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Moving STEM Beyond Schools: Students' Perceptions about an Out-of-School STEM Education Program

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Abstract

Recent reports call for reformed education policies in Turkey in accordance with the need to develop students' knowledge and skills about STEM education and improving STEM workforce in the country. This research implemented an integrated out-of-school STEM education program for 6th grade students who come from disadvantaged areas in a large urban city in Turkey. The study investigated students' perceptions about the STEM activities implemented in the program. Forty 6th grade students (15 female) studying in public schools participated in the study. The data source used in this study was the activity evaluation forms completed by the students at the end of each activity. The evaluation forms were qualitatively analyzed to identify students' perceptions on the content and skills gained, the challenges and limitations faced and suggestions for improvement. The results present recommendations on the implementation of integrated out-of-school STEM education programs.

Introduction

Countries look for strategies to develop young generation's knowledge and skills for designing and developing innovation, technology, and scientific literacy in order to confirm their place in the global economy. Science, Technology, Engineering, and Mathematics (STEM) has become a government policy in countries such as United States (National Academy of Sciences [NAS], 2006; National Academy of Engineering [NAE], 2009; National Research Council [NRC], 2012). Australia, China, Korea, and Taiwan have been working to develop K-12 STEM curriculum designed as "integrative cross-disciplinary approaches within each of the STEM subjects" (Fan & Ritz, 2014, p. 8). Increasing attention is given to STEM disciplines and STEM teaching across Europe (Corlu, Capraro & Capraro, 2014). Recent reports call for reformed education policies in Turkey to develop students' knowledge and skills about STEM and improving STEM workforce in the country. The Turkish Ministry of Education strategic plan (Ministry of National Education of Turkey [MoNE], 2009), 2015 STEM Education Turkey Report (Akgündüz et al., 2015) and the Turkish Industry and Business Association's recent report on STEM (TUSIAD, 2014) highlighted the urgent need for preparing Turkish students with STEM competencies.

Research on STEM education has focused on designing STEM training programs and STEM after school clubs to increase students' interest and attitudes, and developing surveys to accurately measure their attitudes towards STEM. Studies investigating the impact of STEM trainings and STEM after school clubs revealed improvement in students' attitudes towards STEM fields and STEM careers (Mohr-Schroeder et al., 2014; Shahali et al., 2015; Tseng, Chang, Lou, & Chen, 2013). Identifying the goals and the content are noted as two critical steps in the design of STEM education programs. Building the programs on students' early interest and experiences, and engaging them in the practices of STEM education are noted as crucial factors in developing and sustaining their motivation and engagement with STEM education (National Research Council, 2011).

STEM Projects and Education Programs in Turkey

The implementation of STEM education activities varies to the school type in Turkey. Only a very small percentage of students having education in specialized schools have access to STEM education at international standards (Corlu, Capraro, & Capraro, 2014). Other opportunities include education projects supported by the Scientific and Technological Research Council of Turkey (TUBITAK) that aim to empower STEM education with activities for students and teachers. For example, in a project funded by TUBITAK, 5th grade students (n = 20) used design-based methodology for STEM education, designed solar robots and kaleidoscopes, and created graphs with motion detectors. These activities helped develop positive attitudes towards science (Yamak, Bulut, & Dündar, 2014). In the engineer project students were encouraged to think like engineers by using simple and inexpensive materials (Çavaş, Bulut, Holbrook, & Rannikmae, 2013).

STEM projects also focused on training preservice and in-service teachers. Sungur Gül and Marulcu (2014) focused on the engineering discipline, worked with preservice and in-service science teachers on engineering design processes and activities using robots and Legos. Researchers found that preservice and in-service teachers, who were not familiar with the engineering design processes, had improvement in their perceptions of engineering processes. They gained a broader perspective in terms of the significance of engineering, features of engineering and engineers, and the use of Legos. Bozkurt (2014) also revealed that preservice science teachers' decision-making skills and science process skills improved with engineering design based laboratory activities. Corlu (2013) developed an analytic rubric to evaluate STEM teaching practices in terms of STEM community, STEM integration, and STEM assessment through course syllabi. By assessing the course syllabi, this analytical rubric aimed to present teaching practices in science, technology, engineering and mathematics. Results showed significant difference between externally accredited STEM programs and non-accredited STEM programs (Corlu, 2013). The interest on developing STEM training programs in Turkey is revealed by the increasing number of projects implemented in school and out-of-school contexts. Yet, there is still limited research on how students perceive the activities implemented in these programs and their impact on their learning.

The Conceptualization of STEM education in the Turkish Context

STEM education is defined as an approach for developing knowledge, skills, and beliefs about STEM subjects with an interdisciplinary approach (Corlu, Capraro, & Capraro, 2014). The intersection of the disciplines is important for emphasizing the interconnected nature of STEM areas. Bybee (2010) reported that STEM education is mostly interpreted as science and mathematics and that technology and engineering disciplines are not emphasized. However, engineering generally takes a central role in the projects implemented in Turkey. The projects mainly aim at improving engineering knowledge and skills by using science concepts. For example, studies conducted in the Turkish context revealed that activities that stressed engineering design processes helped teachers and students improve engineering and science processes and skills (Bozkurt, 2014; Çavaş, Bulut, Holbrook, & Rannikmae, 2013; Ercan & Bozkurt, 2013; Yamak, Bulut, & Dündar, 2014).

As for the conceptualization of STEM, the literature revealed two categories appeared as the components of an exemplary STEM integration curriculum model: (a) *content integration*, merging of different STEM content areas in an activity, and (b) *context integration*, use of different STEM contexts to make the content more meaningful (Moore, Stohlmann, Wang, Tank, & Roehrig, 2014). The review of the STEM studies conducted in Turkey revealed that the studies mainly emphasized the context integration model (Çavaş, Bulut, Holbrook, & Rannikmae, 2013; Sungur Gül & Marulcu, 2014). There is a need to practice content integration model that brings STEM education disciplines together in a unit or within an activity. This study followed the integrated STEM education approach which was "an effort by educators to have students participate in engineering design as a means to develop technologies that require meaningful learning and an application of mathematics and/or science" (Moore et al., 2014, p.38). In Turkey, raising science and mathematics literate students are the main concerns of the national curricula. Integrated STEM education programs are needed to train students as STEM literate individuals who can solve real life problems. According to PISA results, 68.7% of the students in Turkey belonging to low socio-economic and cultural group have limited access to quality educational resources and programs (OECD, 2013). There is a need to provide STEM education opportunities to disadvantaged students who have limited access to such programs in their formal education programs. To address this need, this research implemented an integrated out-of-school STEM education program for 6th grade students who come from disadvantaged areas in a large urban city in Turkey. This study aimed to investigate students' perceptions about the STEM activities implemented in the program.

Method

The Study

The study was conducted in the context of a STEM education program implemented at a large public university in Turkey. The project, funded by the Scientific and Technological Research Council of Turkey's Science and

Society Innovative Educational Applications grant, aimed to improve 6th grade students' perceptions towards STEM fields and careers. The purpose was also to provide learning activities to students from the disadvantaged areas of Ankara who had limited opportunities to attend such activities and education in their schools and communities.

The STEM education program lasted 40 hours during three weekends in March 2015. Thirteen faculty members from different universities in Turkey who had expertise in science, math and technology disciplines implemented 13 modules. Nine graduate students helped faculty members during the STEM education program modules that lasted between 90-180 minutes. Each day between two to four modules were implemented with two groups of students (20 students each) in parallel sessions. During this 5-day intensive STEM training, students attended to the modules from 9:00am till 5:00pm every day. 15 minutes after each STEM module was reserved to the activity evaluation.

The modules followed hands-on and collaborative engagement within variety of STEM activities, including: (1) Egg-drop, (2) Scaled model of the solar system, (3) Application Inventor, (4) Designing a vacuum cleaner, (5) Designing enduring buildings, (6) Pot-Kin Car design, (7) Time to investigate-calculate-build and test, (8) Design of a wind turbine, (9) We are building our own structures, (10) Interrogate and learn: Force and motion with probes, (11) Cryptology and Egyptian number systems, (12) Design of a Kaleidoscope, (13) STEM Commercial Video.

Participants

Forty 6th grade students (25 male, 15 female) studying in public schools participated to the study. Students' ages ranged between 10 and 12. Project invitations were sent to the schools and science centers in Ankara. Out of 70 students who applied to the program online, 40 of them were selected following the criteria of being (1) in different schools, (2) having interest in STEM, (3) and not attending to a STEM training before. According to the 5th grade science and mathematics scores, majority of the students were high-achievers. In the online application form, when asked about their motivation for participation to such programa, all students stated that they enjoyed conducting experiments and investigations, making discoveries, designing things, and following developments in science and engineering.

Data Sources

The activity evaluation forms completed by the students at the end of each activity were used as the data sources. 15 minutes were reserved for these written evaluation periods after each module. Researchers developed the activity evaluation form to collect information on students' perceptions of the activities in terms of content and skills gained, the challenges and limitations faced, and their suggestions for improvement. The questions were: What did you learn in this activity? What skills you developed in this activity? What challenged you in this activity? How would you use the things you learned in this activity in the future? What do you suggest to improve this activity? Students provided written responses to these questions. A total of 520 evaluation forms were collected.

STEM Education Program Activities

1. Egg-drop. The activity was based on a design challenge. Students designed a package that would keep the egg inside from breaking when it was dropped from the 4th floor. The package and the egg simulated space vehicles that would land on Mars safely. Students worked in collaborative groups. Simple and easy-to-find materials were used in the activity such as eggs, tapes, newspapers, balloons and cardboards. Students tried to design a package using all or some of the materials. Students first brainstormed, drew their designs on the papers and discussed potential solutions. Groups were then allowed to finalize their design choosing the best working example. A representative member was chosen from each group to drop the package from the 4th floor. Meanwhile, other members of the groups observed and checked whether the package kept the egg safe inside. When all trials were completed, all students went back to the class. During a big class discussion, the best design was selected after evaluating the status of the eggs. Limitations of each design were discussed with possible further suggestions. Finally, students watched a short NASA video presenting the landing of a real spacecraft safely on Mars.

2. Scaled model of the solar system. The activity included the design of a small-scale model of our Solar System using basic mathematics knowledge (e.g., proportion, numbers of many figures) and the data about the Solar System. Materials used were cardboards, papers, pencils, calculators, compasses, and rulers. The activity began with students' brainstorming on the Solar System and examining their prior knowledge about proportion and the Solar System. Then, students watched a short video depicting the Solar System followed by a small discussion about location and sizes of the planets and stars. Students were presented with data on the planets and some other objects in the Solar System, their distance to the Sun, and their diameters. Students were then expected to guess their locations. In groups, students worked on the scale factor that they would base their Solar System model on. At this stage, a small ball was given to the groups to represent the Sun. Groups drew their models on large cardboards. Finally all groups went to the garden to place their cardboards in a way that would represent the Solar System. A final in-class discussion was conducted on the sizes and locations of objects in the Solar System.

3. Application Inventor. This activity aimed to help students gain knowledge about basic programming. The AppInventor software developed by the MIT was used for beginners to program applications through fixed coding schemes without writing actual codes. The AppInventor program allowed developers to write codes for mobile android devices and design various applications by importing data from the sensors of the devices. Through the application inventor activity, coding schemes and loops were taught to the students and they were expected to develop various applications by using drag and drop method. After being informed about the details of programming language, students tried to write codes with proper parameters provided by the instructors. Additionally, students were asked to bring their android devices beforehand to be able to test their codes at the end of the activity. The instructors also provided students with the proper testing tool if they lacked one. Students were enrolled to the AppInventor with their email accounts so that they could access their codes after the activity to continue programming.

4. Designing a vacuum cleaner. The real world problem presented to the students in this activity was designing a vacuum cleaner to clean dust in their room. Students first discussed the use of electrical energy economically and contributing to the national economy. Students were then introduced the steps of the design cycle consisting of five steps; ask, imagine, plan, create and improve. In groups, students then drew and discussed their designs and collected data with their materials. Using reasoning and creative thinking, students tested their models. Whether dusts were collected inside the vacuum cleaner and its speed were some of the results of these tests. Students debated on their different suggestions based on how the alternative models could work. The appropriateness of their designs were further analyzed, discussed, and evaluated. A design challenge took place where the best design of the class was selected in terms of the amount of dust it collected. Within this design challenge, all groups produced solutions to improve their models based on their models' performance and the explanations they generated.

5. Designing enduring buildings. The activity included the design of the most enduring building that could carry the biggest weight in class. Working in groups of four or five, students used spaghetti and modeling clay. The engineering design cycle introduced in the vacuum cleaner activity was followed again. The students came up with many different models in the planning phase, but they completed the cycle with one final model only. All groups discussed the limitations and the strengths of the previous models they planned. At the planning stage, the instructors visited the groups and gave examples of different building models from real life. Once each group completed their buildings, they were tested. Mobile phones were put at the top of each building. Some buildings could only carry one mobile phone. The models that could carry three mobile phones won the challenge. With the participation of all students, discussions on the successful designs followed.

6. Pot-Kin Car design. In this activity, students were expected to design a model car that saved highest energy output in consideration of the principle of energy (potential to kinetic energy) transformation. The activity aimed to optimize the level of energy over the signed route by decreasing the rate of heat loss. Students were challenged to design their cars within their restricted budget from the engineering market. At the end of the activity, cars were tested in terms of meeting two conditions: (1) The car should be able to move on a flat surface, and (2) after starting to move, it should go at least six meters forward. In groups, students drew their designs and constructed their cars with the materials they bought from the market. Cars meeting required criteria were compared in terms of the speed they reached along the signed route. The fastest car was selected as the winner. As a final step, a group discussion was conducted to improve students' designs.

7. Time to investigate-calculate-build and test. Students in this activity designed and built bridges. Simple materials such as toothpicks, sticks, paper, tape, and Styrofoam were used. The instructor formed groups and students worked collaboratively. Students first began to draw sketches of their bridge designs. They discussed and took notes on possible results, necessary materials, strengths, and limitations. When students completed their designs, they tested them with a variety of materials. At the end of the activity, after all groups finalized their bridges, a design challenge was completed to choose the best bridge. Different weights were hanged to the bridges and they were tested. The most enduring bridge was selected as the winner. A group discussion took place on what could be done to make the designs better.

8. Design of a wind turbine. In this activity, students were expected to design a wind turbine by taking the advantage of wind energy. Materials used were straws, sticky tapes, cardboards, strings, paper cups, cork stoppers, wooden sticks, pins, and play dough. A week before the activity, participants were informed about the wind turbine activity to conduct a research about generic design of wind turbines for the next week. In the first stage, students brainstormed among wind turbine designs under the guidance of information acquired by the previous research. Later, students were assigned to groups of four or five to sketch their initial wind turbine design. In the meantime, students justified their wind turbine design to the instructor. Wide range of material supply enabled students design particular wind turbines; therefore it was ensured that each group worked relatively far enough from each other. After the completion of wind turbine construction, groups tested the turbines against a ventilator.

9. We are building our own structures. In this activity, students in groups built a resistant structure from recyclable household materials in ninety-minute period of time. All kind of items expected to strengthen the structure such as plastic cup and toothpick could be used on the condition of efficient budget management. During the design phase, groups were allowed to use tablet PC's to make calculations of strength throughout the activity. At the end of the activity, each structure was evaluated in terms of weight bearing capacity. The activity followed the 5E instructional model (engage, explore, explain, elaborate/extend and evaluate). In the engage phase, students were expected to approach a real-life problem from the perspective of an engineer. The instructor shared a picture of a wrecked bridge to encourage students generate solutions from an engineer's point of view. Then, in exploration stage, same materials were distributed to each group to design a structure by referring to maximum features of the given materials such as being the tallest and the strongest. Each group had a certain budget to buy the items already priced by the instructor. It was significant to devise the structure with maximum efficiency and minimum budget. Before the construction phase, groups were responsible for sketching the structure to be able to calculate balance and momentum of the artifact. In the elaboration stage, students exhibited their artifacts in front of the classroom to discover the strength of the structure in terms of weight bearing capacity. Finally, both group and individual performances were evaluated in reference to criterions of creativity, strength, and length.

10. Interrogate and learn: Force and motion with probes. To experiment with force and motion probes, the software Logger Pro 3, Vernier Force and Motion system, and movement detectors were used in the activity. The software was downloaded and prepared before the activity time. Students explored the topics "Force and Motion" by experimenting with probes. Throughout the activity the students drew and interpreted graphs on speed, position, and friction.

11. Cryptology and Egyptian number systems. The activity aimed at introducing ancient numbering systems attributing to Egyptian numbering system and definition of cryptology with its applications in decimal system. Students were expected to learn about the symbols of ancient Egyptian numbering system and manage to convert a number written in decimal system to one written in ancient Egyptian numbering system. Papers, images of hieroglyphic alphabet, and the table of ancient Egyptian numbering system were the materials used for the activity. Students devised their own numbering systems and a class discussion was hold about the conclusions of each student.

12. Design of a kaleidoscope. This activity required students design a kaleidoscope to associate kaleidoscope construction with its' mathematical implications. Plastic mirror, cardboard roll, sticky tape, glue, colorful plastic beads, white cardboard, craft knife, transparent punched pocket, and translucent opaque binder were the materials distributed for kaleidoscope design and construction. In the beginning of the activity, each student shared the results of kaleidoscope research with their classmates. Then, students were assigned to groups of four. Each group discussed the essential steps of a kaleidoscope design and wrote the stages down on a piece of paper. In the meantime, instructors started inquiry based learning process by posing questions in reference to the points of consideration during the design stage. Then, groups constructed the kaleidoscopes with the materials distributed by the instructors. At the end of the activity, groups had a chance to examine other groups' designs under the guidance of instructor questions referring mathematical indicators of kaleidoscope construction.

13. *STEM Commercial Video.* In this activity, students designed STEM commercial videos using all of the engineering skills and design skills improved with the project. Students were first presented with a scenario and engineering design cycle to prepare STEM commercial videos. In the scenario, the commercial video they designed was going to be played on TV channels to attract sixth grade students to next year's STEM project. Students first planned their videos filling in the storyboard template with script, visuals, narration, and audio. They also generated ideas for slogans that would be used in their commercials. Students were expected to design their commercial videos following the four criteria: 1) the storyboard should be completed and should get confirmation from the instructors, 2) the commercial video should be limited to 2-3 minutes, 3) the commercial video should attract audience attention with visual and audio elements, and 4) the commercial video should give information about STEM and promote it. Students developed their videos on the Pawtoon video-editing program. Once students finished their videos, all videos were shown on the screen and students voted to select the best video that would win a price.

Figure 1. Students working on STEM activities

Data Analysis

Students' responses to the activity evaluation forms were analyzed qualitatively to examine students' perceptions about the STEM activities with a focus on the content and skills gained, the challenges and limitations faced and suggestions for improvement**.** The results of the data analysis emerged under four categories: (a) subjects learned, (b) skills developed, (c) future use, and (d) suggestions. These categories were used to generate coding system of the study. In the coding phase, student response rates were calculated in terms of frequency rate in percentages and categorized under these four categories. After documenting and classifying entire codes, similar codes were unified and evaluation theme table was created. Two researchers examined and coded the data sources together to create the codebook and to document the frequencies of the codes. Other two researchers then confirmed the codes and coding through debriefing meetings.

Results and Discussion

The analysis of the activity evaluation forms revealed four categories: (a) subjects learned, (b) skills developed, (c) future use, (d) suggestions for improvement. Table 1 presents the response rates within each category and codes.

Table 1. Evaluation themes

Themes	**#**	**%**
1. Subjects (subjects / topics students learnt in the activity)	**204**	**29**
Solid structure construction	49	24
Kaleidoscope & cryptology	33	16
Velocity-time graph& distance-time graph	22	11
Types of energy	21	10
Renewable & non-renewable energy	20	10
Qualitative & quantitative observation	16	8
Wind turbine	16	8
Tool utilization	14	7
Center of gravity	13	6
2. Skills (skills that students developed in the activity)	**246**	**35**
Handcraft skills	88	36
Cognitive Skills (argumentation, reasoning, thinking, observing, planning, mental skills, imagining)	61	25
Engineering skills	27	11
Design skills	26	11
Computer skills	26	11
Math and science skills	18	7
3. Future uses (how students will make use of the activity)	**140**	**20**
Future career and profession	117	83
School work	23	16
4. Suggestions (students' suggestions for the activity)	**108**	**15**
Materials (better and more comprehensive materials. Also more number of materials)	74	69
Attention and fun	13	12
Time	12	11
Information (more information to be provided at the beginning)	9	9

Subjects Learned

Within the scope of the STEM education program, 13 STEM modules were implemented. Wide array of knowledge encompassing domain specific subjects as well as interdisciplinary concepts were embedded in the STEM activities designed as hands-on and collaborative explorations. The analysis of the evaluation forms revealed that the subjects that were most commonly cited by the students were solid structure construction by experimenting on bridges (24%), cryptology with its applications in decimal system (16%) and kaleidoscope construction considering its mathematical implications (16%). Other frequently noted subjects were drawing and calculating velocity-time and distance time graphs (11%) followed by mechanical energy (10%), renewable and nonrenewable energy (10%), and wind turbine construction (8 %). Conducting qualitative and quantitative observation (8%) was also noted by the students in a way of attributing to all STEM training activities. One of the students, for example, stated: "*I learnt how to conduct a scientific research by doing qualitative and quantitative observation*". Other noted subjects were tool utilization (thermometer, probe, sonar) (7%) and center of gravity (6%).

Skills Developed

Skills developed through STEM activities were coded under six categories: Cognitive skills (argumentation, reasoning, thinking, observing, planning, mental skills, imagining) (25%), math and science skills (7%), design skills (11%), engineering skills (11%), and computer skills (11%). Students noted that they developed their handcraft skills considering that the STEM activities were mainly hands-on that required students design and develop tools. Cognitive skills (e.g., argumentation, reasoning, thinking, observing, planning, mental and imagination) were also notable in students' responses. One of the students, for example, explained: "*I believe that with STEM activities, I developed my argumentation, questioning and reasoning skills".* Students also stated that they developed their engineering skills such as building balanced and resistant bridges and designing fast cars. Design and computer skills were also noted followed by mathematics and science skills (7%). One of the students expressed: "*I improved my imagination and my engineering skills with this activity*". Another student explained his thoughts at the end of the "we are building our own structures" activity: *"I feel that I progressed in both planning and designing stages."*

Future Use

Students believed that they would use their learning in STEM education program in their future career and profession (83%) and schoolwork (16%). Some of the students gave specific examples to the professions such as architect, engineer, doctor and web designer where the STEM activities would contribute. One student, for example, stated: "*When I am employed as an engineer in the Ministry of Transportation, I am going to benefit from what I have learnt from the STEM activities*". Another student noted: "*I am going to benefit from what I have learnt from STEM activities when I become seismologist*". The student who wanted to become a science teacher commented: "*When I become a science teacher, I am going to use the knowledge I learnt from STEM activities*". Another area that students noted was their schoolwork. Students stated that they planned to make use of the activities in their future school life such as homework, projects, and laboratory work. One of the students commented: "*I am going to use the knowledge that I learnt from STEM activities while conducting experiments in science classes*."

Suggestions for Improvement

The students reported suggestions for the improvement of the activities implemented in the STEM education program. The suggestions addressed use of materials (69%), time (11%), attention and elements of fun (12%), and information provided (8%). As for the materials, students had different recommendations. Some of them agreed that they needed more materials to complete the activities. According to some, the materials should have been more advanced to match their age, and some agreed on using more user-friendly materials. One of the students, for example, commented: "*I suggest using more advanced tools for the activity of force and motion with probes".* Students also stated that they needed more time for certain activities. Some students suggested designing the activities with more fun elements. Lastly, students suggested providing more information at the beginning of the activities. One of the students, commented: *"I want to be more informed about the activities throughout the process".*

Conclusion

STEM education is now considered as one of the critical focus areas within Turkish education to increase country's innovation development capacity and to enhance country's competitiveness within the global economy (Corlu, Capraro, & Capraro, 2014). Yet, there is limited evidence on out-of-school STEM models and their impact on students' learning, attitudes, and perceptions towards STEM in Turkey and in the world. This research confirmed the effectiveness of out-of-school STEM education programs in their capacity of engaging students in design and engineering practices that are not common in traditional classrooms (Rogers & Portsmore, 2004). These programs may help expand students' knowledge and interest towards STEM (Weber, 2011).

The integrated STEM education program followed hands-on, collaborative, design-based, and inquiry oriented pedagogical approach. This approach helped students engage in problem solving exercises relevant to their lives (Schnittka, Bell, & Richards, 2010). Students in this study noted the contribution of this approach to their cognitive, design, engineering and computer skills. The activities, giving students tangible application of scientific, mathematical and technological concepts, helped them develop insights into engineering design practices.

Students' perceptions about the STEM activities are critical, as their evaluation of the design, content, and scope of these activities may reveal areas for improvement. This study revealed that students valued hands-on nature of the STEM activities that gave them opportunities to design artifacts and engage in design challenges. The research results suggested that the integration of STEM activities into out-of-school education programs may support developing students' interest in pursuing STEM related careers.

Recommendations

The connections between the STEM activities implemented in out-of-school programs and students' coursework should be closely linked. These connections with formal curriculum would also help teachers and students extend students' learning outside of the classroom with collaborative, applied, and project-based learning activities. During their evaluations, students recommended tapping on their prior knowledge before the activities and providing more information about the activity scope and content. Future STEM education programs may spend more time in eliciting students' knowledge to address their learning needs and misconceptions. Inquiry based activities would encourage students' learning of concepts addressed in the STEM activities.

The research findings suggested that collaborative learning opportunities enhanced students' engagement with STEM, yet students needed practice on collaborative learning processes. Future STEM activities may model effective collaborative work, and present students guidelines for collaboration. The study revealed that students had difficulty in completing some STEM activities due to the time limit. Planning therefore emerged as an important finding under the design skills. Future STEM activities may emphasize the planning phase of engineering design processes, and scaffold students' planning stages. The study results presented students' high interest towards STEM careers after they attended to the program. Future research may track their interest, 6 months and 1 year after the programs to examine whether their ideas sustained in the long term.

The STEM education program implemented in this research was supported by a grant. While the project used low-cost materials for the STEM activities, systematic integration of STEM into curriculum would require continuous financial and administrative support. Future research should investigate policy and curriculum models for the implementation of large-scale STEM programs. The STEM education approach used in this research suggested implementing STEM activities that address at least two disciplines in hands-on applied STEM activities. Same approach could be integrated to formal curriculum with the inclusion of activities covering objectives from different STEM disciplines and using big-idea focused problem solving projects. Future research may investigate the integration of the activities presented in this research to formal curriculum followed in schools.

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