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Dr. Skateboard's action science: Teaching physics in context

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Abstract

In order to create student interest and promote new connections to the understanding of fundamental physics concepts, there is a need for new approaches and methods that are both contemporary and relevant. Dr Skateboard's Action Science, a curriculum supplement comprising video instruction and classroom activities, is an example that focuses on the physical science concepts found in the areas of forces, motion, 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.

Dr Skateboard's Action Science is designed to teach fundamental physics concepts using an approach that utilizes transformative educational strategies that help students move from memorizing facts and content to constructing knowledge in meaningful and useful ways. Students learn to develop questions, consider multiple points of view, and seek explanations in ways that require critical thinking and problem solving. The goal of this approach is to make physics education transformative through action science, a process in which educators integrate familiar experiences and materials from students' lives in order to amplify scientific concepts. In the case of Dr Skateboard's Action Science, the materials and experiences focus on skateboarding and bicycle motocross (BMX).

Dr Skateboard's Action Science integrates specific scientific concepts in a curriculum that contains both video instruction and classroom activities. Both sets of materials are designed to address both physics content and scientific process skills in both the National Science Standards (U.S.) and Texas Essential Knowledge and Skills (TEKS). The main purpose of this educational approach is to provide an interesting way of instructing students in the areas of motion, forces, Newton's laws of motion, and simple machines set in a real world context.

Background and Description

Dr Skateboard's Action Science was designed and developed by a collaborative team that included university faculty and personnel from local school districts, as well as teachers and students. The development team also included pivotal videographers who captured footage from school demonstrations, edited the four video parts following the script for each part, and placed appropriate graphics throughout each episode. The action sports footage provided a contemporary approach for providing students with physics content from familiar places that included skate parks, schools, classrooms, and community sites.

In order to create relevance in the action scenes that appear throughout the videos, a group of professional athletes in BMX and skateboarding were utilized. The athletes demonstrated physical science concepts, such as the relationships between centripetal force and moment of inertia, by performing high-flying and intricate maneuvers that included back flips and spins. With extensive experience performing for students in schools, this group provided the visual content that became the backbone of the video as it served to engage learners in the fundamental physics concepts. This is also another pathway to invite students to learn, in that they may not be initially attracted to science instruction yet do recognize and respect the difficulty of the maneuvers performed by the professional athletes.

In turn, the four-part video provides a series of instructional opportunities that allow students to explore relevant science content in class. It is the premise of this approach that students will better understand science content as a result of engaging in a curriculum that integrates their real world interests. Additionally, there is an underlying message that the characteristics that make action sports athletes successful, such as practice, persistence, dedication, and goal-setting, also can extend to students' individual academic and education pursuits. As one Principal of a participating school commented:

> The message regarding the importance of education, the fact that skaters can be smart students, and the need to set life goals took on a different meaning after seeing this presentation. The encouragement and presentation will be something that our students will never forget. (S. Haynes, Bonham Elementary School, El Paso, Texas, personal communication, April 14, 2007)

Accompanying the four-part video are 20 classroom activities, 5 for each of the parts that focus on the themes forces, motion, Newton's Laws of Motion, and simple machines, respectively. Sample videos and classroom activities may be found at *Dr Skateboard's Action Science* (n.d.). The activities utilize common household materials such as paper clips, card stock, string, and tape. This provides teachers with an affordable and practical series of experiments that engage students in hands-on explorations of the physics concepts presented in the video instruction. As the activities were being developed, they were field tested in real classrooms and revised on the basis of interactions with the 15 teachers involved in the design, development, and implementation of the activities.

Using the Approach

Dr Skateboard's Action Science is an example of transformative education, a student-centered curriculum supplement built around interesting content linked to specific physics knowledge and skills in science. The videos and classroom materials provide the classroom teacher with an instructional series rich in science and include topics such as moment of inertia and centripetal forces, inertia, center of gravity, and momentum. The purpose is to contextualize the classroom process of acquiring critical knowledge, developing proficiency in problem-solving, engaging in self-directed learning, and participating in collaborative teams.

The activities and materials are designed for students to interact in small teams, and this sharing within cooperative groups is a fundamental constructivist strategy that allows the teacher to facilitate the learning process. As a student-centered approach, it also helps to develop a common base of experiences on which to help students make connections to content. In the classroom, problem-solving strategies depend on the development of conceptual understandings, and hands-on explorations of simple topics combined with collaborative interactions among learners help to build an understanding of processes and concepts (Apple, 1993). It is important for educators to not merely regard the learner's point of view alone as fully complete and significant (Dewey, 1970), but to guide the students in the analysis and synthesis of content information. The learner is always defining meaning within the context of action and reflection (Brooks & Brooks, 1993), and the social situations, including discussion, explanations, and hands-on experiences, provide the context for knowledge construction.

The video segments themselves do provide action, but also relevant content for the classroom and complement the activities that teachers can implement in the classroom. Used in tandem, these can help reinforce the conceptual emphasis in a lesson. For example, the portion of the "Newton's Laws" video that covers the concepts of force, mass, and acceleration has been designed as an effective introduction to the activity "Force Makes a Mass Move." This brief video segment serves as a hook to introduce the activity and additionally as a review for the content covered in class. In that sense, the materials serve both pre-activity and post-activity purposes, and allow the teacher the flexibility to have students explain fundamental physics as well as pursue inquiry extensions. Each activity contains both a teacher section and a student section. The teacher section provides standards alignment information, background knowledge, guiding questions with answers, and extensions for student enrichment. The student section contains the classroom science activity, connections to real-world examples, explanations of concepts, and actual photographs of BMX riders and skateboarders in action.

Each learner understands content and concepts differently based on his or her previous experiences, and the materials help to provide a context for understanding both science concepts and real-world connections. So much fascinating content is at the fingertips of learners everywhere, and with computer access and technology becoming more affordable, more information is accessible. The main emphasis is to engage students in the exploration of science in a real-world context and to link physics to action sports. 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 & Algrehn, 1990, p. 198). Learning is the responsibility of the learner, but the teacher guides the student into developing meaning from content material and classroom experience.

It is important to engage learners 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 skate park to investigate topics such as inclined planes, levers, fulcrums, and screws. The purpose of this approach is to allow the students to explore meaningful science topics set in the context of something they enjoy doing.

Exploring Center of Gravity in the Classroom

Another classroom example from the program is the use of the video segment in the "Forces" video that focuses on the concept of center of gravity, which additionally bridges the concepts of gravity and lift. Prior to showing the video segment, the teacher can use open-ended questions with students in order to activate their previous knowledge concerning this content. Sample questions could include: "What do you do when you ride a skateboard or a bicycle?" "How do you balance on a skateboard or bike?" "What forces are acting on you as you are trying to ride a bike or skateboard?" Additionally, previously marginalized students who have experience in these activities, but who may struggle in science, can become experts in this discussion and contribute greatly to the classroom investigations.

Then, the teacher could conclude the series of questions by asking "what is the center of gravity and why is it important?" and then facilitating the conversation in order to introduce the segment in the "Forces" video that covers both gravity, lift, and the center of gravity. This approximately 4-minute segment of the video then serves as the engagement to the activity "Flatland BMX and the Center of Gravity," in which students create irregular cardboard shapes and determine the object's center of gravity through a series of step-by-step procedures. Students exploring a concept should be given opportunities to work with hands-on materials 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 is utilized in explorations and experiments.

Next, students modify their shapes by either adding paper clips (which increases the mass) or by cutting off part of some of the cardboard (which decreases the mass). In turn, they come to see that there is a fundamental relationship between the center of gravity and the mass distribution in an object, and that the center of gravity can move in relation to an increase or decrease in mass at a particular location. After the classroom lesson, the teacher can revisit the activity by asking the students to explain their findings and the relationships they discovered. As students explore concepts, they develop a broader understanding of those concepts. 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 et al., 2006). Finally, there is a list of open-ended questions for students to answer, as well as a series of extensions that they can engage in if there is additional time and motivation to explore these concepts. This entire activity can be done in the time frame of a normal class period with minimal set up and clean up, and can provide both the teachers and students with an interesting alternative to exploring these fundamental physics ideas.

Inquiry Activities Using the Ideas of Levers and Fulcrums

A constructivist curriculum must be designed so that it reflects real life situations (Bentley, 1995), and the use of relevant contexts helps to contextualize the concepts, as well as helps provide connections across subject areas (Hofstein & Yager, 1982). Research scientists cross over the barriers between academic disciplines all the time, seldom operating solely on isolated areas of content but rather integrating the use of language, knowledge, and process application. Science programs that emphasize investigation give students the ability to retain facts through critical thinking by working through problems logically and making connections to the real world.

The materials in Dr Skateboard's Action Science were also designed to emphasize inquiry in classroom explorations. 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 materials that uses a lever and a fulcrum and can propel a small marshmallow the farthest distance.

In making this transition 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. There are also 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, p. 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.

Conclusion

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 students 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 students in a science learning approach based on action sports and focused on the goals and objectives in physical science, the process skills and overall content knowledge of the students have the potential to greatly increase. Studies have shown that students who are involved in active learning in meaningful contexts acquire knowledge and become proficient in problem-solving (Robertson, 2008). In the longer term, research in this area will seek to determine how the implementation of curriculum approaches built around student interests such as skateboarding and bicycle motocross (BMX) can impact student achievement in science content and conceptual understanding.

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