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Dr. Skateboard's action science: Increasing science knowledge and skills for middle school teachers

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Focus Area: Science Education

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ABSTRACT

Dr. Skateboard's Action Science maps to the physical science Texas Essential Knowledge & Skills (TEKS) standards that all middle school students need to learn. Dr. Skateboard's Action Science explores scientific concepts in a curriculum supplement that is designed to address both physical science content and process skills. The video instruction focuses on fundamental concepts found in the areas of motion, forces, Newton's Laws of Motion, and simple machines. The use of familiar activities, situations and objects, such as skateboarding and bicycle motocross (BMX), around which students can explore and explain scientific concepts can be defined as action science. The main purpose of the approach is to provide an interesting method of engaging students in the exploration of science in a real world context.

As an extension of this approach for the classroom, approximately 25 teachers were chosen to be part of a cohort chosen by the Gaining Early Awareness and Readiness for Undergraduate Programs (GEARUP) program. GEARUP was developed to expand students' educational opportunities and to assist participants in becoming college eligible and then academically successful in higher education. The participating teachers were involved in a series of workshops designed to enhance their instructional methods and science content knowledge, which they would utilize in teaching students participating in a GEARUP summer institute. The goal of the workshops was to model the use of student-centered constructivist approaches through the integration of video instruction and classroom activities materials for use in science classrooms.

Key Words

Action Science, Physics, Forces, Motion, Simple Machines

Education Plan for Teacher Preparation

Dr. Skateboard's Action Science is a curriculum supplement that integrates both skateboarding and BMX. It incorporates a four part video series and twenty classroom activities for students and teachers to use in the classroom. The video and classroom materials focus on the physical science concepts found in the areas of motion, forces, Newton's Laws of Motion, and simple machines. These materials also provide the classroom teacher with an instructional series rich with science content information. The activities include topics such as momentum, center of gravity, inertia, centrifugal and centripetal forces. The purpose of the activities is to engage students in meaningful science topics set in the context of something they enjoy doing, namely skateboarding and BMX. The main emphasis is to link the concepts of science to action sports and to engage students in the exploration of science in a real world context.

Dr. Skateboard's Action Science engages the learner in the process of acquiring critical knowledge, developing proficiency in problem solving, engaging in self-directed learning, and participating in collaborative teams. For the educator, the video segments and activities should be used in tandem, as the videos provide action, but also relevant content for the classroom. The video segments may be shown in their entirely within a given episode, or the instructor may choose to use a portion of the video to highlight a given topic that will be explored in a classroom activity. For example, the teacher may want to show the portion of the "Forces" video that covers the concepts of centripetal and centrifugal forces prior to doing the activity "Finding or Fleeing the Center of a Loop". For each of the activities, the associated section of the video segments can be used as hooks to introduce the activity and as a review for the content covered within the classroom. The activities are provided on the DVD as single lessons from which to print copies for classroom instruction. The entire activity manual is also available complete with a glossary of terms and definitions.

In the classroom, constructivist curriculum must be designed so that it reflects real life situations (Bentley, 1995). Curriculum developers who use the social context of learners, define this approach of content organization as contextualizing the concepts and organizing the content taught in distinct disciplines of study (Hofstein and Yager, 1982). Research scientists cross over the barriers between disciplines all the time, and seldom operate solely on isolated areas of content, but integrate the use of language, knowledge and process application. Relevant and relatable materials give students the ability to retain facts through critical thinking by working through problems logically and making connections to the real world. "Students should know what it feels like to be completely absorbed in a problem. They seldom experience this feeling in school" (Bruner, 1962). Studies have shown that students, who are involved in active learning in meaningful contexts, acquire knowledge and become proficient in problem solving. (Robertson, 2008).

Students exploring a concept should be given opportunities to work with materials and manipulatives so that they can have experiences that are real and fundamental. Hands-on learning plays a valuable role in the constructivist paradigm, as it is the process of "learning by doing" (Dewey, 1970) that actually engages the learner. So much fascinating content is at the fingertips of learners everywhere, and with technology becoming more affordable, more and more information is accessible to students. It is important to place students in learning situations that effectively integrate their own experiences and familiar materials that students can use to better understand specific concepts (Eisenkraft 2003). For example, students who enjoy skateboarding can be given opportunities to explore the concepts of velocity, acceleration, center of gravity, and moment of inertia. They may also use the skateboard and a local skatepark to investigate topics such as inclined planes, levers, fulcrums and screws. The purpose of this approach is to allow the students to explore meaningful content set in the context of something in which they have experience.

The student is always defining meaning within the context of action and reflection (Brooks and Brooks, 1993), and meaning can be seen in context within a social situation. Each learner understands content and concepts differently based on his or her previous experiences. Yet, educators must beware of regarding the learner's point of view as fully complete and significant in and of itself (Dewey, 1970). The students need opportunities to address misconceptions and to develop concepts in real world situations. "Students come to school with their own ideas, some correct and some not, about almost every topic they are likely to encounter" (Rutherford and Algren, 1990). Learning is the responsibility of the learner, but it is the teacher who must guide the student into developing meaning from content material and classroom experience.

As students explore concepts, they develop a deeper understanding of the purposes of specific content. When they relate what they are learning, seeing or doing to others, they can begin to see similarities in their understandings, as well as self identify misconceptions they may have about content material (Bybee, 2006). This sharing within cooperative groups is a fundamental strategy in constructivism, as it allows the teacher to facilitate the learning process, and the students to develop a common base of experiences. Problem-solving strategies depend on conceptual understandings, and hands-on exploration of simple topics combined with collaborative interaction among students helps to build an understanding of processes and concepts (Apple, 1993).

Teacher Preparation Summer Institute Overview

As an extension of the use of Dr. Skateboard's Action Science, approximately 25 teachers were chosen to be part of a cohort chosen by the Gaining Early Awareness and Readiness for Undergraduate Programs (GEARUP) program, a five-year program funded by the Department of Education. GEARUP was developed to expand educational opportunities and to assist students in becoming college eligible and then academically successful in higher education. The participating teachers were involved in a series of workshops to enhance their instruction and science content knowledge, and the goal of the workshop series was to model the use of the materials associated with Dr. Skateboard's Action Science for use with students in classrooms.

The summer institute for teachers ran on June 11-12, 2009, with follow-up trainings held on June 19 and June 26, 2009. The workshops were designed to increase their content knowledge in physical science as well as their attitudes towards science teaching and learning. Additionally, the teachers were to participate in two days of professional development and enrichment centered on pedagogical strategies and educational approaches for teaching science at the Middle School level. In the initial training sessions, the goals were to engage the teachers in activities from Dr. Skateboard's Action Science and to model the use of activities from each focus area in the classroom. The focus areas were forces, energy, motion and Newton's Laws of Motion, and the participating educators engaged in the actual activities in the same manner in which they would in turn facilitate students in the GEARUP Summer Student Institute.

Throughout this training the teachers were engaged in hands-on activities, which they in turn used to guide Middle School students in fundamental content understanding in Physics, Materials Science, and Mathematics. Pedagogical practice sessions focused on the use of inquiry-based learning, questioning strategies, brainstorming, constructivism, learning styles, and guided facilitation techniques for involving students in classroom explorations. This training approach allowed the faculty to support the teachers with focused instruction in pedagogy and provided multiple opportunities for engaging students in additional demonstrations. The workshops were designed to help the teachers critically examine the perspectives, philosophies, materials, and strategies for effective learning.

On the morning of June 11, the teachers were given background information and introductory materials related to the concept of action science and how familiar objects can be used to teach science. Additionally, teachers were provided with an overview of the DVD (Dr. Skateboard's Action Science) and the classroom resources available on it. Following this introduction, the teachers were lead through two activities from the DVD: Forces: Flatland BMX and the Center of Gravity & Energy: Dropping in with Potential and Kinetic Energy.

The training for this was well received, as teachers participated enthusiastically and commented on how useful and practical this approach would be for them to use with their students. For example, the use of the video segment in the "Forces" video focuses on the concept of the center of gravity, which additionally bridges the concepts of gravity and lift. Prior to showing the video segment, open-ended questions were used with the teachers in order to activate their prior knowledge concerning this content. Sample questions included, "What do you do when you ride a skateboard or a bicycle?", "How do you balance on a skateboard or bike?" and "What forces are acting on you as you are trying to ride a bike or skateboard?". Additionally, this approach can help reach previously marginalized students, who may have experience in these activities, but may struggle in science, and can now become experts in this discussion and contribute to the classroom investigations.

Finally, each workshop segment concluded with a series of focused science content questions such as, "What is the center of gravity and why is it important?" and the discussion was facilitated in order to introduce the segment in the "Forces" video that covers the concepts of gravity, lift and the center of gravity. This approximately 4 minute segment of the video then served as the engagement to the activity "Flatland BMX and the Center of gravity" in which participants created irregular cardboard shapes and determined the object's center of gravity. Teachers exploring a concept, just like students, should be given opportunities to work with hands-on materials so that they can have experiences that are real and fundamental.

Next, the teachers modified their shapes by either adding paper clips (which increased the mass) or by cutting off part of some of cardboard (which decreased the mass). In turn, they came to see that there is a fundamental relationship between the center of gravity and the mass of an object, and that the center of gravity would move in relation to an increase or a decrease in mass. After the classroom lesson, the teachers were asked to verbally explain their findings and the relationships they discovered from within the activity. As the teachers explored the concepts, they developed a broader understanding of those concepts, and a deeper self constructed content knowledge base. When they related what they were learning, seeing or doing to others, they began to see similarities in their understandings, as well as self identify misconceptions they may have about content material (Bybee, 2006). Finally, there was a list of open-ended questions for the teachers to answer, as well as a series of extensions that they could use to engage students if there was additional time and motivation to learn more. Each activity in this series was modeled in terms of constructivist instruction and done in the time frame of a normal class period. This approach provided the teachers with relevant ways to deliver science content and interesting alternatives to exploring these fundamental physics ideas with students.

On the morning of June 12, the teachers were given a review of the previous day and then moved directly into the next two activities; Motion – Speeding Down a Ramp with Velocity & Newton's Laws: Action Reaction/Rocket Car. The topics covered in these activities were also fundamental to the concepts to be explored in the workshops with the actual materials the teachers would use with the students in the coming weeks. After the successful completion of the activities, the teachers were given activity kits, which consisted of all the necessary materials for the classroom activities for a class of approximately 25 students. This was followed by a discussion that centered on the deconstruction of the activities, both from content and pedagogical perspectives. This was done in order to identify aspects that worked well, areas to strengthen for the coming weeks, as well as the pedagogical strategies to employ when using these materials with students.

On June 19, the teachers reassembled for a review of the previous week in which they used these activities with students involved in a summer GEARUP program. Following this session, the teachers were lead through a Socratic Questioning demonstration and then through a discussion and presentation on inquiry-based science. Additionally, the teachers participated in 2 new classroom activities; Simple Machines: Skateboards Have Levers & Fulcrums as well as Simple Machines: Levers & Fulcrums Using Inquiry. The purpose was to show more resources from the DVD as well as different methods of extending the classroom materials to emphasize inquiry in the context of the classroom.

As such, the materials in Dr. Skateboard's Action Science can also be utilized to emphasize inquiry in classroom explorations, and the teachers were guided in this approach in a student-centered, teacher facilitated method. For example, as a foundation for discovery, the teacher can use the video segment in the “Simple Machines” episode that relates to fulcrums and levers, and then have the students perform the classroom activity “Skateboards Have Levers and Fulcrums”. After the activity, the teacher may revisit these ideas and then create an extension inquiry exercise for the students to do in teams. The teacher can provide the students with the same materials used in the activity such as rulers, tape, plastic spoons, rubber bands, and modeling clay and challenge the students to design a simple machine made of at least three of the provided that uses a lever and a fulcrum and can propel a small marshmallow the farthest distance.

In making this transition from procedural activities to open-ended explorations in class, the teacher guides the students towards developing their own ideas and within a given time period, has the students create and test their unique designs. By engaging students in a design competition, there is a spirit of enthusiasm and excitement among the groups. This approach also presents excellent opportunities to develop cooperative group skills and to have students use critical thinking to solve the problem presented. "Students should know what it feels like to be completely absorbed in a problem. They seldom experience this feeling in school" (Bruner, 1962, page 50). Finally, the teams of students not only have to launch the marshmallow, but they also have to record the distances, calculate the average distances travelled and indentify the lever and fulcrum within their machine. In this manner, the students have to present their ideas, justify their understandings and support their findings with experimental data.

On June 26, the teachers reassembled for a final training session and review of their previous week in the use of the action science approach. They were lead through a series of brainstorming exercises, as well as demonstration of its features, using concept-mapping software and each teacher was given a complimentary trial copy of the program. The features of the software as well as its use in brainstorming and the development of concept maps were modeled for the group. Next, the teachers were lead through a presentation on how classroom culture impacts education, which emphasized learning styles and the importance of emphasizing critical thinking in the science classroom. This approach was then demonstrated through a guided facilitation science demonstration that showed how to integrate this approach in a practical manner. Finally, the 5Es of Constructivism were presented so that teachers had an understanding of the teaching and learning process around which all this training was built and delivered.

Constructivism is a learning strategy that builds upon students' existing knowledge, beliefs, and skills (Brooks and Brooks, 1993). Within a constructivist approach, as students encounter new information, they work to synthesize new understandings based on their current experiences and their prior learning. In other words, the constructivist approach to learning states that learners of all ages build new ideas on top of their personal conceptual understandings (Eisenkraft 2003). In this process, students and teachers experience common activities, while applying and building on prior knowledge. Learners construct meaning while continually assessing their understandings of concepts. Constructivism can be characterized as a five-phased process known as the 5Es, in which each phase begins with the letter E. The 5Es include the engagement phase, the exploration phase, the explanation phase, the elaboration phase and the evaluation phase (Bybee, 2006). Students and adults are enabled to construct a deeper and more comprehensive understanding through activities that match their cognitive capabilities. "The important point is that each (learner) has their own construction, their own understanding, rather than some common reality" (Duffy and Jonassen, 1992, p.6). The key is to build on previous learning and to apply new learning in a meaningful context.

Evaluation Results

The teachers were pre-tested and post-tested in both their physical science content knowledge and their attitudes toward teaching and learning. The content test was the same measure that students used in the summer institute and the attitudes test was modified from the Science Teaching Efficacy Belief Instrument Form B (STEBI-B). The teacher participants were from similar demographic and geographic locations in the city of El Paso in the state of Texas.

This research study may be defined as the design, collection, and interpretation of data and information in order to understand the value of an instructional methodology (Isaac, 1971). To measure the increases in student learning in teaching efficacy and science teaching outcome efficacy, specific educational objectives were tested and the results analyzed. Each evaluation instrument was administered twice to each participant over the course of the intervention. The educational objectives reflected the core attitudes and behaviors that teachers needed to achieve in the area of science education as stated by the state and national science standards.

Science Content

The teachers were pre-tested and post-tested over the science content using a 10-question exam that addressed the fundamental concepts to be covered in the summer institute. The topics included center of gravity, potential energy, kinetic energy, motion, velocity, force and motion. The questions consisted of 5 open-ended descriptive questions in which the participants answered textually to describe situations depicted in images. The other 5 questions were multiple-choice questions and the teachers had to choose the best answer for the statement. The tests were assessed and given a score out of 20 total points. The scores of the teachers on the pre-test (N=26) ranged from six (6) to eighteen (18) with higher scores indicating stronger and more positive content understanding to the topics in physical science (Mean = 11.96). The scores of the teachers on the post-test (N=22) ranged from thirteen (13) to twenty (20) with higher scores indicating stronger and more positive attitudes towards student achievement and teacher ability in science (Mean = 16.91).

The teacher scores for the science content area showed a regular improvement over the period of the summer institute, with teachers increasing almost 5 full points on average. This demonstrates an average increase of 25% for content knowledge in physical science content during the summer institute, a finding that can be seen as extremely effective and important. Although the number of teachers did decrease from 26 to 22 from the pre-test to the post-test, the impact of this approach on teacher content cannot be underemphasized.

Attitudes Towards Teaching Science and Students in Science

Additionally, the teachers were pre-tested and post-tested using the Science Teaching Efficacy Belief Instrument Form B (STEBI-B). The STEBI-B measured the two factors of science teaching efficacy, an individual's personal science teaching efficacy and science teaching outcome efficacy. Personal science teaching efficacy can be defined as the belief about one's own capabilities to facilitate the learning process within the context of science. The instructor for the students for learning science content can define Science teaching outcome expectancy as the measurement of the expectations.

The teachers were initially pre-tested before instructional sessions began in order to develop a baseline of their aptitudes and expectations towards teaching, as well as their current understanding and abilities in effective pedagogy. The teachers were post-tested at end of the fall workshops. Using a 5 Point Likert Scale (5=High to 1 = Low), the pre-tests and post-tests were evaluated. The scoring instructions provided a method for ensuring that the relationship between negatively and positively phrased statements would produce consistent values (Enochs & Riggs 1990).

The surveys were administered with no set time limit, and the estimated time for each survey was 15 minutes to complete the 23 questions. The attitudes questionnaire contained items that were phrased both positively and negatively, and the participants submitted all the information. Both positive and negative items contributed to the final total in which higher scores indicated more positive attitudes toward computers and technology. The highest possible score on the examination was 115.

Each of the 23 statements was characterized within a five-point Likert scale. The definitions for the scale were as follows: “strongly agree”, “agree”, “uncertain”, “disagree” and “strongly disagree”. There were 13 positively phrased questions and 10 negatively phrased questions. The scoring for each question was as follows:

Positively Phrased Items: 1, 2, 4, 5, 9, 10, 11, 12, 14, 15, 16, 18, and 22
Scoring: Strongly Agree=5, Agree=4, Uncertain=3, Disagree=2, Strongly Disagree=1
Negatively Phrased Items: 3, 6, 7, 8, 13, 17, 19, 20, 21 and 23
Scoring: Strongly Agree=1, Agree=2, Uncertain=3, Disagree=4, Strongly Disagree=5

The scores of the teachers on the pre-test (N=26) ranged from seventy-one (71) to one hundred and six (106) with higher scores indicating stronger and more positive attitudes towards student achievement and teacher ability in science (Mean = 83.96). The scores of the teachers on the post-test (N=22) ranged from seventy-seven (77) to one hundred and eleven (111) with higher scores indicating stronger and more positive attitudes towards student achievement and teacher ability in science (Mean = 97.05).

Generally, teacher attitudes increased in the areas of science teaching and the expectations towards learners in science. Over the period of the summer institute, the teacher scores increased over thirteen full points (13.09) on average. This demonstrates an average increase of almost 11% for science attitudes during the summer institute. As in the content exams, the number of teachers did decrease from 26 to 22 from the pre-test to the post-test.

Educational Importance of the Study

The use of action science as a mechanism for integrating transformative education is an approach that appears to be enhancing the interest and motivation of middle school teachers in science. It is the purpose of Dr. Skateboard's Action Science to positively impact achievement for Middle School students in the area of physical science knowledge and skills. By immersing teachers in a science learning approach that is based on action sports and focuses on the goals and objectives in physical science, the participating teachers' overall content knowledge and attitudes towards the teaching of science and learners greatly increased.

Based on these preliminary findings, the teacher's content understanding and personal beliefs of their abilities to teach and facilitate learning show that the teachers participating in the pedagogical workshops believe they now have a greater impact in teaching. Additionally, the results from the science teaching outcome expectancy point out that the teachers also believe they have a greater effect on student learning. The increased capacity for teachers to translate increased self-efficacy and outcome expectancy beliefs into increased teaching confidence, and that increased science content acquisition is also a positive effect in their teaching.

The educational importance of this study can be extended to reflect that the results of increased science content and attitudes combined with the increased expectations for student achievement by the teachers also extended across the disciplines of the study, as well as across gender. The importance is that with the instructors providing classroom time for students to actively engage in concepts, the depth and breadth of content understanding can be increased, and this may help to increase the number and diversity of students participating in science, mathematics, engineering and technology majors. Finally, this study gives relevance to the idea that more focused group work directed by teachers, can be effective in other scientific disciplines, including chemistry, computer science and mathematics. This type of training can be seen as effective in helping increase conceptual understanding of classroom material in the context of workshop explorations.

Overall, immersion in the GEARUP Summer Institute did change teachers' attitudes toward teaching and learning science as well as their content knowledge associated with the science of the workshops. Teachers in the sample exhibited relatively positive attitudes toward teaching science and the expectations for students in science, but showed a marketed increase in this efficacy over the course of the study. On average, teachers involved in the GEARUP Summer Institute positively increased their attitudes (11%) and content knowledge (25%). The results indicated that the GEARUP Summer Institute did help to increase physical science content understanding, an area often undeserved for Middle School teachers. In other words, no matter if the teachers liked science or not, enjoyed teaching or not, the GEARUP Summer Institute approach helped to increase science content understanding and attitudes towards teaching and learning.

References

Apple, M.W. (1993). *Official knowledge*, New York: Routledge.

Bentley, M.L. (1995). Carpe diem, *Science activities*, Vol. 32, No. 3, pp. 23-30.

Brooks, J. G. & Brooks, M.G. (1993). *The case for the constructivist classroom*, Alexandria, Virginia, ASCD Press.

Bruner, J. (1962). *The process of education*, Cambridge: Harvard University Press.

Bybee, R. W. et al (2006). The BSCS 5e instructional model: Origins, effectiveness, and applications (Executive Summary). [On-Line} Accessed September 9, 2007 at http://www.bscs.org/pdf/bscs5eexecsummary.pdf

Bybee, R. W., & Van Scotter, P. (2007). Reinventing the science curriculum. *Educational leadership,* 64(4), pp. 43-7.

Dewey, J. (1970). *The child and the curriculum*, Chicago: Chicago University Press.

Eisenkraft, A. (2003). Expanding the 5E model. *The science teacher*. Vol. 70, No. 6 pp. 57-59. National Science Teacher Association (NSTA), Arlington, VA.

Hofstein, A and Yager, R. (1982). Societal issues as organizers for science education in the 80s, *School science and mathematics*, Volume 82, pp.539-547.

Robertson, W.H. (2008). *Developing problem-based curriculum*, Ames, Iowa: Kendall/Hunt Publishing.

Rutherford, F. James and Algrehn, Andrew (1990). *Science for all Americans*, New York: Oxford University Press.