Journal of Mathematics Education
December 2016, Vol. 9, No. 2, pp. 90-96

Mathematics Uncovered Through Action Science

William H. Robertson
The University of Texas at El Paso, U.S.A.

In an event-based series of on-site activities with high school students through an Action Science approach, fundamental concepts were explored including the foundations for functions, geometric think and spatial reasoning, the development of mathematical models, as well as techniques for working with spatial figures to understand underlying relationships. The activities in which students participated were designed to teach fundamental mathematics concepts in algebra and geometry in an approach that utilized transformative educational strategies, which helped students move from memorizing facts and content to constructing knowledge in meaningful and useful manners. With an emphasis on a collaborative data collection process, students proposed solutions to problems in which they interacted with action sports athletes who performed maneuvers on ramps and other props. The team of athletes, utilizing a peer-mentor approach, worked alongside the students in activities that incorporated mathematics, while the students collected real world data. These interactions within field-based learning opportunities allowed the students to explore practical applications of mathematics principles in geometry and algebra in the context of BMX and skateboarding.

Key Words: Action science, mathematics, geometry, algebra, science, physics, skateboarding, BMX.

Action Science is the use of familiar objects to teach principles in science, technology, engineering and mathematics (Robertson, 2014). It has also become synonymous with how concepts in these areas are realized in action sports; including skateboarding and bicycle motocross (BMX), in order to teach the content that students need to learn in school, such as geometry, algebra and physics (Robertson, 2009). Action Science is also a practical way to present fundamental topics of science, technology, engineering and mathematics (STEM) education embedded in approaches that are entertaining, also known as edutainment (Robertson and Lesser, 2013). The use of edutainment in this manner is meant to inspire broader interest in STEM for middle and high school students and to develop a culture of education that makes learning more accessible to all students (see figure 1).

By incorporating action sports within an active learning framework, the engagement of students and educators increases, along with the overall interest in teaching and learning. Students involved in this approach see that teaching and learning can be fun, so that rather than not wanting to go to

school or avoiding certain subjects, they are actually motivated to learn. The importance of using relevant and practical methods of instruction and curriculum delivery that build on student interests and increase enjoyment in the learning process are critical at the secondary levels, especially in the STEM fields. By integrating mathematics and science concepts within student-centered learning opportunities, the practical integration of STEM topics is lived out experientially.

Figure 1. *Action Science brings extreme and entertaining activities in the context of STEM learning.*

Teachers need to present themselves as respectful guides and compassionate helpers who grant students the opportunities to become actively involved in classroom interactions and in their own learning (Hasslen, 2008). As such, the traditional relationship between the teacher and the student changes, so that the teachers now serve as facilitators, mentors, co-learners and role models, which exemplifies transformative educational strategies. More importantly, educators become change agents by working to establish links within their communities, and trying to engage their students in

active learning projects that require them to interact with individuals outside the school (Donovan, 2002). For the transformative teacher, learning can take place in different venues and not solely in the classroom (Palmer, 1998), utilizing informal spaces and unique settings, such as an active sports demonstration and series of activities outside a local high school.

The activities in which students participated were designed to teach fundamental mathematics concepts in algebra and geometry in an approach that utilized transformative educational strategies, which helped students move from memorizing facts and content to constructing knowledge in meaningful and useful manners (Mezirow, 2003). For example, in an event-based series of on-site activities utilizing skateboarding and BMX athletes working alongside high school students, fundamental concepts, including the foundations for functions, geometric think and spatial reasoning, were explored by the students. By embedding mathematic principles within hands-on field-based activities, active learning through action sports brings relevance to the idea that mathematics is the language of science. With an emphasis on a collaborative data collection process, students proposed solutions to problems in which they interacted with action sports athletes who performed maneuvers on ramps and other props. The team of athletes, utilizing a peer-mentor approach, worked alongside the students in activities that incorporated mathematics, while the students collected real world data.

The Skatepark Mathematics Extravaganza – An Action Science Innovation

How can a teacher get young people interested in science and mathematics? What efforts are there to integrate the experiences of students into the things they need to do and learn in school? How can action sports, like skateboarding and bicycle motocross (BMX), be used to teach physics, algebra, data collection, and help students to grow in their engagement and motivation in science, technology, engineering and mathematics (STEM)? The answer lies in part with the use of Action Science within a Skatepark Mathematics Extravaganza.

In November of 2014, a series of live demonstrations and field-based activities were led by educators, along with a team of professional and top amateur BMX riders and skateboarders, who performed at six high schools in the El Paso, Texas. These events, entitled the "Skatepark Mathematics Extravaganza", were done in order to engage local students in focused explorations of mathematics in a real world setting that is relevant to youth culture (see figure 2). Following each demonstration, students participated in field-based data collection activities, designed to give an academic purpose to the presentation.

I've been a skateboarder for over forty years, and I have performed for thousands of students in elementary, middle, and high school levels

throughout the United States, Canada, Mexico and in South America. Additionally, I have been an educator for over twenty-five years, currently as a professor in STEM education with experience teaching at the middle school and high school levels. As an educator and a skateboarder, I knew I would have unique opportunities to instruct and to work with students and teachers, and the development of Action Science is a natural example. Through skateboarding and education, I have learned creativity, practice, patience, discipline, and goal setting. Many of my audiences of students and parents typically don't see the connection between skateboarding and science.

Figure 2. *Live action sports demonstrations help to engage and motivate students to learn mathematics.*

The task of the students was to gather data from three different stations in the skatepark where the riders would perform maneuvers. The first station was the half-pipe, a semicircular ramp structure, where riders moved back and forth and where students had to calculate angular motion. The second station

was an inclined plane that was approximately two meters high and six meters long. The riders would drop in on the inclined plane ramp and the student would record the time it took the rider to reach the edge of the ramp. From this data, the students could calculate the acceleration of each rider. The third station was a grind rail, a metal beam affixed to elevated supports on which a rider would travel up to and slide across. The students had to calculate the velocity of the rider as each athlete got to the grind rail, and then determine at the final velocity a rider achieved at the end.

So, how does this related to mathematics? Well. in terms of the acceleration activity, a BMX rider or skateboarder moved down an inclined plane, where an acceleration (a) was produced that the students needed to calculate. Beginning from a stop with an initial Velocity (Vi) equal to 0, the rider dropped in on the inclined plane and accelerated through the bottom of the transition to the flat ground. The distance of the inclined plane was six meters**.** Then, the students had to record the time (t) in seconds for each attempt by each rider and then first calculate the final velocity in order to calculate the final acceleration for each rider. This required the students to understand that acceleration is a change in velocity and in mathematical terms, they needed to use the time recorded to find both the final velocity and the overall acceleration. In terms of basic understandings in algebra, this activity focused on the foundations of functions, in which students must understand that a function represents a dependence of one quantity on another and that the relationships can be represented through equations and diagrams that they needed to produce.

Practically and logistically within the grind rail activity, the students were organized into small groups at each station and looked to collect data and make calculations. As the rider began to approach the grind rail from a stationary position, the rider had an initial velocity (Vi) that was equal to 0 m/s. From this point, the rider would then cover a specific distance (ten meters) and hit the grind rail at a second velocity (V2). Once on the grind rail, the rider would cover another distance of 4 meters and exit the grind rail at a final velocity (Vf). As a team, the students had to calculate the final velocity of the rider by recording the time (t) in seconds at each interval and deriving velocity values for Vi, V2 and Vf, using the basic equation of V=distance (meters)/time(seconds). This required the student teams to break down and analyze the problem, as well as synthesize the equations to produce results that addressed both the velocity of the rider leading up to the grind rail and then using that value to help calculate the final velocity upon exiting the grind rail. In this way, the students could determine mathematically if the rider went faster or slower on the grind rail, and they could justify their position by the values they produced in their calculations. This activity required students to use properties and attributes of functions in order to solve a complex problem, where the students had to collect and organize data and interpret the results in order to make a decision requiring critical thinking.

The Skatepark Mathematics Extravaganza was designed to teach fundamental mathematics concepts in algebra and geometry in an approach that utilized relevant teaching and active learning, which help students situationally towards constructing knowledge in meaningful and practical ways. The demonstrations and subsequent field-based activities allowed the students to explore practical applications of mathematics principles in geometry and algebra in the context of BMX and skateboarding. In this effort, the team entertained and educated over 4000 at the six participating high schools, and instructed a total of sixteen sessions of the Skatepark Mathematics activities for an estimated 1750 students.

Action Science and Edutainment

Edutainment has recently been a major growing area of education, showing great promise to motivate students with relevant activities. The Skatepark Mathematics Extravaganza and the materials from an Action Science-based approach are examples of cutting-edge fusions of popular culture and STEM concepts designed to engage and to motivate middle and high school students. Action Science resources are not workbooks or a series of activities to implement, they are pedagogically-enhanced professional development opportunities for teachers, which utilize a constructivist methodology that can be integrated into the classroom pragmatically.

The importance of an active environment for learning that integrates oral, visual, and kinesthetic strategies by the teacher allows for learning to be student-centered. In this approach, teachers become change agents, linking the relevant life experiences of the students to the content of the curriculum, and in no area is this more needed than in middle school science. The teacher must establish connections within the learning communities, and engage their students in active learning projects that require them to interact with individuals inside and outside the school. For the constructivist science teacher, learning needs to be extended into the fabric of student's lives, not solely as a subject to be explored uniquely in a classroom.

The purpose of this approach as it applies to mathematics education is to provide teachers with resources rich in compelling content that is motivating and relatable. Action Science is about students in today's classrooms and is designed to help teachers with relevant and practical approaches in STEM instruction. As with all students, whether they be in K-12 classrooms or in university settings, but even more so with marginalized students, education needs to be engaging and inspiring. With foundations in edutainment, Action Science is a great example of student-focused transformative approach designed to reach the modern learner.

Conclusion

The connection of mathematics content to real world experiences is vital in order to engage students effectively and to provide them with a reason to delve into deeper conceptual understandings. The use of skateboarding and BMX show how popular activities that resonate with students can help to make learning mathematics topics fun and enjoyable. The importance of using relevant and practical methods of instruction and curriculum delivery that build on student interests and increase enjoyment in the learning process are critical at the high school levels, especially in the fields of algebra and geometry. The use of edutainment in this manner is meant to inspire broader interest in mathematics for high school students and to develop a culture of education that makes learning more accessible to all students (Robertson and Lesser, 2013). Edutainment has recently been a major growing area of education, showing great promise to motivate students with relevant activities. By highlighting mathematics within an Action Science approach that included on-site demonstrations and field-based activities, cutting-edge fusions of popular action sports and mathematics concepts are integrated in order to engage and to motivate high school students.

References

Donovan, B. (2002). An illustration of practice in search of theory. *Theory and practice, 41,* 17-26.

Hasslen, Robin. (2008). From a tarpaper shack to a transformed classroom: A teacher's journey. *Kappa Delta Pi Record, 44,* 52-54.

Mezirow, J. (2003). Transformative learning as discourse. *Journal of transformative education 1*(1), 58-63.

Palmer, P.J. (1998). *The courage to teach: Exploring the inner landscape of a teacher's life*. San Francisco: Jossey-Bass.

Robertson, W.H. (2009). Dr. Skateboard's action science: Teaching physics in context, *The science education review, 8*(1), 30-34.

Robertson, W.H. & Lesser, Larry (2013). Scientific skateboarding and mathematical music: Edutainment that actively engages middle school students, *European Journal of Science and Mathematics Education, 1*(2), 60-68.

Robertson, W.H. (2014). *Action science: Relevant teaching and active learning*. Thousands Oaks, CA: Corwin Publishers.

Author:

William H. Robertson
The University of Texas at El Paso, U.S.A.
Email: robertson@utep.edu