European Proceedings of
Educational Sciences
EpES
www.europeanproceedings.com
e-ISSN: 2672-815X

DOI: 10.15405/epes.23056.58

ERD 2022
Education, Reflection, Development

SPACE EDUCATION ACTIVITIES TO ENCOURAGE STEM STUDIES - A THEORETICAL PERSPECTIVE

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Abstract

Today, subjects in science, technology, engineering, mathematics (STEM) are a significant concern in educational systems worldwide. Students who study these subjects acquire skills and knowledge that enable countries to develop advanced technological infrastructures in industry and academia and move local and global economies towards a more advanced future. However, in recent years, many countries have reported reduced student interest in STEM studies. However, some literature finds that students who take part in space education activities develop curiosity about and interest in STEM subjects. Many of these space education activities are informal. In addition, space education allows students to explore several subjects at once in a multidisciplinary approach, which allows students to develop important skills required in the knowledge-intensive industry and academia. This article proposes a way to integrate multidisciplinary STEM studies via space education into formal education systems. It provides an overview of space education and suggests several unique space education activities that could be implemented into formal educational systems.

Keywords: Integrated curriculum, Multidisciplinary studies, Space education, STEM

https://doi.org/10.15405/epes.23056.58
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Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2672-815X

1. Introduction

This article describes space education activities that can be done in the classroom. Based on the study's findings regarding the knowledge and skills that students acquired, we hope to develop a Space Education Program (SEP) for Israeli middle schools that will lead to the inclusion of space education in the formal syllabus. In addition to increasing students' interest in STEM subjects, SEP is structured to support multidisciplinary learning that includes advanced teaching methods, advanced skills, and technological literacy, all of which can effectively prepare students for future work in industry or academia.

1.1. Space education

Space education includes content, workshops, and activities that aim to promote, deepen, and reinforce STEM studies using content in the field of space. The topic of space excites the imaginations of children and adolescents. Thus, studying space can motivate students to engage in major STEM studies at high school and university (Pujol et al., 2006). Those involved in space education share several basic assumptions about its importance. First, as already noted, space is interesting and may motivate teenagers to learn more about STEM subjects. Second, space education can serve as a gateway to academic STEM studies, preparing students to work in research or other areas of STEM fields (Afful et al., 2020). The subjects of space engineering and aviation incorporate a wide range of scientific and technological capabilities and challenges. Therefore, a wide range of STEM skills are required to engage in these fields, including aeronautical engineering, materials engineering, electrical and electronic engineering, mechanical engineering, computer communication, astronomy, physics, biology, and chemistry. These and other subjects directly relate to the fields of space and aviation engineering, and knowledge of these subjects is regularly reflected in the technological and scientific abilities to develop and build satellites, launchers, aircraft, space probes, and the like. The complex, multidisciplinary nature of space education may make teaching and learning it difficult, especially for young students whose knowledge of physics, mathematics, and engineering is limited. However, space education combines and illuminates different fields of knowledge in ways that are not purely theoretical, but have clear practical implications. Therefore, space education may encourage students to delve deeper into the basic fields of mathematics, physics, biology and chemistry, which provide necessary foundation for advanced study in space engineering. The field of space can excite young people's imagination and curiosity and motivate students to invest more effort in technological and science studies (Isaacson et al., 2020).

1.2. STEM, space, and a multidisciplinary approach

According to English (2016), the STEM acronym is often used to reference just one of the disciplines it includes, most commonly science. Although more and more studies are advocating the integration of STEM disciplines, few studies address multiple disciplines, and their findings are mixed and provide inadequate directions for advancing STEM studies (Caprile et al., 2015; Honey et al., 2014; Marginson et al., 2013; Prinsley & Baranyai, 2015). According to previous studies (McGee et al., 2019) knowledge and skills from two or more disciplines more effective to be applied to real-world

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problems and projects with the aim of shaping the total learning experience. Space education addresses this need by combining a multidisciplinary approach with practical application. Research on STEM integration into curriculum development is a new field, and the impacts on student outcomes are still unclear. More research is needed on the impact of STEM integration in general on student learning outcomes and also on the impact of integrating particular disciplines into school curricula. In addition, it seems that mathematics education receives a smaller positive impact from STEM integration programs than other STEM disciplines, and more research is needed to identify the factors that influence this. Likewise, the impact of K-12 integrated STEM programs on engineering learning outcomes appears to be under-researched (English, 2016). Hence, the integration of space education in the formal framework is requested in the context of the integration of the disciplines, as multidisciplinary learning, and as the realization of the theory in an applied manner.

2. Problem Statement

2.1. Implementing space education

Previous studies describe various informal SEPs offered by space agencies all over the world (Haubold, 2003). Evaluations of these informal education programs indicate that space education via such programs can rouse students' curiosity and motivate them to pursue courses and eventually careers in science, technology, or engineering. These informal education programs are also positively viewed by science and technology teachers, who can utilize them to teach students about space (Khan et al., 2005). However, despite the positive impacts of informal SEPs (Thrash, 2004), space education has not yet been broadly integrated into formal education curricula, and no syllabus for space education in middle schools has been fully developed. The lack of formal education in this field is the principal reason for the general lack of knowledge about space.

2.2. Student motivation to study STEM subjects

In today's world, young people, especially students, could not imagine living their lives without the latest technical innovations at hand, such as smartphones, laptops, and tablets. However, these same students demonstrate clearly reduced interest in STEM subjects, a trend that is visible all over the world. For example, Potvin and Hasni (2014) describe students' declining interest in science and technology in Canada. Rosca and Todasca (2014) suggest that Romanian students are less interested in studying chemistry due to the weak correspondence between chemistry education and education in other subjects, such as physics, biology, and mathematics. Meng et al. (2014) report decreasing interest in STEM subjects at secondary schools in Malaysia. In New Zealand, Brunton and Coll (2005) find that close links between schools and industry can encourage student interest in STEM subjects.

3. Purpose of the Study

In this paper, a space education program (SEP) is defined as the formal teaching, training, and integration of content about space into formal studies of science and technology. STEM skills refer to the

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following cognitive skills: scientific literacy, digital literacy, mathematical literacy, creative thinking, and critical thinking.

The outcomes of the research described in this paper will be used to design an SEP teaching model that can be integrated into middle school science and technology curricula.

4. Research Goals and Objectives

The study aims to

i. examine the effect of SEP on middle school students' acquisition of cognitive skills
ii. examine the impact of SEP on middle school students' subject knowledge of science and technology
iii. examine students' general attitudes toward science and technology
iv. develop an SEP program that can be integrated into formal science and technology curricula at the junior high school level.

5. Research Questions

The following research questions will guide the study: What is the impact of SEP on middle school students' science and technology knowledge? What is the impact of SEP on middle school students' cognitive skills? What is the impact of SEP on students' attitudes toward the subjects of science and technology? What is the impact of SEP on science and technology teachers' attitudes and practices?

6. Research Methods and Intervention

The intervention used in the present study integrates space education into the science and technology middle school curriculum for high-achieving students. In Israel, high-achieving students can major in science and technology, with additional hours allocated to these subjects.

A total of six gifted classes with 35 students each will be taught using the regular science and technology curriculum. However, three of these classes will also receive the intervention program during a two-hour physics lesson that takes place once a week. They will comprise the research group. The three other gifted classes will serve as the control group and will not receive the intervention program.

The research group will be taught using SEP and introduced to educational content and experiences related to space. For example, launching a rocket into space will be used to illustrate Newton's third law. Newton's first law will be analyzed using examples and applications from the International Space Station. Case studies of satellites will be used to teach about energy. The intervention program will also use innovative teaching methods, including model building, engineering problems, and other project-based learning that emphasizes teamwork skills.

In contrast, the same science and technology syllabus will be used to teach the control group, but the examples in their textbooks, which do not involve space, will be used. These include vehicular road traffic and energy calculations that use simple cases on Earth.

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7. Findings

This chapter presents an overview of updated unique space education activities that have significant potential for implementation in the Israeli classroom, especially through the intervention program and SEP. The impact of these activities will be also examined in the framework of the present research relating to cognitive and STEM skills acquired by the students.

7.1. Rakia mission

The Rakia mission is a space program that took place in the beginning of 2022. The mission was led by the second Israeli astronaut, Eytan Stibbe, who joined the AX-1 private space mission. The mission enabled Israeli entrepreneurs and researchers to advance innovative ideas and provided a rare opportunity for them to test their enterprises in a unique study environment, thereby contributing to international and Israeli research. The mission also made a range of educational activities accessible to all Israeli students and children. For example, this mission is the first time that Israeli students have had access to first-hand information from and about the International Space Station in Hebrew. In addition, a series of new Israeli artworks were shown under sub-gravity conditions (Reaching across the globe and to the stars, 2022).

7.2. Beresheet lunar space probe

Beresheet was a small robotic lunar lander and lunar space probe operated by SpaceIL and Israel Aerospace Industries. Its aimed to inspire youth and promote STEM careers and to land a magnetometer, time capsule, and laser retroreflector on the Moon. The lander's gyroscopes failed on April 11, 2019, causing the main engine to shut off, and the lander crashed on the Moon (Shyldkrot et al., 2019). In December 2020, the launch of Beresheet 2 was announced. The planned launch date is in 2024, and the mission profile includes two separate probes that will land in different areas, along with a space probe that will orbit the moon. During 2023 year, SpaceIL, in collaboration with the Israel Space Agency and the Ministry of Education, is expected to promote student projects connected to the Beresheet 2 mission. Sensors installed on the probes will collect data that teachers and students can use to conduct their own research.

7.3. World Space Week

World Space Week is an international celebration of science and technology and the contributions of these fields to bettering the human condition. In 1999, the United Nations General Assembly declared that World Space Week will be held each year from October 4 to October 10. During World Space Week, space agencies, aerospace companies, schools, planetaria, museums, and astronomy clubs around the world hold space education and outreach events. These synchronized events attract public and media attention. World Space Week is coordinated by the United Nations with the support of the World Space Week Association (WSWA). The goals of World Space Week are to provide unique leverage in space outreach and education; to educate people around the world about the benefits of space exploration; to encourage the use of space to support sustainable economic development; to demonstrate public support

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for space programs; to excite young people about science, technology, engineering, and math; and to foster international cooperation in space outreach and education.

8. Conclusion

STEM studies in schools often have two main goals. The first goal is to impart necessary knowledge and tools to graduates; the other is to prepare graduates for professional futures in academia and industry (Johri & Olds, 2014; Purzer et al., 2014; Journal of Pre-College Engineering Education). Engaging in the field of space does not always require academic studies in the field of space specifically; such jobs are open to graduates in a wide variety of advanced technological fields and require high levels of fundamental knowledge in technology and the sciences. Therefore, space education may have a broad and significant positive effect well beyond fields directly connected to space. The potential of engaging in the field of space or aviation creates hope in the hearts of hundreds of thousands of children, students, future generations, and people of the "big world." Children who can make decisions about their professional futures based on inspiration and a sense of competence will directly affect national security and their countries' economic and social futures.

The "Apollo effect" was observed in the United States in the 1960s and the 1970s. In 1969, the U.S. Apollo crew became the first men to land on the moon. A generation of American children saw scientists, engineers, and astronauts on television and were filled with inspiration. Scientific and technological fields became popular, and thousands of children chose to study science and engineering. This increase began with President Kennedy's announcement of the Apollo space program in 1961 (Peng et al., 2017). Similarly, since the launch of Beresheet, the first Israeli space moon probe, in 2019, interest in space-related engagement has increased significantly (Shyldkrot et al., 2019). Admittedly, it is still difficult to establish a correlation, but there is no doubt that space education is gaining momentum, and it is possible that we are currently seeing Israel's own "Apollo effect." We hope that this "Israeli Apollo effect" will continue for years to come through creative, inspiring educational work.

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