

IMPROVING STUDENT ACHIEVEMENT, INTEREST AND CONFIDENCE
IN SCIENCE THROUGH THE IMPLEMENTATION OF THE 5E LEARNING CYCLE
IN THE MIDDLE GRADES OF AN URBAN SCHOOL

by

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ABSTRACT

The purpose of this investigation was to ascertain if the implementation of the 5E learning cycle model in lesson planning and lesson presentation could improve student academics, interest and confidence in science. The 5E learning cycle model consists of five phases of teaching: engage, explore, explain, elaborate, and evaluate. The phases are not linear and can be taught in a dynamic approach to address demonstrated student comprehension of the content.

During this investigation, students completed an interest survey every six weeks and completed pre- and post-tests throughout the treatment period. The treatment consisted of an Illinois State Achievement Test (ISAT) preparation unit and three mini-units: atoms, force and motion introduction, and speed and motion graphing. There were slight gains noted in student self-expressed interest and confidence in science throughout the treatment period and school year, and student self-expressed interest and confidence fluctuated. Interest in a science career demonstrated the greatest gain. Students also demonstrated small gains within the mini-units. However, greater gains were achieved and noted within the ISAT preparation unit, especially when compared to a traditionally taught classroom. Within this research project, it was determined that the 5E model has the potential to improve student academics, interest and confidence in science, when implemented properly and with dedication and fidelity.

INTRODUCTION AND BACKGROUND

Project Background

Teaching and Classroom Environment

I am a third year science teacher at Colin Powell Middle School in Matteson, Illinois, where I currently teach seventh grade science. Colin Powell Middle School is in the Matteson School District #159 and is located in southern Cook County in Illinois. Colin Powell Middle School is an urban middle to low-income school. According to the *Interactive Illinois Report Card* (2011), the ethnicity of the students is 92.2% African American, 3.2% White, 2.9% Hispanic, 2.1% Multi-racial, 0.4% Asian, and 0.1% Native American. Fifty-nine percent of the students at Colin Powell are on the free or reduced lunch program. The total school population is approximately 800 students, 265 in sixth grade, 285 in seventh grade and 250 in eighth grade. There are two science teachers in each grade level. Our school also houses self-contained special education classes.

I teach 141 students in five class periods that are 40 minutes in length; my average class size is 28 students. Intermingled in my classes are English language learners, learning disabled resource, Response to Intervention, and special education inclusion students.

Our district is struggling to make adequate yearly progress (AYP) in reading and math Illinois State Achievement Test (ISAT) scores. Therefore, the primary educational focus in grades kindergarten through fifth grade is on reading and math. Social science and science are not taught with consistency in the early grades. Colin Powell Middle School made overall AYP in reading and mathematics on the 2010 ISAT test, with the

seventh grade students meeting or exceeding standards in reading by 79.6% and math by 79.7% (Interactive Illinois Report Card, 2011). Science was not evaluated for AYP in 2010. The AYP goal for the 2011 ISAT scores is for 85% of the students to meet or exceed standards.

In seventh grade students are prepared to meet ISAT goals through science lessons and activities. The students learn the metric system, the scientific process, lab safety, ecological awareness, force and motion, and space science. The students are also expected to gain content knowledge on standards-based earth, physical and chemical science concepts through a one day a week activity based upon ISAT preparatory material. Three weeks prior to ISAT testing, all lessons and activities are intensely focused on ISAT preparation, review and success. The entire focus of the seventh grade curriculum map is on meeting and exceeding ISAT goals.

Focus Question

I am highly motivated to help my students succeed in science. Science at Colin Powell has been taught in the traditional manner of reading the book, lecture/taking notes, completing worksheets, the use of a lab or activity as a culminating assignment and a final test. I have noted a disconnection between the science content the students were taught last year and their recall of that information this year. When asked to recall their favorite part of sixth grade science in a bell work question at the beginning of this school year several students reported the “dissection of a frog” as their favorite. Other stated that the “rollercoaster thing” was their favorite. However, when asked what they learned in that lab or activity, very few of the students were able to recall science content

information in relation to the lab or activity. At the beginning of this school year, my students demonstrated a lack of interest and motivation in science and the general scientific literacy deemed necessary to be competitive in today's global community.

I first became intrigued by the 5E learning cycle model in the summer of 2009. I saw the potential for it to help improve my students' interest and motivation in science, while also helping the students retain content information. I implemented a unit on measurement using the 5E learning cycle model as an assignment for a graduate course at Montana State University. Throughout the unit, I noted an improvement in student achievement and interest. I continued to use the 5E learning cycle model in developing unit and lesson plans throughout the year, and I continued to see gains in student comprehension of content material. I began to wonder if implementing the 5E learning cycle could help my students improve their overall science content knowledge, process skills, and interest in science to help my students achieve greater success in science.

Therefore, the purpose of this action research-based project was to determine the impact of the 5E learning cycle model on student achievement, interest, and student measured self-confidence in a science classroom within a middle/low income urban school district. My focus question was "Can student achievement, interest and self-expressed self-confidence be improved in science through the use of the 5E learning cycle model?" I also addressed the following sub-question: Will lessons and units written and implemented using the 5E learning cycle model increase and encourage student interest in science as a career?

CONCEPTUAL FRAMEWORK

In an environment of high stakes testing with an emphasis on closing the achievement gap, teachers, administrators, curriculum developers, educational organizations and governmental agencies search for methods to improve educational instruction in the urban classroom. The achievement gap between white and black American students is most evident in American urban school districts (Lewis, James, Hancock, & Hill-Jackson, 2008). The low standardized test scores in the urban schools signal a need for large scale urban educational reform (Emdin, 2008; Johnson & Marx, 2009; Rivet & Krajcik, 2004).

Yet, urban schools are often faced with numerous obstacles, such as limited resources, a lack of highly qualified teachers, overcrowding of classrooms, and student attendance issues (Buck, Cook, Quigley, Eastwood & Lucas, 2009; Johnson & Marx, 2009; Lee & Buxton, 2008; Rivet & Krajcik, 2004). These factors can create or contribute to other obstacles, such as ineffective instructional methods used by teachers in urban environments. As noted by Johnson and Marx (2009), teachers in urban districts often create teacher-centered educational settings, “where students are encouraged to be passive acceptors of education and teachers become authoritative disciplinarians” (p. 116). In contrast, research suggests that students, especially students in urban environments, are more successful when they take a more active part in their education and the classroom environment becomes more student-centered (Burke, 2007; Emdin, 2008; Johnson & Marx, 2009; Lee & Buxton, 2008; Rivet & Krajcik, 2004).

An additional consideration in urban education is the student attitude or connection to the science content being taught in the classroom (Buck et al., 2009;

Emdin, 2008). Students in urban districts often experience disconnection between the content area being taught and the students' authentic lives (Burke, 2007; Emdin, 2008; Johnson & Marx, 2009; Lee & Buxton, 2008; Timperley & Parr, 2007)). Emdin (2008) argued that cultural differences between classroom science instruction and urban students help create the disconnect, while Burke noted "how cultural norms and experiences are embedded in science content creating schisms between students, teachers, schools, and learning" (p. 358). Students in urban school districts are often disengaged from science as it is taught to them in the urban teacher-centered classrooms. Evidence of this can be found in the lack of student participation in the science classrooms, low standardized tests scores and the low numbers of urban students that pursue careers in science. Urban students are not engaged in science, and educators need to ask what can be done to gain their interest (Emdin, 2008).

Educators need to help urban students form connections between classroom science and the student experiences of living in an urban environment (Burke, 2007; Emdin, 2008; Johnson & Marx, 2009). One strategy for helping students make connections between classroom science and personal experiences is the 5E learning cycle instructional model. According to Llewellyn (2007), the 5E model can help "students move from concrete experiences, to the development of understanding, to the application of the principles" (p. 135). The 5E model consists of five phases of instruction within the learning cycle: engagement, exploration, explanation, elaboration, and evaluation (Bybee, 2009; Bybee et al., 2006a; Bybee et al., 2006b; Bybee, 2002; Chiapetta & Koballa, 2006; Coe, 2001; Ergin et al., 2008; Turk & Calik, 2008; Volkman & Abell, 2003). The 5E model begins with the *engagement* phase. Within this initial phase, teachers seek to gain

student interest to solve a problem in a manner that enables the student to connect past activities to future activities, while allowing the teacher to assess prior knowledge. If done successfully, the engagement phase creates curiosity and a desire within the student to learn more on the topic presented (Bybee, 2009; Bybee et al., 2006a; Bybee et al., 2006b; Bybee, 2002; Coe, 2001; Turk & Calik, 2008; Urey, 2008; Volkmann & Abell, 2003). This curiosity and student interest can also be created through the use of discrepant events during the engagement phase. According to Llewellyn (2007), “discrepant events serve to create cognitive dissonance,” because the students cannot easily explain the event in consideration of their prior experiences or knowledge (p. 136). Discrepant events lead to cognitive dissonance as the learners are attempting to place the event into their prior schema or current understanding of a concept. According to Moyer, Hackett, and Everett (2007), cognitive dissonance or disequilibrium is a “puzzlement” that the students arrive at when “the explanation used for an earlier experience just does not seem to fit with a new experience” (p. 7). To establish a resolution with their puzzlement, students need to modify their previous conceptions or misconceptions to fit the new experience. Discrepant events can quickly activate the students’ interest and desire to learn more (Llewellyn, 2007).

Once the students are engaged, they require time to explore the questions or problems raised within the engagement phase. The *exploration* phase consists of hands-on activities, labs, class discussions, and the use of other skills that enable conceptual change through student preliminary investigations. Throughout the exploration phase students generate new ideas linked to their prior experiences (Bybee, 2009; Bybee et al.,

2006a; Bybee et al., 2006b; Bybee, 2002; Coe, 2001; Turk & Calik, 2008; Urey, 2008; Volkmann & Abell, 2003).

Confirmation of the students' newly acquired knowledge is accomplished in the *explanation* phase. The student is provided with an opportunity to compare what they have learned to the teacher presented concepts during the explanation phase. During this phase, a teacher has a responsibility to present scientific terms, content information and scientific language to the students. This phase also enables students an opportunity to develop their own explanations to an event or problem (Bybee, 2009; Bybee et al., 2006a; Bybee et al., 2006b; Bybee, 2002; Coe, 2001; Turk & Calik, 2008; Urey, 2008; Volkmann & Abell, 2003). According to Llewellyn (2007), "the Explanation stage is the appropriate time for teacher-led instruction" in the form of "guided instruction, short lectures, audiovisual resources, online sources, and computer software programs" (p. 136).

Within the *elaboration* phase students have an opportunity to apply their new knowledge in ways that are meaningful and applicable to their real-lives. Teachers challenge their students to broaden and deepen their understandings through additional activities, while their students extend their conceptual knowledge on the topic (Bybee, 2009; Bybee et al., 2006a; Bybee et al., 2006b; Bybee, 2002; Coe, 2001; Turk & Calik, 2008; Urey, 2008; Volkmann & Abell, 2003). The elaboration phase is also referred to as the extension or extend phase (Balci, Cakirogluss & Tekkayass, 2006; Eisenkraft, 2003).

Finally, students are encouraged to assess their understanding and their progress in gaining new skills and knowledge within the *evaluation* phase. The evaluation phase also provides the teacher an opportunity to monitor student progress through formative

and summative assessments (Bybee, 2009; Bybee et al., 2006a; Bybee et al., 2006b; Bybee, 2002; Coe, 2001; Turk & Calik, 2008; Urey, 2008; Volkmann & Abell, 2003).

The 5E model is built upon the educational philosophy and psychology of Johann Herbart (Bybee, 2009; Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook & Landes, 2006a; Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook & Landes, 2006b). Herbart's pedagogical model stated that students need to build new knowledge based upon and connected to prior knowledge to enable the formation of new concepts (Bybee et al., 2006a; Bybee et al., 2006b). Students come to learning with their prior conceptions of how things work, and this prior knowledge influences how the students learn new concepts, skills and ideas (Balci, Cakirogluss & Tekkayass, 2006; Bybee, 2009; Bybee et al., 2006a; Bybee et al., 2006b; Bybee, 2002; Collins, 2002; Powell, Short & Landes, 2002; Rivet & Krajcik, 2004; Taylor, et al., 2007). The 5E model of instruction is also based upon earlier learning models that incorporate these concepts and that have been a part of educational theory for years, such as those of Piaget and Dewey (Bybee, 2009; Bybee et al., 2006a; Bybee et al., 2006b; Taylor, et al., 2007).

According to Bybee, et al. (2006a) the 5E model is a "direct descendant of the Atkin and Karplus learning cycle proposed in the early 1960s" that was incorporated into the Science Curriculum Improvement Study (SCIS) program (p. 2). The SCIS learning cycle model consisted of three stages: exploration, invention and discovery (Bybee et al., 2006a; Bybee et al., 2006b; Chiapetta & Koballa, 2006; Coe, 2001; Everett & Moyer, 2009). The BSCS 5E model incorporates two additional phases to the SCIS program – engagement and evaluation (Bybee et al., 2006a; Bybee et al., 2006b).

Among the models recommended for teaching within a constructivist learning theory, the 5E model is the best known (Ergin, Kanli & Unsal, 2008). According to Llewellyn (2007), the constructivist learning theory “is founded on the premise that we search for and construct meaning from the world around us” (p. 55). In the constructivist learning theory, students construct and reconstruct information as they process it in relation to their prior knowledge and experiences (Llewellyn, 2007). According to Llewellyn, the 5E model and the constructivist learning theory both place emphasis on the “cognitive aspects internal to the learner” (p. 56).

As stated in *A Comparative Study of 5E-Based and Commonplace Materials and Teaching* (2009) it was determined that “commonplace science instruction led to a significant achievement gap by race, whereas 5E-based instruction did not” (p. 45). The use of the 5E model of instruction helped students, regardless of race, ethnicity, or gender reach higher academic achievements than students in traditional or commonplace instructional environments (Wilson, 2009). According to Magharious and McCracken (2009), the 5E model “may provide a useful framework for the development of meaningful inquiry-based learning experiences that include a culturally-responsive component” (p. 17). The 5E model may help bridge the cultural divide that can be found in the urban science classroom.

As noted by Chiapetta and Koballa (2006), the 5E model, as an “inductive approach” to learning, provides a method whereby students learn and discover science through their personal explorations (p. 150). As defined by Chiapetta and Koballa, an “inductive approach provides students with learning situations in which they can discover a concept or principle through experiences in the laboratory, field, or classroom” (p. 150).

The inductive approach to learning provides the students a concrete experience to build upon with their newly acquired knowledge (Chiappetta & Koballa, 2006).

Everett and Moyer (2009) stated that “science is more than doing activities” – it is actively engaging students in the language and processes of doing science (p. 48). More importantly, according to Gallenstein (2003), as learning occurs within the 5E model, students take “ownership of math and science concepts and appear to be more comfortable with their mathematics/science abilities” (p. 33). Within the 5Es, students are actively involved in the acquisitions of science content knowledge and developing scientific processes and skills in meaningful ways, which allow them to connect this new information to their prior knowledge (Bybee et al., 2006a; Bybee et al., 2006b; Bybee, 2002; Chiappetta & Koballa, 2006; Gallenstein, 2003; Powell et al., 2002).

The effectiveness of the 5E model has been documented in numerous reports (Balci et al., 2001; Bybee, 2009; Bybee et al., 2006a; Bybee et al., 2006b; Coe, 2001; Ergin et al., 2008; Powell et al., 2002; Taylor et al., 2007; Turk & Calik, 2008; Urey, 2008; Volkmann & Abell, 2003; Wilson, 2008). Research has indicated that student attitudes toward science improved through the use of the 5E model (Balci et al., 2006; Bybee, 2009; Bybee et al., 2006a; Bybee et al., 2006b; Ergin et al., 2008; Taylor et al., 2007). The 5E model has been proven to motivate students in learning, while helping students to develop higher level thinking skills in science (Balci et al., 2006; Bybee et al., 2006a; Bybee et al., 2006b; Ergin et al., 2008). Finally, the 5E model has proven to contribute positively to students’ academic achievement in science (Balci et al., 2006; Bybee et al., 2006a; Bybee et al., 2006b; Ergin et al., 2008). If teachers used the 5E model with a medium or high level of fidelity, their students achieve a higher post test

achievement score than students whose teachers maintained a low fidelity (Bybee et al., 2006a; Bybee et al., 2006b; Taylor et al., 2007).

The 5E model has potential applications within a number of educational domains, including:

- State science frameworks
- School district science frameworks
- Institutes of higher education – general courses
- Institutes of higher education – teacher education
- Curriculum (e.g. textbooks, units, modules)
- Specific lesson plans
- Informal education (e.g., museums, media)
- Professional development opportunities
- Non-science disciplines
(Bybee et al., 2006a; Bybee et al., 2006b)

Bybee et al. (2006a) noted that the BSCS 5E Instructional Model has become the instructional model for a vast amount of teaching material used in teaching science, “and consequently, has had a vast impact on the teaching and learning of science throughout the United States and internationally” (p. 13). In a *Report Prepared for the Office of Science Education National Institutes of Health* prepared by Bybee et al. (2006b), it was noted that a Google search of 5E model produced more than 235,000 lesson plans implementing the 5E model, more than 73,000 examples of universities mentioning the 5E model in syllabi, more than 131,000 examples of teacher educational programs or resources listed that use the 5E model, and 3 states endorse the use of the 5E model of

instruction. The 5E model is based upon effective and proven educational theories and has an expanding base of research to support its use in the classroom (Balci et al., 2006; Bybee et al., 2006a; Bybee et al., 2006b) to improve science education and to help teachers and students meet the high expectations of the high stakes testing environment.

Urban schools face many challenges. The 5E model of instruction may help teachers overcome some of those challenges, such as a lack of student interest in science or the inability of students to relate to the content being taught in the science classrooms. The effective and consistent use of the 5E model may help teachers address some of these and other deficits in urban education. Through the effective use of the 5E model, teachers can create classroom environments where students take an active role in their education, which is a necessary component for successful urban education (Emdin, 2008; Johnson & Marx, 2009; Lee & Buxton, 2008; Rivet & Krajcik, 2004; Timperley & Parr, 2007). Through the use of the 5E model, teachers can also encourage the development of problem solving skills and meaningful conceptual understandings, which is another necessary component of successful urban education (Buck et al., 2009; Johnson & Marx, 2009; Lee & Buxton, 2008; Magharious & McCracken, 2009; Rivet & Krajcik, 2004). According to Rivet and Krajcik (2004), good teaching practices in urban schools encourage students to solve problems “that are of interest to them and to construct objects and perform experiments, reflect on real-life experiences, and access information through technology” (p. 672). The consistent and effective use of the 5E learning cycle model may be the first step to eliminating the achievement gap in science education.

METHODOLOGY

Treatment

The treatment and data collection for this study began in September 2010 and concluded in April 2011. The research methodology for this project received an exemption by Montana State Institutional Review Board and compliance for working with human subjects was maintained (Appendix A). The 5E model was used throughout the school year. The treatment periods evaluated for this project were an Illinois State Achievement Test (ISAT) preparation unit, an atomic structure unit, force and motion introductory unit, and a unit on speed and motion in relation to graphing.

The ISAT preparation unit included the use of the 5E model to help students develop and display their science readiness skills and content knowledge specific to the ISAT test. The entire unit was completed in three weeks. The ISAT preparation unit was not a comprehensive unit. The purpose of the unit was to focus on areas students demonstrated the greatest potential to significantly raise their ISAT test scores. The content areas selected for the ISAT preparation unit were genetics, earth's structures, and space science.

All of the ISAT preparation units were prepared and presented in the 5E model. For example, students engaged in the space science review by attempting to answer the question, "When is the sun closest to the Earth?" within a class discussion. The exploration of the solar system followed, as students used models of the earth and the sun in an attempt to justify or explain how the sun could be closest to the earth in January. Students used Review 19: The Solar System (Appendix B) to gain an explanation on the solar system using the *Buckle Down Illinois ISAT, Science* (2006), and elaborated on

lunar phases using a wiffle golf ball model activity and Moon Phases worksheet (Appendix C).

A fellow seventh grade science teacher also taught an ISAT preparation unit within this same time period. However, she taught the topics in a more traditional teaching style of lecture or explanation first, and then a student activity to reinforce the concept. For example, her students, after reading background information on the topic from the *Buckle Down Illinois ISAT, Science* (2006), completed an Internet web quest on earth's structures and the rock cycle. Notably, her students experienced some of the same labs/activities as my students in the genetics and solar system ISAT lessons, such as the Crazy Traits (Appendix D), SpongeBob genetics worksheet (Appendix E), and wiffle ball lunar phases. However, her students always participated in an explanation prior to any engagement or exploration.

The atomic structure unit and force and motion introductory unit were mini-units taught during ISAT testing. The atomic structure focused on the structure of the atom in relation to the periodic table and energy, and the forces and motion unit focused on introducing the students to some key concepts of force and motion. My goal was to provide the students with strong background knowledge in these key concepts to enable a deeper understanding within their upcoming force and motion unit.

These mini-units were also prepared and presented in the 5E model. For example, students engaged in the force and motion introductory unit with the bell work question "If you wanted to go somewhere as fast as possible, how would you get there? What are some things you could do to make your vehicle/method of transportation even faster?" Students explored speed through the How Slow Can You Go lab (Appendix F), a lab

based upon *Making Sense of Motion* (King, 2005). They explored the concept of work through the Marbles at Work lab (Appendix G), and they explored friction and potential and kinetic energy through an online skate park simulation inquiry activity through the University of Colorado at Boulder (Appendix H). An explanation and elaboration was offered as students took notes on the key concepts and completed a reflective activity requiring them to illustrate or explain the definition of each term using examples from their labs.

The final treatment for this project was a unit on speed and motion in relation to graphing. Students engaged through a bell work question on position – “How would you describe where you sit to someone who has never been in our classroom? Be specific!” Students explored motion and speed in relation to graphing through Moving Man, an Internet simulation through the University of Colorado at Boulder (Appendix I). Student explanation and elaboration was presented through interactive notebook notes, guided reading worksheets, and story graphs.

Throughout the treatment period, students were evaluated through teacher observations, bell work responses, completion of assignments within each unit, quizzes, and the pre- and post-tests. Students maintained an interactive science notebook throughout the treatment period. The students used their notebooks to record class notes, organize and record lab reports, and to reflect upon their learning. I used the student workbook, *Buckle Down Illinois ISAT, Science* (2006) and the textbook, *Motion and Forces* (2005) as a student and teacher resource throughout the treatment period.

Data Collection

To determine the focus area for the ISAT preparation unit, students completed an ISAT pre-test using the *ISAT Sample Book, Grade 7: Sample Items for Reading, Mathematics, and Science* (2011). Questions in this book are specific to science and addressed all of the Illinois State Standards in science. The test questions required students to “bubble-in” the correct answer on to a scantron sheet. There were 57 questions, and students were given one class period of 40 minutes to complete the test. The content areas on which a high percentage of the students scored at the mid-range were deemed the areas that could be improved the quickest to help raise the students’ overall test scores.

Student results from the pre- and post- ISAT tests were grouped by the percentage of correct responses for each question to determine overall student academic growth in reference to the state standard each question addressed. The questions and results specific to the presented topics, genetics, earth’s structures, and the solar system, were highlighted and compared to results for topics not covered within the ISAT preparatory review. Other considerations were content areas covered within the school year and content areas not formally covered. The test results were also grouped by the number of questions attempted and completed for each test.

In addition, the cooperating seventh grade teacher administered the pre- and post-test using the *ISAT Sample Book, 7th Grade* (2011). A similar comparison was made of the overall percentage of correct responses for each question to determine her students’ overall academic achievement and growth. Data was also collected and recorded on the number of questions attempted and completed during each testing period. Finally, a

comparison was made between the 5E and traditional classroom. Questions from the *ISAT Sample Test Book* (2011) were grouped into five categories: taught within the year, genetics, solar system, earth's structures, and not covered. The percentage of improvement was compiled by question and averaged to determine the student average improvement per question in each content area or category. These averages were compared between the 5E and traditional classroom. A comparison was also made on the number of test questions students attempted to answer.

Ninety-six students completed a pre- and post-Atoms Test (Appendix J), 98 students completed the pre- and post- Motion, Speed, and Work test (Appendix K), and 114 completed the Graphing Speed and Motion Test (Appendix L). The Atoms Test contained six multiple choice questions, six fill in the blank questions, and one extended response question. The Motion, Speed and Work Test consisted of 11 multiple choice questions and six short response questions. The Graphing Speed and Motion Test consisted of seven multiple choice questions. Pre- and post-tests were paired by students' name, and tests that could not be paired were discarded from data analysis. Student success with each question was tallied, and an overall percentage of correct response was determined for each test question. The extended response and short response questions was evaluated to determine growth in the students' ability to explain key concepts in each unit. A comparison was made between the pre- and post-test percentage of success by question and improvement in the extended response and short answer questions to determine the areas of greatest overall growth and to discern any deficits in learning.

In addition, the data collection methods in all units also incorporated the use of formative assessments to daily evaluate overall student achievement and monitor student

academic growth. Formative assessments consisted of daily bell work questions, student lab reports, and class work assignments. Student interactive notebook activities and reflections within their science notebooks were also monitored and evaluated formatively to determine the students' ability to summarize and reflect on the science content in their notes.

Baseline data collection on student self-expressed confidence, interest and interest in a science career was gathered through the Student Survey Questions (Appendix M). Students completed the Student Survey Questions assessment every six weeks to monitor changes in students' attitudes in regards to science, such as interest, confidence and favorite aspects of science. A final Student Survey Questions assessment was completed at the culmination of the treatment period. The data from the Likert Scale responses were divided into three groups, low to medium response levels indicated with a response of 0–4.5, and medium to high response levels indicated with a response of 5–9.5. The “I don’t know” or no responses were a third group. All data were translated into percentages to discount the variance in the number of student participants for each survey.

In addition, the student written responses to the Student Survey Questions were collected and analyzed to determine if there were any noted trends in student response that would indicate an increase or decrease interest and/or confidence in science. Finally, information from the Student Survey Questions, written comments and Likert scale responses, was analyzed to determine changes in student interest in pursuing a science career.

The data collection techniques for this project are summarized in the Data Collection Matrix (Table 1).

Table 1
Data Collection Matrix

Focus Questions:	Data Source #1 Experiencing	Data Source #2 Enquiring	Data Source #3 Examining
Can overall student achievement be improved in science through the use of the 5E instructional model?	Student Survey Questions	Student Survey Questions Bell Work Responses	Pre- and Post- ISAT Sample Test 7 th Grade Atom Pre- and Post Test Motion, Speed and Work Pre- and Post Test Motion and Speed Graphs Pre- and Post-Test Science Notebooks
Will lessons and units written and implemented using the 5E instructional model increase student interest and self-confidence in science?	Student Survey Questions	Student Survey Bell Work Responses	Science Notebooks Pre- and Post- ISAT Sample Test 7 th Grade
Will using the 5E instructional model encourage and increase student interest in science as a career?	Student Survey Questions	Student Survey Questions	Science Notebooks

DATA AND ANALYSIS

There were two primary themes documented in the data. The first theme was students' attitudes toward science or self-expressed interest and confidence in science, and student interest in a science career. The second theme was student academic achievement, which was discerned through demonstrated improvement in the pre- and post-tests, as well as in the formative assessments conducted throughout the treatment. The number of students participating in each assessment varied. Student daily absences were a factor in all assessments.

Students' attitudes towards science, including interest, confidence and interest in a science career, were measured through the Student Survey Questions (Appendix M). Student responses on their self expressed interest in science varied. Interest peaked at 67.4% on the third survey ($N=129$), up 6.4% from the pre-treatment survey of 61% (Figure 1). However, on the fourth survey ($N=138$) student interest dropped to 61.6%. Interest slightly rose in the fifth and final survey ($N=126$) up to 63.5%, which demonstrated only a 2.5% increase over the treatment period. The percentage of students indicating a *low* to *medium* interest in science on the pre-treatment survey decreased from 36.6% on the pre-treatment survey to 34.9% on the final survey, a difference of 1.7%. The students who did not respond or indicated an "I don't know" response were comparable with 2.4% of the student on the pre-treatment survey and 1.6% of the students on the final survey.

Throughout the treatment period several students who had indicated a *low* interest in science, wrote similar statements in the open response questions. They wrote that

“hands on learning like expiremants” (sic) were their favorite things about science, while the least favorite part was “working in the book.” One student indicated a *low* interest level in science and wrote, “I don’t have a favorite part of science” and that “everything” was their least favorite. Students who indicated a *medium* to *high* interest in science, also indicated that “Doing the labs. Having fun with my lab group. Doing hands-on assignments” were their favorite part about science.

The vacillating trend noted in Figure 1 was noted in the written comments made by students regarding their favorite and least favorite aspect of science. At the midpoint, most students expressed their favorite aspect with complete sentences, such as “I like the labs & learning about the ecosystem.” At the end of the treatment period, most students indicated that their favorite aspect of science with one or two words, such as “Labs” or “Hands on.” I also noted many students, even those that had indicated a *medium* to *high* interest in science had indicated that “notetaking(sic)” and “reading textbooks” as their least favorite aspects of science. Again, the short answer responses were very short and precise on the final survey, which was in contrast to the more descriptive statements of earlier surveys.

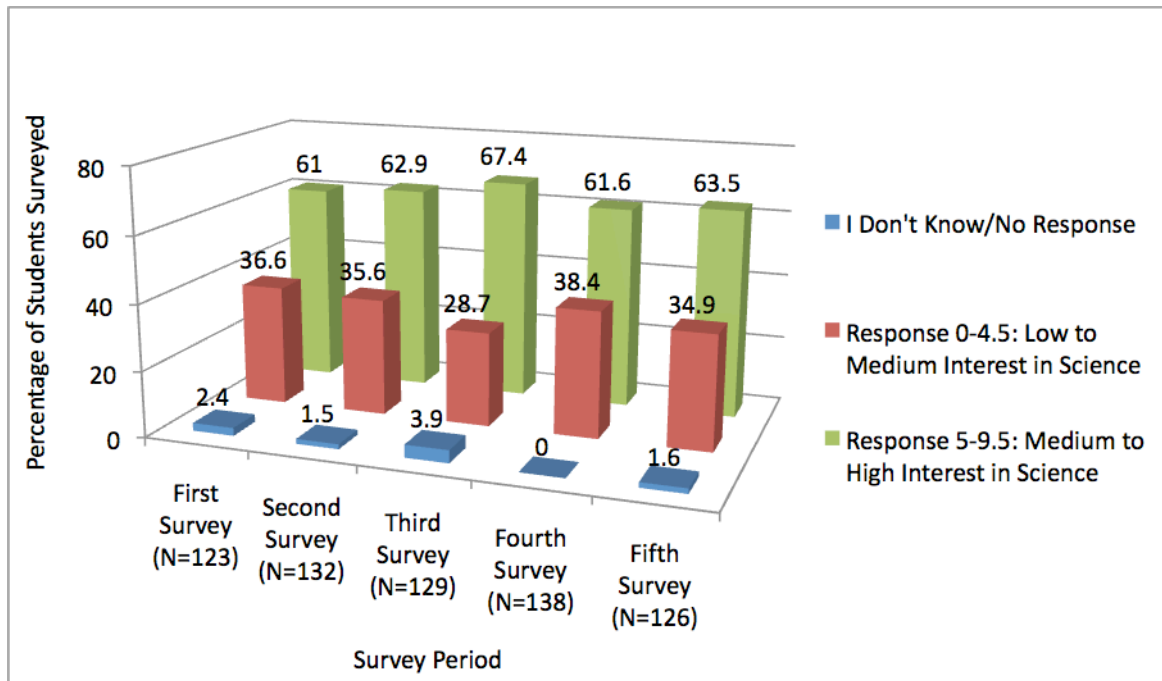


Figure 1. Student Interest in Science, (N=123, first survey; N=132, second survey; N=129, third survey; N=138, fourth survey; N=126, fifth survey).

Initially, student response indicated a slight decrease in overall confidence, as seen in the decrease of 3.5% in *medium to high* confidence from the first survey (N = 123) of 72.4% to second survey (N = 132) of 68.9%. This was also reflected in a 4.3% increase in *low to medium* confidence, as seen when the results from the initial survey of 25.2% increased to 29.5% in the second survey. Yet, at the end of the treatment period, on the fifth survey (N=126), student self-expressed *medium to high* level of confidence had increased to 79.4% or up 7% up from the initial pre-treatment survey of 72.4% (Figure 2). Likewise a decrease of 6.2% was noted of the students who indicated a *low to medium* confidence in science. On the pre-treatment survey, 25.2% of the students indicated a *low to medium* confidence in science, and 19% of the students indicated a *low to medium* confidence in science on the final survey. The students who did not respond

or indicated an “I don’t know” response were comparable with 2.4% of the student on the pre-treatment survey and 1.6% of the students on the second survey.

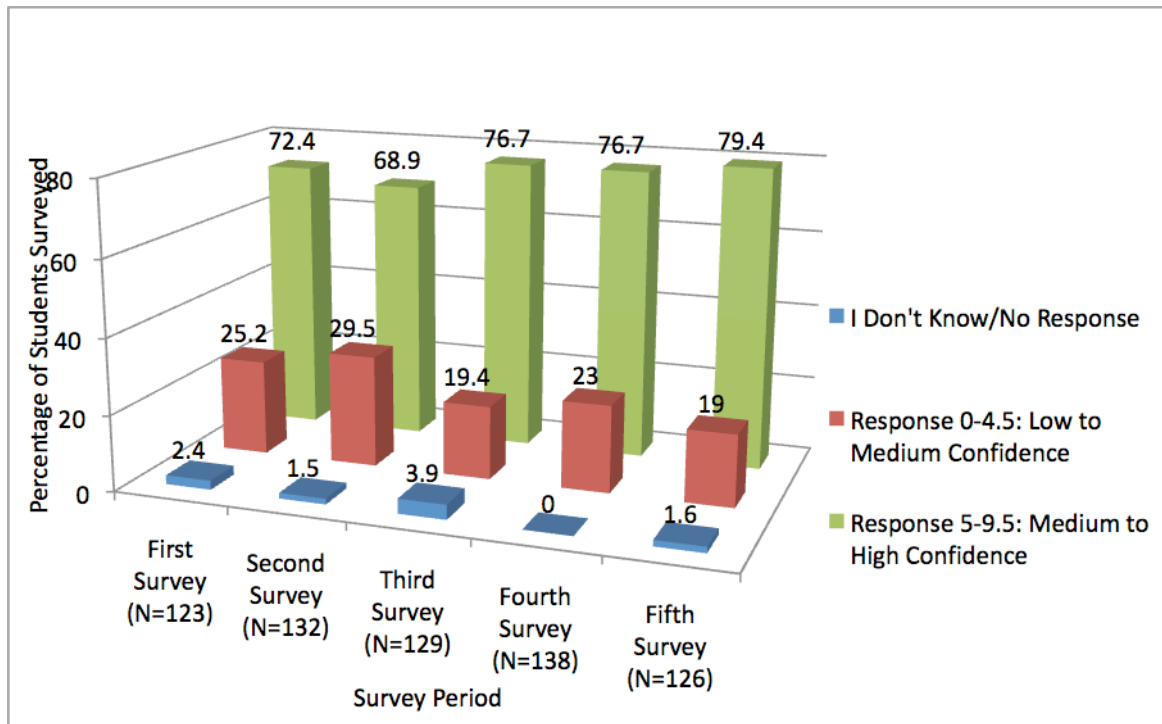


Figure 2. Student Confidence in Science, (N=123, first survey; N=132, second survey; N=129, third survey; N=138, fourth survey; N=126, fifth survey).

I noted on the second survey, when student expressed self-confidence decreased, in contrast to the surveyed responses, one student indicated on the second survey a *high* confidence as their response and wrote in the margins of the survey, “This year< (sic) Past years it has been around 5.” I also noted that students with *low* confidence ratings on the second survey responded to the question regarding their favorite part of science with statements such as “I don’t like science at all,” or “I don’t like this part of science. I like working out of the book most.” It was also noted that on the final survey students who expressed higher confidence than interest in science wrote similar statements that

working “hands-on” in science helped them better understand science “because your actually doing what your learning.”

The greatest survey response changes were in the students’ interest in pursuing a career in science (Figure 3). In the pre-treatment survey, 61.8% of the students had a *low* to *medium* interest in pursuing a career in science. This overall percentage decreased by 12.6% of the students, as indicated by the 49.2% of the students who reported a *low* to *medium* interest in pursuing a science career in the final survey. Likewise, the students conveying a *medium* to *high* interest in pursuing a career in science increased from 33.3% of the students in the pre-treatment survey to 49.2% of the students in the second survey. This represents an increase of 15.9% of the students expressing an interest in pursuing a career in science from the pre-treatment survey to the final survey. The percentage of students who did not respond or indicated an “I don’t know” response also decreased from 4.9% of the students in the pre-treatment survey to 2.8% of the students in the second survey.

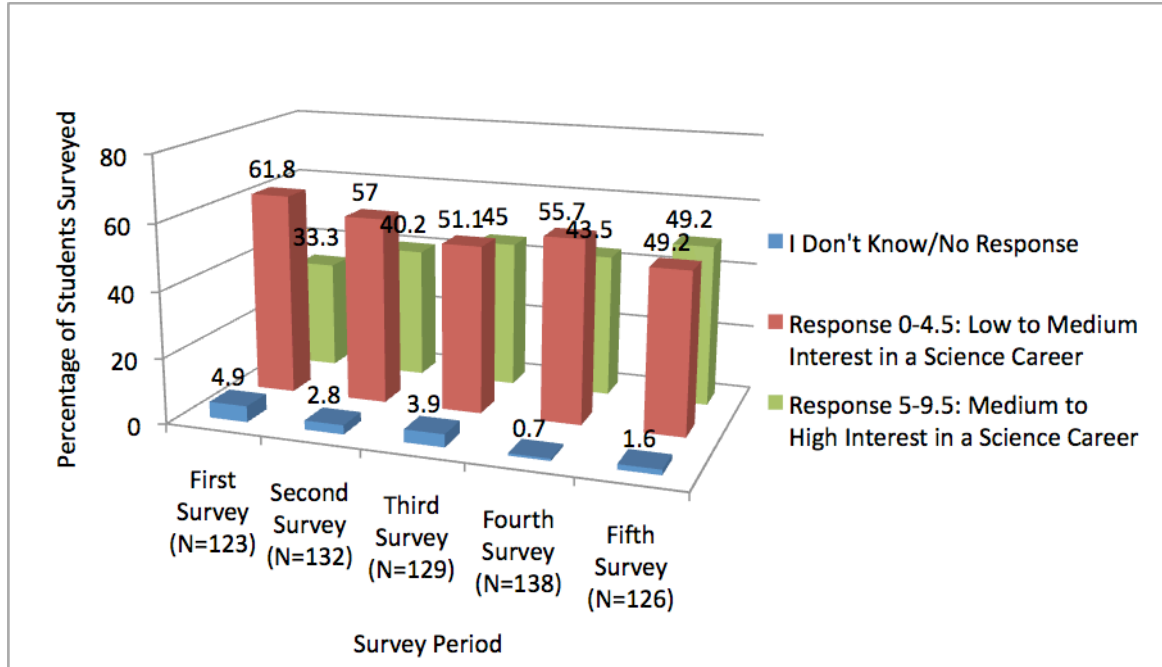


Figure 3. Student Interest in a Science Career, (N=123, first survey; N=132, second survey; N=129, third survey; N=138, fourth survey; N=126, fifth survey).

On the surveys, several students wrote in the margins near the question to indicate their career choice. One student expressed interest in “video game science,” while another student stated, “I want to be a pediatrician.” Most of the students who intended to pursue a career in science conveyed that active science, such as “doing experiments” and “the hands-on part” was their favorite part of science. However, I also noted that several students who had indicated a *low* to *medium* interest in pursuing a career in science, also indicated that the “experiments (sic) labs and activities” were their favorite part of science. There appeared to be no unifying factor for students either with *low* to *medium* or *medium* to *high* interest in pursuing science as a career. Yet, students demonstrated an overall increase in their interest in pursuing a career in science.

The second theme, student academic achievement and improvement was documented throughout the mini-unit on atomic structure, the introductory unit on force and motion, the motion and speed graphing unit, and ISAT preparation unit. Students ($N=96$) demonstrated improvement in all test questions in the atomic structure unit. Students demonstrated the greatest improvement, a 31% gain, in knowing the smallest unit of matter (Figure 4). Students also demonstrated a 26% improvement in knowing that the smallest particles cannot be seen with an unaided eye. The smallest gain, 7% was made in naming the smallest sub-atomic particle as the electron.

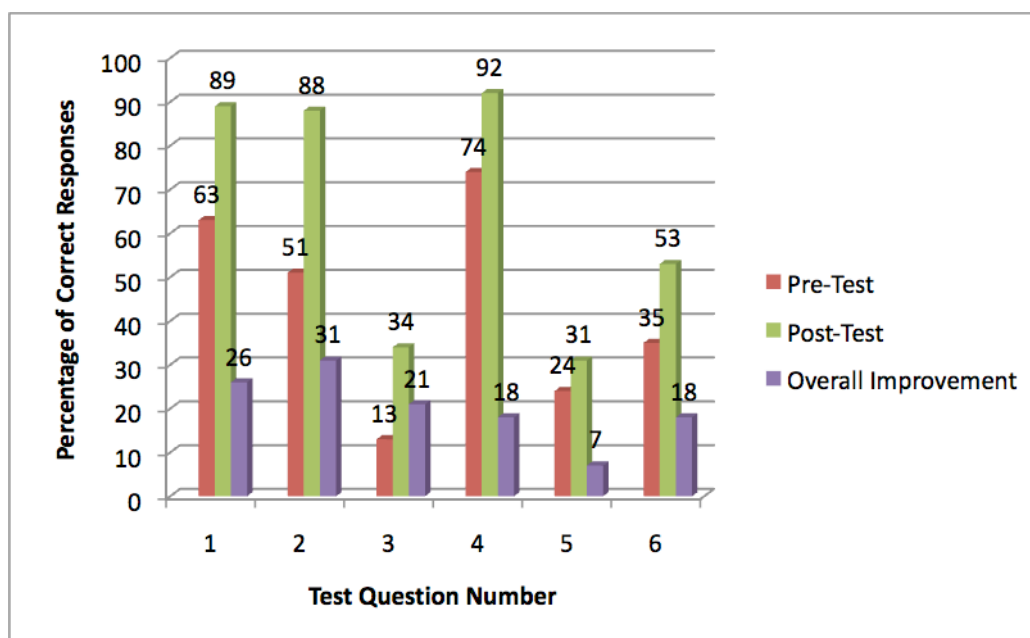


Figure 4. Atoms Pre and Post Test Results by Percentage of Correct Responses, ($N=96$).
 Question 1: The smallest particles that make up atoms are?
 Question 2: Which is the smallest unit of matter?
 Question 3: Atoms form bonds through interactions between?
 Question 4: Atoms are made up of what three sub particles?
 Question 5: The smallest sub particle of an atom is?
 Question 6: What particles are found in the nucleus of the atom?

However, students still demonstrated some difficulty in expressing how an atom becomes charged. This was indicated in the extended responses to the question on how

an atom becomes negatively charged. Students responses included, an atom becomes charged when “It loses(sic) its electrons. It gains neutrons. It gains protons” or “by rubbing against something like carpet. It is positively charged when they connect.” More success was evidenced by the 81% of the students who correctly identified the labels within the periodic table on the fill in the blank section, such as atomic number, atomic mass, atomic symbol and element name. None of the students were successful with identifying the labels on the periodic table on the pre-test.

Students ($N=98$) made modest gains in the force and motion introductory unit. The greatest percent gains, 13% of the student demonstrated an improvement in knowing how to find the speed and how to describe motion (Figure 5). However, students demonstrated no growth in identifying the unit for measuring time, and students demonstrated a negative growth, a 6% decrease, in knowing what units are used to measure length or distance and in knowing the components of the formula for speed. Interestingly, 83% of the students correctly identified the factors necessary to measure speed, an increase of 13% from 70% in the pre-test on one test question. Yet in a similar question, 91% of the students identified these factors on the pre-test, while only 85% identified them correctly on the post test for an overall decrease of 6% improvement. Students’ responses on the short answer questions varied. Several identified the correct answer on the post test, while indicating an “IDK” (I don’t know) on the pre-test. Others wrote examples from the labs in place of definitions, such as potential energy is “skate park when the skater is at the top of the ramp.” Others left the questions blank.

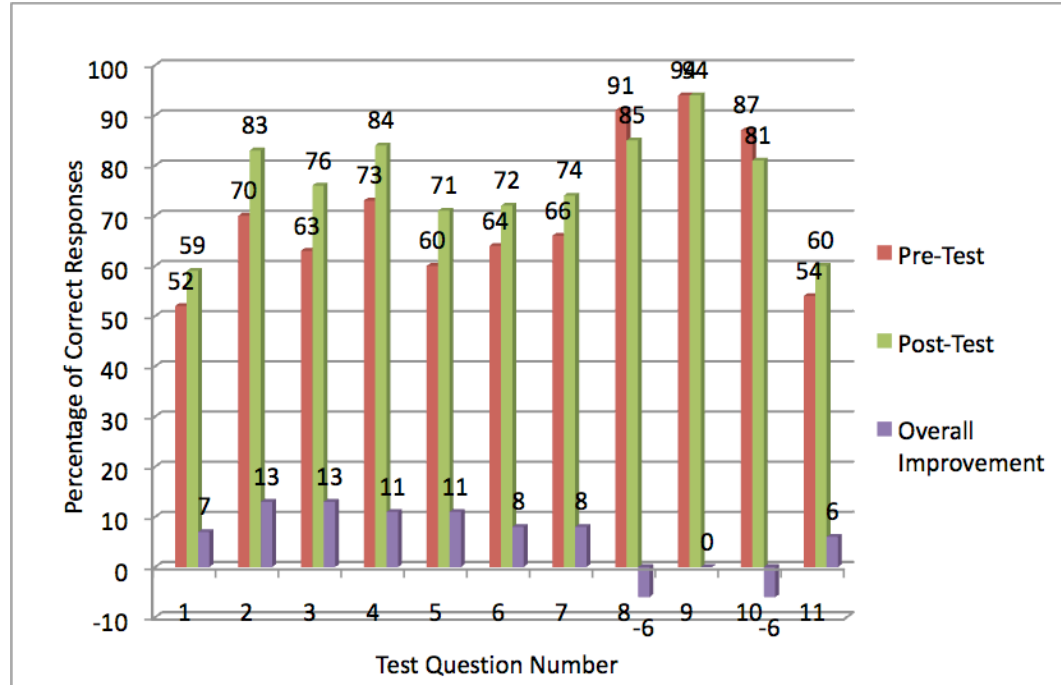


Figure 5. Force and Motion Pre and Post Test Results by Percentage of Correct Responses, (N=98).

Question 1: A change in position over time is called?

Question 2: Lisa is watching friend run a race. What does she need to know to find her friend's speed?

Question 3: A ball moves 5 meters in 10 seconds. What does this information tell you about the motion of the ball?

Question 4: If you push or pull an object?

Question 5: When you do work on an object, you transfer?

Question 6: Which of the following does work?

Question 7: Which of the following is true? (Pushing an object will change how it moves.

Question 8: Which units are used to measure distance?

Question 9: Which units are used to measure time?

Question 10: What do you need to know to measure speed?

Question 11: A man runs 50 meters in 5 seconds. What is his speed?

Greater overall student (N=114) gains were noted in the graphing speed and motion unit than in the force and motion introductory unit. The greatest gains demonstrated, 28% and 27% improvements respectively, were in identifying motion on a graph in relation to the direction, either away from or towards the motion sensor (Figure

6). The lowest demonstrated gain was on the question that referenced someone standing still. Only a 12% gain was demonstrated on the post-test. On the pre-test, 83% of the students selected the correct response of standing still, while on the post-test, the correct response was selected by 95% of the students. The area of greatest deficit after completing the unit, as indicated in the students' test results, was in understanding what the steepness of the slope represents. An average of 17% gain was made by students on all four questions referencing greater or lesser speed in relation to direction from the motion sensor. More importantly, the students averaged a passing percentage for all four questions at only 47%. Less than half of the students demonstrated mastery of the concept of slope steepness in relation to speed and direction.

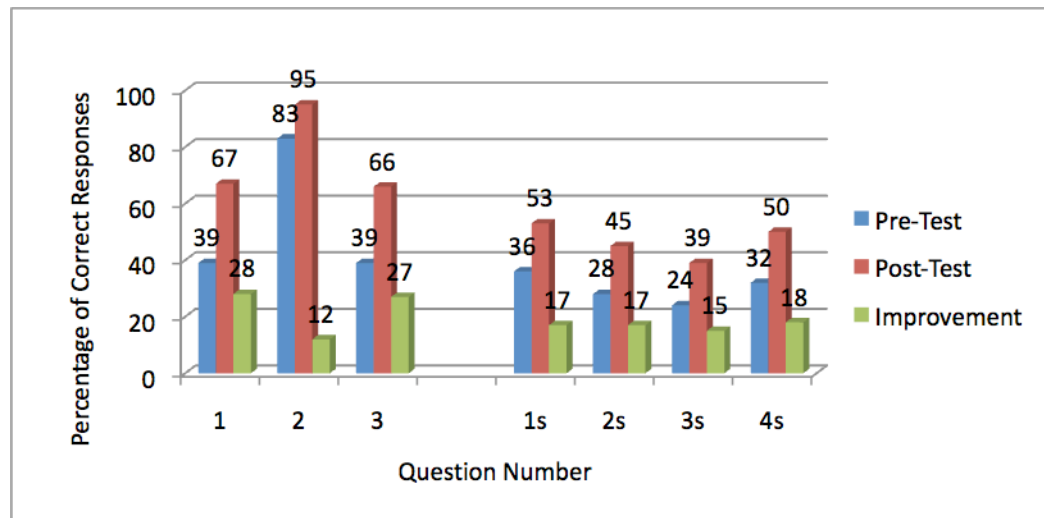


Figure 6. Motion and Speed Graphs Pre- and Post-Test Results, (N=114).

Question 1: Which graph represents a student walking at a constant speed away from the motion detector?

Question 2: Which graph represents a student standing still?

Question 3: Which graph represents a student walking at a constant speed towards a motion detector?

Question 1s: Which line on the graph represents a person moving towards a motion detector with lesser speed?

Question 2s: Which line on the graph represents a person moving away the motion detector with the lesser speed?

Question 3s: Which line on the graph represents a person moving away from the motion detector with the greatest speed?

Question 4s: Which line on the graph represents a person moving towards the motion detector with the greatest speed?

The ISAT preparatory unit allowed for a comparison between a 5E model classroom and more traditional taught classroom. Student numbers varied on each testing date and in each classroom, so the overall percentage of correct answers were documented and compared. The gains made by students in the 5E classroom varied in comparison to the students in a more traditional classroom. I noted considerable gains by the students in the 5E classroom on several questions. For example, on one question on the solar system, students in the 5E classroom demonstrated a 22% improvement in comparison to the decrease in improvement of 17% in the traditional classroom, or 39% difference in improvement between the 5E and traditional classroom. However, I also noted comparable data, such as the 11% and 10% improvement respectively in the 5E and traditional classroom on a question regarding the formation of fossils. The only areas in which the 5E students did worse, or demonstrated less improvement than the traditional students was in the content areas not covered during the school year or in the ISAT review. I also noted that gains were made in content areas taught in the 5E model within the school year and not a focus area during the formal treatment period. For example, 5E students demonstrated a 20% improvement on the question regarding the scientific process, in comparison to a 3% improvement in the traditional student scores.

When the test questions were grouped together by content area and the average percentage of improvement for each question was determined and compiled by how

students were taught, greater gains were noted by the students taught within the 5E model (Figure 7). For example, students in the 5E classroom improved an average of 3.4% on the questions pertaining to genetics on the post-test. Students in the traditional classroom demonstrated a decrease in overall success on genetics with an average of -1.2% improvements per test question. Students within the 5E classroom also demonstrated a 7.6% improvement on test questions pertaining to content material taught within the school year, which was not a formal part of the treatment for this project. The traditional students demonstrated a 2% average improvement on the same test questions. The students in the 5E classroom even demonstrated a 10.8% improvement on test questions on content material not formally covered within this project or within the school year, whereas the traditionally taught students decreased their average success on test questions by a -2.8%.

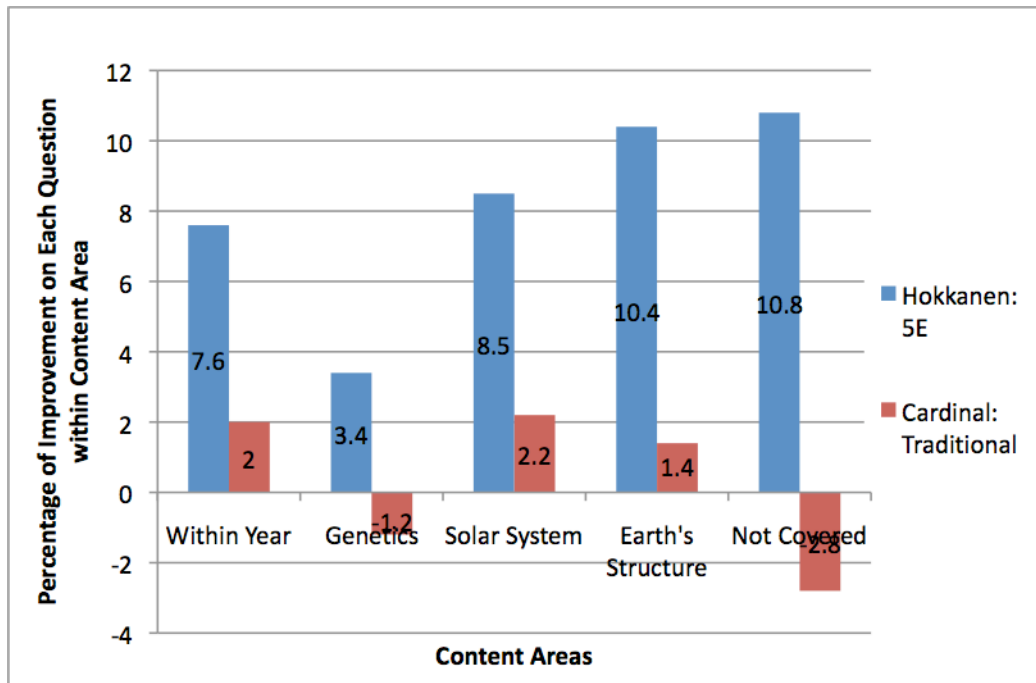


Figure 7. Demonstrated Improvement on Sample ISAT Test, (N=138, 5E Pre- and Post-Test; N=116, Tradition Pre-Test; N=117, Traditional Post-Test).

A final consideration was the number of test questions answered in each testing period. A comparable percentage of students finished the ISAT Sample Test in both the pre-test and post-tests (Figure 8). In addition, there was a 21% and 22% improvement in student ability to complete the ISAT Sample Test, respectively between the 5E and traditional classroom. There was no marked difference noted in the student's ability to improve upon the number of test questions they could answer in a 40 minute class period between the 5E and traditional classroom.

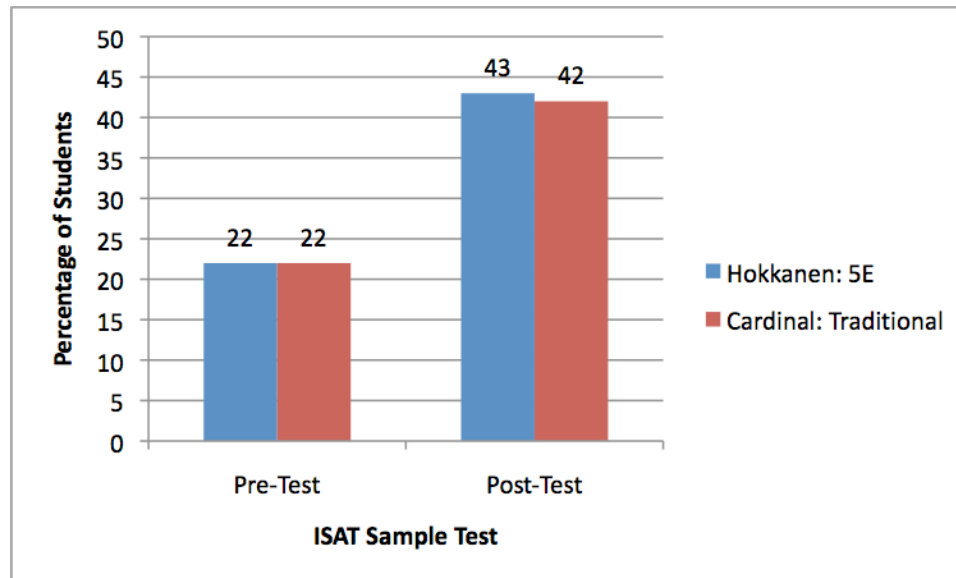


Figure 8. Percentage of Students Completing All Test Questions, ($N=138$, 5E Pre- and Post-Test; $N=116$, Tradition Pre-Test; $N=117$, Traditional Post-Test).

INTERPRETATION AND CONCLUSION

These results demonstrated modest improvement in overall student achievement and students' self-expressed interest and confidence in a science within a 5E learning environment. Greater gains were made in increasing student interest in a science as a career. Areas in which the students did not demonstrate as strong as gains can be directly attributed to the lesson presentation or completion. For example, in the introductory unit on motion and forces, the unit was cut short by school events and spring break. I was unable to fully implement the *explain* and *elaborate* sections of this unit. While I instructed students to complete these sections in their notebooks, there was no time to formatively check and review their reflections. The notebook reflections would have helped the students make the connections between the labs they explored and the concepts the labs demonstrated.

The most remarkable academic improvement was noted within the ISAT preparation unit, especially when held in comparison to a more traditionally taught classroom. The teacher I used as a comparison is an excellent and experienced teacher. She has taught science exclusively for four years, and within the elementary setting for over 20 years. The data from the ISAT pre- and post-test clearly demonstrated the effectiveness of the 5E model and the importance of student exploration of science concepts prior to an explanation. Even the success of my students in content areas not covered within the school year can be attributed to the 5E model. The 5E model encourages and empowers students to define and create their own learning, which can help students develop their scientific skills and confidence.

In student attitude towards science, especially the dip in confidence as shown in the second survey could be a result of students being uncomfortable with a new style of learning. One student noted on the second survey that they liked “working more out of the textbook.” As anticipated, student confidence rose as students became more comfortable with the 5E model. Factors that might have influenced student interest in science were students’ overall attitude towards school, ISAT testing, which began right after the third survey, and overall school issues, such as an increase in discipline problems, as indicated by the overall rise in school detentions. As noted, student interest in the Student Survey Questions also appeared to wane, as students wrote less and less on each consecutive survey after the second survey. Student interest in science as career increased, even though there was no focus on science as a career within the units. Perhaps experiencing science in a different way – more hands-on and more engaged - has enabled more students to envision themselves working in the science field.

However, in considering all of the data, one of the primary weaknesses of this research project was my newness to the school. This was also my first time presenting this content information, as I was acclimating to my new environment. While the other seventh grade teacher was very cooperative and understanding in allowing me to change the lesson presentation format in my classroom, the 5E model slowed me down in comparison to the more traditional style of teaching. It took me longer to cover the same content material, so I often felt pressured to hurry through sections, and sometimes I did. This flawed the presentation of the material through the 5E model, and potentially some of the data.

I noted that the highest gains in this research project can be attributed to dedicated 5E teaching. For example, my students engaged in powerful 5E lessons in graphing speed and motion, which forced them to address their misconceptions through *exploration*, *explain* what was happening in their own words, and *elaborate* through story graphs. The focus of these lessons was on the slope in relation to direction of movement. The lowest gains demonstrated where the 5E model was flawed in presentation or time, such as not allowing enough time for the activities that would help students tie their *explanations* to their *explorations* within the introductory unit on force and motion or the lack of enough student-centered attention to the steepness of the slope in relation to speed in the graphing unit. The areas that demonstrated the least gain demand an improved 5E model presentation. The 5E model has proven successful, when implemented properly and with dedication, to improving overall student academics in science and student expressed interest, confidence and interest in a science career.

VALUE

My students have gained in science knowledge and interest in science, as a result of this research project. While academic growth was expected, the ISAT pre- and post-test data demonstrated that the 5E model helped my students achieve more than students in a traditional taught classroom. The increase in student interest and confidence in science, albeit slight, demonstrated a much needed trend in science education, especially within minority populations. One of my students has repeatedly told me, that she does “not like science, not really,” but that she “like(s) the way we learn science” in the classroom. Hopefully the 5E model instruction has encouraged her and others to see science a little differently, and she and others will be more willing “like” science in the future.

The greatest value in this research project has been on its impact on me as a teacher. This project has helped me develop and cultivate my teaching style into a more effective model. I enrolled in the MSSE program within my first year of teaching science. I was secondary certified in social studies history, and not endorsed to teach science when I accepted my first science teaching job. I had not taken one pedagogical course on science teaching prior to my enrollment at Montana State. My introduction to and coursework on the 5E model was enlightening. However, it was my commitment to the 5E for this project that forced me to continue to practice my skills in designing and implementing 5E lessons and unit plans. As I continue to grow in confidence in the content areas I teach and within my new school, I will continue to make improvements to my 5E teaching. As I continue to make those improvements, my future students will see greater gains and greater academic achievement in science, and will hopefully develop

even greater interest and confidence in science. The 5E model is a strategy that has the potential to help close the achievement gap and open doors into the world of science for my students.

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APPENDICES

APPENDIX A

EXEMPTION BY MONTANA STATE INSTITUTIONAL REVIEW BOARD

Appendix A

Exemption by Montana State Institutional Review Board



INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects

FWA 00000165

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c/o Veterinary Molecular Biology
Montana State University
Bozeman, MT 59718
Telephone: 406-994-6783
FAX: 406-994-4303
E-mail: cherylj@montana.edu

Chair: Mark Quinn
406-994-4707
mquinn@montana.edu
Administrator:
Cheryl Johnson
406-994-6783
cherylj@montana.edu

MEMORANDUM

TO: Susanne Hokkanen

FROM: Mark Quinn, Ph.D. Chair *mark quinn cy*
Institutional Review Board for the Protection of Human Subjects

DATE: November 12, 2010

SUBJECT: *Improving Student Achievement, Interest, and Motivation in Science Through the Implementation of the 5E Learning Cycle in the Middle Grades of an Urban School [SH111210-EX]*

The above research, described in your submission of November 12, 2010, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal Regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- ☐ (b)(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- ☒ (b)(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- ☐ (b)(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- ☐ (b)(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- ☐ (b)(5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- ☐ (b)(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

REVIEW #19: THE SOLAR SYSTEM

Appendix B
Review #19: The Solar System

Name _____ Period _____

Buckle Down Workbook Activity
Earth and Space Science
Pages 157-200

Review 19: The Solar System

- ☐ Read pages 190 and 191.
- ☐ Answer the following questions:

1. What galaxy is our solar system located in? _____

2. The four planets closest to the sun are called what? _____

3. Saturn, Jupiter, Uranus and Neptune are what type of planets? (Hint: they are the next four planets) _____

- ☐ Read pages 192 and 193
- ☐ Answer the following questions:

4. What keeps the planets in their orbit around the sun? _____

5. How many days does it take for the moon to orbit the Earth? _____

6. What is a *new moon*? _____

a. a full moon? _____

b. a waxing moon? _____

c. a waning moon? _____

7. What is a lunar eclipse? _____

8. What is a solar eclipse? _____

9. What is the impact theory? _____

10. What do scientists use to measure distances between stars? _____

- ☐ Read pages 196 and 197.
- ☐ Answer the following questions:

11. What is the color of stars with the lowest surface temperature? _____

12. Using the Hertzsprung-Russell Diagram, describe our Sun's color temperature and brightness. _____

ISAT PRACTICE

- ☐ Read the questions on page 200.
- ☐ Write the correct letter/answers in the space provided.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

APPENDIX C

MOON PHASES WORKSHEET

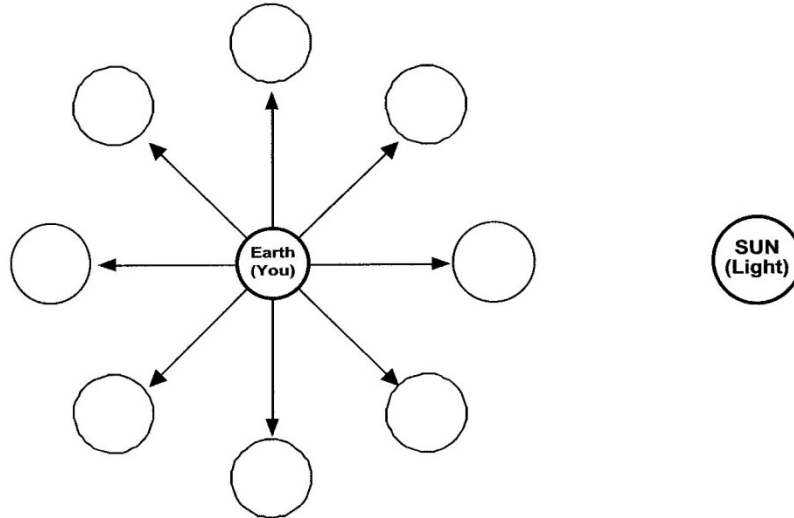
Appendix C

Moon Phases Worksheet

Moon Phases

Name _____

Directions: Get a "moon pop" from your teacher. Hold the moon pop in front of you at each position in the diagram making sure the white side is always facing the "sun". Shade in the circle on the diagram to match the amount of the white side you see on your moon pop.



1. Label each phase on the diagram: New moon, Full moon, Waxing crescent, Waning crescent, Waxing gibbous, Waning gibbous, First quarter, and Last quarter.

2. After you have completed and labeled the diagrams, show your teacher to have this box initialed.

3. What does it mean when someone says the moon is "waxing" or "waning"?

4. A solar eclipse occurs when a new moon comes between the sun and the Earth. Draw and label a diagram to show the positions of the sun, moon, and Earth during a solar eclipse.

5. A lunar eclipse occurs when the Earth comes between the sun and a full moon. Draw and label a diagram to show the positions of the sun, moon, and Earth during a lunar eclipse.

APPENDIX D

CRAZY TRAITS ACTIVITY

Appendix D

Crazy Traits

CRAZY TRAITS

OBJECTIVES

- Students will understand that traits are inherited from parent organisms.
- Students will learn that traits are inherited randomly.
- Students will learn dominant traits will be seen in a population more frequently.

KEY VOCABULARY

allele, genotype, phenotype, trait, inherited, dominant, recessive, probability, genetics, gene

SUGGESTED GRADE Levels

4-9

ILL LEARNING STANDARDS

Life Science: 4.A, 10.A, 10.B, 11.A, 12.A, 12.B

Mathematics: High: 4.A, 10.A, 11.A, 12.A, 12.B

PACE YOURSELF

45 minutes




AT A GLANCE

Students will see how chance affects an organism's genetic make-up in this hands-on, minds-on activity about traits.

ADVANCED PREPARATION

- Put a capital A on one side of each poker chip and a lower case a on the other side.
- Determine what body shape will be dominant and which will be recessive (triangle or square). Cut 50% more of the dominant shape than the recessive.
- Make a chart on poster paper or the board similar to the one below.

Trait	Phenotype if dominant allele is present (AA, Aa, aA)	Phenotype if two recessive alleles are present (aa)
Body color	Purple	Green
Body shape	Rectangle	Triangle
Nose color	Yellow	Green
Lips	Thin red ribbon	Thick red ribbon
Hair color	White	Blue
Eye size	Small	Large

4) Optional: Make a Crazy Trait Character of your own to show during Warm Up

MATERIALS

Per student:

- 1 piece of red, construction paper, or waxed paper
- About 5 cm of thin or thick red ribbon (for lips)
- Small or large black googly eyes
- White or blue cotton ball (for hair)
- Yellow or green poker chip (for nose)
- Two different colored pencils or markers
- Student data sheet
- Bar graph paper

Per Pair:

- One red chip with an "A" on one side and an "a" on the other
- One blue chip with an "A" on one side and an "a" on the other
- Glue

MSICHICAGO.ORG

CRAZY TRAITS

WHAT YOU NEED TO KNOW

A **trait** is an observable characteristic of an organism. Traits are passed from parents to their offspring in a process known as **heredity**. The study of heredity is called **genetics**.

There are many different kinds of traits that make us unique. Behavioral traits, for example, help determine how an organism acts. A Labrador retriever's desire to fetch is a behavioral trait. Other traits may increase an individual's risk of developing medical conditions, such as heart disease or sickle cell anemia.

There are also physical traits, which determine our physical makeup and how we look. There are many physical traits:

- Eye color
- Skin pigmentation
- Height
- Nose shape
- Attached or free ear lobes
- Can roll tongue or cannot roll tongue
- Dimples or no dimples
- Freckles or no freckles
- Naturally curly hair or naturally straight hair
- Straight thumb or hitchhiker's thumb
- Cleft chin or no cleft chin

Traits are determined by **genes**. When parents reproduce, they each pass on two or more variations of a gene to their offspring. These different forms of genes are called **alleles**.

An offspring randomly inherits two alleles, one from each parent. If the alleles are different, one will dominate over the other and will always be expressed. This is called a **dominant allele**. A **recessive allele** is a form of a gene that is always hidden when a dominant allele is present. A recessive allele will only be expressed when it appears with another recessive allele.

This can be illustrated with eye color. Each child inherits two alleles for eye color, one from each parent. The allele for brown eyes (B) is always dominant and the allele for blue eyes (b) is always recessive. If a person receives two brown eye alleles, then they will have brown eyes. If a person receives one brown eye allele and one blue eye allele, the person will have brown eyes, because brown eyes are dominant. If a person receives two blue eye alleles, they will have blue eyes, because recessive traits are expressed when there are two recessive alleles present.

Brown Eyes
Dominant Allele



Blue Eyes
Recessive Allele





Brown Eyes
Dominant allele hides recessive allele

MSICHICAGO.ORG

CRAZY TRAITS

An organism's **genotype** is the combination of alleles it has. Using the example above for eye color, a person's genotype would be Bb if they had one brown eye allele and one blue eye allele. The organism's actual observable form of a trait is the **phenotype**. In this case it would be brown eyes.

Genes have a lot to do with our traits and how we look, but non-genetic or environmental factors also determine traits. For example, an individual's hair color is determined by **inherited** traits, but exposure to sunlight or various chemicals may alter it. An individual may be predisposed to have a high risk of developing heart disease, but a healthy diet and plenty of exercise can lower the risk. Height is determined by genes inherited by our parents, but if an individual does not get essential nutrients then he or she will not reach their potential height.

WARM UP

1. Ask students what a **trait** is.
2. Explain that a trait is a characteristic passed down through genes from parent to offspring.
3. See if they can list any examples (eye color, dimples, attached or free earlobes, height). Have them try to roll their tongues. That's a trait! When they give a thumb's up, is their thumb straight, or a hitchhiker's thumb bent at a 45 degree angle?
4. Tell students that today they are each going to be making a Crazy Trait Character to learn about traits.

ACTIVITY

Part 1: Students determine the genotypes for their character's traits.

1. Explain to students that offspring inherit traits from their parents randomly. Each parent donates one allele, and it can be either the dominant form of the gene or the recessive.
2. Give each pair of students two poker chips. One blue and one red chip with a lowercase a on one side and a capital A on the other. These represent the alleles donated by the mother (red) and father (blue).
3. Demonstrate how to shake the poker chips up in your hands and lay them out. Then show students where to record the information on their data sheet (genotype column). They should take turns shaking the chips and recording **their own** results on their sheet. Each student should shake the chips six times. Once for each trait.
4. After students have filled out the genotype column on their sheet, talk to them about what it means (refer to WYNTQ).

Part 2: Students determine the phenotypes for their character.

1. Model for students how to determine the phenotype for each trait. (Less advanced students may need 2-3 examples or should complete this part with their partner).
2. Have students complete the phenotype column on their data sheet using the chart you created in Advance Preparation.

For less advanced students, you may want them to choose their supplies and have them double check with you before they glue.

Part 3: Hands-on!

1. Distribute supplies and have students create their Crazy Trait Character!

MSICHICAGO.ORG

CRAZY TRAITS

Specify that each student should only use one cotton ball for their character.

Part 4: Wrapping It Up

1. Without talking, have students hold up their character and look around the room. What color do they see more of? What shape? Why is that?
2. Write the six traits on the board and take a tally for each trait.
3. Have students complete a bar graph using two colors—one for dominant traits and one for recessive traits—comparing the dominant and recessive traits for each characteristic.
4. Discuss the results as a class and talk about real life examples of dominant and recessive traits that they are familiar with (blue eyes, red hair, dimples).

CHECK IN

1. What is one trait that you have?
2. How would you describe the word phenotype?

DIFFERENTIATED INSTRUCTION

For more advanced students, have them take the activity one step further by creating a Punnett square for their character. Then, you can have their character mate with another character in the class. What would their offspring look like? (Choose one square on the Punnett square for them to use for each trait, for example the bottom right)

EXTENSIONS

LANGUAGE ARTS

Have students write a short story or paragraph about their character. What would their name be? What types of things would it like to do? Where would it live?

SCIENCE

- Make a T chart on the board comparing traits that are inherited versus learned.
- Share this article about sickle cell anemia, an inherited blood disorder, with students.
http://kidshealth.org/kid/health_problems/blood/sickle_cell.html

ET CETERA

Go to the library and check out the Bill Nye DVD on Genes.

RELATED EXHIBITS

- Genetics
- YOU! The Experience

APPENDIX E

BIKINI BOTTOM GENETICS

Appendix E

Bikini Bottom Genetics

Bikini Bottom Genetics

Name _____

Scientists at Bikini Bottoms have been investigating the genetic makeup of the organisms in this community. Use the information provided and your knowledge of genetics to answer each question.

1. For each genotype below, indicate whether it is a heterozygous (He) OR homozygous (Ho).

TT _____ Bb _____ DD _____ Ff _____ tt _____ dd _____
 Dd _____ ff _____ Tt _____ bb _____ BB _____ FF _____

Which of the genotypes in #1 would be considered purebred? _____

Which of the genotypes in #1 would be hybrids? _____

2. Determine the phenotype for each genotype using the information provided about SpongeBob.

Yellow body color is dominant to blue.

YY _____ Yy _____ yy _____

Square shape is dominant to round.

SS _____ Ss _____ ss _____



3. For each phenotype, give the genotypes that are possible for Patrick.



A tall head (T) is dominant to short (t).

Tall = _____ Short = _____

Pink body color (P) is dominant to yellow (p).

Pink body = _____ Yellow body = _____

4. SpongeBob SquarePants recently met SpongeSusie Roundpants at a dance. SpongeBob is heterozygous for his square shape, but SpongeSusie is round. Create a Punnett square to show the possibilities that would result if SpongeBob and SpongeSusie had children. HINT: Read question #2!

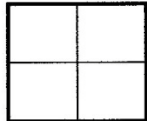


A. List the possible genotypes and phenotypes for their children.

B. What are the chances of a child with a square shape? ____ out of ____ or ____%

C. What are the chances of a child with a round shape? ____ out of ____ or ____%

5. Patrick met Patti at the dance. Both of them are heterozygous for their pink body color, which is dominant over a yellow body color. Create a Punnett square to show the possibilities that would result if Patrick and Patti had children. HINT: Read question #3!

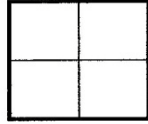


A. List the possible genotypes and phenotypes for their children.

B. What are the chances of a child with a pink body? ____ out of ____ or ____%

C. What are the chances of a child with a yellow body? ____ out of ____ or ____%

6. Everyone in Squidward's family has light blue skin, which is the dominant trait for body color in his hometown of Squid Valley. His family brags that they are a "purebred" line. He recently married a nice girl who has light green skin, which is a recessive trait. Create a Punnett square to show the possibilities that would result if Squidward and his new bride had children. Use B to represent the dominant gene and b to represent the recessive gene.



A. List the possible genotypes and phenotypes for their children.

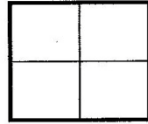
B. What are the chances of a child with light blue skin? ____%

C. What are the chances of a child with light green skin? ____%

D. Would Squidward's children still be considered purebreds? Explain!



7. Assume that one of Squidward's sons, who is heterozygous for the light blue body color, married a girl that was also heterozygous. Create a Punnett square to show the possibilities that would result if they had children.

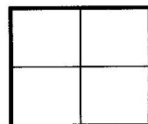


A. List the possible genotypes and phenotypes for their children.

B. What are the chances of a child with light blue skin? ____%

C. What are the chances of a child with light green skin? ____%

8. Mr. Krabbs and his wife recently had a Lil' Krabby, but it has not been a happy occasion for them. Mrs. Krabbs has been upset since she first saw her new baby who had short eyeballs. She claims that the hospital goofed and mixed up her baby with someone else's baby. Mr. Krabbs is homozygous for his tall eyeballs, while his wife is heterozygous for her tall eyeballs. Some members of her family have short eyes, which is the recessive trait. Create a Punnett square using T for the dominant gene and t for the recessive one.



A. List the possible genotypes and phenotypes for their children.

B. Did the hospital make a mistake? Explain your answer.



APPENDIX F

HOW SLOW CAN YOU GO LAB

Questions to consider: If you wanted to go somewhere as fast as possible, how would you get there? What are some things you could do to make your vehicle/method of transportation even faster? What you would do to make your vehicle move as slow as possible? How could you create a fair test using a marble in motion to explore your ideas?

Using the materials provided, develop a way to test your motion questions. You may use any arrangement of barriers you wish to employ, but with these as guidelines:

- Include a sketch of at least three configurations of barriers using during the investigations and the effect of the barriers or obstacles had on the marble's movement in each configuration. Fill in your chart with the estimated distance (cm) and time data for each trial you conduct.

Sketch of configuration 1		Sketch of configuration 2		Sketch of configuration 3	
	Configuration 1		Configuration 2		Configuration 3

Time trial 1	Distance: Time:	Distance: Time:	Distance: Time:
Time trial 2	Distance: Time:	Distance: Time:	Distance: Time:
Time trial 3	Distance: Time:	Distance: Time:	Distance: Time:

Part II

Share your results with the class once your group has completed the trials and filled in the data chart.

****Which group was most successful and demonstrated the longest travel time across the table?**

Answer the following questions when you have completed your investigations.
Questions:

1. Why did you find that making the marble take the longest time across the table was more challenging than having it take the shortest time across the table? _____

2. What are some ways you can make the marble move across the table top?

3. How did you use barriers on the table top? How did other groups use the barriers? What arrangement of barriers gave the “best” results? Why?

4. What combination of factors proved to be the most effective in accomplishing your ultimate goal of having a long travel time? Why?

5. How might increasing the speed of the marble and the path length the marble travels work together to increase the total time the marble is in motion?

6. Why did your group’s arrangement of barriers prove to be more or less effective than other groups? _____

APPENDIX G

MARBLES AT WORK

Appendix G Marbles at Work



Name _____ Date _____

Part I: energy

1. What happens when the marble hits the back of the cup? Is the cup's motion smooth and continuous (all at once)?
2. What happens to the cup when you roll a marble very slowly into it? What happens when the marble moves faster?
3. What happens to the cup when the marble is rolled from a close distance? From far away?

MARBLE'S AT WORK

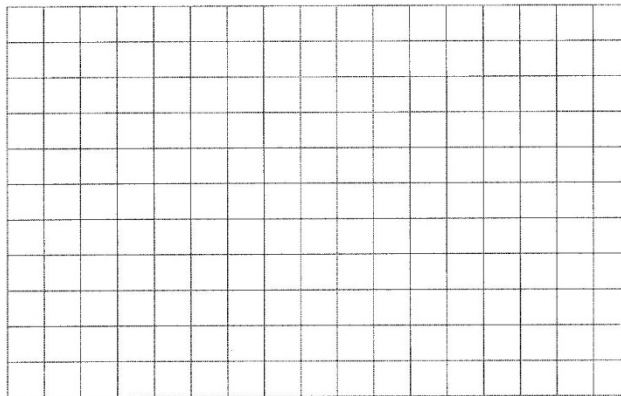
Name _____ Date _____

Part II: height

Measure how far the cup moves when one marble is released from each of these ramp heights:

Height released (1 marble)	Trial 1	Trial 2	Trial 3	Average
30 cm				
22.5 cm				
15 cm				
7.5 cm				

- How does the height from which the marble is released affect the distance the cup travels?
- Which of these marbles had the most gravitational potential energy?
- Graph your results (make sure you label your graph!)



MARBLES AT WORK

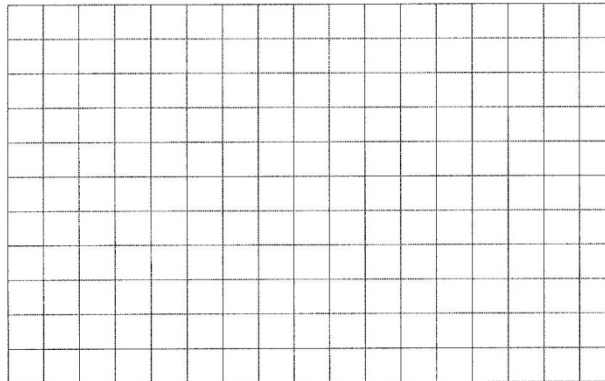
Name _____ Date _____

Part III: mass

Measure how far the cup moves when two marbles are released from each of these heights:

Height released (2 marbles)	Trial 1	Trial 2	Trial 3	Average
30 cm				
22.5 cm				
15 cm				
7.5 cm				

1. How does the mass of the marbles affect the distance the cup travels?
2. Which of these marbles had the most gravitational potential energy?
3. Graph your results (make sure you label your graph!)



APPENDIX H

ENERGY SKATE PARK

Appendix H
Energy Skate Park

Name: _____

Period: _____

Energy Skate Park

Learning Goals:

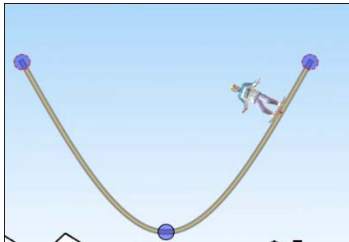
- Predict the kinetic and potential energy of objects.
- Design a skate park
- Examine how kinetic and potential energy interact with each other.

Open the PhET simulation “Energy Skate Park.”

Type in: <http://www.colorado.edu/physics/phet>

Click on **Simulations**, then **Work, Energy, and Power** on the left side.

Click on **Energy Skate Park**.



Part 1-Designing a Skate Park

- a. Thanks to your great skateboarding skills, city officials have asked you to add your expertise with designing a new skate park. In the space below, draw what your idea of what it would look like.

- b. Re-create your drawing using the simulation. Pick a skater and test out your track. Describe/draw what happened to your skater when you put them on the track (ex. skater got stuck in the loop, skater fell off, skater made it through the whole track). Save your design under the **file** menu.

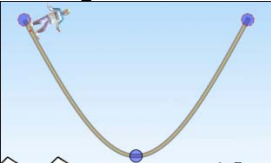
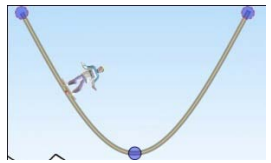
Part 2-Predictions, definitions

- a. In the space provided, define the following words:

Kinetic energy-

Potential energy-

- b. On a scale of 1-10 (1 being the least, 10 being the most), predict the amount of kinetic and potential energy when the skater is on different parts of the track.

Skateboarder Location on track*	Prediction-Kinetic energy	Prediction-Potential energy	Explanation of your reasoning	Corrections (#2)
Top of track 				
Middle of track 				
Bottom of track				



*Before starting the simulation, drag the bottom part of the track so that it touches the ground.

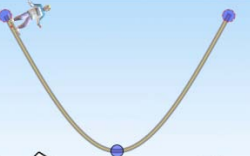
- a. Start the skateboarder simulation. Click on the bar graph icon and check your predictions. Go back and make corrections if needed.

- b. Compare what happens to potential energy and kinetic energy as the skater moves up and down the track. What general statement can you make about the relationship between potential and kinetic energy?

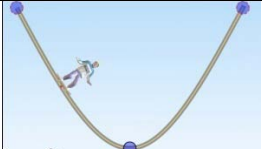
Part 3-Observations

a. Skater

Start your skater at the top of the track. Draw or write what happened to the skater.

Position of Skater	Result	Possible reasons why it happened.
		

Start your skater in the middle of the track. Draw or write what happened to the skater.

Position of Skater	Result	Possible reasons why it happened.
		

b. Length of the track

Make the right side of the track longer. Start your skater on the right side and draw or write what happens to the skater.

Right side longer	Result	Possible reasons why it happened
		

Make the left side of the track longer. Start the skater on the right side again, and draw or write what happens to the skater.

Left side longer	Result	Possible reasons why it happened
		

c. Loops

Under the “tracks” menu at the top of the page, add a loop to the track. Draw or write to your skater when you start it from the top of the track.

Picture of track with loop	Result	Possible reasons why it happened

d. Explore

Change the position or shape of the track on your own. You can also change your skater/mass and the coefficient of friction. Write down what you changed, and what happened to your skater in the table below. *Remember to change only one variable at a time!!

Change you made (manipulated/independent variable)	Description of what happened to the skater (responding/dependent variable)

--	--

Part 4-Refine your design

1. Reopen your original design from Part 1. Click on the pie chart or bar graph icon. Re-draw your original design below:
2. On your design, draw a “P” at what point the **potential** energy of the skater is the greatest.
3. On your design, draw a “K” at what point the **kinetic** energy of the skater is the greatest.
4. On your design, draw a “P=K” at what point the kinetic energy is **equal** to the potential energy.
5. Explain how kinetic energy and potential energy affected your track design.
6. If your skater was not able to complete the track, design another track. Draw or write how you changed your track in the space below.

APPENDIX I

MOVING MAN LAB

Appendix I Moving Man Lab

Moving Man Lesson

Learning Goals:

- Be able to describe movement by looking at a motion graph

Directions:

Open up the simulation "Moving Man."

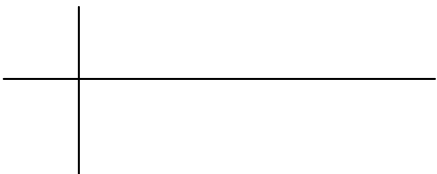
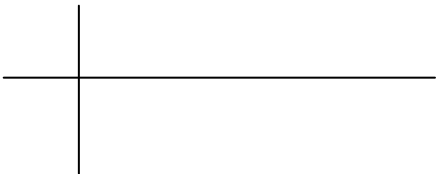
- Either type in: <http://www.colorado.edu/physics/phet> or Google "phet" to get to the website.
- Click on **Play with Sims**, then click on **Motion** on the left side. Click on **Moving Man**.



- Close the velocity and acceleration graphs by clicking on the minus sign on the right hand side of each graph.
1. Play with the *Moving Man* by dragging him back and forth. Click on the playback button at the bottom of the page to look at the graphs when you are done. Notice what is happening to the graphs as he moves. Write in the chart what you've noticed, and why you think it happened.

"Look, I noticed that...."	"Well, I think this happened because..."

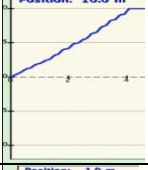
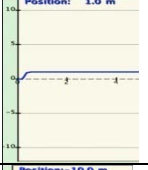
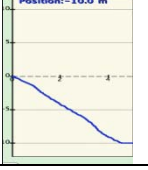
5. What do you think will happen to the line if the man moves away from the house? Draw your prediction in the space below, then test out your idea. Write why you think this happens in the space marked “explanation.”

GRAPH (Prediction)	Explanation
	Why do you think it should look like this?
GRAPH (Actual)	Explanation
	Why do you think it looked like this?

9. Summary

Based on what you saw in the examples, summarize what you know.

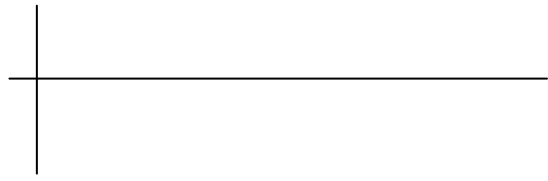
When the graph looks like this:	Describe how the man is moving.
---------------------------------	---------------------------------

EXPLAIN and EXPLORE

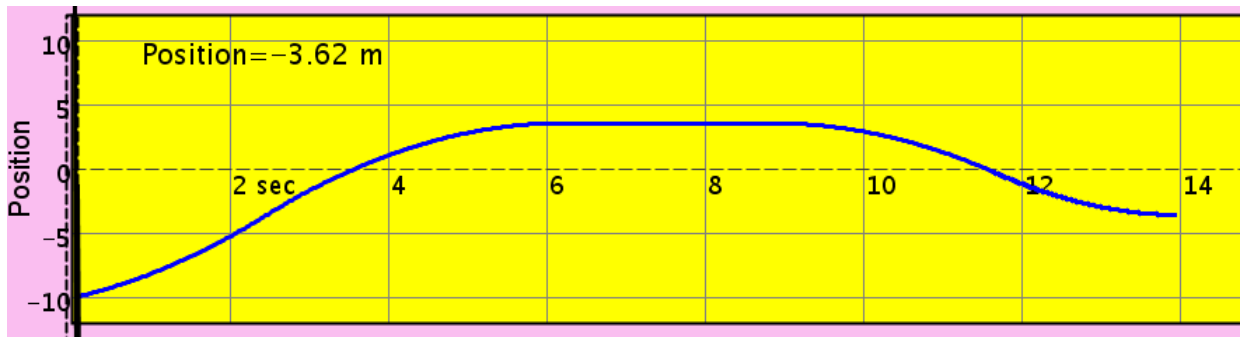
1. Without using *Moving Man*, draw what you think the line would look like for the following story.

A man is napping under the tree. He wakes up and walks toward the house. He stops because he is worried that he dropped his keys. He stands still as he searches his pockets for his keys. When he discovers he can't find them, he runs towards the tree. He hits the tree and gets knocked out, so he can't move.

Graph (prediction)	Graph (actual)
	

2. Now use *Moving Man* to see if your graph was correct. If not, go back, and draw the correct line on the 2nd graph.

3. in the space below, write your own story for the following graph.



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APPENDIX J

ATOMS TEST

Appendix J
Atoms Test

Name: _____

Period: _____

Atoms

Choose the letter of the best answer for each question.

- _____ 1. The smallest particles that make up matter are
- a. large enough to touch
 - b. large enough for most people to see
 - c. too small to see without eyeglasses
 - d. too small to see with the unaided eye.
- _____ 2. Of the following, which is the smallest unit of matter?
- a. a compound
 - b. water
 - c. a molecule
 - d. an atom
- _____ 3. Atoms form bonds through interactions between
- a. protons
 - b. neutrons
 - c. electrons
 - d. nuclei
- _____ 4. Atoms are made up of the following three sub particles
- a. protons, neutrons, electrons
 - b. protons, nuclei, electrons
 - c. nuclei, membranes, proteins
 - d. electrons, nuclei, proteins
- _____ 5. The smallest sub particle of an atom is
- a. neutron
 - b. electron
 - c. proton
 - d. molecule
- _____ 6. What particles are found in the nucleus of the atom?
- a. protons and electrons
 - b. electrons and neutrons
 - c. neutrons and nuclei
 - d. protons and neutrons

11. Atomic number equals the number of _____ or _____.

12. Atomic mass equals the number of _____ and _____.

13. How does an atom can become charged? Describe how the atom becomes negatively charged. Describe how the atom becomes positively charged. (3 pts.)

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page, providing a template for writing or drawing. There are no margins, text, or other markings on the paper.

APPENDIX K

MOTION, SPEED AND WORK TEST

Appendix K
Motion, Speed and Work Test

Name: _____

Period: _____

Motion, Speed and Work

- _____ 1. A change in position over time is called
- a) acceleration
 - b) motion
 - c) location
 - d) distance
- _____ 2. Lisa is watching a friend run a race. What does she need to know to find her friend's speed?
- a) distance and time
 - b) position and motion
 - c) distance and position
 - d) time and motion
- _____ 3. A ball moves 5 meters in 10 seconds. What does this information tell you about the motion of the ball?
- a) direction and size
 - b) distance and time
 - c) speed and weight
 - d) size and distance
- _____ 4. If you push or pull an object,
- a) its motion will change
 - b) its velocity will remain the same
 - c) its mass will change
 - d) it will not accelerate
- _____ 5. When you do work on an object, you transfer
- a) power
 - b) velocity
 - c) energy
 - d) acceleration
- _____ 6. Which of the following does work?
- a) a book lying on a table
 - b) a person holding a book over her head
 - c) a person reading a page of a book
 - d) a person pushing a book across the floor
- _____ 7. Which of the following is TRUE?
- a) All objects move in the same direction.
 - b) Pushing on an object will change how it moves.
 - c) Pulling an object in motion will not affect its motion.
 - d) Most objects move at the same speed.

_____ 8. Which units can be used to measure distance?

- a) seconds
- b) cubic centimeters
- c) meters
- d) liters

_____ 9. Which units can be used to measure time?

- a) meters
- b) seconds
- c) milligrams
- d) liters

_____ 10. What do you need to know to measure speed?

- a) distance and weight
- b) direction and time
- c) distance and time
- d) direction and position

_____ 11. A man runs 50 meters in 5 seconds. What is his speed?

- a) 250 meters
- b) 1/5 meter/second
- c) 10 meters/second
- d) 25 meters/second

12. What is energy? _____

13. What is potential energy? Give an example. _____

14. What is kinetic energy? Give an example. _____

15. What is the scientific definition of work? _____

16. What is friction? Give an example. _____

17. What is force? Give an example. _____

APPENDIX L

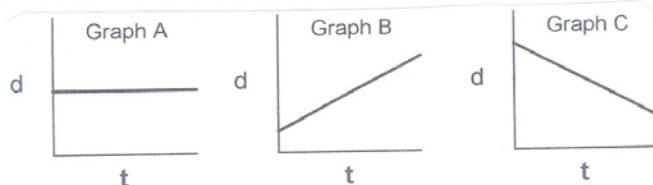
GRAPHING SPEED AND MOTION TEST

Appendix L

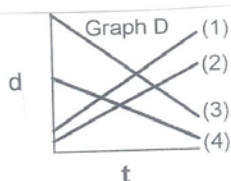
Graphing Speed and Motion Test

Name: _____

Period: _____

Circle the letter/number answer after each question that best answers that question.Use the graphs below to answer the following questions:

1. Which graph represents a student walking at constant speed away from a motion sensor?
(A) (B) (C)
2. Which graph represents a student standing still? (A) (B) (C)
3. Which graph represents a student walking at a constant speed toward the motion sensor?
(A) (B) (C)

Use this graph to answer the following questions:

1. Which line on graph D represents a person moving towards the motion detector with lesser speed?
(1) (2) (3) (4)
2. Which line on graph D represents a person moving away from the motion detector with lesser speed?
(1) (2) (3) (4)
3. Which line on graph D represents a person moving away from the motion detector with greatest speed?
(1) (2) (3) (4)
4. Which line on graph D represents a person moving towards the motion detector with the greatest speed? (1) (2) (3) (4)

APPENDIX M

STUDENT SURVEY QUESTIONS

Appendix M

Student Survey Questions

Survey Questions

1. What is/are your favorite part about science? What do you like the most about science?
2. What is/are the least favorite part about science? What do you like the least about science?
3. What is the usual way you learn science in the classroom? Please put the following in 1st, 2nd, and 3rd order, according to how you are most used to learning science in the classroom: (Write 1, 2, 3 in front of the learning activity.)

_____ Reading textbook or other material
 _____ Lab or Activity
 _____ Lecture/Note taking
4. How would you describe “hands-on” learning?
5. Does working “hands-on” in science help you better understand what you are learning? Why or why not?
6. Rate your confidence in science. Indicate on the line with a circle or mark. (1 is the lowest confidence – 9 is the highest confidence)

1.....2.....3.....4.....5.....6.....7.....8.....9
7. How interested are you in science? How much do you like science? Rate your interest in science right now. Indicate on the line with a circle or mark. (1 is the lowest interest – 9 is the highest interest)

1.....2.....3.....4.....5.....6.....7.....8.....9
8. How likely are you to pursue or work towards a career in science? Indicate on the line with a circle or mark. (1 is the lowest likelihood – 9 is the highest likelihood)

1.....2.....3.....4.....5.....6.....7.....8.....9