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Qualifications of Students Graduated from STEM ALEX Schools in Egypt

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Abstract

Several studies have been conducted regarding the STEM education system. Some of them focused on how to prepare a STEM teacher, while others focused on the STEM system and its origins and differences from the traditional education system. However, when examining previous studies, no study was found that looked at the learning outcome in STEM for the student. The skills of the graduate student from STEM schools are the output of education in schools. STEM and the evidence for its impact on the individual and society, and the difference of the STEM system from any other educational system, so this study aimed to determine the skills of graduate students from STEM schools. And to reach that goal, an attempt was made to answer the question of what are the qualifications of students who graduated from STEM schools in Egypt. Where an attempt was made to answer this question by conducting interviews with some of the graduate students from the Stem school in Alexandria in Egypt, and asking them some questions to determine what skills they acquired during the years of study at the Stem School. Interviews were conducted with 15 female students from STEM Alexandria School. Those who graduated in 2020 are now enrolled in different specializations and universities in different countries, and for this reason, the interviews were conducted through the Zoom program. The results of the current study concluded that the students participating in this study acquired many skills under two types of skills, namely soft skills and hard skills. In addition, it has been revealed that the learning process of students is positively affected because the teaching environment in STEM schools is inclusive and rich.

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INTRODUCTION

Education is one of the most important tools for the progress of nations. Education enhances the culture of community members, lifts society out of illiteracy and poverty, and aids economic and social growth. Education does not just change the life of an individual, it changes the whole society. It is seen that the development and progress of health services are at the highest level in countries with a good education system. In addition, it is observed that the economic, industrial and technological level of this country is at the same rate of progress and progress. Education is the mainstay of nations and the secret of their progress and progress (2012, انتظار). Because of the belief of academics and senior officials in all countries, it is seen that developing and developed countries are competing for progress in education. There is a difference between developed and developing countries in this regard. Education in developing countries has not undergone any change as it has been for decades. Recently, these countries have been trying to change their education systems to keep up with the developments of the time. The education system in developed countries is constantly being updated. For this reason, education is the main reason for the progress in these countries and the emergence of all new technological innovations. One of the reflections of these developments on the field has been the implementation of the STEM system (2019, شحاتة).

STEM is a program that specializes in the study of science, technology, engineering and mathematics in all its disciplines to have a greater impact on the human mind based on analysis, understanding, experimentation, interaction, inference and conclusion (Özyurt, Kayıran, & Başaran, 2018). By creating a creative environment for the student, it develops the ability to use his/her mind effectively and appropriately. Thus, by keeping up with the technology occupying the digital world, students can solve the problems they may encounter in business life, which stands out with their ability to think independently and make critical analysis (2021.احمد&محم). STEM education is based on a philosophy based on a learning approach that integrates educational concepts and practices in science and mathematics with the concepts and practices of technology and engineering education that deliberately leads to the formation and creation of new knowledge. It is a project-based approach that involves exploration and inquiry by students. Students are then allowed to communicate with experts and experts both inside and outside the school (2019, رضوان). The STEM system is the result of the integration of four branches of knowledge, science, technology, engineering, and mathematics, integrated into the STM curriculum in proportion to the age and cognitive level of the students. "STEM" is an acronym (Yıldırım, Başaran, Cücük, & Yokus, 2018). The words expressed with letters are listed below:

Science: The systematic study of the nature and behavior of the physical universe and the physical universe, based on observation, experiment, and measurement, and the formulation of laws to describe these facts in general (Vyas, 2016).

Technology: It is the scientific field specializing in the innovation and use of technical means and their connection with the needs of society (Carroll, 2017).

Engineering: is the practical application of knowledge of pure science (Sheppard, et. al.).

Mathematics: A group of related sciences, including algebra, geometry, and calculus, concerned with the study of number, quantity, shape, and space (Bybee, 2010).

STEM system depends on posing a problem or a challenge to students that requires them to work in cooperative teams with specific tasks. The purpose is to search for additional information from reliable sources to deepen students' knowledge and understanding and the link between different disciplines. And then students analyze the information, classify it, and make hypotheses for planning and designing proposed models for experiments, raw materials and the necessary tools. After that, they work to implement the proposed ideas and solutions that contribute to solving the problems

raised in the challenge to be presented eventually to the target group (Martín-Páez, Aguilera, Perales-Palacios & Vílchez-González, 2019). In the STEM system, the students are required to submit at the end of each semester what is called a "capstone" which is a project that the students work on throughout the semester. So that they apply what they have learned by researching, collecting information, and analyzing it, and providing hypotheses to solve a problem. The education system in STEM does not depend on receiving, but rather presents the students with topics or problems. The students set goals, plan, analyze, and then make a presentation and present the hypotheses they have set to solve a problem during this process. This research-based educational system allows students to question, create, do scientific research, and learn multiple skills (Eppes, Milanovic & Sweitzer, 2012). All this makes the STEM student a distinguished student with awareness, scientific research skills, teamwork, presentation skills, and self-expression. Therefore, STEM schools have become a destination for many students and a recommendation offered by graduate students to younger students. Some of the previous studies that were conducted on the STEM education system focused on the reason why students choose STEM schools, and the majority of the results concluded that there are two reasons. The first reason is the interest and passion of STEM students in science, technology, engineering, and mathematics programs, while the second reason is the increasing need in the labor market for specialists in science, technology, engineering, and mathematics (Vulperhorst,2018).

Since its inception, the United States of America has been interested in developing its educational system and has been particularly interested in developing the teaching of science and mathematics in its schools. As this was one of the most important reasons for its progress and global leadership, and with the beginnings of the 1990s, the formal dimension was given to teaching STEM curricula in American schools in a manner integrative. There are a huge number of schools that have different images, styles, and names that adopt the formula of integrated STEM curricula in the United States. However, studies have classified these schools into four main types, namely: elite or selective schools based on STEM education, inclusive schools centered around STEM education, schools of technical vocational education centered around STEM education, and comprehensive secondary schools that don't focus on STEM education (2016منصور& مسيل,).

Schools of science and technology appeared in Egypt with the opening of the first school for outstanding students in science and technology in 2011. The establishment of schools followed it, until it reached the present time of 16 schools, with the presence of a trend from the Ministry of Education and Technical Education in Egypt towards establishing a school for outstanding students in sciences and technology in each of the governorates of the Republic (2018 محمود& قطري). Therefore, Egypt was keen to establish special schools for outstanding students that apply the integration system (STEM) to achieve a number of them, including caring for those who excel in science, mathematics, engineering, and technology, and taking care of their abilities. The aim is to maximize the role of science, mathematics, and engineering in Egyptian education, to disseminate a modern educational system such as the STEM system in Egyptian schools, and to implement of new curricula and teaching methods based on investigative projects and the integrative approach. Other aims are to encourage the orientation towards scientific disciplines among a large percentage of Egyptian students and prepare a distinguished and qualified scientific base for university education and scientific research (المسلمانى ,2020).

The Department of Outstanding Schools in Egypt follows the central system of the education policy in Egypt. Upon the establishment of the Outstanding Schools, a central unit was established in the ministry called the STEM unit, which is responsible for the schools. The STEM unit coordinates and transfers expertise, forms work teams, builds partnerships with various authorities, and follows up the progress of work in schools, follow-up exams, and take the necessary measures to evaluate the efficiency of schools and measure their ability to play their role. The Ministry is keen to select teachers at the highest level in terms of educational and scientific preparation, and they are selected through

accurate tests in the subjects they will teach, and their enjoyment of computer and English language skills, after which they are given specialized courses (2021, عبد العظيم& مسيل).

PURPOSE OF THE RESEARCH

In the current study, it is aimed to reveal what skills the students studying in STEM ALEX schools in Egypt have when they graduate from the schools. From this point of view, it can be said that the research question of this study is: "What skills do students who study in STEM schools graduate from these schools have?" The sub-objectives of the research were determined as follows:

What soft skills do students graduated from STEM schools have?

What hard skills do students graduated from STEM schools have?

What are the effects of the STEM school environment on student achievement?

METHOD

RESEARCH DESIGN

This study aimed to determine the skills acquired by students who graduated from STEM schools in Egypt and to reach this goal the case study model was used. It is one of the qualitative research methods. A qualitative case study is a research methodology that assists in the exploration of a phenomenon within a given range through multiple data sources and undertakes exploration through a variety of lenses to reveal multiple aspects of the phenomenon (Baxter and Jack, 2008). In a case study, a real-time phenomenon is explored within its original scope, bearing in mind that context will make a difference (Rashid, Rashid, Warraich, Sabir & Waseem, 2019). Although the case study is an intensive study of one case, the aim of it, at least in part, is to shed light on a larger group of cases (population), and here when the focus shifts to a sample of the cases here, the study becomes a cross-case study (Gamie, 2019).

PARTICIPANTS

Interviews were conducted with a randomly selected sample of graduated students from STEM Alexandria School in the year 2020. The sample included 15 students in 4 different countries (11 students studying in Egypt, one student in Hungary, 1 student in South Africa, 2 students in Turkey, one in Gaziantep, and the other in Ankara) where the interview was conducted with the student who stays Gaziantep Face-to-fac, and Zoom program was used to conduct the interviews with 14 students. As the number of specializations that students have enrolled in now and after graduating from STEM Alexandria School are 10 different specializations.

Table 1. *Number of students, majors, and countries in which students study*

Number of students	*Specialties*	*Country*
1	Public health	University of Debrecen, Hungary
1	African Leadership Academy	In Johannesburg, South Africa
1	Medicine	Ankara University, Turkey
1	BUSINESS	Gaziantep University, Turkey
1	Computer Science	The American University in Cairo, Egypt
3	Faculty of Computer and Information	Egypt
1	Medicine	Egypt
3	College of Veterinary Medicine	Egypt

1	Faculty of Dentistry	Egypt
1	College of Pharmacy	Egypt
1	Faculty of Sciences	Egypt
15 students	10 majors	4 countries

DATA COLLECTION

Since the primary characteristics of qualitative research are to reveal the perspectives and meanings of the research subjects and to see the world through the eyes of researchers, it is necessary to obtain in-depth rather than superficial information. In qualitative research, semi-structured interviews are mostly used because, in this technique, both the questioner and the respondent can make partial corrections to the questions prepared by the researcher (Gamie, 2019). Semi-structured interviews were conducted with a sample of students who graduated from STEM School in Alexandria to determine the skills acquired by these students during the period of study in STEM schools. During the interview, the students answered some questions that were identified and modified according to the opinions of experts. Semi-structured interviews were conducted with a random sample of students who graduated from a STEM school in Alexandria in Egypt, where one interview was conducted face to face and the rest of the interviews were conducted through the Zoom program. The interview took 30 to 45 minutes. Interviews were conducted with 15 students to determine the skills acquired by these students during the period of study in STEM schools. The data collection process phase took two months. During the interview, the students answered some questions that were identified and modified according to expert opinions. The questions asked to the students during the interview were as follows:

1. How would you describe the school environment (education system) in STEM schools from your point of view?

2. What skills did you acquire during your 3-year study at STEM School?

3. How did you acquire these skills while studying at STEM Schools?

4. What activities did the school offer you and how did these activities help you in acquiring new skills?

5. How did the skills that you gained at STEM help you get an opportunity to study at a university or a scholarship in another country?

6. How did the group assignments you were asked to do at school help you gain new experience?

7. How would you describe your relationship with friends at school during the school day and in the dormitory? And what did you learn from them?

8. How is a student who graduated from STEM different from a student who graduated from another high school?

9. What traits have changed in your personality during your studies in STEM?

10. Do you recommend to another student to study in STEM Schools and why?

DATA ANALYSIS

In this study, the answers of students who graduated from STEM schools in Alexandria were subjected to content analysis. The data collected in the content analysis was conceptualized and then logically organized according to emerging concepts and the topics explaining the data were identified accordingly. This is accordance to Karataş (2015) who argued that the data collected in the content analysis must be conceptualized and then logically organized according to emerging concepts and the topics explaining the data must be identified accordingly.

The concepts to be revealed were arranged through semi-structured interviews with students. In content analysis, data should be divided into categories, lower and higher ratings should be made, and matrices should be made to reveal the relationship (Krippendorff, 1989). Forms of students' personal information and the answers they gave in interviews were encoded and themes created, and their frequencies were digitized and displayed in tables. Data analyzes were interpreted depending on the categories.

VALIDITY AND RELIABILITY

In order for the findings obtained in the researches to be used in practice, the bias in the research should be minimized. In quantitative studies, tests are performed to determine validity and reliability. However, whether this strategy is correct to use for qualitative studies is still a matter of debate. The strategies adopted by the researchers for this purpose in qualitative research are decisive in increasing the validity and reliability of the research. For example, in order to ensure reliability in qualitative research, data collection tools are evaluated by experts in their fields (Noble & Smith, 2015). To ensure the reliability of the data, interview questions were sent to the experts via e-mail to verify their suitability. According to the opinion of the experts and their observations, the interview questions were modified. Then, a pilot study was conducted with five students. The essence of the pilot study is to ensure the reliability of the questions that will be used for the main study. For internal validity in the study, the obtained data were compared and their concordance checked. It also examined how they differ from results obtained in similar studies on the topic and what similarities they show in terms of context. Although the differences have changed in terms of context and experiences, there are results regarding the skills acquired by students that differ according to some criteria. Therefore, external validity was guaranteed in terms of sharing similar results in other studies. While collecting data in qualitative research, audio recordings of the interviews can be made with the consent of the participants, and then the interviews are transcribed (Russell & Gregory, 2003). The students were told that the audio would be recorded during the interview. Accordingly, the interviews were audio-recorded, and then these audio files were transcribed into texts after the interviews to start the process of data analysis.

Qualitative studies are often done about people's lives, so any research involving people requires an awareness of the ethical issues that these interactions may cause (Orb, Eisenhauer & Wynaden, 2001). The purpose of the study was clarified to the participants before starting the interview, and it was also explained how the information would be collected, analyzed, and used, and the confidentiality of the use of the information was emphasized. Based on the consent of the participants, interviews were started and information was collected and analyzed to achieve the purpose of the study.

FINDINGS

In the current study, after interviews were conducted with 15 students graduating from STEM schools in the year 2020, the data obtained from the interviews were collected and analyzed according to qualitative research methods. The data collected were analyzed by coding. After coding the data, the codes were transformed into themes. Three themes were obtained that generally express the skills acquired by the students: soft skills, hard skills, and the impact of the school environment on student achievement. These three themes and the codes reached by the researchers can be seen on the Table 2.

Table 2. *Themes and codes*

Themes	*Theme 1: Soft skills*	*Theme 2: Hard skills*	*Theme 3: The impact of the school environment on student achievement*

Codes	Time management	Computer skills	Belonging
	Communication skills	Scientific activities	Rich environment
	Work under stress	French language skills	Provide opportunities for creativity
	Presentation skills	English skills	A school environment that encourages work
	Teamwork	Application	Diversity of activities
	Expressing oneself	Competitions	An environment that encourages creativity
	Self-learning	Volunteering	
	Problem-solving	Searching	
	Experience		
	Self-confidence		
	Competitiveness		
	Adapting		
	Analyzing		
	Flexibility		
	Active		
	Self-development		
	Self-acceptance		
	Accept others		
	Social intelligence		
	Independent		
	Self-control		

As it is seen on the Table 2, each theme is subdivided into codes that also express a larger set of skills. For example, the theme "soft skills" is divided into a large number of sub-skills such as time management, adapting, self-acceptance, and flexibility; the theme "hard skills" indicates some other skills as volunteering, scientific activities, and searching. The third theme, on the other hand, includes codes about the impact of the school environment on students' achievement, like providing opportunities for creativity, and a school environment that encourages work.

Table 3. *The frequency of codes under Theme 1: Soft Skills*

Themes	*f*	*Codes*	*f*	*Codes*	*f*	*Codes*
Theme 1: Soft skills	10	Time management	7	Self-learning	4	Flexibility
	21	Communication skills	5	Problem Solving	6	Active
	8	Work under stress	8	Experience	7	Self-development
	15	Teamwork	6	Self-confidence	4	Accept others
	10	Expressing oneself	5	Competitiveness	5	Social intelligence
	5	Presentation skills	5	Adapting	6	Independent
	6	Self-acceptance	3	Analyzing	6	Self-control

It can be seen on Table 3 that the most frequent code under the theme Soft Skills is "communication skills". Frequency of "teamwork" and "time management" skills follow this code.

Table 4. *The frequency of codes under Theme 2: Hard Skills*

Themes	*f*	*Codes*	*f*	*Codes*
Theme 2: Hard skills	10	Computer skills	5	Application
	5	Scientific activities	19	Competition
	4	French language skills	11	Volunteering
	15	English skills		
	28	Searching		

Table 4 indicates that the most frequent code under the theme “Hard Skills” is “searching” skills. “Competition” with 19 and “English skills” with 15 follow the “searching” skill.

Table 5. *The frequency of codes under Theme 3: The impact of the school environment on student achievement*

Themes	*f*	*Codes*
Theme 3: The impact of the school environment on student achievement	12	Belonging
	3	Rich environment
	6	Provide opportunities for creativity
	16	A school environment that encourages work
	7	Diversity of activities

According to Table 5, it can be seen that the school environment affects the students’ achievement on 5 different levels. The most frequent code is “a school environment that encourages work”. Frequency of “belonging” follows it.

DISCUSSION, CONCLUSION, AND IMPLICATIONS

The current study was carried out to reveal the skills acquired by students in a STEM school in Egypt as a result of STEM practices. In this qualitatively designed research, data analysis was used with content analysis. As a result of the research, various codes were obtained and these codes were categorized under 3 themes. These codes are as follows: "soft skills", "hard skills" and "the impact of the school environment on student achievement".

John and Chen (2017) revealed in their research that STEM applications improve students' soft skills. Wilkins, Bernstein, and Bekki (2015) proved in their studies that students' communication skills are positively affected as a result of skill assessments in the STEM system. When the codes under the "soft skills" theme are examined, it is seen that the most common code in the data is communication skills. Therefore, the current study results seem to support the research of Wilkins, Bernstein, and Bekki (2015). Musiimenta et. al. (2019) revealed in their research that STEM applications improve students' 21st century skills. They said that among these skills are teamwork, time management skills and computer skills. In the current study, "teamwork" and "time management" codes under the soft-skills theme and the "computer skills" code under the hard-skills theme support the findings of the study. It was also explained by Bybee (2010) that a STEM-enhanced curriculum is effective in improving students' basic 21st century skills. It has been stated that students will adapt, strengthen their communication, develop social skills, and gain self-management skills through STEM. It is seen that some of the codes revealed in the current research overlap with the results of the Bybee (2010) research. For example, in the current study, it is clear that the codes of self-control, communication skills, adapting, self-learning, self-confidence and self-management under the soft-skills theme support the research findings. Siekmann and Korel (2016) say that thanks to STEM education, students' creative and critical thinking skills are improved. At the same time, they state that problem solving activities in STEM applications enable students to follow technological developments. The "problem solving" and "analyzing" codes under the "Soft Skills" theme, which is the first theme in the current study, support this situation. Since STEM education progresses intertwined with art, history and language disciplines (Başaran, 2018; Başaran & Bay, 2023; Durucu & Başaran, 2022; Aguilera & Ortiz-Revilla, 2021), the second theme in the findings part of the current study, which positively affects the

foreign language acquisition processes of students, is revealed in the codes of "French skills" and "English skills" in "hard skills".

As a result of the research, it can be said that STEM education provides the development of students' soft skills such as: time management skills, communication skills, and teamwork skills. At the same time, research has revealed that STEM education develops students' hard skills such as: computer skills, language skills, and research skills. The present study also revealed that the environments of schools providing STEM education have an impact on students' achievement. It can be said that the school's providing a rich environment for students, providing opportunities to increase creativity opportunities, and providing diversity in activities have a positive effect on students' success.

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AUTHOR CONTRIBUTION

- The first author made significant contributions to the creation of the conceptual framework, planning, data acquisition and analysis and interpretation of the data.
- The second and third author contributed to the review of the findings related to the article's content, the preparation of the draft, and the final form of editing.