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Sports as a Creative Way to Teach Science

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Abstract

This study investigates the development of scientific concepts by participants in a program which addresses the creative diversity inherent in learning by using sports as the context through which scientific principles can be explored. Through the vehicle of sports not only are students learning the underlying principles of science embedded in the mechanics of performing a sport, but they are also learning the scientific principles in an atmosphere that embraces the psycho-social-creative-emotional connection to learning.

Keywords: STEM, science, sports, girls, minority youth, psycho-social-creative learning, urban schools

1. Introduction

1.1. Background and Overview

Our research addresses the creative diversity inherent in learning by using sports as the context through which scientific principles can be explored. Through the vehicle of sports, not only are students learning the underlying principles of science embedded in the mechanics of performing a sport, but also they are learning the scientific principles in an atmosphere that embraces the psycho-social-creative-emotional connection to learning. For instance, in their everyday lives students learn how to ride a bike, throw a ball, and/or jump rope. They learn these activities in an environment that is non-competitive and non-threatening academically. What they are not aware of is the scientific and mathematics principles laden in performing these activities. In the classroom students learn these scientific and mathematical principles in a context that is foreign to their everyday experiences. They learn about the trajectory of a golf ball without connecting this principle with the actual practice of hitting a golf ball.

This line of research is unique in that the academic and the everyday experiences of students can be bridged through the creative process of using sports as a mechanism to

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learning science and mathematics. By using sports as a creative vehicle for learning scientific and mathematical principles, the program described here responds to the call for creating innovative and creative programs that provide access to cutting-edge strategies in promoting science literacy.

1.2. Theoretical Framework

A current view of how individuals process information and construct meaning proposes several independent forms of information processing, including logical-mathematics, linguistic, musical, spatial, creative, bodily kinesthetic, interpersonal and intra-personal (Gardner, 1993). Because individuals may differ in their specific profile of "intelligence," education needs to be diverse in its offerings, both in terms of content and format of instruction. Creativity is at the heart of human intelligence. Fostering the development of creativity has increasingly been acknowledged as an important aspect of learning (Wyse and Ferrari, 205; Collard and Looney, 2014). The development of creativity can be fostered by designing environments, physical artifacts, and learning activities characterized by centeredness on student interests and on playful exploration (Donaldson, 2016; Davies et al., 2013). Creative learning environments promote the experience of flow, which—as with other effective science, technology, engineering, and math programs—depends on alignment of learning activities with students' skills, talents, and interests (Rathunde and Csikszentmihalyi, 2005; National Research Council, 2011).

The previous decades have witnessed many voices calling for reform in the teaching of science and mathematics. Over two decades ago in the United States of America, the federal government identified six National Education Goals which boasted that the United States would be first in the world in science and mathematics by the year 2000 (Culotta, 1990; Vinovski, 1996). Policymakers, scientists and mathematicians have focused on change to develop the scientific and mathematical knowledge that will produce a healthy economy and maintain a meaningful democracy (Tate, 1994, Barlow, 1999). Under the current administration, science, technology, engineering, and mathematics (STEM) education is a focus of priority in funding and educational efforts (Penuel, Harris, and DeBarger, 2015; Gonzalez and Kuenzi, 2012).

While standards provide a map for improving the science and mathematics education of all students, urban schools and the communities to which they belong face barriers to providing adequate science and mathematics programs. When examining the conditions of many urban schools and communities, the reform necessary to reach improved student achievement seems daunting (Barlow, 1999; Kozol, 2000; Darling-Hammond, 2010). In particular, minority students (i.e., African-Americans, Latinos and women) and students from low socioeconomic backgrounds confront great challenges in performing well in science, mathematics and technology related fields (Kraft, Papay, Johnson, Charner-

Laird, Ng, & Reinhorn, 2015; Foltz, Gannon, & Kirschmann, 2014; National Academies, 2011; Hammrich, 1997; Hammrich, 1998; Hammrich et.al., 2000; Hammrich, 2002; Hammrich, 2008; Hanson, 1996; oakes, 1990; Scheurich, et.al. 2010). National agencies such as the National Science Foundation and National Science Board have identified these challenges as being urgent, calling for innovative and creative programs to provide underrepresented learners with access to the most advanced tools in science, mathematics, and technology education (Córdova, 2016; NSF 2014).

The American Association of University Women publication *Gender Gap: Where Schools Still Fail Our Children* posits a variety of positive impacts that sports can have on children. Girls and minority youth in the late elementary through middle school years tend to struggle with self- esteem, physical fitness, skill development, goal setting, and problem solving. Sports are one ideal mechanism to reach girls and minority youth during these uncertain years in which they explore their self-identities (AAUW, 1998). Research links physical activity and involvement in sports for girls to higher self-esteem, positive body image, goal setting, academic achievement, social skills, and lifelong health (Schaillée, Theeboom, and Cauwenberg, 2015; Srikanth, Petrie, Greenleaf, & Martin, 2015; AAUW, 1998).

Abrahamson and Lindgren (2014) argue that the intuitive mode of learning embedded in students' everyday lives is of a different nature from the analytic mode common in the STEM disciplines, and therefore students need embodied forms of learning to reconcile the modes of learning. Facilitating this reconciliation can be accomplished through instructional practices which integrate *embodied* cognition where body-based learning facilitates cognitive processes of learning and *embedded* cognition where the physical and social context mediates learning (Nathan and Sawyer, 2014). The program in this study supports and furthers this vision by providing mathematical and scientific concepts through the vehicle of sports. In doing so, the program is reaching students on multiple levels of intelligence, engaging students in embodied and embedded cognition, and taking areas of student interest as a starting point for strengthening the education of students in science and mathematics. It also creates an authentic and diverse atmosphere in which girls and minority youth are empowered—an atmosphere which counteracts the obstacle to learning described by Adrienne Rich: "when someone with the authority of a teacher, say, describes the world and you are not in it, there is a moment of psychic disequilibrium, as if you looked into a mirror and saw nothing" (2011, p. 218). Learning science through sports describes a world in which students see themselves.

This program seeks to address equity in science by providing students exposure to science through sports. The program is designed for sixth, seventh, and eighth grade girls attending urban middle schools and furthers the vision of its predecessor programs (Hammrich, 1997; Hammrich, 1998; Hammrich et.al., 2000; Hammrich, 2002; Hammrich, 2008). The program's vision is to increase students' positive attitudes, achievement, and exposure to science. What is unique is that the program teaches science concepts within the contexts of playing sports. By doing so, the program is successfully reaching students in a variety of ways and strengthening the education of students in science and mathematics by creating a unique and diverse pedagogical atmosphere. By using sports as a vehicle for learning scientific principles, the program is responding to the national call for creating innovative programs that provide access to the latest strategies in promoting science literacy.

This study investigated the efficacy of a sports-based science educational program in improving participants' understanding of scientific concepts. The research question was: Do participants in a program for learning science through sports demonstrate greater understanding of scientific concepts?

2. Method

The Sports Program targets 6th - 8th grade students and focuses on the use of sports as a vehicle for science exploration. The program provides hands-on, inquiry based sports science activities that allow students to develop a repertoire of experiences, which can then be used as the foundation for learning scientific concepts. There are a total of 8 sport science modules that focus on science and mathematics concepts in life, earth, and physical sciences. Each module lasts for 5 weeks. The sports are golf, tennis, fencing, basketball, track and field, volleyball, health related fitness, and soccer. Program components include an in school program, after school program, teacher training, family education and summer camp.

In this within-group time series experimental study (Creswell, 2012), the middle school students took individually administered pre- and post-tests covering skills and concepts inherent to the science and mathematics concepts they were exposed to in the sport. University science faculty developed the instruments. The students' responses were open-ended allowing them to express their creative understanding of the content. Sample questions include the following examples: What does the word velocity mean? What is speed? What is a projectile? What is a trajectory? Each question was scored as correct or incorrect. There were four questions for each activity. In reporting the scores for each activity the four questions were grouped into either correct or incorrect for the entire concept.

Pretests were administered at the beginning of each module's activity, and posttests were administered at the end of the module's activity. The pretest and posttests were identical instruments. Students' grades from the beginning of the year to the end of the year were also compared to see if there were any gains in their academic achievement. Also, parents were surveyed prior to and after their child' participation in the program to see if their awareness to the connection between sport and science and mathematics changed.

3. Results

Gain scores were analyzed using a simple *t* test. Based on raw scores, the percentage of correct responses was used as the measure. The data consistently shows statistically significant mean increases from pre to posttest ranging from 27 to 60 percentage points ($p < .001$ in each case). Looking at these gains in a different way, in every case, the lower quartile on the posttest exceeded the upper quartile on the pretest. All of the results from the program are summarized in Table 1.

Table 1. Pre- and Posttest Mean Scores and Standard Deviations

Sport Science	n	Pre-test: m	SD	Posttest: m	SD	Gain
Tennis-Geometry	52	29	22.1	84	17.3	55**
Fencing-Forces	40	38	21.4	86	14.2	48**
Basketball-Motion	32	27	16.5	77	23.3	50**
Golf-Mechanics	50	34	19.4	93	8.6	59**
Volleyball-Aerodynamics	48	28	19.4	77	22.5	49**
Soccer-Mechanical Engineering	35	28	19	88	12.2	60**
Track (field)-Aerodynamics	33	36	22.3	90	12.5	54**
Track (running)-Biomechanics	42	33	15.5	60	18.7	28**

Notes. Scores are raw scores, reported as a percent of correct response.
**Denotes statistically significant gains (p>.001)

Additionally, we point out that of the sixth graders who completed the sixth grade program 67% returned as seventh graders. Furthermore, 54% of all students who completed the seventh grade program returned to participate as eighth graders. We believe that these retention rates speak volumes about our students' attitudes toward the program.

Also with respect to students' grades at the beginning of the year compared to the end of the year, *t*-test results showed that the students achievement scores (grades) in both mathematics and science increased significantly ($p<.05$) during the year pre to post.

Another positive benefit of the program is that of the parents surveyed prior to and after their child's participating in the program, parents increased their awareness of the connection of sport to science and mathematics by 60 percent (33% awareness at the beginning to 83% at the end of the year).

4. Discussion

The only quantitative analyses of the *SISS* program we have been able to perform thus far are the analyses of simple gain scores of participants presented in the previous section along with their classroom grades in science and mathematics prior to and after participating in the program. With no potential comparison available as to what gains would be expected in a traditional approach to learning these concepts, we can draw no strong conclusions regarding the effects of the program at this point. Thus, while these results are suggestive of a positive effect of the program, nevertheless they must be regarded as preliminary and not generalizable. However, we have ample qualitative evidence that the program has had a positive effect on the lives of many of the students. The journals kept by the middles school students are one source of such evidence. In reflecting about the program, the features cited most frequently by these students are that they are having fun ("this is fun"), enjoying the program ("I really like participating in this program"), and learning science and mathematics ("I am learning about angles, measurement, and reflection"). Some of the students were able to see connections among the things they were learning in the program and what they are studying in school ("Throwing a ball is like learning about trajectory in school").

5. Conclusions

Based on the significant increase in students' understanding of science concepts through sports, it seems that sports provide a creative way to facilitate students' cognitive understanding of science concepts. While programs that address the equitable achievement for all students in science and mathematics are not new, using sports as a vehicle through which science and mathematics interest and achievement can be attained is unique. This approach bridges the application of concepts embedded in science and mathematics to the mechanics of performing a sport. Sports provide a unique and innovative approach to reaching students in a friendly atmosphere while learning concepts usually too abstract for them to grasp due to their limited experience and exposure.

Another unique feature of this project is the focus on middle school science and mathematics. It responds to a dearth of attention to this level in public schools and fills a gap in the relevant literature (Meyer, 2011). Middle school students often experience a drop in grades due to lack of organizational skills and difficulty adjusting to the requirements of several teachers. Learning science and mathematics principles through participating in sports will help students through this transition phase and will reduce the chances of "falling through the cracks".

In conclusion, one project or one group of committed science and mathematics educators alone cannot tear down all of the barriers for students in the areas of science, mathematics, and technology. One set of dedicated teachers, mentors, or undergraduates by themselves cannot change the often negative course of employment or postsecondary education for future scientists or mathematicians previously described in the professional literature. But this project clearly is a start. Ongoing, pro-active involvement by the students themselves can teach important science and mathematics skills, while simultaneously expanding new horizons through early transition awareness.

What became evident in the program implementation was that (a) intervention programs that are specifically designed to include role models have a strong and positive impact on students' achievement in science and mathematics and assist to help identify with science and mathematics as possible areas for study or employment; (b) program interventions evolve in stages of development, growth, and change; and (c) parental behavioral expectations for their children have important implications for their interest and achievement in science and mathematics. In order to promote the sustained success of students in science and mathematics, there must be a conscious effort to provide support for collaboration among schools, parents, and the community as ideas for useful strategies are developed, implemented, and evaluated.

What we have learned over the course of implementation of the program is that any such intervention program would be strengthened if designed such that: (a) students come to see the intervention program as an extension of their formal education; (b) older students serve as mentors and role models for younger students; (c) students are presented means for academic success; (d) students are presented with avenues towards possible careers; and (e) students are expected to succeed academically. Using sports to teach science is one possible approach to academic enhancement for students living in the urban environment. The results indicate that the program is serving the population of students in a positive manner.

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