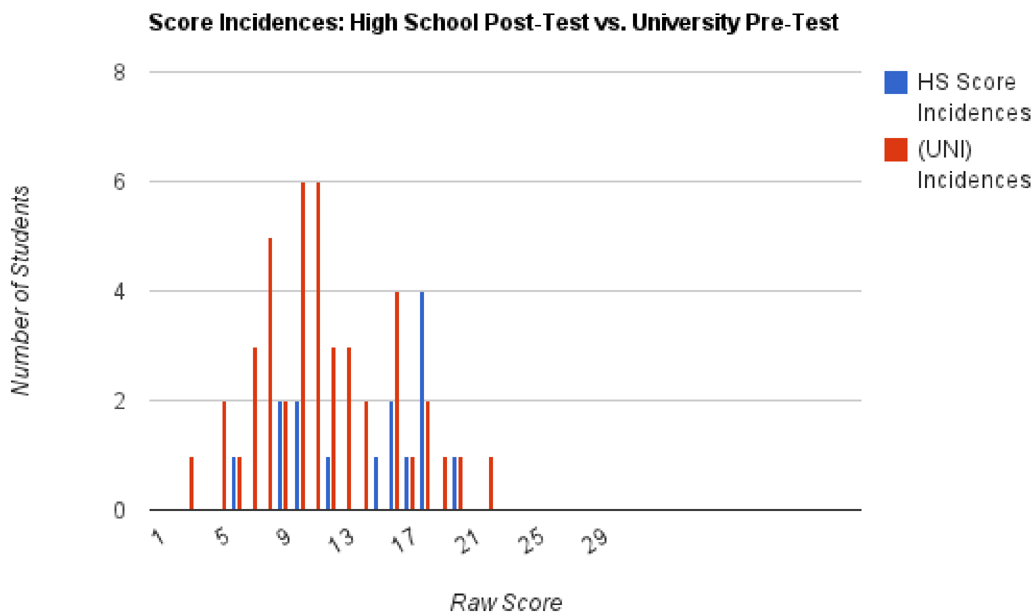

Figure 5. A comparison of raw score incidences between high school post-test and university pre-test results.

The high school sample was obtained from a class of 15 students as compared to the university sample of 44 students. As a result, the overall number of score incidences was higher for the university sample. To better compare the diagnostic survey results, the scores were normalized by dividing each incidence by the total number of students (See: Figure 6).

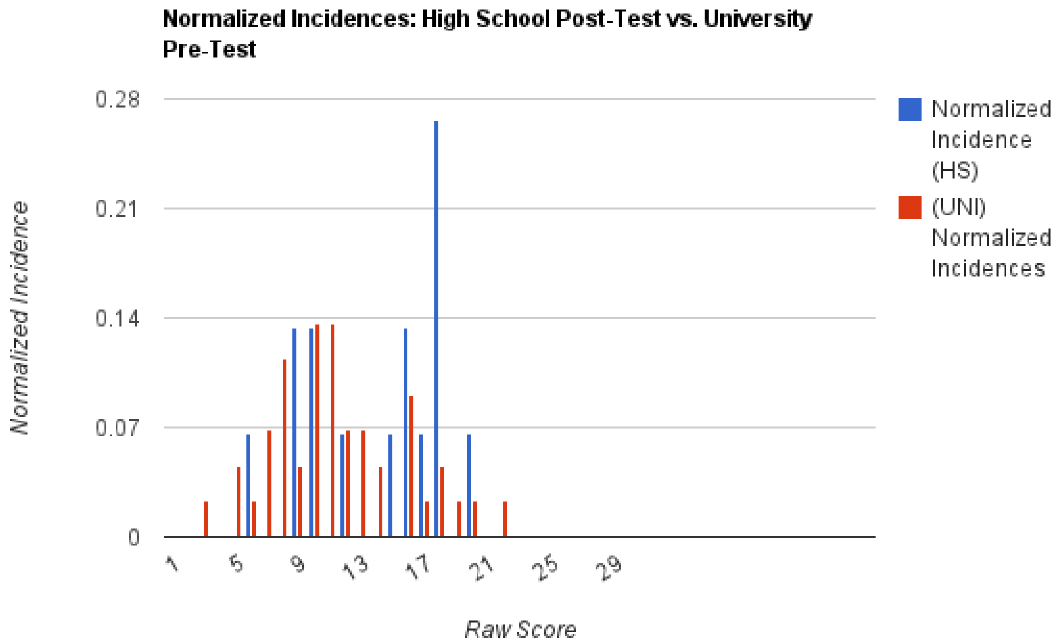

Figure 6. A comparison of normalized raw score incidences between high school post-test and university pre-test results.

In the post-class survey, the high school students correctly answered an average of 14.13 questions correctly out of a possible 30. This is higher than the average of 11.22 correct answers for the pre-class survey of the university students.

In comparing the scores, it is possible to assume that the students involved in this distance-learning course will be equally or better prepared for a university physics course than the students sampled by the university pre-class survey.

CHAPTER V
CONSIDERATIONS AND CONCLUSIONS

Considerations

When attempting a distance-learning physics course, there are a few considerations to take into account. One potential problem is ensuring teacher involvement on the high school end, as the ultimate goal of the high school teacher in such a course is to achieve accreditation. In order to increase his involvement, Mr. Hutchins was given the responsibility of assigning and grading homework and tests. This responsibility requires the teacher to follow the progress of students throughout the semester so as to adequately create assignments related to the material being covered. Due to the nature of the text being used in this course, not all homework problems were well suited for an introductory, algebra based course, and as a result, they must be assigned with discretion.

Another avenue of increasing teacher involvement in the lectures was by having the teacher control the PowerPoint and CRS presentations. While involvement in such a scenario is minimal, it increases teacher participation by ensuring that the teacher follows along with the lecture and is exposed to clicker questions and student comprehension.

Other important concerns arise when considering the technological requirements of such a distance-learning course. While Morristown West High School did not have dedicated physics facilities, they did have facilities and funding dedicated to the installation and implementation of technology required for a distance-learning course. If another high school were to implement such a course, it would be necessary for the school to have access to the high-speed internet and hardware required for smooth, clear video-conferencing, or for the participating university to be able to supply such technology.

Similarly, when establishing such a course, the high school's class schedule must be considered. MWHS's block scheduling was beneficial in accommodating the university's semester schedule. For high schools not on the block schedule, it is possible that the participating graduate student might be required to commit to teaching for 2 semesters, or one high school year. Within the semester, there were also difficulties, albeit few, in weekly scheduling. It is not unlikely for a high school's spring or fall breaks to not coincide with the university's breaks. In this case, the university's breaks fell mostly on the days in which I would not normally be planning to teach directly to the students. As a result, there was no disruption as the students continued with the planned web-activities or problem solving reviews with their high school teacher.

Conclusions

In reviewing the semester and course, it is apparent that a high school physics course taught via distance-learning can be successfully implemented with a Classroom Response System. Although the results of the high school post-survey were not exceedingly more positive than those of the university pre-survey, the high school students benefitted from the availability of physics instruction, and those who continue onto college will likely be better prepared for university level physics courses. The implementation of the Classroom Response System also proved successful as the students showed an increased willingness to participate in class and group discussions despite the disconnect created by the distance-learning set up. The experience provided by the course as a whole will certainly better prepare the students for future endeavors, as the technological familiarity, encouraged participation and interactivity, and exposure to physical concepts become increasingly important in higher levels of education.

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VITA

Alexander Taylor Pegram was born in Murfreesboro, TN, to the parents of Walter and Jennifer Pegram. He is the younger brother of Dr. Trey Pegram. He attended Reeves-Rogers Elementary and continued to Central Middle School and Oakland High School in Murfreesboro, TN. After graduating high school, he attended Middle Tennessee State University to study physics. Having numerous opportunities to practice teaching, lecturing, and tutoring at the university, he developed an interest in physics education. In August of 2010, he graduated from Middle Tennessee State University with a Bachelor's of Science degree in Physics. Afterwards, he accepted a graduate teaching assistantship at the University of Tennessee, Knoxville, in the Physics and Astronomy department. Alexander graduated in August 2012 with a Master's of Science degree in Physics. He is continuing to educate and learn in Japan with the Japanese Exchange and Teaching Program.