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A STEM Model to Engage Students in Sustainable Science Education through Sports: A Case Study in Qatar

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Abstract

Sport is a powerful tool to make deeper connections, stimulations, and understanding of STEM (science, technology, engineering, and mathematics) education. Science in sports is a unique program established to present sports as a medium for STEM education. The program included 248 students (112 females and 136 males) from 15 secondary schools in the state of Qatar. The participants took part in interactive, hands-on learning workshops where they were challenged to design sports equipment from innovative materials while adhering to specific design criteria. Quantitative and t-test analysis were performed on data collected over five years from 2012 to 2017 of the program to analyze its effectiveness. Along with Research and Development (R&D) study obtained from pre and post surveys of students, teachers, and facilitators to further analyze participants' behaviors and attitudes.

Introduction/Objectives

Sports can promote social integration, economic development, develop teamwork capabilities, and improve physical & mental health. The state of Qatar has been recently brought to the limelight of sports industry as it has grabbed the opportunity to host the most sought-after sports event, the FIFA world cup 2022. The coverage and discussions on the event and the wide-spread enthusiasm for the sports is a well-timed opportunity for the educational community to emphasize the positive impact of sports on students of all ages. Educators believe sports as paramount while providing a wholesome educational experience. The research objective was solely focused on acquainting students with STEM and its relevance in daily life by engineering simple sports products

Method

The facilitator offers extensive two-hour daily workshops for a week with diverse hands-on activities (refer to Figure 1) to engage the students in experiential learning. The main goal of providing workshops to the students was to acquaint them with enough scientific information to design and construct the sports products- concrete boat, bowling ball, golf ball, and baseball.

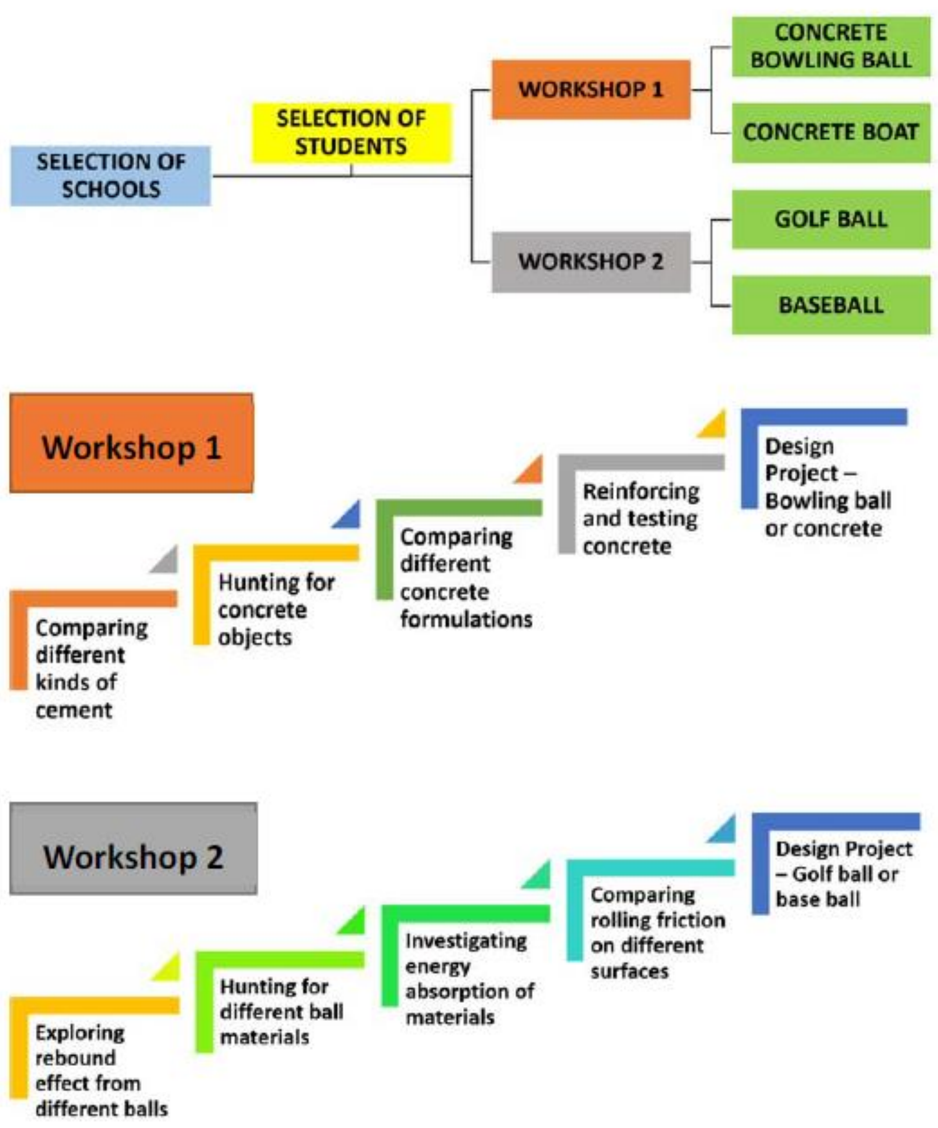

Figure 1 Schematic diagram of 'Science in Sports' program methodology.

Students adhere to the evaluation criteria, as in Table 1. The sessions were allocated to repeated testing and designing of the product prototypes. In case of failure in creating the product according to the desired criteria, they will start over again or fix the products for positive results.

Table 1. The list of parameters that need to be satisfied for excellent results.

Product.	Parameter	Requirement
	Surface smoothness	Smooth surface
Concrete Bowling ball	Weight of the ball	Less than 5.5 Kg
	Distance traveled	3m and hit the pins as shown in Figure 2b
	Buoyancy without weights (External factors)	Floating < 5 Sec.
Concrete Boat	Buoyancy without weights (Internal factors)	Floating < 60 Sec.
	Loading capacity	Maximum weights
	Diameter	7.3cm to 7.6 cm
Baseball	Weight	142g to 149g
	Ability to rebound	Maximum
Golf ball	Diameter	Between 4.5 and 5.5 cm
	Ability to rebound	Bounce once and clear the obstacle
	Ability to roll and stop (Friction)	Stop at target area

Data Collection Methods

1. Pre/post -questionnaires

The students completed a set of study questionnaires to assess their attitude on STEM and its impact in the real world. The questionnaires consist of multiple-choice questions that stem from the student opinion on STEM education, their career interests in scientific fields, and their skills. The students may recommend from four standards of agreement: "agree", "neutral", "disagree," and "do not know". The questionnaires are assessed using standard Monitoring and Evaluation (M&E) procedures.

1. Evaluation of project presentation

After completion, the products were examined by external evaluators from sports facilities, academia and leading economy driving industries. Participants were evaluated on their STEM competencies acquired through the sports product engineering project. They presented their project experience in a PowerPoint presentation, implementing digitalization in the process, and self-mentoring themselves in preparing for the evaluators' queries

Results and Discussion

The sports-based program has conferred productive insight into students' cognitive skills development as well as their attitudes towards STEM domains and aspirations. The SIS program has positively influenced participant students' cognitive development as they successfully designed their sports products.

1. Bowling Ball Design

The participants successfully constructed and designed bowling balls that met different criteria, such as surface smoothness, specific weight, and distance rolled, for the final evaluation.

2. Boat Design

The resulting boats ported the expected quality of concrete that displayed efficiency in terms of parameters like workability, durability, strength, cost and finishing appearance. Students were successful in presenting a fully functional product.

3. Golf ball design

Students chose optimum materials that contributed to accomplishing their design criteria, specifically balancing the required rebound-ability to cross the obstacle and the desired diameter.

4.. Baseball design

The students were successful in choosing materials that contributed to accomplishing the design criteria, specifically the rebound ability. They combined different materials like rubber, yarn, fabric etc, depending upon their weight and rebound ability to construct a ball structure, looking for the best rebound effect.

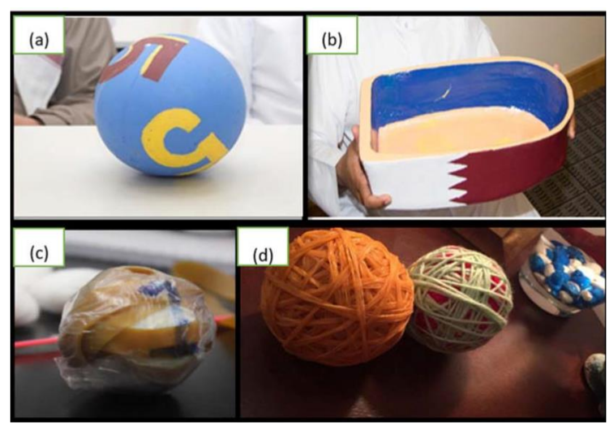

Figure 2. Examples of students' sports products that were displayed during the program- adjourning event.

Descriptive Statistical Analysis

Analysis of the study was quantitatively carried out by conducting pre and post workshop surveys. The study clearly manifested the increment in students' interest for interactive STEM curriculum. The analysis also reported a considerable growth in their self-efficacy and innovative skills along with their positive inclination towards STEM, in general and career wise.

Table 2. SIS cycles by t-test analysis (n =248).

STEM interest Indicators	Cycle	Statistics			Samples test		
		Partici-pants N	Pretest Mean (SD)	Posttest Mean (SD)	Mean Diff (SD)	t Value	p-Value
• We live in a better world because of Science,	1st	51	3.07 (.932)	3.79 (.865)	.730 (1.185)	4.4	0.000
Technology, Engineering, and Math (STEM).	2nd	56	3.38 (1.205)	3.98 (1.032)	.603 (1.680)	2.68	0.01
• Learning Science, Technology, Engineering,	3rd	35	2.98 (.570)	3.81 (.900)	.836 (.889)	5.56	0.000
and Math (STEM) is essential for my future success.	4th	52	3.46 (.865)	3.66 (.913)	.202 (1.195)	1.22	0.229
• I would like to have a career as a scientist or researcher. • I have the skills to implement a scientific ex-periment.	5th	54	2.31 (.746)	3.03 (.693)	.722 (.757)	7.02	0.000

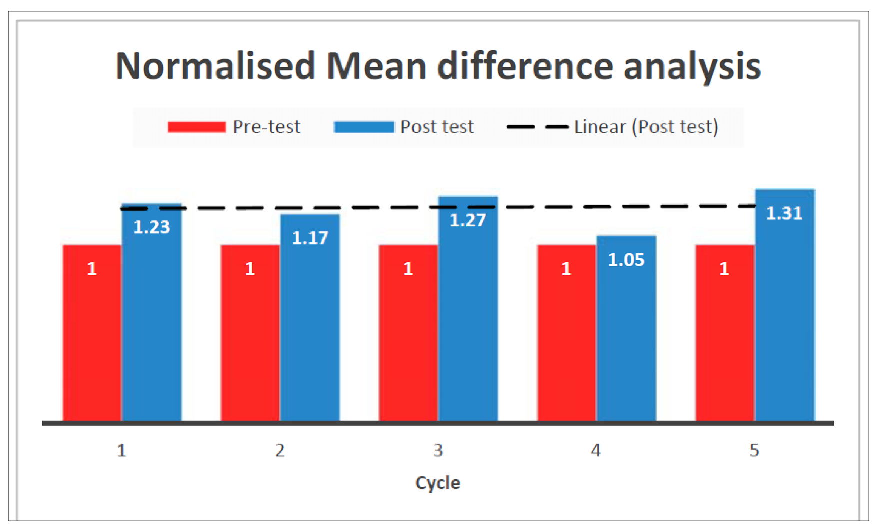

Figure 3. Normalized Pre-test & Post test mean difference comparison of population for 5 cycles (n =248).

Demonstration and presentation of design projects

A conference was organized at the end of the program as an adjourning event for two days, displaying and examining the students' final products in the presence of an evaluation panel.

As students presented their products to the panel, they displayed their presentation skills along with the communication dispositions. The participants were assessed critically for their organizational ability, research methods implementation, and creative collaboration as they presented their project experience.

Figure 4. Students displaying their products for evaluation. Students in the respective image are testing their concrete boats by incrementing the weights in the boat thereby testing its load carrying capacity. Bowling pins are laid 3 m away from the ramp for the evaluation of bowling ball.

Conclusion

The implementation of the sports-driven program, 'Science in sport', could enhance high school students' inclination towards STEM fields and careers. Participants self-motivated by sports, bolstered competencies by engaging through engineering design process while developing a sports product during the challenge. The program exploited the students' enthusiasm in sports to participate in an inquiry driven learning approach to experience design and engineering. The program outcome also offers opportunities for student enthusiasm and pride through product achievements.

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