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THE EFFECTS OF THE ADDITION OF PROBEWARE AND POWERPOINT® TECHNOLOGY ON AN EIGHTH GRADE FORCE AND MOTION UNIT

By

James Edward Parkinson

A THESIS

Submitted to
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ABSTRACT

THE EFFECTS OF THE ADDITION OF PROBEWARE AND POWERPOINT® TECHNOLOGY ON AN EIGHTH GRADE FORCE AND MOTION UNIT

By

James Edward Parkinson

This study examined the effects, in terms of student engagement and achievement, of the addition of PowerPoint® presentations and probeware to the force and motion unit of an eighth grade science class. With the addition of PowerPoint, it was expected that the students would be more attentive to the lectures and demonstrations in class, while it was expected that the addition of probeware to the class's lab activities would encourage a greater interest and understanding of the material. It was found that the additions of these technologies did increase achievement as shown by significantly increased scores between the pretest and posttest given to the class. It was also determined that the addition of probeware did increase engagement in terms of the percentage of assignments missing between the previous two school years and the year being studied.

DEDICATION

To my parents, Jim and Sandra Parkinson, for all of their support and motivation through the years. There is no way I could have made it this far without your support.

To my wife, Carolyn Parkinson, who, in struggling toward achieving her dreams and goals, inspires me to do my best with mine.

To James Aprato, Donald Wielenga, and Paul Groves (among many others): teachers who inspired me to consider teaching as my life's work.

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*Images in this Thesis are presented in color.

Problem

Over the last seven years of teaching, I have noticed an interesting trend in their overall engagement and achievement in the subject of science. Most children enjoy their science classes in elementary school; however, as they progress through the secondary grades, many students interest in the subject of science wanes, and it is only in the college years when some students return to an appreciation of science. When questioned about their dislike of the subject of science, the overwhelming response from students seems to be "science is hard" or, more distressing, "science is boring". Upon further informal discussion many of these complaints can be further summed up as "science is tedious". When further pressed, students will talk of how they used to enjoy the simple labs of elementary school, where they are given materials and told what to look for. This has changed for them in the secondary grades as the students are increasingly expected to act as scientists, gathering and analyzing large amounts of data.

Part of the problem is their perception of what is done in a modern science lab as stated by Marcum-Dietrich and Ford: "The foremost goal of secondary science education is to provide students with a firm understanding of scientific phenomena [and] provide students with the opportunity to experience… the world of real science" (2003). The students see what is going on in their science labs: hand gathering and graphing of data as a form of analysis, and believe that this is how science is done in the everyday world of science, often because this is what their educators are telling them. In reality, a modern scientist rarely does these things. Yes, all scientists gather data, and graphing is a very useful form of analysis, but the modern scientist uses computers, among other highly technical data gathering and analysis devices, to do these things. A visitor to a modern science lab will not see an investigator sitting in front of a thermometer, pH sensor, or spectrophotometer, stop watch in hand, recording data every set period of time. Data gathering and analysis will be done by a computer for two reasons: first, the computer will gather the data more precisely than any human can (and at more precisely regular time intervals) and second, because the scientist has more important work to do (such as arranging for materials to continue the experiment, planning the next step in this experiment, or even considering how to approach a completely different problem) that can not be done by computers.

Review of published research (eg. Susskind, 2003; Crow, 2005; and Linn et al, 1987) found that, although there have been previous investigations done into the relationship between the application of PowerPoint® presentations during classroom discussions and the use of probeware in the lab, and student achievement and engagement, the vast majority of this research was conducted with students at the high-school or college level. It was also found that what research had been done at the Junior High level, grades seven and eight, was focused almost exclusively on graphing skills. This left open the question: Does the addition of these technologies to the Junior High science classroom have an effect on overall engagement and motivation of the student in learning? Additionally, can this change in motivation and engagement be seen in terms of overall achievement and in students work habits?

Possible Solution: Probeware

My solution to the problem of achievement and engagement in secondary science would be the addition of probeware technology to lab activities and the use of PowerPoint® presentations as part of both lecture/discussion sessions and assigned projects. Probeware is the name given to scientific instruments that are used for gathering data, which is then transmitted to a computer, or other handheld device, often for immediate graphic analysis. This is supported by Millar (2005) who indicated that the appropriate use of technology can encourage and support constructivist environments and two studies commissioned by the Concord Consortium which examined students' progress with probeware. The first of these studies established that students with access to probeware scored, overall, higher on both pre and post-tests, and the second showed that the students with probeware learned better overall. (Trotter, 2008)

Note that students in the first study, when using probeware both before and during the study time, scored higher, not just in the posttests, but also in the pretests (Trotter, 2008). This suggests that the probeware has a further reaching effect than just on the phenomena in question. In fact, several studies have observed that the use of probeware has a positive effect on a student's ability to interpret graphs (Linn et al, 1987; Adams & Shrum, 1990; Marcum-Dietrich & Ford, 2003). This makes sense as students often confuse aspects of graphs, such as height and slope. This indicates that, under traditional classroom circumstances, students tend to see a graph not as a representation of data, but as static picture (Brasell, 1987; Linn et al, 1987).

The use of probeware in the lab has two distinct advantages: first, graphing is concurrent with the phenomena being observed; and second, it provides a degree of accuracy not possible using hand data gathering. The production of real time graphs forces the student to think hard on the relationship between the graph and the phenomena in question (Millar, 2005). Linn et al states, “Seeing graphs appear in real time as an experiment progresses provides an explicit representation of scientific phenomenon under study” (1987). The apparent advantages of real time graphing are even greater when we consider the situation from a cognitive angle. Phenomena that are observed are first processed and stored in short term memory, and then later, if the information is deemed important enough, moved to long term memory. In a traditional lab situation the lab is broken down into several separate pieces: first the student gathers the data, then records the data. If the student is fortunate, they will do both of these parts, thus, connecting the data to the phenomena. Usually, due to lack of lab space and necessary assignment of roles in the lab to avoid student behavior problems, one student is assigned to observe and measure the phenomena and a second student is assigned to record the data. Thus, the data and the phenomenon in question stay in discreet chunks, some of which may be remembered while others are forgotten. Finally, in most instances, the student takes the data home for analysis. This leads to a cognitive disconnect between the data, the phenomenon in question, the data from that phenomenon, and the graph that is developed. This is one of the situations where a teacher has to consider the correct use of technology; technology itself is not a panacea. Sigel and Foster (2000) point out that computers in class are necessary not just for the gathering of data, but also because onsite analysis is crucial. If students need to go to a computer lab for data analysis, most students consider it a separate activity and so the graphs produced are not linked, in memory, with the phenomenon from which they are derived. By having the data gathered and graphed in real time, we gain several advantages: real time graphing encourages students to process the graph and the phenomena at the same time, rather than sequentially, this allows both parts (the phenomena and the representation) to pass to the long term memory at the same time, thereby creating and maintaining the cognitive relationships both qualitative and quantitative. (Brasell, 1987; Millar, 2005)

Another advantage to the inclusion of probeware to the secondary science laboratory is the improvement in the overall understanding of graph interpretation. Metcalf and Tinker (2004) noted that teachers in their study observed that students with probeware "developed a deeper understanding of the content area, and more skill at reading graphs". This is understandable, as the graphs were produced in real time and, as noted above, this allows the phenomenon, the data from the phenomenon, and the graphing of the data to all be cognitively chunked together, and therefore recalled together. This means that the student will be more likely, upon encountering a new graph, to actually stop and consider what might be going on in the situation being graphed, even though the student did not observe the phenomenon themselves.

A further advantage to probeware can be found in the students' attitude. Metcalf and Tinker (2004) have found that not only does the use of probeware aid in student understanding but that students using probeware in labs developed more patience and better problem solving skills. This is probably due to the overall flexibility of the probeware computer interface. For example, the study reported here was performed using Vernier® LabPros® and Vernier®'s suite of sensors for the LabPro®, probeware that were investigated by the researcher, from other companies were similar in that changing from one sensor to another was a simple proposition: unplug the unwanted sensor and replace it with the desired sensor. In the case of the Vernier® sensors, it is even easier as the computer that the sensor is attached to will automatically identify what sensor is plugged in and create the appropriate data table and graph. Moreover, more than one sensor can be utilized at the same time; in this case the data table is enlarged and more than one graph is presented. This means that, through any combination of one or more sensors, students can investigate a variety of situations, leading to better attitudes and problem-solving skills by reducing general frustration.

In summary, probeware benefits the classroom by increasing cognitive connections between phenomenon, data, and graph. Students can gather more data through multiple trials of a lab, because of reduced time needed for each trial. Students do not need to write down the data, because the computer is recording it for them. Students display better attitudes and problem-solving abilities in students due to the ease of developing and modifying investigations. Finally, students should have greater overall understanding of new material as graph interpretation skills develop more quickly than in a traditional lab setting.

Possible Solution: PowerPoint®

The addition of PowerPoint® presentations provides advantages to the classroom environment. PowerPoint® to lectures/discussions has been demonstrated to cause student reception of these types of classroom activities (lectures, discussions, etc.) to improve, both in perception and attitude (Susskind, 2003). PowerPoint® also allows visualization of concepts that were extremely difficult or even impossible using traditional presentation formats. The addition of PowerPoint® to class discussions also, forces the instructor to carefully consider lecture notes, rather then scribing them on the chalk-board or overhead projector, thus improving their craft.

One of the major useful additions to classrooms provided by PowerPoint® is the change in student perceptions of and attitudes regarding lectures/discussions and the teacher presenting information. Susskind (2003) pointed out that in general, students' attitudes regarding lectures were improved when the lectures were accompanied by PowerPoint® presentations. Specifically, students found that the presentations were more interesting and easier to follow and take notes on. This makes sense through casual observation of the secondary school student. By this point in their lives, the vast majority of them have had more substantive contact, both informational and entertaining, with their televisions and computers than with their parents. Assuming that teenagers sleep 8 hours a day on average, and are at school 7 hours, and are spending an average of 6 hours on media consumption (of which approximately 3 hours, depending on age, is on television) (Roberts and Foehr, 2008) this leaves a scant 3 hours of substantive time with, probably busy, parents or other human beings.

Recent developments in the PowerPoint® program also bring advantages to the classroom. The newer versions have enhanced visualization allowing multiple repetitions of an animated demonstration (on screen rather than having to be reset for each repeat of the demonstration) to be done quickly (Crow, 2005), increasing the likelihood of transfer of concepts from short term to long term memory. With enough preparation time, a teacher can do more than embed video and music into the presentation. They can create entire custom animations of crucial concepts. For example, when teaching electrical force and induction, a traditional instructor would possibly draw a "comic" strip featuring two balloons (with symbols to represent positive and negative charges within the balloons, and one with more of one charge than the other to represent an overall charge on that balloon). As the strip starts, we would see the charges start evenly distributed in both balloons (though one of the balloons still has more of one charge, positive or negative, than the other). In the second frame the uncharged balloon (the balloon with the same number of positive and negative symbols) is brought near the charged balloon. In the third frame the positions of the negative charge symbols in the uncharged balloon, representing the electrons, would be shown redistributed either closer to or further away from the charged balloon due to the electric force of the charged balloon, thus creating a positive and negative side to the uncharged balloon through electrical induction. The problem is all but the most perceptive of the students would look at this strip and see three distinct images and not the flow from one image to the next. With a PowerPoint® presentation, a teacher can animate the situation so that the students can see the balloons move closer together, pause to discuss the implications, then "see" the charges move in the uncharged balloon in response to the proximity of the charged balloon, again pause to discuss the implication, and then "see" the charges induced on either side of the still uncharged balloon. Indeed, with judicious use of the copy frame functions of PowerPoint®, or the step back key, the teacher can the animate the whole procedure into on continuous animation showing that these are not distinct steps, but one continuous process.

The advantages of PowerPoint® do not just include benefits to the students but also to the teacher's craft as well. Susskind (2003) points out that, with the use of PowerPoint®, the lectures seemed more structured and the lecturer better prepared.

Again, this makes sense as the instructor, rather than just making notes on the board or overhead projector as the lesson progresses (though this should not be totally eliminated), is forced to consider the progression of the entire class, or even just the lecture portion of the class, days prior to the actual presentation of the material. Thus, the material and its progression are firmly seated in the instructor's conscious mind making divergences and non-sequiturs, or outright forgetting of material, much less likely.

In conclusion, with the addition of PowerPoint® presentations, appropriately considered and constructed, the expectation is that both students and teachers will benefit in several ways. The students gain a presentation format that they find more engaging and interesting than the traditional format. The students also gain multimedia shows/animations that provide more concrete demonstrations of abstract topics, thus increasing retention of topics. The teacher also benefits from a forced future consideration and preparation of material for the class in question.

Setting of Research

The research for this project was conducted at Holt Junior High School in Holt, Michigan, using an 8th grade science force and motion unit with an overall count of 99 students separated over four class hours, 70 of whom allowed their data to be used for this project. Data gathered during the February count day for 2008, and obtained from the curriculum department of Holt Public Schools, indicated that the school itself contains a student body of 961 students across the seventh and eighth grades. Of these students, 114 (11.86%) identified themselves at African American, 5 (0.52%) American Indian, 18 (1.87%) Asian, 58 (6.04%) Hispanic, 749 (77.94%) White/Caucasian, and 17 (1.77%) as Multiracial. The same data indicate that 277 (or 28.8%) of these students qualify for free or reduced lunch.

At the beginning of the study, a survey was distributed to each of the students with the intent of determining the student overall past history (with no type of individual identifiers) with technology in general, and technology in the classroom in particular. These data were analyzed as a group to learn more about the students that the overall study was to incorporate. Information, from the survey, indicated that of the 94 students surveyed, only 3 did not have a computer at home. Fifty-five indicated a comfort level with computers such that this was their preferred method of working on assignments. Another 22 had a high preference for using the computer; and, only 4 of those surveyed indicated that they were strongly disinclined to use a computer as a learning tool.

The unit in which the study was conducted was an eighth grade force and motion unit. This unit covered a variety of physical science concepts such as velocity (speed in a given direction), acceleration (change in velocity), forces (pushes or pulls), periodic (repeating) motion, momentum (difficulty to stop a moving object), work (forces acting to move objects), and energy (the ability to do work). Many of the concepts had been discussed in previous grade years. However, these concepts had not yet been taught to the level of detail that was used in this particular class.

Implementation

This study (examining the effects of the addition of technology to the classroom on student achievement and engagement) was conducted during the Force and Motion unit of an 8^{th} grade science class at Holt Junior High, in Holt, Michigan. Data were gathered using two surveys (see Appendix B), one administered before the unit and one administered after, as well as a pretest and a posttest (see Appendix A), again given before the start of the unit, and then upon conclusion of the unit. The equipment used over the course of the lab included seven laptop PCs as well as Vernier® LabPro®s and the necessary sensors. Instruction for the class incorporated daily PowerPoint® presentations and lab activities (Appendix D, Table 1) that were given biweekly at the very least. These presentations and activities were developed during the Summer semester of 2007 at Michigan State University. The students were issued copies of 2006 edition of *Force, Motion, and Energy* from Holt, Winston, and Reinhart, from which reading assignments were occasionally given for homework.

The surveys for this project served two purposes. The presurvey (Appendix B) was designed to ascertain the students' prior exposure to, and use of, technology; the postsurvey (Appendix B) was designed to ascertain the students' impressions of the newly designed materials that were used for this study. In the presurvey, the students were asked general questions about the availability of technology in the home: do they have a computer, what kind (Macintosh® or PC), what operating system, what do they use it for, etc. as well as past experience with technology in the classroom. In order to ascertain what level of technology instruction would be needed, the students were also asked to rate their comfort in working with Microsoft® Word, PowerPoint®, and Excel®, the common productivity software found on all of the students' computers.

In the post survey (Appendix B), the students were asked for their impressions of the usefulness regarding the lab activities and PowerPoint® presentations of lecture notes. In addition, they were asked to rate the effectiveness of all of the new materials in helping them to learn the topic in question as well as asking them for any comments or suggestions for improvements. It should be noted that while this survey is being used for analysis, it is simply an informal survey that is given to the students in this class whenever a new activity is introduced. It should also be noted that due to time constraints and changes in the curriculum required by the school district, not all of the activities on the post survey were actually done in class; the students were asked to disregard and not mark the activities that were not presented.

The statistical data that were gathered for this study came primarily from a comparison of the pretest and posttest (Appendix A) for the Force and Motion unit. It should be noted that, with the exception of the order of two questions, the pretest and post tests were identical. For further analysis, each of the questions were aligned to one of the State of Michigan benchmarks

The technology used for the implementation of this study included several laptops of varying manufacturer and model. All of these computers were PCs, using Windows 98®, or a more recent version, as an operating system. All of these computers had the LoggerPro® software from Vernier® installed as well as copies of Microsoft® Word® and Microsoft® Excel®. Though the versions of Windows®, Microsoft®

Word®, and Microsoft® Excel® were varied, all were functional for the purposes of these labs.

Also used in this study were sensors and data loggers from Vernier. This study used the LabPro® model of Vernier® Data Logger, chosen due to its relatively low price and the large array of sensors that had been developed for use with this device. The sensors used in this unit were all from Vernier® and included sonic motion detectors, which determine distance by emitting bursts of ultrasound and measure the amount of time that it takes for the sound to echo back to the detector; photogates, which register the timing at which an object passes through the arms of the gate; dual-range force sensors, which measure the force pushing or pulling on a hook that is attached to the sensor; and temperature probes.

PowerPoint® presentations for this unit were developed on a Dell XPS 1710 laptop running Windows® XP and the PowerPoint® 2003 software. The images were projected from an InFocus X1a digital image projector that was mounted to the ceiling of the classroom in which the study was conducted.

With the exception of the days of the pretest and posttest (Appendix A), each day of the Force and Motion Unit began with an agenda of the day's activities projected on the overhead screen. Upon the sounding of the tone signaling the beginning of the class hour, the schedule was changed to the day's first activity, usually a brief lecture concerning the subject in question for the day or a review of the material covered in the previous day or the previous lab. This was always followed by a thought question that either asked the students to explain some aspect of the previous day's material or to make hypothesis regarding the current day's concepts. The thought question was then followed by the day's main activity. Usually, this involved either discussions of the previous or upcoming lab, or the lab itself, if there was a lab that day. Upon completion of this discussion, and the accompanying notes, or lab, the students were given their homework and the remaining time, usually around 10 minutes, to work on it.

Lab/Activity Title	Information Covered
Motion Matching Lab	Creating and analyzing position versus time graphs
Acceleration of Students Lab	Understanding of the concept of acceleration as it relates to speed, change in position, time, and the graphing of these variables
Acceleration due to Gravity Lab	Understanding of how gravity causes object to accelerate and identifying what other variables would affect the rate of this acceleration
Force Demonstration Observations	Identifying the different forces acting on various objects as well as understanding what the different parts of a force are (force itself, agent of the force, and receiver of the force)
Static versus Kinetic Friction Lab	Determining the relative strengths of static and sliding kinetic friction as well as accurately interpreting data from a graph
Projectile Motion Lab	Understanding that motion and acceleration in one dimension, does not affect motion in other dimensions.
Pendulum Lab	Understanding the concept of periodic motion as well as what variable affects the periodic motion of a pendulum.
Momentum Lab	Understanding what momentum is, what variables momentum is based on, and that momentum is not a force.
Work Activity	Identifying what variables determine work and applying problem solving skill and the scientific method to devising a way to gather the information needed to answer a question.
Unconventional Potential Energy Lab	Understanding that gravitational potential energy is not the only form of potential energy and understanding how to measure the amount of energy released from a chemical reaction

Table 1: Information covered in each activity

The first lab that was introduced for this unit was the *Motion Matching Lab* (Appendix D). This lab began with a brief introduction to the LoggerPro® software after which the packets for the lab were distributed. The class was then divided into two groups, due to the space requirements for the lab. As the effective range of the sonic motion sensors being used in this lab is six meters, the size of the available lab area made it so that only three lab groups could work concurrently. The class in question was usually divided into six lab groups to facilitate effective distribution of labor and efficient use of lab time. The concept for this lab was determining how time and position were graphed and how motion and acceleration are represented on such a graph. This was done using the sonic motion detectors and three, graphs of increasing complexity, pre-generated by the instructor. The students were told to access the first graph, and to try to have the data line generated by their movements in front of the detector match the line on the graph. Once the students felt that they were having a reasonable degree of success matching the first line, they were told to move on to the second graph and repeat the process. Once the students were comfortable with the second graph they were then to move on to the third graph, where the process was repeated one more time, without repeats. Once the students had completed the third graph, they were instructed to print the results. The assessment for this lab was that the students took this printout home and wrote an explanation of what caused each of the differences between their graph and the line that was pre-drawn for them. The remaining students, those who were in the second group and did not immediately start the lab, were given an assignment out of their text book that addressed the conceptual material covered in the lab. This assignment and the final analysis of the graphs generated in the lab were the homework for the evening.

The next lab, the *Acceleration of Students Lab* (Appendix D), examined the concept of acceleration. The class, as well as the motion sensors, and the accompanying computers were moved to the school's wrestling room. The computer gathered distance and time data as the students ran a series of shuttle runs. The students were divided into two groups so that, using two computers, the maximum possible in the space available, the class would be able to gather data on each student's run. The files were then exported to Microsoft® Excel® (Excel®) and the resulting files were then uploaded to the schools server for later analysis. On the following day, the students were taken to the computer lab and introduced to graphing using Excel®. Each of the students was instructed to create a histogram of their data or, due to the lack of quality of some of the data sets, the data set of one of their friends. These histograms were then printed and the students drew a trend-line showing the pattern that they saw in the data points. The students explained why the trend line had the shape that it did based on their recollections of their movements in the wrestling room on the day prior.

The third activity, *Acceleration Due to Gravity* (Appendix D), illustrated not only the effect that gravity has on the motion of an object, positive acceleration, but, after discussion of the history of Sir Isaac Newton and his ideas on gravity, forced the students to consider what other forces might affect falling objects. In this lab, students were instructed to use the sonic motion detectors to find the rate of acceleration of a falling softball, Styrofoam bowl, and a coffee filter. In keeping with the call to have students behave like scientists, the students were shown how, using the LoggerPro® software, toperform a linear regression on the velocity data so as to find the acceleration of each of the falling objects. As homework, students completed any unfinished questions from their lab packet and developed a hypothesis as to what factor(s) might have affected the falling objects, causing them to not accelerate at the same rate, contrary to the findings of Sir Isaac Newton.

The fourth activity, *Force Demonstration Observations* (Appendix D) was performed after the class had discussed what a force was, and two of the crucial aspects of any force: the agent, the object that exerts the force, and the receiver, the object that the force is acting on. What followed were examples of applied force, buoyancy, magnetic force, electrical force, friction, elastic force, gravity, pressure, and through discussion, and, after introducing, or in most cases recalling, Newton's First Law of Motion, normal force. For each of these demonstrations, students were instructed that they had to draw an illustration of each force in action while being sure to label the agent and the receiver of that particular force.

The fifth activity, *Static versus Kinetic Friction* (Appendix D), investigated forces by asking students to identify whether static or sliding friction was the stronger force. This was done by attaching a dual-range force sensor to an eye-screw that had been placed in a block of wood. The block of wood was sitting on top of a secured sheet of 40 grit sandpaper and the students tried to get the block of wood to slide across the sandpaper by pulling on the force sensor. The computer recorded the force acting on the sensor, which, according to Newton's Third Law of Motion, should be the same as the force acting on the wood block in an attempt to get it to move. The exact point at which the block started to move was ascertained by attaching a sonic motion detector which gathered data on the movement of the wood block as time passed and the force acting on the block increased. The students then sketched the resulting graphs of force on their lab packet. Students were to study their graphs at home and identify what happened to the force acting on the block when the block started to move. They were also asked how this observation could be related back to the original question of whether static or sliding friction was a stronger resistance to motion. Inspiration for this lab comes from a similar lab originally proposed by Hisim (2005).

In light of many student's appreciation of such science television shows as *C.S.I.: Crime Scene Investigations* and *Mythbusters*, the next lab, *Projectile Motion* (Appendix D), used video analysis to determine whether acceleration in the y-direction, by gravity, affected the motion of an object in the x-direction, forward motion. This was done by analyzing a video of a basketball free throw, provided by Vernier® bundled with the LoggerPro® software. Due to constraints on teaching time, this activity, which was originally planned as a laboratory activity, was done as a demonstration for the students. The movie file was pulled up in LoggerPro®, projected on the overhead projector, and played for the students. The file was then rewound back to the first frame and the class discussed the considerations of frame-by-frame video analysis, specifically the need for a reference distance and a known point on the moving object from which to record data. The movie was then analyzed one frame at a time by placing data points on the top of the ball in each frame. The computer then used these data points, and the axis and reference distance, to calculate position in the x and y directions. By seeing the graph of these positions, the students were able to identify when the ball was accelerating, and in which directions as a curve on the graph would illustrate acceleration, positively or negatively. A straight line would indicate constant, unchanging, motion in the given direction.

The next lab, the *Pendulum Lab* (Appendix D), related to periodic motions. In this lab, the students were asked to identify what factors affected the period of a swinging pendulum. After discussing the problem, the class settled on length of the pendulum and the weight of the pendulum as being the possible sources of varying periods. The students then used photogates to measure the period of the pendulum under varying conditions to identify which, if any, of the factors had an effect.

In the eighth lab, the *Momentum Lab* (Appendix D), students investigated momentum without specific use of sensors or computers. This lab was designed as a control, so that the students' responses to the labs with technology could be compared to at least one lab activity with no discernable use of technology. In this lab students were asked to compare the momentum of same sized balls made of different materials by examining how far these balls pushed a book after rolling down the same length of ramp from the same height. The students cut a paper cup in half from top to bottom. This half cup was taped to a paperback book, which was placed at the bottom of a 100 cm ramp, made of a piece of wooden molding, held at a fixed incline by a ring-stand. The students then rolled the balls from 50 cm up the ramp and 100 cm up the ramp and then used these data to determine whether the momentum of a moving object was determined by the mass of the object, or how fast it is moving. This lab, of course, assumes that balls of the same size and shape will accelerate at the same rate due to gravity when placed on ramps of the same incline.

For the ninth activity, the *Work Activity* (Appendix D), students to determined how much work was needed to lift a classroom of students to the top of their junior high football field, home audience, bleachers. Ideally this activity would have had three parts: identify what information is needed, determine how you would get the information (design the lab), and finally, actually get the information (implement the lab). The first part of the lab, identify what information is needed, was intended to be done as a whole class exercise. The students would then be broken down into their lab groups to design a method of getting the information. The students would then be allowed to implement their methods. Ultimately, during the closing discussion, the students would be asked to identify good and bad aspects of each of the methods attempted. Unfortunately, due to the outside temperature at the time, the implementation portion of this activity was impossible. Therefore, once the students had developed with a workable method for finding the information needed, a data sheet (made of randomly generated, reasonably sized, numbers for data) was supplied to the students so that they could actually move on to data analysis.

The final activity was *The Unconventional Potential Energy Lab* (Appendix D). Most science teachers, when teaching potential energy only discuss gravitational potential energy, which was discussed in the lectures and discussions. This lab was intended for students to realize that energy can be stored in more than just position. Students were to use the temperature probes to measure the change in temperature of water as a known amount of calcium-carbonate, sidewalk salt, was added and allowed to dissolve. The students were given a calculation sheet to determine how much energy in total was released, and how much energy was released per gram of calcium-carbonate.

In conclusion, it should be noted that there were three additional activities that were designed for this unit. Unfortunately, due to constraints on time, inclement weather, and changes in the core ideas in this area that the school district wanted covered at this level, these activities had to be eliminated. However, as these assignments were originally intended to be part of the unit designed for this study, these assignments can be found with all of the other activities discussed in Appendix D.

Data Analysis

The data from the pre-survey and post-survey (Appendix B) were gathered to provide discussion points and anecdotal information for this project. Similar surveys are often used in this classroom to gather information regarding the background of the students, to inform instruction. Surveys similar to the post-survey included here are often given at the conclusion of implementing newly developed activities, as student opinions and thought processes are crucial to determining the effectiveness of an activity and what might need to be done to make that activity more effective.

The pre-survey (Appendix B) for this study was primarily given to determine student's prior experience and comfort level with technology. As shown in the Tables 2-4, a majority of the students surveyed have a computer in their home and seem very comfortable with computer technologies in recreational applications. However, this comfort level seems to drop significantly when considering work or productivity programs. It should also be noted that comfort level in the lab with the computers available should not be a problem as 94.5% of those students surveyed indicated that they have a PC and that 83.7% of those surveyed knew that their family had a computer running Windows® (10 of the surveyed students did not know what operating system their computer ran). Since these are the general make and operating system of the computers used for this study, knowledge of how to run the computers should not be, and was not, a problem.

	1	2	3	4	5
Student ratings of comfort with computers	3	1	11	22	55
Key 1=I only use the computer when I have no other option 5=I use the computer for work/assignments whenever possible					

Table 2: Pre-survey results; student comfort level with computers

Student self-ratings of ability in:	1	2	3	4	5
Microsoft® Word	1	0	7	22	64
Microsoft® Excel®	38	18	23	10	6
Microsoft® PowerPoint®	11	8	14	27	35
Key 1=I have never used this program before 5=I understand all the functions of this program and could use it in a business setting					

Table 3: Pre-survey results; student comfort level with common office programs

Available Technology					
Does the student have a computer at home?	**Yes**	**No**			
	89	3			
What kind of computer do the students have?	**PC**	**Macintosh (Apple)**			
	86	5			
What operating system runs on your home computer?	**OSX (Apple)**	**Linux**	**Windows®**	**Other**	**Don't Know**
	4	1	77	vista	10
What activities do you use your home computer for?	**Playing Games**	**Writing**	**Finding information**	**Chatting with friends**	
	75	76	80	77	

Table 4: Pre-survey results; computer technology available in the students' homes

Just as with the pre-survey, the post-survey is similar to surveys commonly given whenever new activities or tools are introduced. As can be seen in Table 5, the majority of students found most of the added tools to be useful. The exception was the use of Excel®, and this may just be due to lack of continuous exposure to the program. As can be seen in Table 6, the majority of the students appreciated the design of the new activities as well. Again, the exception to this trend were activities that either involved or were very suited to the application of Excel®, specifically the *Acceleration of Students* lab or the *Work Activity* (Appendix D). One could hypothesize that this deviation from the norm was due to the calculation intensive nature of the lab, or just due to the students' lack of familiarity, and overall user unfriendliness, of Excel®. Comments and ratings for each of the tools and labs will be discussed below, however a complete list of student comments, where applicable, can be found in Appendix C.

Student Ratings of Considered Technologies	1	2	3	4	5
PowerPoint®		2	10	28	47
Sensors in the lab activities	1	2	16	35	34
The LoggerPro® software	1	7	16	31	32
Excel® spreadsheets	3	14	23	16	11
Key:					
1=not useful at all 5=extremely useful					

Table 5: Post-survey results; student ratings of various new technologies

Student Ratings of Newly Designed Activities	1	2	3	4	5
Off to the races lab		2	13	31	38
Motion Matching	2	4	17	33	31
Acceleration of falling objects	1		15	41	29
Newton's Laws Demonstrations		4	18	36	27
Demonstration of Forces	3	1	16	31	37
Forces Lab	1	6	32	33	19
Projectile Motion Lab	1	13	29	26	14
Pendulum Lab		4	21	34	24
Momentum Lab	2	2	12	31	31
Work Lab	10	20	27	17	12
Potential Energy Lab		4	13	33	25
Key: 5=this was a great activitiy, it gave me a solid understanding of the concept 4=This was a good activity. I got the main idea, but some small fixes would help. 3=This was an okay activity, it could work better, but only with some major fixes 2=This was a problem activity, it could work, but needs to be seriously rethought. 1=This activity actually confused me and hurt my understanding of the topic. Drop it!					

Table 6: Post-survey results: student ratings on newly implemented activities

Considering the comments given on the pre-survey, the addition of PowerPoint® to the classroom was not novel to the majority of the subjects of this study, although 98% of the students surveyed said that they found it at least moderately useful (ranked the addition of PowerPoint® with a three, four, or five on a scale from one to five; see Figure 1). The remarks given in the comments section of the post-survey provided a similar insight as those found during the literature survey (mentioned above). By and large, the students seem to think that the addition of PowerPoint® to the classroom, both the class in which the study occurred and their previous classes in which PowerPoint® was a part, had a positive influence. Comments show that the students appreciated the inclusion of PowerPoint® since they think these presentations made discussion sessions more interesting, made given notes easier to read, made some topics easier to understand (forces especially), and allowed complex concepts to be shown in a graphical fashion through the creative use of animations.

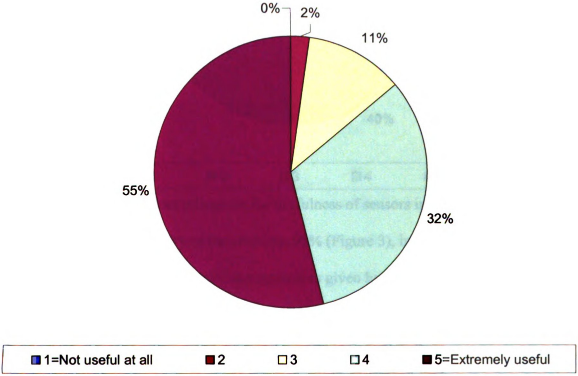


Figure 1: Student Ratings on the usefulness of PowerPoint® in the classroom.

As with the introduction of PowerPoint®, a majority of the students, 97%, found the introduction of computer-based sensors to the lab activities to be useful (Figure 2).

Comments from the students discussed the precision both of timing and of measurement to be particularly beneficial, especially in terms of the labs where time intervals were short enough, human reflex times not fast enough, or human senses not fine enough that reliable measurements were not possible otherwise (see, as examples, The Static versus Sliding Friction Lab, The Pendulum Lab, and The Acceleration due to Gravity Lab).

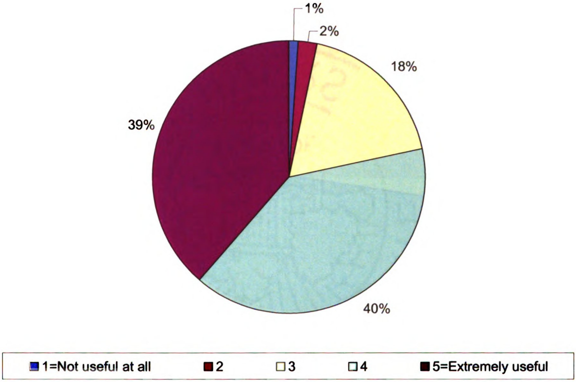


Figure 2: Student ratings on the usefulness of sensors in the classroom

Although, a majority of the students, 91% (Figure 3), indicated that they found LoggerPro® software to be useful, the comments given by the students were more mixed than for the previous technologies discussed. While students appreciated the fact that data were gathered for them, and that graphs of the data collected were produced in real time, many of the students found using the software to be confusing. A comment often given verbally, and in a couple of cases on the post-survey, indicated that some of the students found the interface of the software to be confusing or difficult to use (although approximately the same number of students thought that it was easy enough and extremely useful). Of those who found the software to be confusing, many did recognize that it would definitely be less confusing with more exposure to the technology, both in terms of number of lab activities utilizing the technology and in terms of the amount of time given for each of the activities.

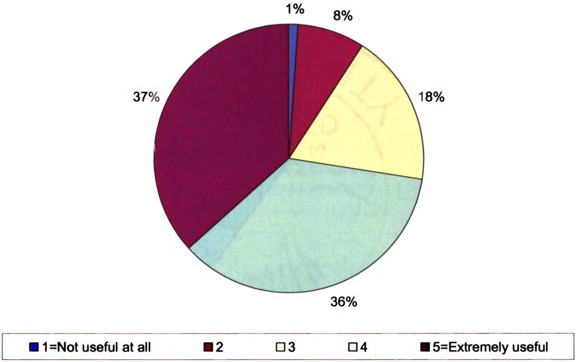


Figure 3: Student ratings on the usefulness of the LoggerPro® software.

The data gathered from the post-surveys (Appendix B) regarding Excel® seem to be the most puzzling regarding the newly introduced technologies. This is due to a disparity seen between the student ratings of Excel®; while the ratings of usefulness from the students (75%) is the lowest of all of the new technologies (Figure 4), their comments seem to indicate the exact opposite in student perceptions. While many students remarked that there were not many situations where Excel® was used in class, and some did indicate that they still found it confusing, many of the students, more than with

LoggerPro® , indicated that they did find Excel® to be useful and that they wanted to use it more often. Whether is due to the program being more prevalent in the outside world or due to encounters in computer technology classes in previous years is not known; but, the students' comments indicate an overall comfort with the program that is belied by their overall ratings of the program in the survey.

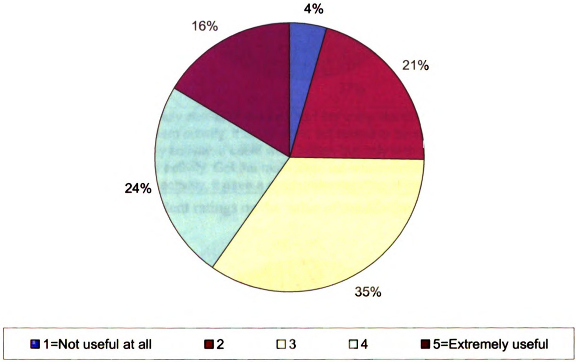


Figure 4: Student ratings on the usefulness of Microsoft® Excel® in the classroom

The same criteria as applied to the technologies above were used to determine whether or not an activity was successful; one indicated that the activity hindered understanding of the topic from a students perspective and no change could fix it, a three indicated that the conveying understanding of the material was somewhat successful but would need significant changes, and a five indicated that the activity was extremely successful in promoting understanding. The post-survey results indicated that each lab was found to be successful by a majority of the students.

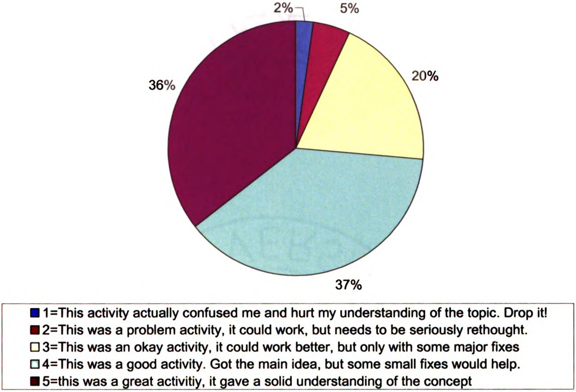


Figure 5: Student ratings on the value of the *Motion Matching Lab*

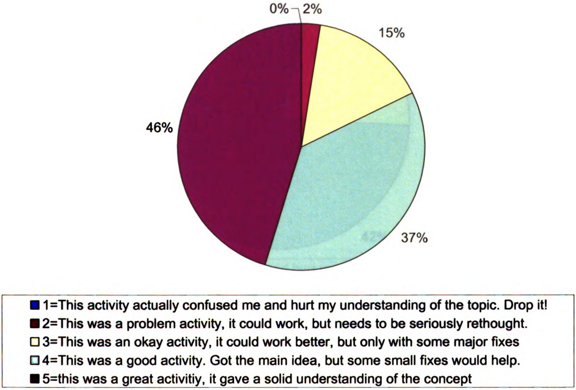


Figure 6: Student ratings on the value of the *Acceleration of Students Lab*

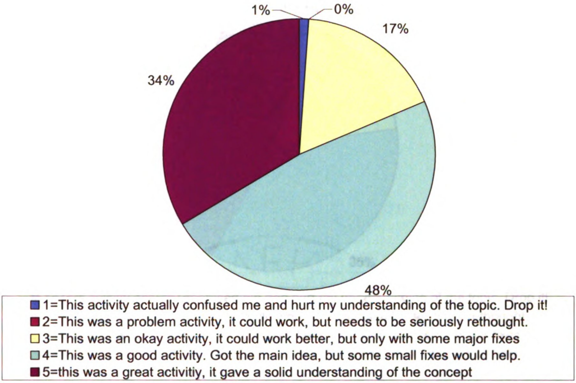


Figure 7: Student ratings on the value of the *Acceleration due to Gravity Lab*

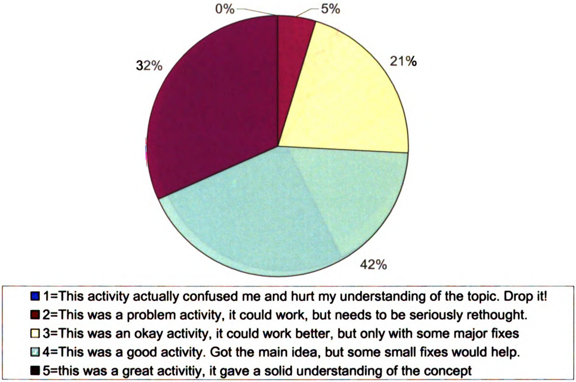


Figure 8: Student Ratings on the value of the *Newton's Laws Demonstrations*

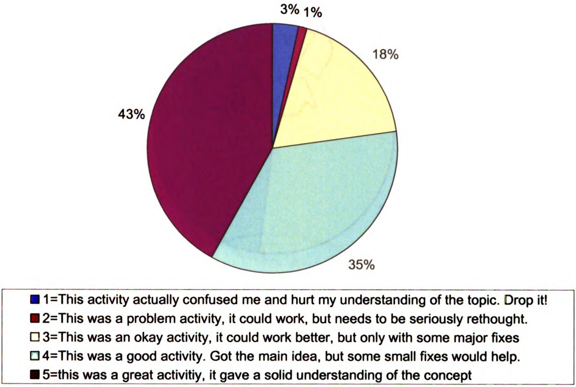


Figure 9: Student Ratings on the value of the *Demonstration of Forces*

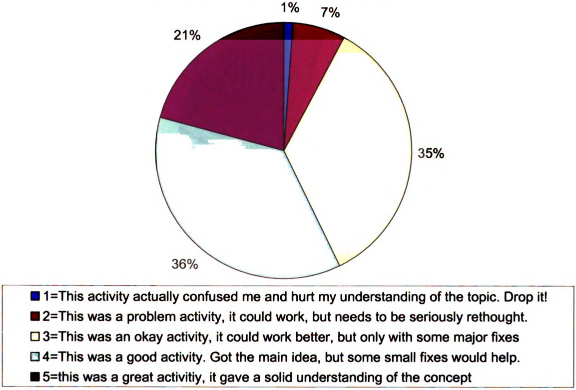


Figure 10: Student Ratings on the value of the *Static versus Kinetic Friction Lab*

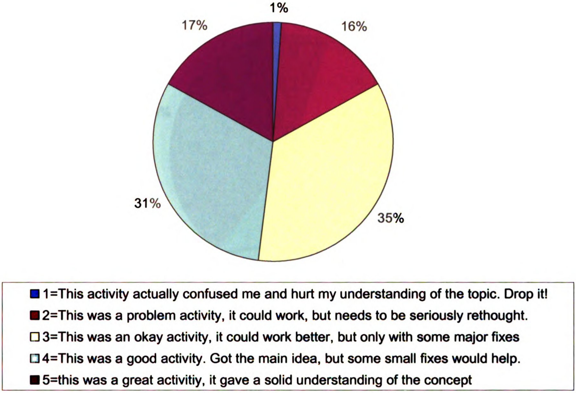


Figure 11: Student Ratings on the value of the *Projectile Motion Lab*

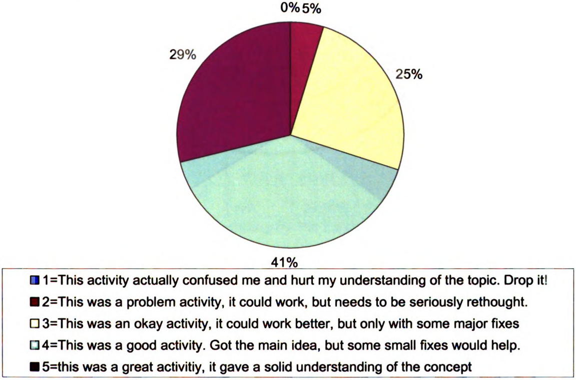


Figure 12: Student Ratings on the value of the *Pendulum Lab*

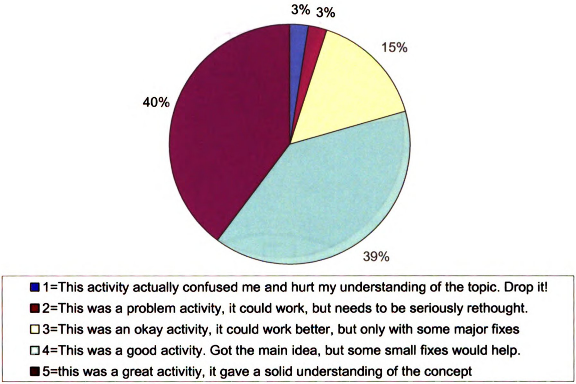


Figure 13: Student Ratings on the value of the *Momentum Lab*

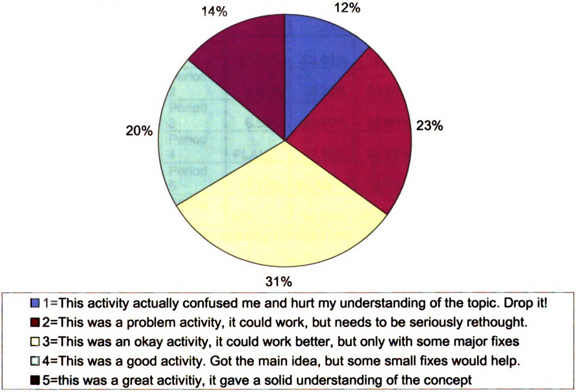


Figure 14: Student rating on the value of the *Work Activity*

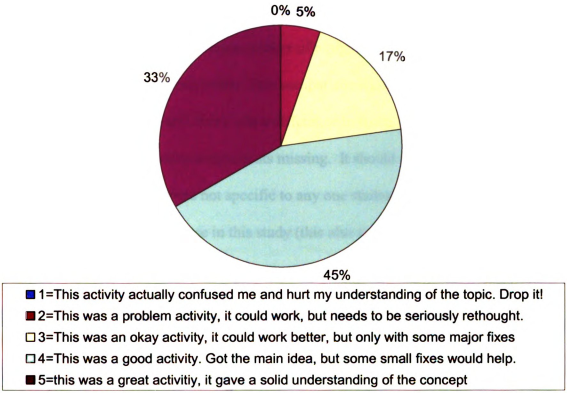


Figure 15: Student Ratings on the value of *The Unconventional Potential Energy Lab*

	2008	2007	2006
Period 1	17.40%	23.60%	19.20%
Period 2	9.47%	28.30%	22.60%
Period 3	6.58%	36.40%	25.60%
Period 4	PLAN	37.50%	10.60%
Period 5	11.10%	PLAN	9.13%
Period 6	N/A	21.50%	PLAN

Table 7: Percent assignments missing for the Force and Motion Unit (2006-2008)

A measure of student engagement was determined by finding the percentage of missing assignments for each class for the year of the study and comparing it to the two years previous (Table 7). The percentages of missing assignments per class were then compared using a student's t-test. The percentages of missing assignments were used for these data, rather than the raw number of missing assignment due to the difference in number of assignment actually assigned. In order to give the students a good feel for the new technologies, there were a larger number of assignments from this unit given to the study year than to the previous years. This comparison showed that, with a p-value of 0.029, using a student's t-test, there was a difference in terms of overall percentage of assignments handed in versus assignments missing. It should also be noted that the data used from previous years were not specific to any one student and was not originally collected for the purposes of use in this study (this also applies to the discussion of average test grades below).

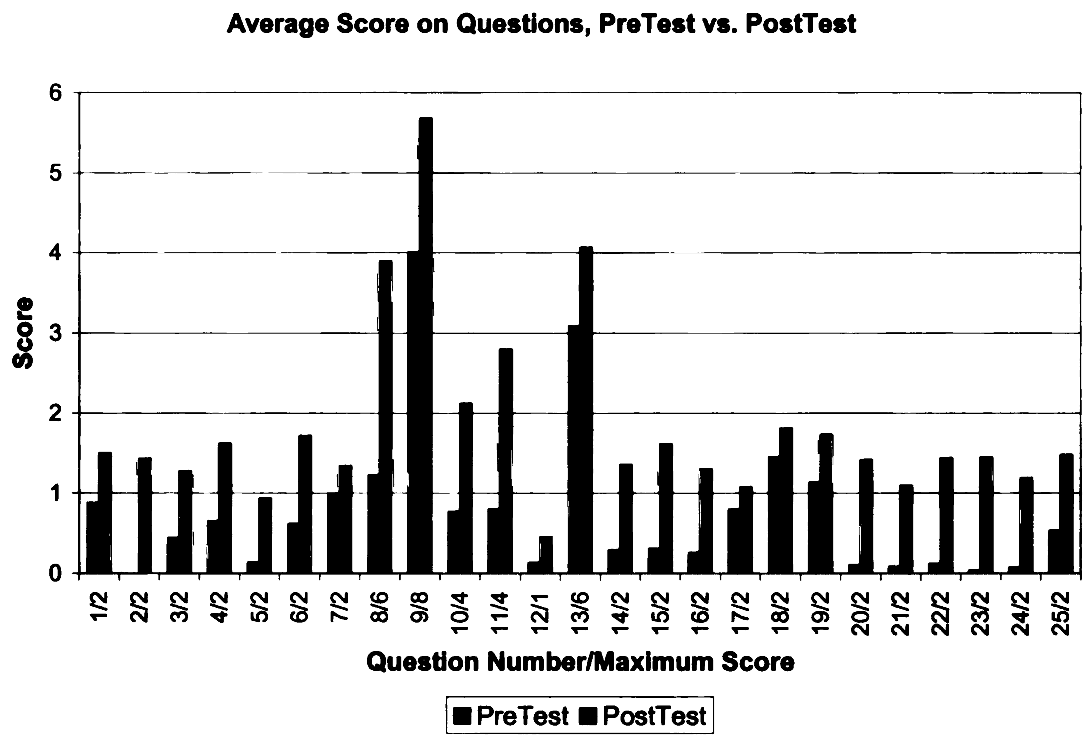


Figure 16: Pretest and posttest score data comparing each individual question.

The data for the pre-test and post-test (Appendix A and Figure 16) were analyzed for differences using a student's t-test for each question. The t-test was initially done on each individual question so the variance could be examined and discussed in the case that some of the questions showed a statistical difference, whereas other questions did not. In the end, with p-values for each question being less than or equal to 0.002, it was determined that there was a statistical difference in performance for all questions for the pre-test and post-test. Note that, although 70 students gave permission to have their data used for this study, only 57 pre and post tests were used. This is because the remaining 13 students either were absent the day of the pre-test and took more than 2 days to make up the pre-test, or were absent for the post-test under the same conditions.

It is worth noting that the degree of variance between the average scores on the pre and posttest varied significantly from question to question. For example, questions nine and thirteen had high average scores on the pretest, which only increased on the posttest, though the difference between the pre and posttest scores was not nearly a pronounced as that seen in other questions. In the case of question nine, this less pronounced difference is likely due to the fact that the graph construction skills needed to succeed on this question were covered earlier in the year, and therefore, this question could be reduced to a matter of reading comprehension rather than knowledge of a new skill. In the case of question thirteen, the inflated pretest score is probably due to the fact that three out of the six point were given based on whether the student correctly answered yes or no to each of the three question parts, and this could be easily done using knowledge learned about these topics in previous grades.

On the other hand, there were also questions, such as question two and questions twenty through twenty-four. In these cases the variance in score between pre and posttest was disproportionally large. In the case of question two, this variance is probably due to the requirement of the ability to draw connections between two concepts (velocity and acceleration) and not just knowledge the definition of the two concepts. As to questions twenty through twenty-four, these questions either required the students to read the problem, parse out the relevant data, apply the data to a formula, and perform a calculation, or required knowledge of a topics (kinetic and potential energy) that were not covered significantly in previous grade levels.

When determining differences in achievement across years, there were data only for the year of the study and the year immediately preceding it. There were no data for the 2005-2006 school year because during that year this unit's test was rolled into that semester's final exam. So, with average scores only from the year of the study and the year previous to the study, with a p-value of 0.188, there is not enough data to show a statistically significant difference between the year of the study and the previous year. This data was found using a student's t-test of the average percentage score for the unit test for each of the classes in the 2006-2007 and 2007-2008 school years.

Conclusions:

This study investigated the addition of technology to an eighth grade science classroom in three specific, testable, ways: engagement, as determined by the average percentage of missing assignments; achievement over the course of the unit, as measured by comparing pre and posttest data; and achievement through this version of the Force and Motion unit, as determined by comparing the average test grade percentages on the unit final exams between the 2007-2008 school years, and the two years previous. This investigation also looked at the addition of specific technologies though the eyes of the students as they gave their comments on what worked and did not.

In terms of engagement there was a statistically significant difference ($p=0.029$) between the percentages of missing assignments between the study year, and the prior two years. However, because of a less than total commitment of volunteers, (70 volunteers out of 99 students in the study year) compared to the complete data in the previous two years, and differences in the number of assignments, it is difficult to say with certainty that the addition of the technologies in question was the deciding factor.

In terms of achievement over the course of the unit, there was a statistically significant difference. The pretest and posttests (Appendix A) were written so that each question had a corresponding question. As such, it was possible to compare not only the overall results of the pretest and posttest data, but also the individual questions. In every case, a comparison of the questions on the pretest and posttest yielded a p-value of less than 0.002, indicating statistical significance. However, it should be noted that a statistically significant increase in knowledge and ability should be seen over the course of any unit, otherwise the instructor is failing in their duty as an educator. This, of course, casts doubt as to whether the addition of the tested technologies was the significant factor.

In terms of achievement across the years, with a p-value of 0.188, there was not a statistically significant difference between the year of the study and the year previous to the study. Though a trend may be seen with further classes for investigation, at this time it must be stated that the addition of these technologies did not significantly increase or decrease the achievement of the students from the study year over those from the year previous. It should be noted that, due to differences from one class to another and from one grade year to another, that any conclusions would be suspect due to the number of variables involved between the two groups.

An interesting trend was observed in the comments and situations provided by the students. Based on the comments and ratings (see Appendix C, Table 5, and Figure 1), the students felt that the addition of PowerPoint® was useful, as it made note taking easier and the lectures more interesting. In regards to sensors and the LoggerPro® software, a similar trend can be seen (see Appendix C, Table 5, and Figures 2 and 3): for the most part, these additions were welcomed and seen to be positive additions. They increased precision of data-gathering and, though not of discussed by the students, seen in the results of questions on the posttest, a general understanding of how such graphs are to be read. While statistical analysis was not done, due to the non-numeric nature of student comments (Appendix C), there seems to be a strong support in terms of both ratings and comments for these three technologies.

There was a similar trend in the student comments (Appendix C) about the usefulness of Microsoft® Excel®, though not in the numeric ratings. This may be attributable to the fact that this was the first experience that most of these students had with a spreadsheet program or with data sets of the sizes produced in these activities. Whatever the reason, an analysis of the comments versus the rating indicates that, though many of the students appreciated the fact that Excel® spreadsheets were good for creating graphs, they did not see Excel® as being a generally useful tool, more of a curiosity.

Discussion:

This study examined the effects of technology on an eighth grade science classroom in terms of engagement and achievement. And while the addition of these technologies to the classroom is beneficial, it is worth noting that the addition of PowerPoint® presentations and probeware technologies needs to be done with a great deal of consideration. Adams (2006) indicated that PowerPoint® was originally developed for the corporate boardroom, not the classroom, and failure to consider this can actually lead to the harming of students education, rather than helping it. Probeware and the accompanying software, again, can be extremely educationally beneficial. However, in this case there may be a tradeoff: by having the computers do the graphing for the students, are educators trading graph construction skills for graph understanding skills (Adams and Shrum, 1990; Marcum-Dietrich and Ford, 2003)?

According to Long (2008), in a New York youth technology introduction program, 90% of area students went to college, the overall average for the area was 50%. The addition of, and experience with, technology to classrooms and to the outside world is of crucial importance. If one thing could be gleaned from both the comments from the students in this study and from much of the literature examined in preparation for this study, it is that technology needs to be applied, but applied with a great deal of forethought and preparation. Students are less likely to try for college if they do not feel that they have the skills, especially in regards to technology (Long, 2008).

The addition of technology benefits students in two ways. First, technology gives students another way to develop cognitively: by seeing graphing in real time in response to phenomena that they are witnessing. Second, the exposure to technology gives the student the confidence to reach further beyond their current lives, to experience, benefit from, and, hopefully, contribute to society in ways that would be, literally, unthinkable (due to lack of prior experiences), to them if they did not further their educations.

PowerPoint®, for all of its benefits in terms of student engagement and interest in the lecture brings several possible problems to the classroom. The first of these is in expected changes in achievement: Susskind (2003) points out that PowerPoint® does not enhance performance on tests, nor does it influence study behavior. It seems that, academically at least, adding PowerPoint® presentations to the classroom will not change the situation significantly. That said, comments and attitudes, especially from students seeing PowerPoint® in the classroom for the first time, showed a much better attitude in class. From the perspective of the instructor and many of the students, it made the classroom a more pleasant place to work.

In my experience, the addition of PowerPoint® to my classroom was definitely a positive experience. The fact that, in order to create more than just a list of topics, I had to create the presentations days or even weeks ahead of time had a significantly positive affect on my practice in that I had to plan in a more specific manner further into the future. Another benefit was found in the attitudes of my students as they seemed more attentive to the lectures and discussions, even if they had to be reminded more often than usual to make sure that they were taking notes.

Adams (2006) and Susskind (2003) also warned that the use of PowerPoint® in the classroom can inhibit flexibility and spontaneity in the classroom for both the teacher and the student. It could be argued that this lack of flexibility stems solely from the teacher in question, as this was not noticed in this study. Especially at the beginning of the year, when PowerPoint® technology was introduced for this study, students tended to be much less inhibited in asking questions, as compared to later in the year. It is only through the actions and responses of the teacher that these questioning tendencies can be quashed. If the teacher routinely brushes past, or fails to satisfactorily answer, questions that are off the topic on the PowerPoint® presentation, then, of course, the students will stop asking questions. The teacher's reasons for doing this may be a lack of flexibility, or perceived lack of ability to illustrate their point. However, there will still be access to a chalkboard or a whiteboard. This means that "perceived lack of ability to illustrate their point" indicates a failure, through lack of flexibility, of the instructor. PowerPoint® can be used without inhibiting flexibility, it just requires that the instructor be willing to turn on the lights and step away from the screen as the situation warrants.

Adams (2006) also points out that due to its corporate nature, PowerPoint® will tend to guide its users toward creating bullet points; further, this can be a problem for the students due to lack of detail and context. Again, it is up to the teacher properly utilize this technology in their classroom. PowerPoint® does not require that bullet points are done as sentence fragments. Indeed many of the notes that were created for this study were two or 3 sentences long under a single "bullet point". Moreover, it is a simple matter of hitting the backspace button to remove the bullet point mark from the page in the first place making the perceived requirement for small chunks of text a non-issue.

Adams (2006) further points out the prevailing student perception of "If it isn't on the PowerPoint®, it probably isn't important" and therefore, the addition of PowerPoint® can reduce note taking, due to given notes pages, and, class appropriate, divergence. Again, this is a matter of classroom culture and the instructor being willing to take steps to maintain that culture. To curb the feelings of "If it isn't on the PowerPoint®, it probably isn't important", the instructor needs to state clearly, at the beginning of the year, and probably several times over the course of the year, that the notes that are presented on the PowerPoint® are a ***minimum*** and that taking and using just those notes will not result in the best grade possible. It would probably help in this situation for the teacher to include on assessments, especially the beginning assessments, information given to the class verbally or on the white/chalkboard, but not included on the PowerPoint®.

In terms of the reduction of note taking due the students having copies of the printed PowerPoint® slides, the solution is simple, and again teacher implementable: do not give the students note pages. The simple act of writing down information aids in the retention of the material which is written down. Therefore, the smart student should refuse the printed slide sheets in favor of writing their own notes and the smart teacher should refrain from giving the slide/notes sheet in the first place. These sheets work well in the corporate workplace as few extra notes are necessary and the sheets can be referenced at any time in the future. This is not the case for the classrooms.

Like PowerPoint®, probeware can be quite beneficial to the classroom; but again it needs to be implemented with thought. While the literature review indicated that probeware can increase students ability to accurately read and interpret graphs, Adams and Shrum (1990), and Marcum-Dietrich and Ford (2003), found that, upon comparison, students in conventional labs, without probeware, were better at constructing graphs; this makes sense as, with probeware, the computer constructs the graph, not the student. This means that in an optimal classroom, attention would be given to both conventional labs and labs featuring probeware, so that students could develop skill in both graph construction and interpretation.

One way of designing a class so that it developed skills in both graph construction and graph interpretation might be to include the technology gradually over the course of the year. One would start at the beginning of the year by having students hand gather and graph data, and only include the sensors and software at a later point, once the graphing skills have been demonstrated at an appropriate level. Indeed, the addition of the technologies, shown through demonstration, could be used as a point of motivation to develop graphing skills in earlier labs so that the students might be able to use the sensor for gather and analyzing data in later labs

Another concern is the deceptive speed with which experiments can be done with probeware. Though probeware allows students to study phenomena over long periods of time without direct attention (Hisim, 2005), the greatest increases (in understanding) were seen when students had large amounts of time with the materials (sensors) (Metcalf & Tinker, 2004). The conscientious teacher will look past how quickly a single run of the lab can be done and emphasize the benefits of multiple runs of a lab in adherence to the scientific method. Likewise, said teacher will also realize that many of the benefits, in terms of graph interpretation and cognitive chunking, will be lost during long, unmonitored, sessions of data gathering. This is not to say that there is not a benefit to such labs. Indeed, there are many phenomena that can only be determined during prolonged times of data gathering, just that there will be few benefits in terms of graphing skills for the students during those labs.

Based on my experience with the students and the probeware, I would suggest including a variety of labs. As was mentioned above, there are some topics which require extensive amounts of data gathering and others that can be examined through multiple trials in a single class period. I would suggest making sure to include a balance of both types of labs, where both are possible, and not to eliminate lengthy labs just because they take a long time and are not conducive to multiple trials. In reality, modern research in the lab is most often more like the lengthy labs than the short, multiple trial labs. Although the scientist in the outside world also has the advantage of time and therefore the ability to do multiple trials of a lengthy experiment; something which educators with their nine months with a given set of students are not allowed.

In conclusion, the addition of technology to the classroom is a laudable goal with many benefits, but it must be done carefully and intelligently. "Technology is too big a part of our world for kids to not know the most simple stuff". If kids can not explore technology on their own, they will be at a competitive disadvantage (Long, 2008). For this same reason there needs to be a charge to teachers to include technology in the classroom, otherwise there is concern over the possible exclusion of those students who lack access or ability to use technology (North Central Regional Educational Laboratory, 2005). In order to prepare the students for tomorrow, instructors must expose them, again with care and thought, to the technologies of today.

APPENDIX A

Pre and Posttest

Force and Motion Unit Pre and Posttest

Directions: Complete the following statements to the best of your ability.

1) Speed is ______________________________

2) The difference between speed and velocity is ______________________________

3) Acceleration is ______________________________

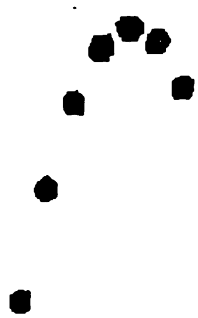
4) A force is ______________________________

5) Energy is ______________________________

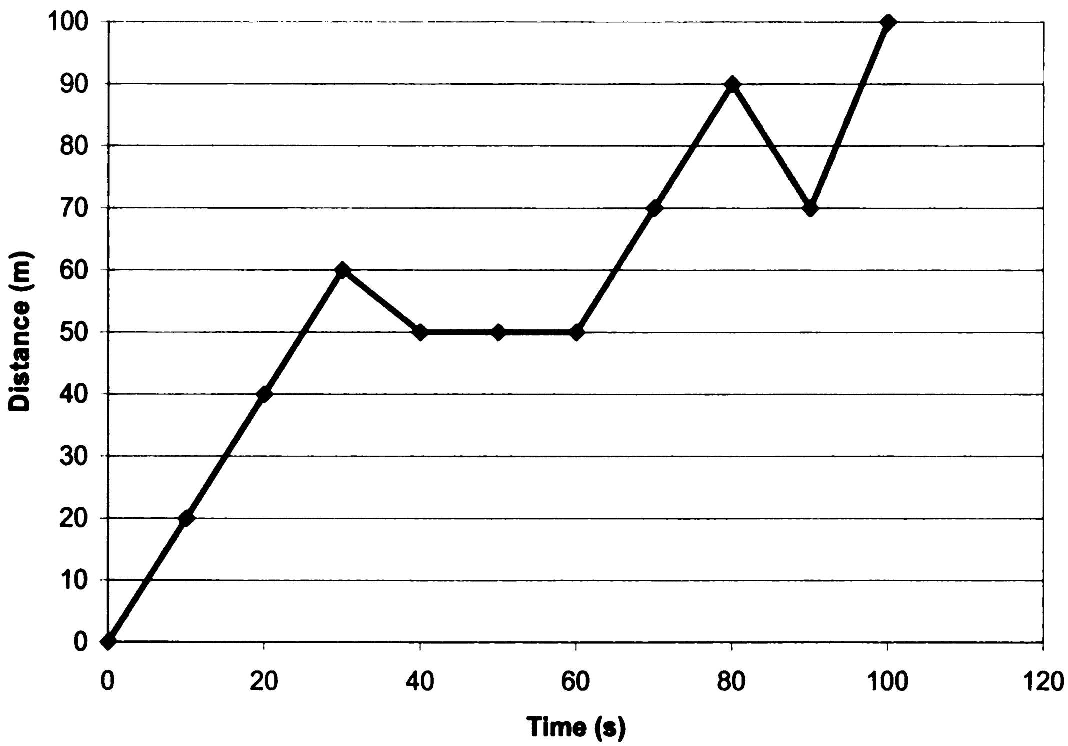
Directions: Use what you know about force and motion from previous classes and experiences to answer each of the following questions.

6) What is the velocity of an object that moves 30 m west in 5 seconds?

7) Draw arrows on the pictures below to represent the velocity of the ball as it is thrown through the air.



8) Michael lives down the street from his school and is walking home. On his way home, he graphs his movement as he goes. Using the graph below, describe Michael's movement on his road home.



9) Dr. Scott is walking from the attendance office to the cafeteria. 3 seconds after leaving the office, Dr. Scott reaches Mrs. Nelson's room (6 meters down the hall) where he stops for 4 seconds to look in on one of her students. Dr. Scott then takes 6 seconds to walk the 20 meters down to Mrs. Stoyk's room. Upon reaching Mrs. Stoyk's room, Dr. Scott realizes that he needs to give message to Mr. Runyon, whose room is 10 meters back. Dr. Scott takes 4 seconds to walk back to Mr. Runyon's room. Dr. Scott waits at Mr. Runyon's room for the next 5 seconds while Mr. Runyon reads and responds to the message. Dr. Scott then covers the remaining 20 m to the cafeteria in 4 seconds.

Use the graphing area below to graph Dr. Scott's movement.

10) Which of the following objects is accelerating? Why do you think so?

a) a skydiver after she's jumped out of the airplane, but before she reaches terminal velocity.

b) a automobile driver as he depresses the brake pedal when approaching a stop sign.

c) the moon as it revolves around the moon.

d) All of the above.

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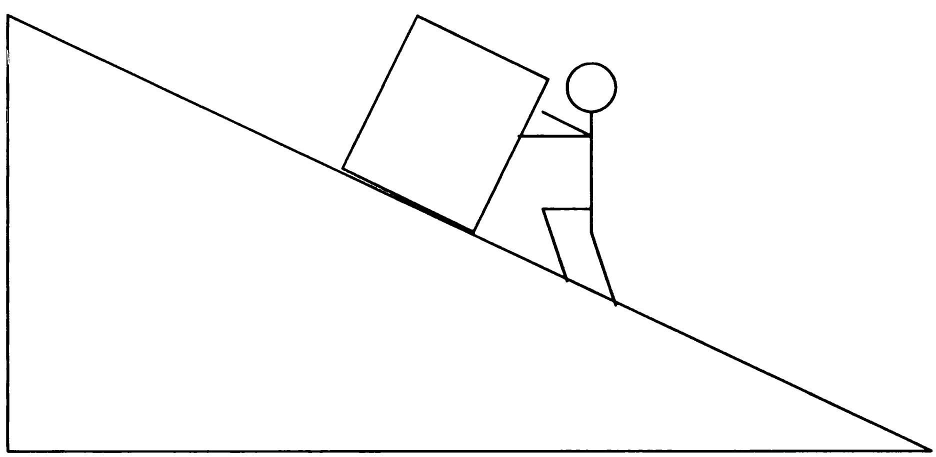
11) Draw and label arrows to represent the forces acting on the box in the picture below.



12) What is the net force acting on a rope in a game of tug of war if the team pulling left exerts 500 N and the team pulling right exerts 480 N?

13) If the box in the picture above is staying still (each answer is yes or no, explain why or why not as well):

a) Is the person exerting a force?

b) Are they using energy?

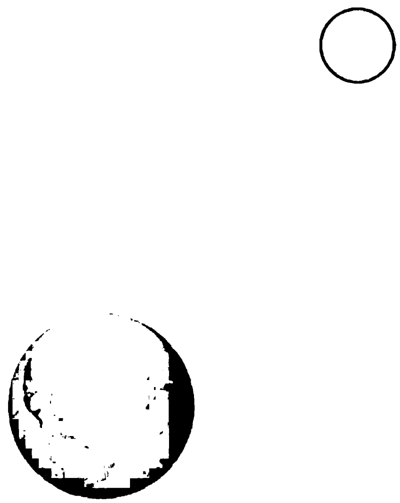
c) Are they doing work?

14) A bicyclist who flies over the handlebars after his bike hits a curb is obeying Newton's __________ Law of Motion. State the law below.

15) How much force is acting on a baseball if it is accelerating at a rate of 10 m/s^2 and has a mass of 0.35 kg?

16) How fast is a 250 kg car accelerating if a 900 N force is acting on it?

17) Explain what forces cause the moon to orbit the earth and how they act to keep the moon in orbit.



18) Is your ***weight*** the same on Earth as it would be on The Moon or Jupiter? Why or why not?

19) Is your ***<u>mass</u>*** the same on Earth as it would be on The Moon or Jupiter? Why or why not?

____

20) What is Kinetic Energy? Give an example of an object that has Kinetic Energy.

____

____

21) What is Potential Energy? Give an example of something that has Potential Energy.

____

____

22) State the Law of Conservation of Energy:______________________________

____

23) How much potential energy does a 3,162,727 N airplane have if it is traveling at an altitude of 5,000 m?

24) How much potential energy would the plane from question 23 have after it descended to 2,000 m?

25) What happened to the potential energy as the plane from questions 23 and 24 descended?

APPENDIX B

Pre and Postsurveys

Technology in School Presurvey

Computer Knowledge

1) On a scale of 1 to 5, rate how comfortable you are using a computer. _______

   (1=I only use the computer when I have no other option, 5=I use the computer for work/assignments whenever possible)

2) Rate your ability to use the following programs (1=I have never used this program before, 5=I understand all the functions of this program and could use it in a business setting)

   a) Microsoft Word______

   b) Microsoft Excel______

   c) Microsoft PowerPoint______

Available Technology (circle the appropriate answer for each question)

1) Do you have a computer at home? Yes No

2) What kind of computer do you have at home? PC Macintosh (Apple)

3) What operating system does your computer use?

OSX (Apple) Linux Windows Other:__________________ Don't Know

4) What do you use your computer for (circle all that apply)?

Playing games Writing (schoolwork or creative writing)

Finding information Chatting with friends Other:____________________

History

In the space below, please list any uses of technology that you have previously experienced in the classroom. (This could be movies, PowerPoint presentations, any kind of technology in a lab, etcetera)

Technology in a Science Class Post-Survey

Over the course of this year in general, and the Force and Motion unit in particular, we have introduced several types of technology to the classroom. Please consider these additions when answering the following questions. Please also comment if you feel that there is any way in which the use of these technologies in the classroom could be improved (how can your teacher use these technologies to better effect?).

1) Please rate the following technologies on their usefulness to you in your learning.

a. PowerPoint notes and presentations

1	2	3	4	5
Not useful at all		Moderately useful		Extremely useful

Comments: ____

b. Sensors in the lab activities

1	2	3	4	5
Not useful at all		Moderately useful		Extremely useful

Comments: ____

c. The LoggerPro software

1	2	3	4	5
Not useful at all		Moderately useful		Extremely useful

Comments: ____

d. Excel spreadsheets

1	2	3	4	5
Not useful at all		Moderately useful		Extremely useful

Comments:____

Please rate the following activities based on how well they helped you learn the concept in question.

5=This was a great activity, it gave me a solid understanding of the concept

4=This was a good activity. I got the main idea, but some small fixes would help.

3=This was an okay activity, it could work better, but only with some major fixes.

2=This was a problem activity, it could work, but needs to be seriously rethought.

1=This activity actually confused me an hurt my understanding of the topic. Drop it!

Off to the races lab (motion and calculating speed)

1 2 3 4 5

Motion Matching (distance versus time graphs)

1 2 3 4 5

Orienteering Course (motion, distance, displacement)

1 2 3 4 5

Acceleration of Falling Objects (gravity and acceleration)

1 2 3 4 5

Newton's Laws Demonstrations (Newton's Laws)

1	2	3	4	5

Demonstration of Forces (examples of various forces)

1	2	3	4	5

Forces Lab (finding and calculating forces)

1	2	3	4	5

Projectile Motion Lab (projectile motion)

1	2	3	4	5

Pendulum Lab (periodic motion)

1	2	3	4	5

Momentum Lab (momentum)

1	2	3	4	5

Work Lab (calculating work)

1	2	3	4	5

Potential Energy Lab (potential energy)

1	2	3	4	5

Kinetic Energy Lab (kinetic energy)

1	2	3	4	5

Bicycle Analysis Demonstration (energy transfer)

1	2	3	4	5

Mousetrap/Mission: Possible Demonstrations (energy transformation)

1	2	3	4	5

APPENDIX C

Postsurvey Comments

Comments in Response to Post-Survey Questions (verbatim from surveys)
1a
Because you can read the notes easier.
Go slower
You could add diagrams to help illustrate ideas
more visuals during long notetaking
easy to read and fun to see the video also
sound effects
I really like the pictures it helped me understand the ideas
could put the powerpoints, after showing them, on school notes so that people can download them at home if they didn't get to finish writing them dowm
This is a lot easier then regualar notes. Makes the class more engaging
are efficient and make everything easier
when we have definitions on the board it really helps because you also use other slides to demonstrate
you could read it instead of teachers handwriting. Some powerpoints could be printed out
easy to see and read, maybe not black backgrounds
they allowed me to actually see the force as it happened :)
you should keep the powerpoints because it's quicker
I like the powerpoin cause you can make some good things
I learned more from other presentation projecs than just mine
you could make more demonstrations in your notes
since there's other writing on the board, using the overhead pointsout the day
in power point there needs to be more picture describing things
I could see it anywhere in the room & it was interesting
helped very much to the understanding of complicated topics
it was good having it at first but later in the year it seemed to be repetetive
much better than boardwork more interesting but maybe agenda could also be on the board incase we miss it the first time
the power point makes notes go faster but could use more visuals
powerpoints made notes more interesting and easier to follow
I like the powerpoint is better than a white board because the marker runs out and you can't see it
I don't like them but are cool
not to hard
the power point helped us understand vocab better and how atoms and ect work
better than notes on a board

considerably more interesting than writing on the board
could switch to a brighter background to make things easier to see
I like it because if I here it more then 3 time I will know it
The power point note were useful so I could take notes and have them and it was more neat
more interesting than just taking notes off a white board, especially when there are animations
this is useful but you should make it more fun
demonstrations on the powerpoint helped me remember vocab words
they were kind of boring
it was useful but if you could make it more fun then it would be better
this is a lot better to understand
with some of the notes we had to repeat some things more than once
it is too boring to learn much, there are way too many notes to take
using the power point notes is much easier to look at than notes on the board or an overhead
make sure you go a little slow and understandable
1b
yes because it would be extremely hard to gather data easily
gives us more time occasionally
just finding graphs
the sensors were useful. They were kind of a pain to use though
we didn't have to do calculation yourself and it was more accurate
the sensors made data gathering so much easier
in some cases they acted up, so reliability could be better overall
I liked this activity
the sensors were sometimes too complicated
at first the sensors data was just a bunch of lines to me. Give us more time to play with them to understand them.
this was ok but not that fun
much easier to gather data with accuracy
worked well
used a lot
it helps us by using a graph
makes measuring easier and faster
most of the time the sensors couldn't read the object
sensors help make data gathering more accurate and less of a hassle
only problems was you could move a little your data would be off
this helped me but also I remember that it also confused me somewhat. At one point I didn't understand, but looking back now, I do & I see how it helped

this was just great
easier to use than traditional sensers (sensors sp) maybe having more, though (funding could be a problem, though) would make it even easier
what's the point?
they weren't perfect, but made gathering data easier
I was able to get more of the idea of what was going on
having more computers so people do not have to wait or share
was a little difficulte to use
keep them there a lot of help at certain times
I feel that some were not that accurate
worked very well gave good data
gets confusing about which lines mean move forward and move backward
get more!! It's easier to use. And funner.
I think it was useful and saved time.
some sensors are hard to use and confusing
I don't like them
1c
we don't use it much
it helped us because it made graphs
this helped me a little
it was really nice for the computer to do the work for me :)
newer technology
this helped to get all our data graphed and organized
it was easy to use
Logger pro software is extremely useful and helps us calculate data
I like it because I think it saved a lot of math and time
easier to use
useful but it can get a little difficult
it was hard but we learned as we didn't more
I liked that it graphed for me
it was useful. That way we didn't have to graph it. We could see the graphs as we went.
It didn't really help me at all so you could do some stuff to make it more noticeable
I like it cause it garh (gather) data by it's slef (itself)
it was kind of confusing and hard to work with
this made it take less time to get the info we needed.
more computers so we can do this faster
this didn't really help me but I do know how to use that graphing
Logger pro helped calculate data easier without hard mathematics
sometimes confusing but helped with gathering data

too complicated
I want it! The software is really easy to use. The only thing that would make it better would be faster computers, but that probably costs a lot
mostly useful but (illegible) a little confusing
its easer (easier) because it every ones anser (answer) closer. A better avereg (averege)
graphing is a lot faster and easier than by hand
Easier than making a graph yourself. Fun to watch your movement appear on screen
Liked not having to hand-draw graphs
this was not that fun it was Lam (lame)
This was so confusing. There is too many steps & buttons
it was easy to use
could use some more moderately
The LoggerPro software was too complicated for me
It was sort of confusing to know if you should move forward or backwards
The Logger software was Extremely useful but there were a few confusing things
software was user friendly and worked well
maybe explain it a bit better?
kind of confusing. Should find the quickest and easiest way before starting the lab.
It was very helpful but it was a little confusing at times
This software was very useful, I had just never used it before, so it was a learning process
use this more often
make it more understandable
1d
make it more understandable
I've used it previously and it's very helpful (use more frequently)
didn't use often so I can't decide
we did not use this enough to comment about it
we didn't use excel very much but it went kind of ok the one time we used it
didn't make enough of an impression
we didn't use it enough
it was a little confusing
I don't even remember these
I like this because we got to see how fast we run or excellerate (accelerate)
it is better than graphing by hand
it was easier to show data
confusing and not very fun

This was only used once and did not give us a good idea of what it could do
it seemed kind of confusing and got hard to understand
I wish we could have used these more
helped a little bit
quite easy to use
No!
not sure
I don't really know much about this
This wasn't really useful to me because I haven't had enough expeirement (experience?)
names on the printer sheets so we don't have to find our papers randomly
I think this was fun
It was kind of confusing
we only used the spreadsheet one time, and it helped somewhat at the time
it took a long time
saved us a lot of work
it was really long
we only use it one time and it was a little confusing but not that hard to use
Fun. I understood it
I think it was useful because it saved time on making the graph
It would have been more useful if we used them more
It helps me understand how the number increases or decreases
It was too much running
Off to the races lab
I think that off to the races was an awesome lab not only was it fun I learned a lot too.
Motion Matching
harder to get done with large groups, people walking in the way of sensors but still effective/interesting
Acceleration of falling objects
fun
Newton's Laws Demonstrations
don't make use draw them
fun
to many notes and didn't have time to write all of them
Great. Small fixes
Demonstration of Forces
fun
can't remember

taking the notes didn't work as well as the mediums for me personally but still effective and interesting
Forces Lab
larger example would work better
Projectile Motion Lab
you should actually do it
you could vieow tape us shooting the ball
a better example
understood better after, very interesting
I didn't really get the understanding of it
good. Could use some small fixes
Work lab
you should take them out and try it
It was confusing. Make it more clear or something. I mean I partially got it, but...
The work lab was so confusing and I didn't just not understand it I got a worse understanding then when I started.
There was no graph showing the data and I couldn't imagine what was going on with just numbers.
The work lab was the worst wone. It needed more explanation. A good thing in this class was lab because it helped explained the science
you can take us to some blethors (?) and see how much we have
helped me understand that work = a, not b (small graph drawn)
Overall Comments
Already Extremely Awesome!
Overall Mr P, you just need to GIVE US MORE TIME! Also, I think that you should explain things slower and more specific
Hands on stuff is really easy for me to lurn better. Try more hands on.
Interacting with labs helps me learn a lot better then just observing things
You could make directions a little smoother, remove the work and projectile motion lab or replace them with demonstrations
Most everything was perfect. Some labs would be better with more explanation but overall everything went well
I loved the activites where I was involved, like the "off to the races lab." it helped me understand the info better.
I think more personal demonstrations, getting kids out of their seats to show them what's happening.
The demonstration of forces and work lab wasn't very helpful and all the others I liked.

APPENDIX D

Class Activities

Motion Matching Activity

One of the main problems that modern science students have is than many lack the ability to express or understand scientific information in graph form. Now, this is not for lack of actual ability, it is generally due to lack of experience with graphs in science. In this lab we are going to look at graphs of distance and time, and showing our understanding of the graph by trying to generate data that will match the graph as closely as possible.

Materials:

1 Computer

1 Printer

1 Go Motion® Sensor

Procedure:

1) Turn on the computer.
2) Double-click on the icon for Logger Pro 3.4.6® on the desktop.
3) Once the Logger Pro® program is up, click on the file Menu, scroll down to Open and left-click.
4) Open the file marked Motion Matching 1
5) Have a group member stand in front of the sensor, facing the sensor, and have another group member press the F11 key (or click Collect at the top of the Logger Pro window)

6) Once the sensor begins clicking, have the group member in front of the sensor move back and forward in front of the sensor.
7) Observe the line produced.
8) Repeat steps 5-7 until you think you have an understanding of how your movements affect the new line being generated.
9) Repeat steps 5-7, only now, try to make your line match the line provided for you.
10) Repeat steps 1-7 for the file named Motion Mapping 2
11) Repeat steps 1-7 for the file named Motion Mapping 3
12) Print a copy of your first attempt at Motion Mapping 3 (don't worry, your grade will not be significantly affected by how closely your data sticks to the line)

Analysis:

1) On your printed graph, mark each instance where your line did not match the given line. Explain what you should have done to get your line to match the line provided (again, on the graph).
2) What happened on the line generated if you moved too quickly?

3) Too slowly?

4) What if you stopped?

Acceleration of Students Lab

Background: In the motion matching lab, you saw that your movement could be shown on a position versus time graph, and that you could tell not only your direction, but also your speed based on the slant of the graph. The lines provided for you in that lab were straight lines. And trying as hard as you could, nobody was able to duplicate these straight lines; the student's lines were always curves. In today's lab, we are going to investigate what those curving lines actually indicate.

Problem: What does a curve, either up or down, mean on a position versus time graph.

Materials: 1 laptop computer (with LoggerPro® software), 1 Go Motion® sensor, 2 chalkboard erasers, 1 metric measuring tape.

Special Conditions: Needs to be done in a space (room or outside) with at least 6m of straight line moving space.

Procedure (Day 1):

1) Use the measuring take to find a straight line distance of 6m.
    a. Place the computer and the motion sensor at one end of this line, with the sensor pointing down the line.
    b. Place the 2 chalkboard erasers at the other end of this line.
2) Connect the motion sensor to the computer.

3) Turn on the computer.

4) Double-click on the LoggerPro® icon on the desktop.

5) Have one student stand in front of the motion sensor, prepared to run to pick up each of the erasers, one at a time, and return them to the computer area as quickly as possible (without throwing the erasers).

6) Have a second student click the collect button in the LoggerPro® window.

7) Have the second students tell the first student to begin.

8) Once the runner has brought both erasers to the computer area, have the second student click stop.

9) Save the gather data in a file marked with the students last name, then first initial (example: ParkinsonJ).

10) Once data has been saved, clear the data.

11) Repeat steps 5-10 until all students have run once.

Day 2 (Library or Computer Lab):

1) Open Microsoft® Excel®.

2) Open "My Computer" (on the desktop), P drive (Share...), Student Folder, Science 8 Parkinson, your file name (example: ParkinsonJ) from the previous day.

3) Follow along with the teacher's example to create a graph of your data using Excel® (be sure to include your name in the title of your graph).

4) Print your graph.

5) Draw a trend-line (curve) to show the overall pattern of the data.

Conclusion Questions:

1) What does the position of each data point on the x-axis represent?

____

2) What does the position of each data point on the y-axis represent?

____

3) Describe what was happening during the shuttle run in the following situations on the graph.

    a. When the trend-line was flat (at the top of each curve)

    ____

    b. When the trend-line was most positive (steepest slant from bottom-left to upper-right)

    ____

    c. When the trend-line was most negative (steepest slant from upper-left to lower-right)

    ____

4) What was happening in the shuttle-run as the slope was changing from positive to flat to negative?

____

Acceleration Due to Gravity

Problem: At what rate does and object fall due to gravity?

Materials: 1 ring stand, 1 right angle clamp, 1 test tube clamp, 1 Vernier® Go Motion® sensor, 1 mounting rod, 1 tennis ball, 1 coffee filter, 1 Styrofoam® bowl, 1 computer

Procedure:

1) Set up the ring stand, right angle clamp, test tube clamp, mounting rod, and Vernier® Go Motion® sensor as shown in the figure below.
2) Using the USB cable attached to the motion sensor, connect the sensor to the computer.
3) Open Logger Pro by double-clicking the "Logger Pro 3.4.6" icon on the desktop.
4) Hold the softball underneath the sensor.
5) Press the spacebar to begin collecting data.
6) As soon as the motion sensor begins collecting data (a clicking noise will be heard), drop the softball.
7) Press Ctrl-L to save that run of data
8) In the Data Table window, scroll over until the words "Run 1" can be seen at the top of the data set.
9) Double click on "Run 1"
10) In the window that opens, change the words "Run 1" to softball, then close the window.

11) Repeat steps 4-10 for the bowl and coffee filter, being sure to hold each of these objects open side up.

12) High-light the flat incline (which lasts for approximately 0.25 seconds) on the velocity graph for the softball.

13) Open the Analyze menu and click on "Linear Fit"

14) Record the slope (acceleration) from the window that appears.

15) Repeat steps 12-14 for the bowl and the coffee filter data.

16) Print a copy of your velocity graph with all 3 Linear Fit windows on it.

Data:

Softball Acceleration:____________________

Coffee Filter Acceleration:________________

Styrofoam® Bowl Acceleration:_____________

Conclusion Questions:

1) Describe the position versus time graph for the softball during the drop. (Was it straight or curved? If curved, was it a smooth curve or did the amount of curve change suddenly? Which way did the curve face, up or down?)_______________

____

____

____

____

____

2) What does a curve mean for the slope of a line? ___________________________

____

3) On a position versus time graph, what does the slope of the line represent?

____

____

4) So what is happening if the slope of that line is changing?

Force Demonstration Observations

Force:________________ Agent:________________ Receiver:______________	Force:________________ Agent:________________ Receiver:______________	Force:________________ Agent:________________ Receiver:______________
Force:________________ Agent:________________ Receiver:______________	Force:________________ Agent:________________ Receiver:______________	Force:________________ Agent:________________ Receiver:______________
Force:________________ Agent:________________ Receiver:______________	Force:________________ Agent:________________ Receiver:______________	Force:________________ Agent:________________ Receiver:______________

Static vs. Kinetic Friction

Problem: Which is stronger, static or kinetic friction

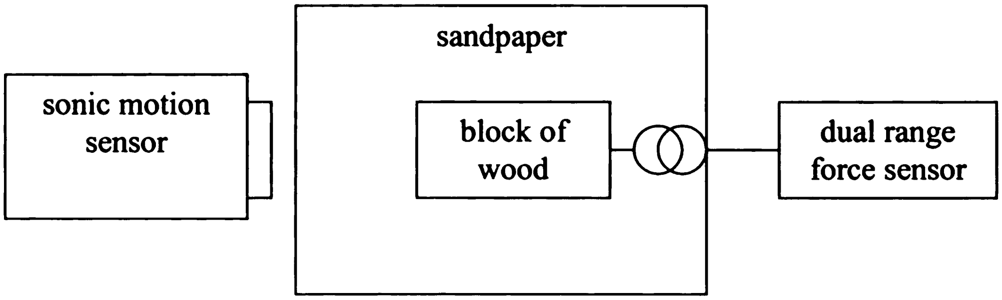
Hypothesis: ____________ friction is stronger because ________________________

____

Materials: 1 computer, 1 sheet of 30 grit sandpaper, 1 block of wood with eye screw, 1 Dual Range Force Sensor, 1 piece of string with loops tied into both ends, 1 sonic motion sensor.

Procedure:

1) Connect the LabPro® unit to the computer, and the dual range force sensor and the sonic motion sensor to the LabPro®.
2) Place one loop of the string through the eye screw (attached to the block of wood), such that by holding the other loop in the air, the string could support the block of wood.
3) Place the piece of wood onto the piece of sandpaper.
4) Place the hook from the dual range force sensor through the free loop of the string.
5) Place the sonic motion sensor on the opposite side of the block of wood from the dual range force sensor, such that the motion of the block of wood can be measured.



6) Turn on the computer.

7) Once Windows® starts, double click on the LoggerPro® icon on the desktop

8) Click on the collect button (green button) in the LoggerPro® window.

9) Slowly increase force, on the dual range force sensor, away from the sonic motion sensor.

10) Once the block of wood has moved, sketch the resulting graphs in the data space below. Be sure to line up where motion started on the distance versus time graph with any significant changes on the force graph. (Did anything special happen, on the force graph, at the instance that the block started to move?)

Data Tables: Sketch the distance versus time graph and the force versus time graphs into the space below. Be sure to follow the instructions outlined in step 10 of the procedure.

Conclusion:

______________________ friction is stronger than ____________________ friction

because ____

____

____

Projectile Motion Lab

Problem: Does a basketball move forward faster during a free-throw as it is approaching the top of the arc, or as it is descending toward the net/floor.

Materials: basketball, digital video camera, computer, LoggerPro® software, meter stick.

Procedure:

This was done for you before class.

1) In an open space setup the camera.
2) Approximately (this depends on the camera used) 10 meters in front of the camera, place the meter stick on the ground so that it is perpendicular to the direction that the camera is facing.
3) Take the basketball and, while have a partner check through the camera, move so that you are just in the left side of the frame, looking down the meter stick.
4) Have your partner start the camera recording.
5) Throw the basketball as you would during a free throw.
6) Stop the camera.
7) Using the USB cable, connect the digital video camera to the computer.
8) Put the camera into VCR mode and rewind the tape that you used to record the basketball shot.
9) Open Logger Pro 3.4.6®

This was done for you before class.

10) Open the insert menu and select "Video Capture"

11) Once the window appears, press play on the camera.

12) Right before you (the one on the camera) shoot the ball, press start capture.

13) Once the ball hits the ground, click stop capture (where the start capture button was).

14) Save file as "Projectile Motion Lab"

15) When you get to your lab station, double click on the Projectile Motion Lab on the desktop.

16) Click on the movie window.

17) Click on the dark square on the upper right corner of the video window and drag to make the video window as large as possible.

18) Click on the "video capture tools" ( ) button at the bottom right of the video window.

19) Click on the "Set Scale" ( ) button on the right bar.

20) Click and drag a line across the entire length of the meter stick (no longer, no shorter) in the video image.

21) Click "OK" in the Scale window that appeared.

22) Click on the "Set Origin" ( ) button on the right bar.

23) Click once at the feet of the person shooting the ball in the video.

24) Click on the "Add Point" ( ) button on the right bar.

25) Click once on the basketball to set a data point. This should advance the video one frame, so once you click the ball should move. If the

ball does not move single click the fast forward button at the bottom left of the frame.

26) Repeat step 25 until the image of the basketball hits the ground.

Data Analysis: The blue data and blue dots represents the ball's y-position and velocity, that is how high off the ground it is and how fast it is moving up and down. The red data and dots represent the ball's x-position and velocity, that is how far forward the ball has moved and how fast it has moved forward.

1) Describe any trend or pattern that you see in the blue dots.__________________

____

____

____

2) What do you think this trend means?_________________________________

____

____

____

3) Describe any trend or pattern that you see in the red dots.___________________

4) What do you think this trend means?_________________________________

Conclusion: Based on your observations, do you think that the balls movement in the y-direction (up and down, the blue data) has any affect on the ball's movement in the x-direction (left to right, the red data). Why do you think so, or not?

Pendulum Lab

Problem: What factors determine the rate of oscillations (swinging back and forth) of a pendulum.

Materials: 1 mass set, 1 spool of string, 1 photogate, 1 computer (with the LoggerPro® software), 1 ring stand, 1 ring clamp, 1 LabPro®.

Question: What variables might affect a pendulums rate of oscillation? ____________

____

Procedure:

1) On the computer, open Logger Pro 3.4.6®
2) Connect the photogate to the LabPro®
3) Connect the LabPro® to the computer
4) Plug in the LabPro®
5) Setup the ring stand and photogate as shown in the picture below.
6) Measure out 3 different lengths of string, each less than 30 cm and each more than 5 cm different from the other 2 (example: 8 cm, 17 cm, and 22 cm).
7) Pick 3 different masses from the mass set.
8) Tie a loop in both ends of each of the strings.

9) Choose one of the strings and drape the string over the ring portion of the ring clamp so that one end is inside the ring, the other end is outside.
10) Pass one end the string through the loop in the other end of the string.
11) Pull the resulting loop tight over the ring stand.
12) Hang one of the masses from the loop in the string hanging from the ring stand.
13) Adjust the height of the ring clamp so that the weight hangs in the laser path of the photogate.
14) Pull the mass back so that, with the string taught, it is 10 cm higher than the point where the weight passes through the photogate.
15) Press the spacebar to start collecting data.
16) Release the mass and allow it to swing freely until it has passed through the photogate 10 times.

Question: What did you notice about the amount of time that each swing took?

____

Find the average time that a swing of the pendulum took and record it on your data table.

17) Repeat steps 12-17 for each of the masses
18) Repeat steps 9-18 for each of the strings

Data Table:

		Length of String (cm)		
		____________cm	____________cm	____________cm
Amount of Mass (g)	____g	Average time per swing (s)	Average time per swing (s)	Average time per swing (s)
	____g	Average time per swing (s)	Average time per swing (s)	Average time per swing (s)
	____g	Average time per swing (s)	Average time per swing (s)	Average time per swing (s)

Conclusion:

1) What determines the pendulums rate of oscillation? ______________________

____

2) How do you know? ____

____

____

____

____

____

____

____

Momentum Lab

Problem: What factors affect the momentum of an object?

Background: Though this will change (become more technical) as your understanding of physics deepens in the future, a good definition of momentum would be a measurement of how hard it is to stop a moving object. It is momentum that allows a bullet or an arrow to do its job, it is momentum that keeps a baseball moving. It is momentum that makes a car accident so dangerous. But, what factors determine how much momentum an object has?

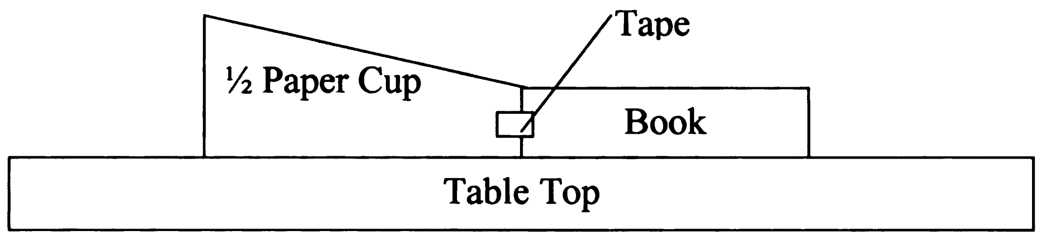
Hypothesis:____

____

Materials: 1 ping pong ball, 1 racquet ball, 1 1" steel ball bearing, 1 1.5 m piece of furniture molding, 1 meter stick, 3 pieces of masking tape, 1 (preferably old) paperback book, one pair of scissors, 1 ring stand, 1 test tube clamp, and 1 restaurant-style paper cup.

Procedure:

1) Using the pair of scissors, cut the paper cup in half lengthwise.
2) Tape either side of one half of the paper cup to the spine of the book and place the book on the desk so that the cut side is down... see illustration below



3) Place the ring clamp at the end of the table.
4) Attach the test tube clamp to the ring stand so that the clamp is 40 cm above the base, is lined up parallel to the end of the table, and the clamp can grasp a rod (or piece of molding) that is slanting from the center of the table to the claw of the test tube clamp.
5) Lay down a piece of masking tape 120 cm from the base of the ring clamp. This will mark where the cup opening and the end of the molding/ramp are to be placed.
6) Place the molding so that 1 end of the molding is in the jaws of the test tube clamp and the other end is resting on the table at the line of masking tape.
7) Tighten the test tube clamp to hold the molding in place.
8) Measure 50 cm up along the molding from where the molding meets the table and make a mark. (Depending on your class hour, this may already be done for you)
9) Repeat step 8 at 100 cm.
10) Place the book/cup assembly so that the opening of the cup is on the piece of masking tape and open toward the ramp that you have now created out of the molding.
11) Place the ping pong ball at the 50 cm mark on the ramp.

12) Release the ping pong ball, allowing it to roll down the ramp.

13) Measure how far the ping pong ball has pushed the book/cup assembly by measuring the distance from the tape to the opening of the cup.

14) Return the book/cup assembly to its original position (before the ball moved it).

15) Record the distance that the book/cup assembly moved.

16) Repeat steps 11-15 for each of the balls at 50 cm

17) Repeat steps 11-15 for each of the balls, but at 100 cm this time.

Data Sheet:

	50 cm of the ramp	100 cm on the ramp
Ping pong ball		
Racquet ball		
Steel ball bearing		

Conclusion Questions (remember to answer in complete sentences:

1) a) What difference, if any, was made by releasing the balls from **different lengths** on the ramp?

b) If there was a difference, why do you think this difference was there?

2) a) What difference, if any, was made by having **different types** of balls?

b) If there was a difference, why do you think this difference was there?

3) a)Was your hypothesis correct or incorrect?

b) How is this conclusion supported by the data?

Work Activity

Background: By this point in the year, you've all said it, "School is too much work!". Actually, school is not much work at all. The only real work that you are doing is hauling yourself and your materials from one room to another (and, occasionally, your locker). This is because, while the social definition of work is anything that requires effort (and I use even this term loosely), the science definition of work is force acting over a distance to move an object. So, from a science point of view, you are doing a more work when you are going to a football game than you do in your average day at school (and that's including ALL of the force you exert when moving a pencil tip across a piece of paper).

Problem: Determine how much work is needed to get the entire class to the top of the Junior High football stadium bleachers.

Questions?

1) When looking for work, the two factors that we much consider are

   ________________________ and _________________________.

2) Explain how we could find each of the factors from question 1, note that we need to correct (metric) units for our measurements.

Factor 1:

Factor 2:

Calculations:

1 lb = 4.448 N

Work required to get the entire class to the top of the stadium

bleachers:____________________________

Student Number	Weight (lbs)	Weight (N)
1	194	
2	93	
3	185	
4	94	
5	114	
6	92	
7	184	
8	141	
9	84	
10	89	
11	120	
12	190	
13	157	
14	106	
15	98	
16	149	
17	199	
18	143	
19	128	
20	179	
21	144	
22	170	
23	128	
24	185	
25	182	
26	143	

The Unconventional Potential Energy Lab

Background: When most people think about potential energy, they think of gravitational potential energy, the energy of an objects position above the ground. However, there are several kinds of potential energy: gravitational potential energy, nuclear energy, and chemical energy, to name a few. Potential energy is really just energy that is stored waiting to do something. In the case of gravitational potential energy, this could be work done on the air that the object passes through as it falls, or work on the thing that the object lands on; in the case of nuclear and chemical energy, this could be work done heating the water molecules in a power plant, or the work done on a city when a bomb explodes.

Problem: How much energy does is released by a gram of $CaCl_2$ dissolving in water?

What form is this energy released in (really, transformed into)? ____________

How could we measure this? ____

Materials: 2 Styrofoam cups, 1 lid for Styrofoam cup, 1 400 ml beaker, 1 temperature probe, 1 computer, 20 g $CaCl_2$, 300 ml of water, 1 100 ml graduated cylinder, 1 metric scale (capable of measuring grams), 1 sheet of weigh paper or 1 weigh pan, 1 chemical scoop.

Procedure:

1) Plug the temperature probe into the USB port on the computer.
2) Turn on the computer (if it was not already on).
3) Open Logger Pro by double-clicking on the "Logger Pro 3.4.6" icon.
4) Place 1 Styrofoam cup into the other Styrofoam cup.
5) Place the Styrofoam cups, opening up, into the 400 ml beaker.
6) Using the graduated cylinder, measure out 100 ml of water and pour it into the Styrofoam cups.
7) Repeat step 6 for a second and third 100 ml of water.
8) Place the weigh paper on the scale and zero the scale. (If you are unable to zero your scale see weighing procedures below).
9) Place $CaCl_2$ on to the weigh paper, a little at a time, using a chemical scoop, until the scale reads 25g.
10) Record actual mass of $CaCl_2$ (I will be very surprised if you get exactly 25g)
11) Pass the probe end of the temperature probe through the straw hole in the lid.
12) Press the spacebar to begin collecting data.
13) Take an initial measurement of water temperature using the temperature probe
14) Pour the $CaCl_2$ into the water.
15) Place the lid onto the Styrofoam cup, making sure that end of the temperature probe is immersed in the water/$CaCl_2$ mixture.
16) Wait until the water attains a new stable temperature (some swirling, as you would a cooling cup of coffee, may be needed to speed up the reaction).
17) Print copies of both the graph produced and the data table for each group member.

Weighing Procedure:

1) Place weigh paper on the scale.
2) Find and record the mass of the weigh paper.
3) Add 25g to the mass of the weigh paper to find the target mass of $CaCl_2$ and weigh paper.
4) Add $CaCl_2$ to the weigh paper until target mass is reached.
5) Record actual mass chemical and paper weighed.
6) Subtract the mass of the weigh paper to find the actual mass of chemical.

Data:

Mass of weigh paper: ________________

Mass of weigh paper and $CaCl_2$: ________________

Initial Temperature: ________________

Final Temperature: ________________

Volume of water used: ________________

Data Analysis (calculations):

Weighing without zeroing:

_________________ + 25 grams = _______________

Mass of Weigh Paper   Target Total Mass

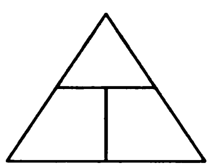
_________________ - _________________ = _________________

Actual Total Mass   Mass of Weigh Paper   Actual Mass of $CaCl_2$

Energy Calculations: For this lab, we will be finding the amount of energy released in calories and then converting this to Joules. Note that a calorie is the amount of energy required to raise the temperature of 1 gram of water 1 degree Celsius. Also note that the calories listed on the packages of food that you eat are measured in Calories (big C), these are actually kilocalories or 1,000 calories.

Mass of Water: Use the formula and the triangle below to calculate the mass of water that you used. Remember that the density of water is 1 g/ml (show your work)

$$Density = \frac{Mass}{Volume}$$



___________=

Mass of Water

Temperature Change:

__________________ - __________________ = __________________

Final (highest) Temp. Initial Temp. Temperature Change

Energy Released:

__________________ X __________________ = __________________

Mass of Water Temperature Change Amount of Energy Released (calories)

__________________X 4.184 J/cal =__________________

Energy Released (calories) Energy Released (joules)

______________÷______________=__________________

Energy Released Mass of $CaCl_2$ Energy Released per gram $CaCl_2$

Describe the energy changes that took place during this lab activity. ________________

____

Off to the Races

The first lab of our force and motion unit is about measuring motion. One of the most basic ways of examining motion is by looking at the speed of an object, or how far an object (or person) moves over a certain amount of time.

Problem: Who is the fastest person in this period of Physical Science?

Hypothesis:____

____

____

Student Procedure: The data collection system is setup on our course with photogates at 0m, 1m, 2m, and at the 10m turn. By this point the course has had a chalk line laid down for the runners to follow.

1) Decide which 2 people in your lab group will run and who will be in charge of controlling the data gathering system.

   Runner 1:______________________________

   Runner 2:______________________________

Data Gatherer 1:____________________________

Data Gatherer 2:____________________________

Data Gatherer 3:____________________________

2) Have runner 1 approach the course.
3) Have a data gatherer press the collect button in LabPro (data gathering software), and then tell the runner to start.
4) The runner will the run as quickly as possible, following the chalk line from the start/finish, around the 10m marker, and back to the start/finish.
5) The data gatherer will then save the data gathered as a file with the students name, in the folder designated for their class period.
6) Repeat for all runners in each group.
7) Once the data has been loaded on to the groups computer by the teacher, open the file for the members of that group.
8) Copy the data for a group member (does not need to be the same for all group members) to data table for analysis.
9) Print a copy of the appropriate runners graph for each group member as needed (be sure to staple this to you lab paper)

Data Table for ______________________________:

Distance Run	Time	Calculations	Velocity
0 m			
1 m			
2 m			
10 m			
18 m (2 m timer again)			
19m (1 m timer again)			
20 m (start/finish line)			

1) Explain what happened on the graph as the runners speed increased; as his speed decreased. (How is speed shown on the graph?)

____

2) Do the velocities that you calculated agree with graph? Why or why not?

____

3) Why do you think the first 3 and last 3 gates are so close together?______________

____

4) What would happen if they were further apart (at 0, 3, and 6 meters, instead of 0, 1, and 2 meters?____

____

Teacher's Preparations: Off to the Races

Materials:

chalk

1 10 meter or greater metric tape measure

4 Vernier photogates

1 Vernier LabPro

7 digital extension cables

8 desks or tables of uniform height

4 red laser pointers

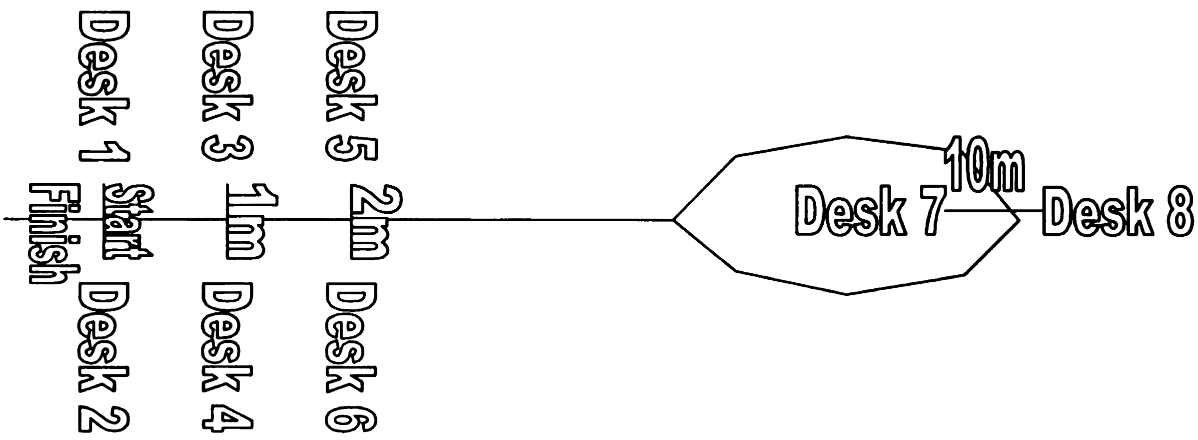
1 computer

1) Find a location suitable for a 10 meter sprint, preferably on asphalt or cement.

2) Using the chalk and tape measure, draw a 20 m race path, such that the path starts and ends at the same point, loops back at the 10 m mark, and otherwise follows the exact same path… see diagram below.

3) At the start/finish line, the 1 m line, and the 2 m line place a pair of desks or tables so that 1 is on each side of the path, about 2 m from the path, and so that the desks are both the same distance from the starting line.

4) At the 10 m turn, place one desk on the inside of the turn, about 2 m from the turn, and one desk on the outside of the turn, about 2 m from the path.



5) Set up the computer and Labpro on desk 3

6) Set up the photogates on desks 1, 3, 5, and 8 and connect these to the Labpro using any extension cables necessary to keep the cables on the ground and out of the race path.

7) Set up the lasers on desks 2, 4, 6, and 8 so that the beams cross the race path and activate the photogates.

Orienteering Activity

In previous lessons we have talked about speed as a change of distance over a certain amount of time, but this is not the same as velocity. In order to have velocity you need to add a direction to your speed. Back before the earth was fully mapped and explored, the practice of orienteering was a common skill. Whether it was using the stars as early explorers did or simple compasses as those before them did, the ability to find your way around without a map was a very important skill.

An orienteering course is very similar to the set of directions that you might give a friend for getting from the school to your house. In fact, the only main difference is that an orienteering course does not necessarily involve any roads or other landmarks... but to be fair, landmarks were often used before as they make the task much easier.

Your grade for this lab comes in two parts: one part is measurement and calculation, from finding the length of your pace to calculating your ***average*** velocity for each leg. The other part comes from how close you are to the end point of the course when you reach what you think is the end of the course (It will not be marked for you, I will measure it once your groups have competed the course).

Materials:

1 Orienteering Course

1 Compass

1 10+m tape measure

1 calculator (very helpful, but not absolutely necessary)

1 meter stick

1 stopwatch

1 numbered yard marking flag

Part 1: Finding your pace.

1 pace = the distance you cover every time your left foot hits the ground.

1) Have the each group member approach the start line of the ten meter distance.
2) Have the each person walk the 10 meters, starting with their right foot and count every time their left foot hits the ground.
3) When the person's left foot goes beyond the 10 m line, have them stop and measure the extra distance (from the line to their left foot) with a meter stick.
4) Fill in and perform the calculation below to find the length of a single pace.

$$LengthofPace = \frac{TotalDist.}{\#ofPaces} = \text{-------------} =$$

Part 2: Orienteering Course

1) Pick the group member whose pace you will be using, who will be keeping track of data, and who will be keeping time.
2) On your Orienteering Course Sheet, convert the distance given to a number of paces for each step by dividing the distance, the length of your pace that you calculated in part 1.

$$\#ofPaces = \frac{Dist}{LengthofPace} = \text{----------} =$$

3) Go with the class to the starting stake on the field.
4) Have your group's time keeper start the stopwatch.

5) Turn the dial on the compass to the first bearing (the number of degrees listed on that leg of the orientation course).
6) Pacer: Hold the compass to your chest so that the arrow outside the dial is facing straight out ahead of you.
7) Turn until the arrow indicating magnetic North lines up with the arrow inside the dial.
8) Take the calculated number of paces.
9) Stop the stopwatch and record time.
10) Repeat steps 3-9 for each leg of the orienteering course.
11) Plant your group's flag on the spot where you ended the orienteering course.
12) Call the teacher over to measure how far your group was from the projected ending point and assign grade (relax, this is a small part of the actual grade).

<u>Conclusion Questions</u>

1) On your orienteering course, calculate your average velocity for each leg.
2) Were these the actual velocities that you were traveling at? Why do you say that?

____

3) Explain what kinds of problems you might have had you not had directions.

____

Orienteering Data and Calculations Sheet　　　　Group Number: __________

Bearing	Distance	Number of Paces	Time Elapsed	Velocity

Distance from Projected Target:

0m	2m	4m	6m	8m	10m
← 5pts		4pts	3pts	2pts	1 pt →

Teachers Preparation: Orienteering Activity

1) Using Masking tape and a tape measure, measure out a 10 path for students to use when calculating their pace (1 such path for each group is recommended, so setting this up outside works better)

2) As the area in which any teacher might do this lab will be different, each teacher will need to construct their own orienteering course, ideally a separate and distinct course for each group.

    a) Identify a starting point for all courses, and an ending point for each course (this makes it more complex for you, but will insure that the student don't go off and tell their peers about the end points, and if they do, it is unlikely that their friends will get the same orienteering course)

    For each course:

    b) Starting at the starting point, use the tape measure (the kind used by the track team for measuring the long jump and the triple jump) to measure a random distance in a random direction. Make note of both the distance and direction.

    c) Mark the end of the leg

    d) Repeat steps b and c for the next 4 legs being sure to start and the end of the previous leg.

    e) For the final leg, measure and record the distance and bearing to your intended destination. This spot should not be obvious, an intersection of lines on the field, or a certain distance a long a line from such an intersection will work well.

Kinetic Energy Lab

(Inspired by a Lab from Physics With Computers)

Purpose: Determine what factors affect the kinetic energy of an object.

Materials:		
	1 physics car with sonic target	1 1.5x0.5m wooden board
	2 200g weights	3 text books
	1 small (paperback) book	1 motion sensor
	1 computer	1 role of masking tape
	1 spring scale	1 meter stick
	1 binder	1 meter stick

Thought Questions:

1) What factor did adding the weights to the cars change?
2) What factor did changing the slope of the ramp change?

Procedure:

1) Using the spring scale, find the mass of the physics car
2) Place one text book at the end of the lab table.
3) Place the small book on top of the textbook.
4) Place the wooden board so that one end rests on the textbook (but not on the small book) and the other end rests on the table, creating a ramp.
5) Connect the motion sensor to the computer.
6) Place the motion sensor on top of the small book.
7) Aim the motion sensor so that it detects motion going down the ramp.
8) Place a line of tape 10 from the base of the ramp.

9) Place the binder on the desk so that the spine of the binder lines up with the tape line at the base of the ramp.
10) Open Logger Pro on the computer.
11) Place and hold the physics car at the top of the ramp.
12) Press the spacebar and wait for the computer to begin collecting data.
13) Release the physics car.
14) When the car and the binder have ceased motion, use the data gathered by the computer to determine the velocity of the physics cart on impact (record this data)
15) Measure how far the binder was displaced by the impact with the binder by measuring the distance from the tape line to the spine of the binder (record this data)
16) Repeat steps 12-15 with 1 and then 2 of the 200g weights taped to the car.
17) Repeat steps 12-16 for a ramp supported by 2 textbooks, and then 3 textbooks.

Data Tables:

		Number of Textbooks		
		1	2	3
Moving Object	Physics Car + 2 200g weights Mass:______	Distance: Velocity:	Distance: Velocity:	Distance: Velocity:
	Physics Car + 1 200g weight Mass:______	Distance: Velocity:	Distance: Velocity:	Distance: Velocity:
	Physics Car Mass:______	Distance: Velocity:	Distance: Velocity:	Distance: Velocity:

Data Analysis: Using the graphing areas below, make a graph of velocity versus the amount the binder moved, and mass versus the amount the binder moved.

Questions (be sure to answer in complete sentences):

1) Was work being done on the binder? How do you know?

2) Which factor, velocity or mass, had a greater effect on the movement of the binder? Why do you think so?

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