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**The American University in Cairo**

**School of Global Affairs and Public Policy**

**THE INITIATIVE OF STEM SCHOOLS IN EGYPT: ISSUES OF PROCESS,  
TEACHERS' COMPATIBILITY AND GOVERNANCE**

**A Thesis Submitted to the**

**Public Policy and Administration Department**

**in partial fulfillment of the requirements for the degree of  
Master of Public Administration**

**By**

**Lamis AbdelMeguid**

**Summer 2017**

The American University in Cairo  
School of Global Affairs and Public Policy  
Department of Public Policy and Administration

THE STEM SCHOOLS INITIATIVE IN EGYPT: ISSUES OF PROCESS,  
TEACHERS' COMPATIBILITY AND  
GOVERNANCE

Lamis AbdelMeguid

Supervised by Dr. Ghada Barsoum

ABSTRACT

This study discusses the Science, Technology, Engineering, and Mathematics (STEM) initiative as the latest policy move undertaken by the Egyptian government to improve the education system and prepare future generations of professionals in these fields. The findings of this study are based on a case study of two schools in Egypt. Data was collected using face-to-face and focus group interviewing along with a review of documents. This thesis discusses the role of the different stakeholders, the program structure, the student and teacher selection processes, teaching techniques, curricula, assessments, sustainability plan, and the views of STEM graduates. The study highlights the positive STEM learning environment but identifies a number of issues that could be threatening the quality and continuity of the STEM initiative in Egypt. These relate to: (1) the complex overarching bureaucratic legislation structure; (2) challenges in curricula design and assessment criteria; (3) teachers' training and system compatibility challenges; and most importantly, (4) the shortfall in the availability of sustainable funding. Relying on the findings of the global STEM experience, the study discusses international best practices and recommendations.

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## 1. Chapter 1: Introduction

This is an introductory chapter. It starts by defining the topic and specific area of study. Hence, it starts by defining what is STEM and why it is perceived to have a unique educational ideology. This is followed by the specific research question for this study, study scope, including the what, where, how, and why aspects of the research, as well as the conceptual framework overarching this work.

The Science, Technology, Engineering, and Mathematics (STEM) education presents a one-of-a-kind research-based schooling that cannot be contained in a book. The system introduces new learning techniques that are more research-based, unlike the traditional educational system of studying out of a book (Drew, 2011). It is meant to serve the most gifted students, who are eager to invest in their 'science' talents (Cross & Frazier, 2010). As the nature of this system is characterized by scientific orientation, it is continuously and rapidly evolving, highly consecutive, and exclusive for the top-notch students (Rollins, 2011). Consequently, acceptance to these schools is limited to the highest scoring students in middle school, who are keen to develop themselves, and improve their chances to enter a STEM college (Cross & Frazier, 2010).

Whereas students have the freedom of digging deep in the researched topic, but each grade still has a broad theme to be covered during the academic year (Rollins, 2011). In fact, each year is building on the one before, meaning that failure to comprehend the necessary information in one grade will hinder the enrichment of the following courses (Rollins, 2011). Due to its research-nature, some schools, particularly in the United States, even worked on creating partnerships with universities to give STEM school students access to the college's academic sources (Cross & Frazier, 2010).

It also puts a burden on the schoolteachers, who should always be up to date with the ongoing technological changes (Rollins, 2011).

Additionally, STEM calls for cross-disciplinary integration. So, some or all subjects (biology, chemistry, physics, etc.) offer complimentary knowledge. While technology is becoming a booming field, its benefits are to be linked to social studies and humanities (Sanders, 2009). As students are encouraged to draw the linkages, an ideal teacher shall be knowledgeable, not only about his taught subject, but also about the possible connections to the other subjects to be able to successfully contribute to students' outstanding achievements (Rollins, 2011; Sanders, 2009).

In addition, educators shall be aware that the level of scientific method their students can ask for may be of higher complication than being applied in the everyday life context; hence, it is the teacher's role to explain the relationship between the theoretical findings and its on-ground applicability (Rollins, 2011). It takes outstanding educators to be able to make STEM students benefit from such a great opportunity by connecting their theories to reality. Conversely, those school students come up with superb technological innovations that may be used for advanced research or even experimented on ground (Rollins, 2011).

Although many communities, parents, and employers are not yet fully acquainted with the benefits of STEM education, 'STEM' professionals, such as engineers, scientists, and technologists, whether academics or professionals, can be of great assistance to the distinguished young caliber; and shall be ready to contribute to the growth of their community (Rollins, 2011). It is especially vital due to the rapidly changing technological advances, which in turn alternate scientific progresses. After all,

the technical progression in health care, product manufacturing, services provision, and environmental preservation is a result of devised scientific advancements by those who excelled at sciences throughout their education (Lemoine, 2013).

We are living in a tech-society, where STEM jobs are three times greater than they were ten years ago (Lemoine, 2013). But, unfortunately, not enough humans have developed a related passion yet. In the United States, only 40% of American students who continue with higher education chose a STEM specialization. Therefore, not even a third of the chemistry and physics teachers in public high schools majored in their subject-specialization (Lemoine, 2013). That is why STEM schools are becoming trendy around the world. Yet, more and more countries are realizing the challenges they will be facing if their citizens do not have enough STEM education, whereas they live in an era where machines are replacing human labor. For instance, in Korea the government has been using the media to excessively promote STEM education (Jon & Chung, 2014). As a result, the number of STEM schools increased, as well as the number of students enrolled in the system has been on the rise since 2007 (Jon & Chung, 2014).

Korean students managed to achieve top results in the fields of mathematics and science in the international student assessment tests (Jon & Chung, 2014). For instance, they ranked fourth in mathematics and sixth in science in 2009 in PISA; and in 2011 they won first place in the “International Science Olympiads” in physics, astronomy, and earth science, and second place in junior science (Jon & Chung, 2014). Even though Korean students excelled at the ranks, the challenging part remains their lack of interest and enjoyment in mathematics and science subjects (Cho et al., 2012), which in turn reflects in their choice of career paths in the future. In response, the Korean government has

attempted to introduce new policies that make STEM education catchier, such as the introduction of art classes and turning the system into ‘STEAM’, which is meant to nurture the artistic side of talented students, who may turn into a Korean “Leonardo da Vinci or Steve Jobs” (Jon & Chung, 2014, p. 41).

This study explores the STEM schools’ initiative that has been implemented recently in Egypt, in pursuit of improving school education. The global realization of the importance of STEM studies in future development, led the state to adapt this initiative as a driver for socio-economic prosperity. The conducted research relied on a case study of two STEM schools in Egypt. The data collection is based on qualitative methods: Interviews, focus-groups, and on-ground observation. Interviewees were selected based on purposive sampling; i.e. those who have a role in decision making and governing the schools, from the governmental side and from the donor’s side. The findings of this study are used to assess the current governance structure of the STEM schools in Egypt, divided into (i) policy-process, (ii) teacher compatibility, and (iii) students’ governance. Accordingly, the main flaws were determined; and recommendations were derived relying on international best practices that have been identified in the literature review.

### **1.1. Research Question**

As Patton (2002) explained, the research question must be clearly describing the issue to be studied, the kind of literature to be looked at, and the significance of the study to the wider research community. Therefore, it must be focused on a population and take place in a specified site. Mirroring the purpose of this study, the research question must reflect the STEM schools’ governance structure in Egypt. This is followed by a number of identified key factors, which led to the understanding of the administrative framework

and the underlying policies governing the system. These key factors evolve around the policy formulation and implementation, as well as the regulations governing students and teachers.

- Main research question:
  - In the Egyptian context, what is the governance structure administering STEM schools?
- Sub-questions for clarification:
  - Who are the key decision makers when it comes to policy setting?
  - How are the schools administered? What are the governing rules for teachers and for students?

## 1.2. Study Overview

The below table details the overall study objectives:

WHAT	This research is focused on unfolding the governance structure of STEM schools in Egypt.
WHERE	The paper is based on a case study on the two schools in Greater Cairo
HOW	The researcher is collecting documents from the website of the Ministry of Education, the STEM school’s website, and the USAID reports; and primary data through interviewing key decision-makers and graduate students.  Also, desk research is conducted to identify the best international models and use them as guidance in developing recommendations for enhancing the Egyptian STEM system.

WHY	The researcher decided to explore the STEM schools' initiative as it represents the latest policy move by the Egyptian government in attempt t o enhance the Egyptian public education.
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### 1.3. Conceptual Framework

Marshall and Rossman (2011) define conceptualization as deciding on the focal area of the study by building a systematic and theoretical framework that outlines the concepts covered by the study: This study uncovers the latest educational policy reform Egypt has undergone in attempt to improve its quality of public school education. The below graph reflects the chain of thought from the bigger umbrella to the undertaken study.

This study relates to the national school education in Egypt. In this regard, the researcher chose to look at the recent formulation of national policies by the government in attempt to improve the quality of national school education. Following this path, it has come to realization that the project of STEM schools represents the latest policy move undertaken by the Egyptian government to enhance the quality of national schooling.

Whereas there is currently a total of nine STEM schools around the country, the two well-established ones are taken as a case study to serve the goals of this research. There are three main components to be studied in exploring the governance structure of these schools, namely policy-process, teacher compatibility, and students' governance.

### 1.3.1. Policy-Process

As explained by Cochran et al. (1999) policy stands for governmental actions with regards to a certain issue to attain desirable results. The policy process entails the “exercise of power in the making of policy” (Hill, 2013, p. 25). Therefore, it is critical to determine the key stakeholders and their administrative powers. Accordingly, this research will explore the reasons behind establishing STEM schools on a national level, the key players in the decision-making process, and the overruling regulations. In line with this, the study will follow the flow of the stages model of the policy process developed by Birkland (2015):

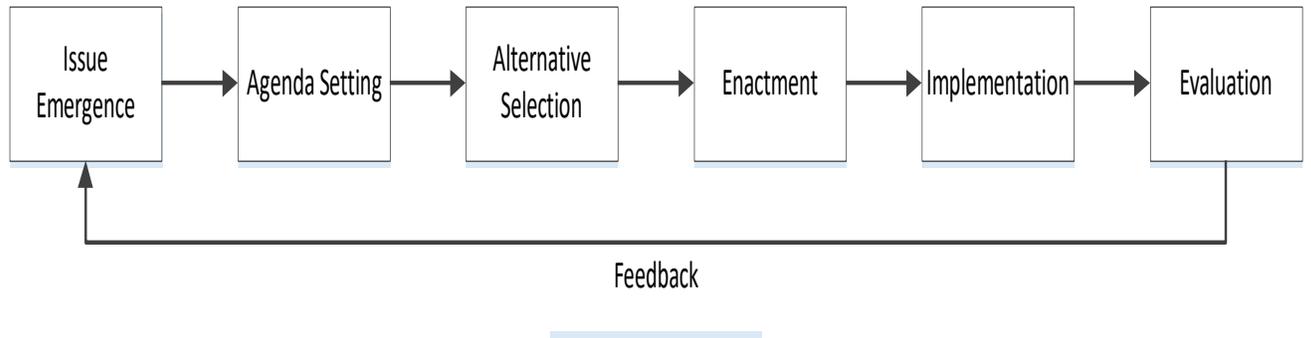


Fig. 1: The Policy Process Model by Birkland (2015)

Fig. 1 explains the flow taking a policy idea to its actual implementation (Birkland, 2015). The policy process starts with an emerging issue. If critical enough, resolving this issue becomes a national priority, i.e. is put on top of the agenda. Next comes the brainstorming of alternative solutions, out of which the best foreseen policy is selected for implementation. Then comes the enactment, which stands for the laws and regulations passed by the state to govern the selected policy implementation (Birkland, 2015). Once the rules are set, the implementation starts. Lastly comes the evaluation,

which assess the implemented actions in conformance with the set timeline of activities, objectives, and goals to be achieved. The evaluation provides feedback on the emerged issue, as in whether the undertaken policy process has solved it (Birkland, 2015).

Following this flow, the following study will shed the light on the following:

- The underlying reasons for initiating the STEM project
- The involved stakeholders, i.e. key decision-makers
- The rule of law governing STEM schools in Egypt, including the overarching constitution, admission criteria, dismissal policy, and certification.
- The implementation plan set for the Egyptian STEM project in terms of initiation and sustainability
- The monitoring and evaluation scheme used to assess the success of the project and the performance of its stakeholders

### **1.3.2. Teacher Compatibility**

As explained by Lunenburg and Ornstein (2008), analyzing and improving teaching is one key factor in a successful school administration. Accordingly, this study explores the advantages and drawbacks of STEM teaching. The analysis is based on the framework on the cycle of HR management developed by Lunenburg & Ornstein (2008):

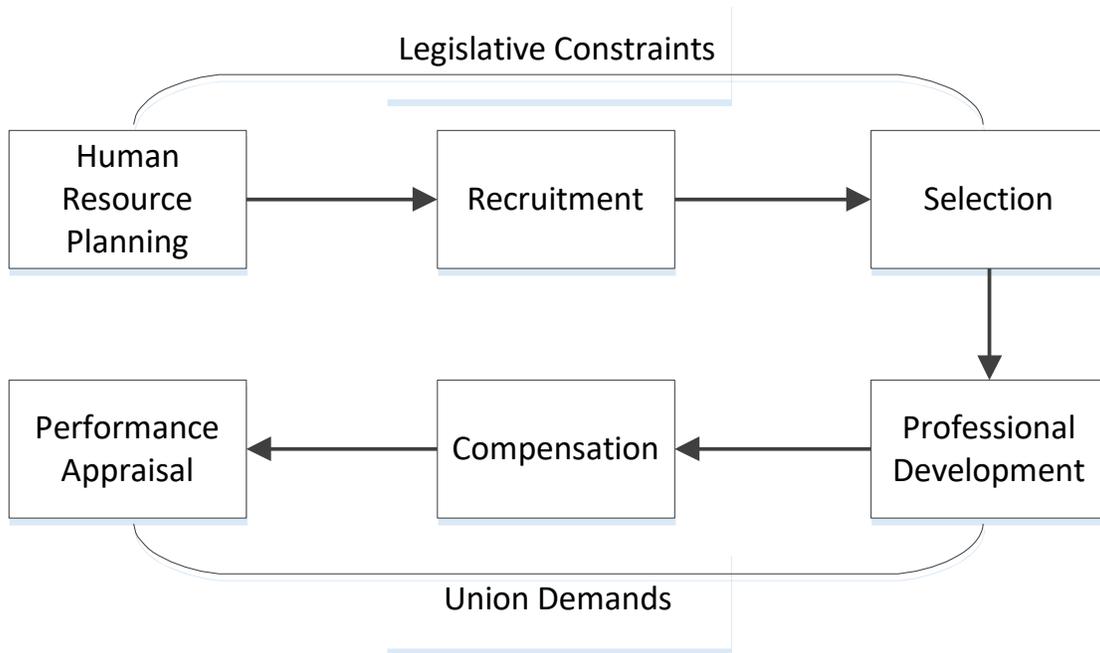


Fig. 2: The HR Cycle by Lunenburg & Ornstein (2008)

Fig. 2 presents the sequence followed in administering school teachers. First, the administrators have to set a plan for the number of teachers they need for each subject. Then, they start the recruitment by announcing the vacancies. After filtering eligible candidates, comes the selection process, which is based on interviewing shortlisted applicants. The recruitment of teachers is constrained by a set of laws that is decided upon by the governing body; in this case MoE. Once selected, accepted teachers must undergo professional trainings to improve their personal and professional skills. Additionally, it is crucial to offer those teachers competitive compensation packages to ensure their retention. Bonuses and appraisals shall be linked to their performance.

### 1.3.3. The Students' Governance

Another crucial factor leading to a successful school administration is the students' governance (Lunenburg & Ornstein, 2008), which covers the overarching decisions that

contribute to enhancing the overall students' learning experience. In this study, students' governance covers the following aspects:

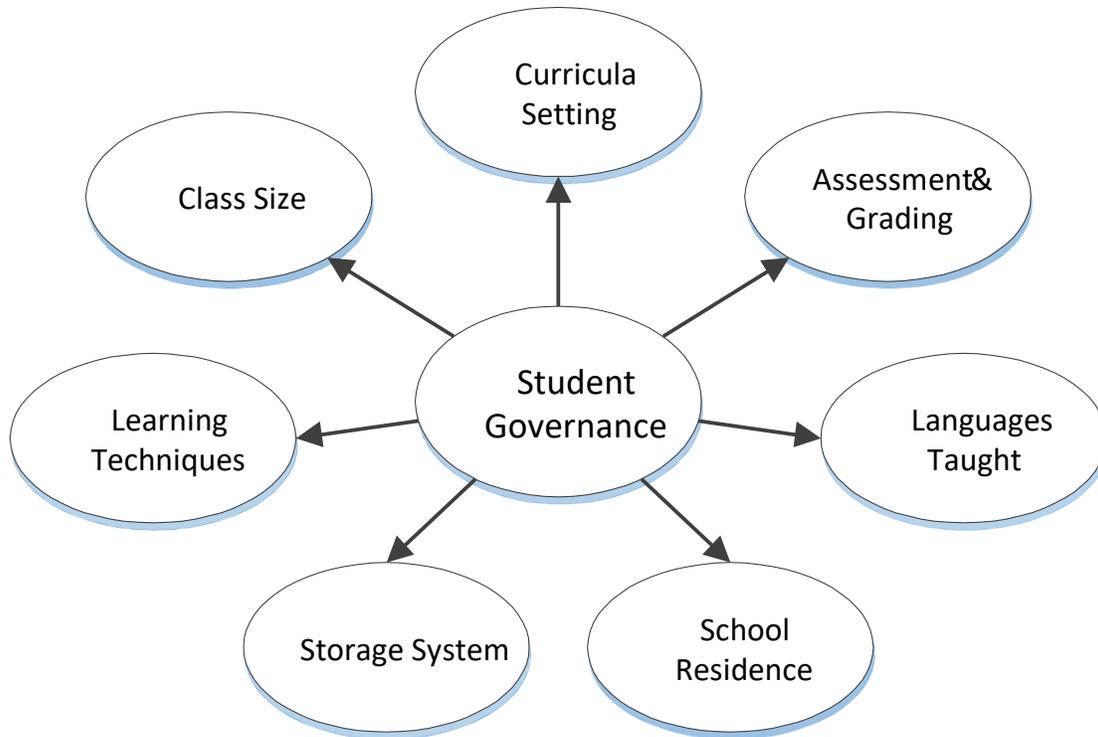


Fig. 3: Author's Conceptualization on the Students' Governance.

Fig. 3 illustrates six features that fall under the students' governance, based on the research done by Lunenburg & Ornstein, 2008. These are:

- The Class Size is about the maximum number of students per classroom.
- The Learning Techniques entail the provided tools and teaching methodologies used for enhancing students' learning.
- The Storage System talks about the maintenance of material and school equipment.
- The Curricula Setting discusses who is involved in formulating the curricula and how they are designed.

- The Taught Languages present what foreign languages are taught in STEM high schools.
- The Assessment & Grading contains the assessment criteria and grading system for measuring students' performance.
- The School Residence describes the residency requirements for STEM high schools.

## 2. Chapter 2: The Global Experience of STEM Education

This chapter discusses the worldwide trend of initiating STEM educational programs. It covers the reasons leading to the birth of STEM education, discussing the main trigger of needing STEM-skilled employees in the job market. Additionally, it introduces the STEM educational ideology and how it differs from other learning methodologies. The American model is being explored for its relevance to the Egyptian one. Following the model, the chapter covers the assessment framework and the lack of STEM-skilled teachers globally; as well as the role of the governments in enhancing STEM systems in their countries. Here, international best practices have been identified and used as examples of success stories.

With the decreasing interest of high school students in science-related disciplinarians, countries have faced a shortage in associated jobs. Hence, the initiative of (STEM) schools (Drew, 2011), i.e. teaching STEM (Lemoine, 2013) have come into existence. These schools, tailored for gifted students, are meant to provide an environment where teens can grow their interest in sciences (Cross & Frazier, 2010), in order to pursue a corresponding college and career path afterwards, as a result to the realization that students tend to perceive STEM subjects as difficult (Rollins, 2011) and hence avoid them in schooling. Beside the regular language and computer courses, this educational system focuses on the teaching of “mathematics, biology, chemistry, and physics” (Rollins, 2011), which prepares students to become technological experts, doctors, and engineers. Whereas STEM targets the most talented students, who tend to be cognitively challenging (Cross, 1997 in Cross & Frazier, 2010; and Drew, 2011), these schools are mandated to hire proficient teachers (Drew, 2011).

In the United States, STEM-schools were founded in the 20<sup>th</sup> century (Hanford, 1997 in Cross & Frazier, 2010) as high schools (Cross & Frazier, 2010), in response to the poor performance of national students on international academic competitions, which persisted for 40 years (Rollins, 2011 & Drew, 2011), such as “Trends in International Mathematics and Science Study” (TIMSS) and “OECD’s Programme for International Student Assessment” (PISA) (Marginson, 2014), which measures children’s capability in applying science and technology at the workplace (Rollins, 2011). In 2009, “the US ranked below average in mathematics and on average in science” in both OECD and PISA. (Lemoine, 2013) In 2003, 23 countries (out of 29) scored higher in mathematics among 15-year-olds than the American students. In OECD science assessment of the same year, American students ranked 19<sup>th</sup> (out of 23) (Drew, 2011). Additionally, in 2006, US scored “below most other nations” in PISA, a rank that has been deteriorating over the years. The same situation persisted in mathematics on the National Assessment of Educational Progress (NAEP)(Rollins, 2011).

The focus of international comparisons on STEM subjects (Marginson, 2014) reflects the importance of those disciplines for economic progression. As stated by Rollins (2011) “The nation’s future depends on our ability to educate today’s students in science, technology, engineering, and mathematics”, whereas more of half the college degrees in China and Japan are earned in STEM fields compared to only one third in the United States; an objectionable ratio (Rollins, 2011). Whereas the US has always been world leader, in 2007, the Chinese managed to jump to the top of list in the number of doctoral degrees awarded in natural science-related topics (Lemoine, 2013). Consequently, Lemoine (2013) recognized STEM schooling as the obvious solution to

bring up new generations of scientists and technologists, which is the only way for economic prosperity, national welfare, and power saving.

Accordingly, poor performing countries have come to the realization that they need a tailored educational program to enhance their nation's performance (Marginson, 2014). For instance, the South Korean government has not only introduced STEM schools, but also integrated curriculum reforms and professional development programs for teachers aiming at enhancing their score on PISA competitions (Marginson, 2014). Similarly, the US government has foreseen its need for talented workforce, since its future welfare depends on a generation of innovative scientists who can keep up with the alternating technological advancements (Rollins, 2011). Hence, it is keen to sustain well-educated top-notch STEM students, using the research collected on how teens learn best in their teaching techniques (Rollins, 2011).

Nonetheless, students still lack interest in studying STEM subjects; and hence, only few choose to enter STEM high schools. Governments must work on grasping attention of the gifted students by providing them with top-notch teachers and exposure to relevant research experiences (Rollins, 2011). To overcome the lack of proficiency in STEM fields and in order to achieve the goal of preparing capable youth for science-related jobs, STEM schools around the world are working on recruiting the best teachers and training them, applying respective administrative policies to enhance the classroom experience, and implementing efficient assessments to measure teachers' performance and keep record of outstanding students, to further nurture their talents (Rollins, 2011).

## 2.1. The Global Need for a Skilled Labor-Pool in STEM Fields

The world is turning into a high-tech competition, making countries with brilliant scientific minds in a powerful position (Drew, 2011). Maltese et al. (2014) stated that employers of STEM-related jobs suffer from finding good candidates for recruitment, which is foreseen to persist for the coming few decades as well. Accordingly, science knowledge has become crucial in the job market of our modern technological world (Marginson, 2014). Therefore, there is a wide belief that STEM education has a strong impact on optimizing productivity through the continuous implementation of technologically advanced innovations (Drew, 2011 & Marginson, 2014). Technology has replaced human capital. For instance, automation has led to the reduction of needed workers. Accordingly, the industrial need for the unskilled mass labor has been replaced with a few technologically competent staff. For instance, insurance companies in the US have replaced five positions with a computer program. Hence, instead of hiring high school dropouts, they now require at least two years of college experience. Being keen to remain as a world leader, the US government has taken upon itself the responsibility of providing high quality science-focused education to its nation, whereas other countries provide discerning learning to selected 'elite' (Drew, 2011).

Countries like Finland, South Korea, Taiwan, Singapore, Hong Kong, and China have managed to excel at STEM education and research development. Hence, secure their future prosperity and prominent position on the world economic map. In 'English-speaking' countries, such as the US and the UK, initiated STEM policies seem to not be as fruitful (Marginson, 2014). Therefore, Marginson (2014) suggested learning from their adapted STEM educational models. The most successful model is designed by Finland

(Marginson, 2014). Yet, no other country, whose initiatives did not yield expected results, has taken it as guidance. In fact, most countries adopt a competitive approach, whereas the Finnish model is based on cooperation and equal opportunity to all students, gender and class (Marginson, 2014 & Dobson, 2014). In East Asia and Singapore, citizens highly value education, starting with pre-schools. STEM is at top of their priorities when it comes to the crucial fields of study, which is highly supported by efficient governmental interventions, focused on providing a 'student-centered, inquiry-based', and 'problem-solving' learning environment that promotes analytical thinking and creativity (Marginson, 2014). In fact, these countries now suffer from a shortage of studying social sciences and humanities. Here again, teachers are well prepared, highly qualified and respected (Marginson, 2014).

Governmental authorities realized the importance of STEM graduates in future prosperity, economic growth, and innovation, whereas many students find that the university level mathematics is 'too hard' compared to what they took in school (Hernandez-Martinez, 2016). As a developing country, Egypt would also benefit from the introduction of STEM education for its future prosperity and economic growth. South Africa, for instance, has suffered for a long history of inequality (Rinne et al., 2015). As a result, the South African 'Department of Education' attempted to make up for the existing inequality and lack of quality education on the primary levels, by implementing a one-year-complementary program "SYSTEM", where students who did not perform well in high school, study a condensed course of physical science, biology, mathematics, ICT and communication skills that compensates for the lack of STEM four-year high school study (Kahn, 2014). This program serves as a higher-level preparation and qualifies its

graduates to enter STEM-linked universities. The program has proven to be successful; 100 proficient science and mathematics teachers came out of it so far (Kahn, 2014).

## **2.2. The Critical Thinking Component embedded in STEM**

STEM in principle promotes for critical thinking, which shall be reflected in the designed curricula. Yet, this is easier said than done. As Ellerton (in Davies and Barnett, 2015) stated critical thinking is a vivid problem that is attempted to be included in all subjects but none succeeded at effectively integrating this concept yet. “It has become the Cheshire Cat of educational curricula” (Ellerton in Davies and Barnett, 2015, p. 409). Decision-makers do cannot really define a set of criteria for a crucial-based curriculum. Yet, Ellerton (in Davies and Barnett, 2015) specified for key areas that can be covered for that sake, namely: (1) Argumentation, (2) Logic, (3) Psychology, and (4) the nature of science. The two refer to the idea of taking a standpoint in a controversial issue by intellectually engaging in a discussion using logical analysis. The third concept takes into consideration our pre-disposed beliefs and cultures that turn our logic into subjective conclusions. The last factor is science related and presents the understanding the scientific laws that make them reliable to build on.

STEM relies heavily on technology in its learning techniques, as it is research based, whereas most students use the Internet to conduct this research. Online search may save time, but the reliance on Google as a search engine also has its downside. Many science topics require the retention of information and not just finding it; and forgetting it later. For the students to excel at their careers later on, they need to retain some of the information and not just know how to find it online. Therefore, Drew (2011) called for integrating exercises that boost analytical reasoning, aside Internet search. It may be the

case that technological advancement, such as software development, are dominating the high-profile job market nowadays; nonetheless, a foreseen bright scientific future entails creative innovative scientists who use their technological skills creatively (Drew, 2011).

### **2.3. The U.S. Model of STEM as Boarding Schools**

The US model adopted by the Egyptian government for STEM education, includes the idea of ‘boarding’, where science-gifted students are asked to leave their homes and reside at a state-funded school. Boarding schools as a concept are meant to isolate children from their communities and put them in a different environment that reshapes their thinking (Spring, 2016). Parents being proud of their children’s achievement, bare the separation at this young age, and rely on the school support system to sustain their children’s wellbeing and update them with any unpleasant occasions (Cross & Frazier, 2010). Yet, in many schools supporting staff expect students to seek help when they need it and do not put the effort in remaining a close personal relationship with their students; therefore, do not foresee psychological discrepancies (Cross & Frazier, 2010). In return, many students resort to their fellow students for peer or group therapy. They find it more comfortable to talk to someone who is close to them and who shares the same concerns and difficulties, turning the students body into the most effective counseling tool the boarding school offers (Cross & Frazier, 2010). So, whereas some students find residential schools as an exclusive privilege, others perceive it as a necessary sacrifice that has to be made in order to be part of this distinctive high-profile opportunity (Cross & Frazier, 2010).

On the one hand, those brilliant mindsets get to benefit from a 24/7 scientific-learning atmosphere that extends beyond the morning hours spent in classrooms, to

include evening and weekend informal talks with fellow students and teachers (Cross & Frazier, 2010). On the other hand, residential academies create psychological pressure on those teenagers, whose suffering varies from homesickness to suicidal attempts (Cross & Frazier, 2010). Therefore, STEM boarding schools are keen to provide counseling support and residential staff, who are meant to monitor students' psychological wellbeing, make sure they familiarize with their new 'home', and offer help when needed (Cross & Frazier, 2010). In this regard, the residential team organizes wellness programs and social activities to boost the students' psychological realm. Bearing in mind their ultimate goal of becoming outstanding scientists, counselors are also responsible for ensuring students' passions are followed by paying special attention to their fields of interests (Cross & Frazier, 2010). Here also comes the teachers' role, as they have the higher influence when it comes to students' academic improvement. Hence, teachers are encouraged to design curricula that are mentally challenging and inspire students to undertake wide and deep research (Cross & Frazier, 2010). A teacher in a discipline of interest may even become a role model for a student who looks up to his knowledge and competency in the subject matter, which puts teachers under the responsibility of providing continuous care and advice (Cross & Frazier, 2010).

#### **2.4. The Criteria for Assessing STEM Students' Performance**

As STEM encourages analytical thinking, assessment shall reflect the understanding of concepts and knowing how to apply them, rather than the mere memorization of the covered topics for each subject. Hence, grading shall reveal the cognitive ability of students, and not just their ability to recall theories (Rollins, 2011). However, many STEM schools around the world have not yet succeeded in applying

proper assessment criteria due to the lack of fit teachers with appropriate understanding of this new ideology (Rollins, 2011). Lemoine (2013) added that a proper implementation of this system would require accountability measures towards the school administration. In that way, decision-makers will be eager to apply efficient and relevant assessment tools that accurately measure students' performance. Ideally, the state set regulations would reflect a benchmark that all schools can use as a guide and request annual goals to achieve the required students' proficiency in mathematics and sciences (Lemoine, 2013).

The underlying issue is the lack of expertise of the teachers, who are responsible for transferring the knowledge to their students. Whereas they are the ones responsible for designing exams to measure students' high-order reasoning, problem-solving skills, and scientific creativity, most teachers still fail to quantify the learners' know-how and only assess the basic understanding of core concepts and principles (Rollins, 2011). This in turn does not well-equip students with the sufficient knowledge to excel at their higher education and future careers (Rollins, 2011). To effectively apply STEM systems, it is crucial to start by nurturing competent teachers who are capable of turning the theoretical framework into practice. Unfortunately, research has revealed that most teachers hired by those schools lack the necessary qualifications to keep up with the learning competences of their students (Kahn, 2014). There is without doubt a fluctuation in the rate of proficiency from one region to another; yet again it is a wide stream issue (Kahn, 2014).

## **2.5. The Need for Competent STEM Teachers**

As a new system, STEM requires specially trained teachers, who first learn how to implement this new learning technique in order to be able to transfer it to students afterwards. Researchers have realized the value of STEM teachers as a treasured asset

that can jeopardize the future of young scientists. In the US, almost three quarters of the science and mathematics teachers did not major in those subjects for their bachelor degrees leading to a need of special tailored training programs (Lemoine, 2013). Hence, Cross & Frazier (2010) agreed with Lemoine on providing higher wages for STEM-specialized tutors in order to attract and maintain the best caliber. As a matter of fact, high quality teaching shall always be a top priority when it comes to STEM (Rollins, 2011). Drew (2011) also stressed on the significance of producing well-trained STEM educators. He argues that spending on them is a long-term investment that pays back by raising masterminded scientists, who will grow their nations in the future. In fact, a teacher qualification has been identified as one of the most critical factors to assess a learner's attainment.

Rollins (2011) identified two main attributes that belong to the perfect STEM teacher:

1. Bearing in mind that STEM relies on research rather than a set book, teachers shall master the content of the taught subject in a way that allows them to answer students' questions that go beyond the set curriculum. Also, they shall be able to drive examples from everyday life and challenge their intelligent students, rather than merely explaining theories.
2. As schooling does not only depend on the comprehension of topics, it is as important to have the talent of teaching; i.e. to be able to apply several methods in and out of the classroom to deliver the content to their students in a stimulating way.

Drew (2011) added that teachers need to:

3. Be devoted and engage students in inspiring discussions, and give them constructive feedback.
4. Connect with each student individually, figure out their interests, and give them guidance to strengthen their skills.
5. Set their own learning outcomes and put criteria to assess it through students' comprehension of the subject matter
6. Be able to draw connections between the different topics taught throughout the school year and come up with real life examples, as well as motivating students to conduct advanced researches.
7. Promote a positive learning environment that encourages analytical thinking, the application of knowledge, and discourages blind memorization.

Drew's findings determined that the teacher's commitment to provide students with the best education is a key factor in measuring educational success. Teachers misunderstand that the research-based system where students spend most of their studying time in front of their computers, means that they do not require guidance throughout. Therefore, he summarized the optimal teacher in 8 words, namely "non-directivities, empathy, warmth, encouragement of higher-order thinking, encouraging learning, adapting to differences, genuineness, and learner-centered beliefs (Drew, 2011). Unfortunately, it has been globally challenging to find compatible teachers, not only for the lack of science-specialized bachelor holders, but also for the inimitability of proficient ones (Rollins, 2011). Accordingly, STEM schools can only depend on

unqualified teachers (Lemoine, 2013), who are not capable of providing the above-mentioned key success factors.

Moreover, just like most services, access to good teachers is in some countries limited to higher socio-economic classes. STEM, therefore, attempts to provide the gifted 'poor' with better chances and opportunities to improve their living standards, as well as providing a brighter technological future to their nation (Drew, 2011). Therefore, Lemoine (2013) identified teacher quality as a major governance concern, and determined that it can only be achieved by providing more attractive compensations to the scarce skillful teachers in order for them to stay in the system. During his study on South Africa, Kahn (2014) summarized the teacher issues in three key words: (1) education, (2) supply, and (3) demand. Building on his findings, one identified issue behind the poor quality of education has to do with teacher's devoted time to students (Drew, 2011). Indeed, Internet access has a great role to play in enhancing STEM schooling. Compared to an offline library, online search allows students to gather information and counter-perspectives from all around the world in much shorter time (Drew, 2011). Yet, without adequate guidance, students may rely on all the wrong information published from unreliable sources or on junk websites. Iris Weiss (in Drew, 2011) argued that a main reason behind STEM failure in the US is that teachers do not spend enough time with students after classes.

Another obstructing aspect is the fact that their teaching techniques are very theoretical, especially when it comes to mathematics and equations, on the one hand. Students do not learn where to apply these theories in life (Drew, 2011). On the other hand, many teachers did not study their taught subject in college and therefore do not

have adequate preparation to teach well. For instance, a study made by Maltese et al. (2014) exposed that only 61% of high school teachers in the US actually hold a science degree, while only 52% of mathematics teachers hold a mathematics degree. Kahn (2014) uncovered similar results on South Africa. More surprisingly, only 20% of the physics teachers hold a physics degree. Also, as teachers are not well equipped to apply this critical ideology, they still base their exams on memorization, which defeats the whole purpose (Maltese et al., 2014; Kahn, 2014). In fact, a main reason behind students' hatred to science and mathematics is that these subjects require a lot of memorization and are not linked to their experiences (Drew, 2011).

Looking at the Korean experience, them noticing that teachers are a crucial asset to STEM's success, their Ministry of Education (MoE) government has ensured the enhancement of their competency by providing subject-specific 'phased teacher trainings' for mathematics, science and technical teachers, especially tailored to STEM-specialized teachers (Jon & Chung, 2014). Respectively, Drew (2011) came up with a number of recommendations that would enhance the learning process in STEM schools:

1. Offering higher financial incentives to STEM schoolteachers.
2. Ensuring that hired teachers are capable of presenting the subject matter using different tools and words as not all students comprehend through the same approach.
3. Developing personal bonds with the students and use the student's background knowledge to build new one.
4. Ensuring that hired teachers are capable of linking real life examples and using stories in delivering taught theories

5. Ensuring that hired teachers are capable of guiding students to undergo actual research that can be implemented if positively verified
6. Designing open-book exams that encourage analytical thinking and the application of learnt statistics/theories.

Whereas the notion of establishing STEM schools is on the rise, the existence of proficient teaching personnel is thinning (Kahn 2014). Those who go to education-related colleges do not focus on the relevant subject that they end up teaching, and those who go for the top schools like engineering and medicine do not resort to teaching careers as the science-related jobs are of the highest paying professions (Collins, 2014). Finland has been on top of the list in the implementation of effective STEM schools. In stating the key success factors, Dobson (2014) stressed on the teacher characteristics. Understanding the importance of the role of teachers, it is a highly-respected profession. First of all, the Finnish ensure that teachers receive proper training and education on their area of specialization. In this regard, they do not just rely on books, but integrate “inquiry-based learning approach”, where they are empowered to analytically think about the topics and problems in hand and come up with possible solutions themselves (Dobson, 2014). Then, they are looked at as experts who are content of selecting suitable methodologies to deliver the set national curriculum to their students. Teachers are not even obliged to implement state-set exams as assessment tool (Dobson, 2014). They are free to choose their perceived best-fit testing strategy. Being aware of the evolving world we are living in, teachers are also mandated to continuously attend development programs to stay up to date with the subject matter and teaching techniques (Dobson, 2014).

## 2.6. The Governmental Role in setting sound STEM Policies

Most nations of the world have equally foreseen the STEM-related job crises (Marginson, 2014). Accordingly, many countries reacted by implementing science-focused schools to make up for the existing disparity in the local job market (Flemming, 1960, pp. 134-135 in Judson, 2014). STEM education is in fact perceived as a national treasure, as it not only crafts the future labor, but also for being a platform for technological-innovation-experiments (Rollins, 2011). Therefore, it is the state's role to provide adequate funding, support, and expertise to implement the system correctly, which requires deep program-related research to come up with suitable solutions for the learning in informal setting atmosphere (Rollins, 2011). STEM experts must understand the alternating learning methodologies and designing corrective assessment tools for admitting students into STEM high schools, for evaluating their performance throughout, and for weighing teachers' match and performance (Rollins, 2011).

Governmental policies with regards to STEM regulation have not differed much from one state to another (Marginson, 2014). In fact, all countries agreed on the significant areas of investment such as: developing teacher's skill and knowledge, modernizing curricula, updating teaching methodologies, such as integrating computer visuals, and designing interactive lectures (Rollins, 2011; Lemoine, 2011). Nonetheless, some research revealed that the "STEM for all" typology is not effective and hence policy makers are encouraged to keep focusing on the brightest minds rather than integrating vaster STEM content across all schools. To attract and retain the top students, the government must work on offering them scholarships, fellowships, research grants, scientific internships, etc. (Lemoine, 2013). Accordingly, Lemoine (2013) referred to the

set 5-Year Strategic Plan for the implementation of effective STEM schools in the US. The Plan covers updating STEM curricula and ensuring equal entry opportunities for female students. Also, preparing 100,000 STEM-qualified teachers over the next decade, as stated by President Obama in 2011, which will integrate transferring knowledge from science agencies, university professors, and businessmen to the chosen teachers; a project that is budgeted at around \$80 million (Lemoine, 2013).

Korea has cut a long shot in STEM educational reform, including development of curricula, teachers' proficiency, students' activities, and school infrastructure (Jon & Chung, 2014). These movements have taken place through the various governmental-led establishments:

1. In 1967, they founded the “Korea Institute for the Advancement of Science and Creativity” (KOFAC), which is responsible for advocating science-related education amongst the Korean citizens; recently focusing its efforts on publicizing STEAM schools (Jon & Chung 2014).
2. In 1999, they established the “National Science and Technology Council”, which took over the responsibilities of allocating funds and reviewing governmental policies that concern science and technology education (Jon & Chung 2014).
3. They initiated the “Advanced Institute of Supporting Women in Science, Engineering, and Technology” (WISET) that works on providing females equal opportunities to pursue scientific careers; hence, promoting female STEM school education (Jon & Chung, 2014).
4. In 2008, they established the “Ministry of Education and Science Technology” (MEST), which combined the “Ministry of Education & Human Resources” with

the “Ministry of Science & Technology”, putting science and technology at the heart of educational objectives through integrating the R&D in those fields in all educational levels. One of the greatest achievements of MEST is the revised curriculum of 2011. On one hand, they integrated arts into STEM schooling and transferred it into STEAM. On the other hand, it integrated more problem-solving exercises into the mathematics curricula to enforce critical thinking in calculations. Nonetheless, this merger did not survive long, which let the government to again separate the Ministry of Education and create a “Ministry of Science, ICT and Future Planning” (MSIP) to handle STEM-related concerns (Jon & Chung, 2014).

In the United States, STEM education is perceived as the key aspect leading to economic prosperity, maintaining the country’s position as a world leader, and finding solutions for the upcoming global challenges, as this highly depends on raising innovative scientists, capable of creating groundbreaking industries and substitute products. Even for those who are not involved in the creation, STEM education will make them knowledgeable enough to make sound consumer choices. This is why Maltese et al. (2014) called for the implementation of STEM-based national curricula. Likely, the government has decided to invest in STEM education and increase the number of its graduates by 1 million (an increase of 34%) by 2020. To achieve this, the United States has delegated the related tasks to several institutes (Maltese et al., 2014):

1. The “Cross-Agency Priority” (CAP) prioritized budget allocation for improving the quality of STEM teachers, attracting more geniuses to enter, conducting on-ground feasible research, updating mathematics curricula, providing equal

- opportunities to women and minorities, and developing higher education accordingly (Maltese et al., 2014).
2. The “National Academies’ Committee on Science, Education, and Public Policy” (COSEPUP) was asked to identify the most needed state actions to enhance science and technology education in the US, in order to achieve economic prosperity and social security. COSEPUP’s findings were cohered with CAP, pointing at the worth of investing in improving teachers’ skills and STEM curricula (Maltese et al., 2014).
  3. The “America COMPETES Act” has taken up the responsibility of supporting STEM innovative research, by providing development trainings for around 700,000 potential STEM teachers; an initiative named “Teachers for a Competitive Tomorrow” (TCT). This program does not only work on trainings, but also supports college degrees that yield STEM teaching degrees (Maltese et al., 2014).
  4. The “National Action Plan for Addressing the Critical Needs for the US Science, Technology, Engineering, and Mathematics Education System”, initiated in 2007, again stressed on the lack of competent teachers and ensured the importance of prioritizing investments to enhance their proficiency. Additionally, they identified the lack in coherency across the subject at one grade, whereas STEM calls for integrated learning. Hence, they suggested implementing parameters for horizontal integration across relevant subjects, designing parameters for vertical association of STEM topics across secondary schools, high schools, and higher education, increasing the wages of STEM teachers to retain them, and finally

creating a ‘national certification standard’ to be attained by interested teachers (Maltese et al., 2014).

Compared to other western countries, Finland produces the highest rates of workers and professionals qualified to take jobs as scientists, technologists, or engineers (Dobson, 2014). The Finnish model remains the best, basically due to the favorable governmental policies over the years:

1. Students are taught to solve mathematical equations starting their very first year in school. In return, they grow up with a critical mindset, capable of handling basic mathematical calculations (Dobson, 2014).
2. Likewise, science classes, including natural and environmental studies, are part of the first-grade curriculum. Gradually, science subjects get split in biology, geography, physics, chemistry and health education. (Dobson, 2014)
3. Students spend less time in classes and on homework, compared to other countries. Children’s leisure time is appreciated. Still, Finnish students are always on top in international assessment tests (Dobson, 2014).
4. For elementary schools and up to the final secondary school year, there are no national exams. Instead, grading is based on daily-class-assessment (Dobson, 2014).
5. Regardless of class or gender, Finland ensures equal quality of education across the whole country (Dobson, 2014).

South Africa is still struggling from the unequal educational opportunities that resulted from the historical segregation between whites and blacks. STEM schools are no

different. In more recent years, the government is implementing various initiatives to combat this notion:

1. The National Department directed all their efforts on 100 'Focus Schools' as a start, instead of spreading themselves thin. These schools will be well managed and shall then serve as guidance for other schools in the neighborhood. As a second step, the project expanded to 529 successful 'Dinaledi Schools' that are home for 18% of the total student rate, concentrating their study on science and mathematics (Kahn, 2014).
2. The state also worked on reform the school admission policies to prevent 'unfair discrimination' based on color or gender. Nonetheless, providing funds is not sufficient to eradicate the existing racism. Although there are continuous attempts to promote equality, it is not yet completely achieved, due to the long historical context. (Rinne et al., 2015) In fact, Rinne et al. (2015) argue that today's administrators lack experience and competency to handle the lack of quality teachers and transform the educational environment in disadvantaged regions on the short run.
3. The government has identified funding as a key factor for enhancing educational quality; yet, it has not yet determined whether it is more efficient to focus on the most disadvantaged schools, as a short-term objective, or to work on unifying a nation-wide learning equality project, as a long-term objective. So, they are still experimenting with the outcomes of investing in the brightest, or the most vulnerable group of students (Rinne et al., 2015).

## 2.7. The Implications derived from the Research on STEM

Whereas STEM is not yet perfected, the special-tailored programs to improve the system are on the rise. Mathematics seem to still be a struggle for many students as out of the 75% who complete the early stage, in high school it is not as popular (Maltese et al., 2014). Also, when it comes to biology, chemistry, and physics, only 30% of high school students choose to take advanced courses (Maltese et al., 2014). Nonetheless, according to Thomas (2000) STEM school graduates in the US go for STEM college degrees “at a rate more than double the national average” (in Cross & Frazier, 2010). Although the public came to appreciate science education, students still suffer from lack of interest towards the learning environment (Maltese et al., 2014). In South Africa, class and gender inequalities remains a barrier to cross-country STEM enhancement, reflecting on the co-occurring low performance on international assessment tests, like TIMSS (Kahn, 2014).

It is well known that science-related jobs are of the highest paying in the market. This is due to the high level of expertise, but also due to the shortage in experts. Realizing this matter, Korean businessmen advocate for science education through funding awareness campaigns, such as TV commercials (Jon & Chung, 2014), which seems to have yielded positive results. A study conducted by Kim et al. (2010) disclosed that 75% of STEM high schools developed interest into scientific methods and pursued relevant university degrees, planning to sign up for a complementing career path (Jin et al., 2012; Kim, 2010; W. Lee et al., 2011 in Jon & Chung, 2014). With regards to the outstanding Finnish model, the country provides well-trained teachers that are

empowered and trusted, no nationally unified examinations, and unending advancement attempts (Dobson, 2014).

Most countries implement intensive STEM education that requires enormous time investment in studying. States are concerned about creating a school environment that only supports academic triumph. STEM students are expected to study much more than others, while not all teens feel a sense of achievement solely through academic achievement. Of course, this has its implications on the students' psychological state and social life. Cross & Frazier (2010) identified three main categories under which all detriments fall, namely "(a) effects on relationships; (b) effects on valued leisure activities and privileges; and (c) social and emotional loss". This is especially true for residential schools where students spend their full day on school premises. Whereas it may allow for more studying time, boarding schools may feel like a prison for the restrictions on going out and cause more emotional stress (Cross & Frazier, 2010). Adding to this the change in learning methodology and advanced level of course work, top students may start to perform poorly on their academics (Cross & Frazier, 2010). Consequently, they may seek acceptance by their bright peers by investing more time in socializing and even less time on studying (Cross & Frazier, 2010). However, those peers would not be willing to spend as much time building a friendship, as they care more about their studies. As a result, around 20% of students per year withdraw from boarding schools (Cross & Frazier, 2010).

Since STEM schools mean to attract the brightest minds, the high sense of competition embedded in the system, grows individuals who seek exaggerated perfectionism and suffer from inflated self-critique (Lemoine, 2013). But, not only does

STEM education feed into a scientific career, but it is also useful in associating political debates and environmental issues with state-related decision making on a broader level (Lemoine, 2013). Furthermore, STEM-educated citizens are capable of making sound health decisions, for instance when it comes to choosing the type of food they eat (Lemoine, 2013). Additionally, it is widely perceived as a prestigious academic institute (Rinne et al., 2015 & Maltese et al., 2014). Hence, within a state, schools compete on the limited human resources of outstanding teachers and students, and parents are pushing their children to get into STEM high schools (Rinne et al., 2015 & Maltese et al., 2014).

## **2.8. The Critique on STEM Schools Globally**

Just like any new initiative, STEM education still has its flaws, starting with the entry assessment tests that may be based on the wrong grounds. Lemoine (2013) argued that the lack of access to all students' data limits the proper program evaluation. More importantly, there is a noticeable gender gap in science education. Although more females get top grades than males in science and mathematics subjects in elementary schools, fewer women enroll in respective colleges (Drew, 2011 & Dobson, 2014).

In addition, the world countries were keener to maintain a reasonable number of STEM colleges' degree seekers that they drew more attention to attracting enough numbers to STEM high schools than they did for providing quality STEM education (Kahn, 2014). Moreover, the enhancement of STEM schools' quality requires funding development programs, whereas many countries did not yet allocate sufficient budgets to achieve that (Lemoine, 2013). In turn, this also has its impact on the quality of recruited teachers that are the main system implementers, as well as on the school infrastructure and provided services (Lemoine, 2013). The lack of understanding of STEM policies by

different stakeholders, including parents, teachers, and administrators, generates conflicts where every group thinks they know better, which result in disrespect and lack of cooperation, which spreads negative energy around the learning environment (Rinne et al., 2015). As Drew (2011) stated: “Barriers and restrictions to STEM education will continue to damage our economy and our culture.”

### **3. Chapter 3: The Egyptian Education System – A Background**

This chapter introduces the evolution of the Egyptian national education throughout history; moving from being exclusively for male elite to offering free education for all citizens. It goes on explaining the responsibilities of MoE in providing public school education in Egypt, their awareness of the poor quality of offered schools and the overarching strategy under which the STEM initiative was implemented. In this regard, the role of the donor organization, USAID is also touched upon.

#### **3.1. Modern Education in Egypt**

Modern education in Egypt in the past only targeted the male elites. Whereas economic advancement was to be achieved solely through the ‘intelligent’ elite, additional schools (of lower quality) were introduced over time to allow the rest of the population to learn basic reading and writing (Álvarez-Galván, 2015). During the British invasion, the Egyptian education witnessed significant changes. The spending on public education diminished (“Schools For Skills”, 2015) and English became the official teaching language at public schools and foreign schools came into play, here again targeting the upper-class elites (Álvarez-Galván, 2015). With independence, the Egyptian government managed to offer free education for all (“Schools For Skills”, 2015) and enforce Arabic as the official teaching language in governmental schools, while private schools remained in English or French (Álvarez-Galván, 2015). It was in the mid-1900s that the fees at public schools were abolished and school education became accessible for all citizens (Álvarez-Galván, 2015). Nonetheless, providing high quality education became challenging with the rapid growth in population and the limited availability of resources, including insufficient school equipment. Unfortunately, it is the poor who had

to suffer these conditions due to their lack of financial capacity to send their children to the high quality private-language schools (Álvarez-Galván, 2015).

Under the national school system there are two main types of public schools: Arabic and experimental (Álvarez-Galván, 2015; “Schools For Skills”, 2015). The Arabic schools teach all subjects in the Arabic language with additional English and French or German classes. The experimental schools teach some of the subjects, such as science, mathematics, and computer science in English (Álvarez-Galván, 2015). Hence, they are more advanced in the English language as a foreign one. In terms of stages, every Egyptian child has the right to basic education, defined in six primary and three preparatory years (MoE, 2011 in Álvarez-Galván, 2015). “Pre-primary education is not part of formal schooling” yet (“Schools For Skills”, 2015, p. 35). Students, who chose and are capable of proceeding, either enter the general secondary education or resort to technical secondary schools, specializing in industry, agriculture or commerce. According to the grades and the high school specialty, students of both tracks have opportunities to continue with higher education (Álvarez-Galván, 2015). As for private schools, there are four types: ordinary, language, religious, and international (“Schools For Skills”, 2015). The main difference to public schools is that private ones are more keen to create a quality learning environment for their students (“Schools For Skills”, 2015).

When it comes to higher education, admission is solely determined by the final high school score (magmu’). Hence, the highest scoring students are the ones who make it to the most competitive universities of medicine and engineering (Álvarez-Galván, 2015), whereas they might not be necessarily the best science-oriented youth.

Unfortunately, the faculties of literature and education are not highly demanded; thus, low scoring graduates are the ones who end up there. Due to this score-restricted system that does not take into consideration area of interest, some students get into universities they are not even interested in. For the faculty of education this indicates low quality schoolteachers, who are not passionate about their job (Álvarez-Galván, 2015).

The Ministry of Education (MoE) has a major role to play in administering national schools. First of all, they hold the major responsibility of setting appropriate policies and legislative standards (Álvarez-Galván, 2015). Developing and updating all curricula is another vital task, where they have to keep into consideration the rapid technological advancement we are living in now a days. Also, they are responsible for formulating the evaluation frameworks to monitor policy implementation, aside the financial and administrative structure (Álvarez-Galván, 2015). Lastly, the Ministry assigns personnel to schools, whether administrative or academic, based on need, and follow up with their adherence to set regulations (Álvarez-Galván, 2015). To achieve these goals, MoE works hand in hand with “the National Centre of Curricula Development”, “the National Centre for Education Research” and “the National Centre for Examinations and Educational Evaluation” (NCEEE) (Álvarez-Galván, 2015).

Álvarez-Galván (2015) identified the main issues facing Egyptian education as follows:

1. The national curricula base the learning process on teacher instruction without students' contribution and the assessment tools encourage mere memorization of the subject matter rather than understanding of underlying concepts. Accordingly, students are not taught how to relate

the content in the book to everyday life situations. (Loveluck, 2012 in Álvarez-Galván, 2015)

2. Egyptian national schools have a serious issue in infrastructure. The enormous number of students goes beyond the capacity of provided equipment. For instance, in one school more than 100 students can be sharing a single computer, whereas only few schools have computer labs to start with. Even worse, many of the provided computers are not operating or lack an Internet connection (Álvarez-Galván, 2015).
3. A noticeable number of children still do not attend school, even amongst those who are enrolled. This is due to the fact that private tutoring has informally become the base of school education, whereas students must not be in class, although it is officially illegal. This widespread phenomenon presents a financial load on the poor parents, who send their kids to 'free' public schools. Sadly, private classes have become a must. Those who do not comply by it are subject to failing, which creates unfairness in the system (Ersado et al., 2012 in Álvarez-Galván, 2015).
4. Private tutoring has arisen due to the very high numbers of students per class, as well as the low salaries of public school teachers, who consider it a way for supplementary income. As they put all their effort in the after-school classes, most of the teachers are unwilling to put the effort of explaining in class/at school. The Egyptian educational system suffers from poor educational governance due to inefficiency planning of education policy, funds, and administration, as well as lack of cooperation

between involved decision-makers, whose responsibilities overlap (Hartmann, 2008 in Álvarez-Galván, 2015).

In 2007, the MoE announced the first “National Education Strategic Plan” in attempt “to promote the sustainable growth of the economy and consolidate democracy and freedom” (Ministry of Education, 2007). The plan is targeted at addressing the most critical issues of enrolment, teacher quality and compensation, classroom density, assessment mechanisms, private tutoring phenomena, public budget allocation, transparency and accountability, and monitoring and evaluation on the governance level. In line with these goals, the following initiatives have been noted down by Álvarez-Galván (2015):

1. Enhancing the quality by modernizing curricula of all levels and providing trainings to teachers and supporting staff.
2. Enhancing school management through decentralizing the single school administration, improving the infrastructure and information technology in schools, developing performance indicators for students and teachers, as well as financial management, and ensuring the school design is up to set construction standards.
3. Reforming curricula and updating pedagogical methods and assessment measures for all three levels: elementary, preparatory, and high school.

### **3.2. The STEM Initiative in Egypt: The Role of USAID**

The STEM initiative in Egypt is a USAID funded project. Hence, the USAID office monitors the related progress and achievements. In its quarterly report on

*Education Consortium for the Advancement of STEM in Egypt (ECASE)*, published in March 2014, the donor organization wrote about the progress made by STEM schools and the achievements of its students, as well as the main challenges facing the system. As stated in the report, the initiative was meant to combat the inefficient ‘thanaweyya amma’. For instance, an alternative assessment framework for STEM schools has been applied to overcome the inefficient scoring system. Based on the report, students have successfully contributed to international science competitions and won remarkable prizes. For instance, in the *Intel International Science & Engineering Fair* of 2014, 49 groups of Egyptian STEM students submitted projects, out of which 25 projects were shortlisted, with a total contribution of 20% to the competition from Egypt. The first and second places went to a girls’ group from an Egyptian STEM School, for their project titled ‘Water Desalination Using Nano-Technology’ and ‘Water Purification’. The donor organization did not stop at supporting the high school education; they also introduced the *College Guidance Program* that helps students get into reputable local and abroad universities on scholarships. Partnerships with various universities in the USA particularly have been successfully achieved, such as the University of Miami, Wisconsin Madison University, University of Minnesota, University of Rutgers, Pittsburgh University, University of Iowa, and Temple University.

In their quarterly progress report (January to March 2014) on “The Education Consortium for the Advancement of STEM in Egypt” (ECASE), the USAID expressed some concerns regarding issues that need to be enhanced:

- Books and equipment delivered to the schools from abroad are not well stored.

Whereas import laws delay the delivery process, the school locks what is received

in inaccessible rooms making it unreachable for students, hence they cannot make use of them.

- The sustainability of the system is still at risk. Infrastructure, science lab equipment, books, IT infrastructure and other material is not well taken care of; hence, depreciates quickly and has to be replaced in a short term.
- As students are expected to have level of competency in the English language, a system of online and evening language classes are being offered to support the students, who are mainly tested on their vocabulary knowledge and writing skills.
- All personnel at the schools are appointed by the MoE, which takes some time. Hence, the sudden release or resignation of a staff member leaves a gap for some time until a replacement is found. For instance, in the incident of a lab manager leaving, the lab was left unmonitored and students lacked the necessary support to use the provided equipment.
- The lack of capacity, qualified personnel, and fund to support the newly established schools around the other governorates in Egypt.

ECASE has taken up the responsibility of building the professional capacity of STEM school personnel through sustainable training. Not only are professional trainings provided to existing teachers, but also to potential ones, as part of the assessment process. In line with the continuous improvement of teacher quality, ECASE always upgrades the recruitment process of new personnel, providing the MoE with a guiding Handbook for the ideal teacher selection. Believing in the major role of school leadership, special workshops, as well as one-to-one virtual coaching, are dedicated to principals and deputy principals. Additionally, Fab Lab trainings are offered to enhance the student body, lab

managers, and capstone leaders. Moreover, teachers and Ministry personnel are provided with guidance and sessions on how to develop intellectually stimulating assessment mechanism and exams to evaluate students' understanding rather than memorizing. Using the PARLO Tracker to measure learning outcomes and evaluating students' performance, training was given to staff members to learn about the difference of STEM system and understand how it operates. Teachers were taught how to log into the system and access the grade book to enter their set scores.

### **3.3. The STEM Initiative in Egypt: The Role of the Ministry of Education**

Falling under the umbrella of MoE, the following mandates (no. 369) were released on the 11<sup>th</sup> of October 2011 to initiate STEM schools in Egypt. The decree stated the following:

1. New schools to be built and to be named STEM, under the supervision of MoE.
2. These schools aim at:
  - a. Supporting gifted and merit students to develop their skills
  - b. Teaching advanced curricula in sciences, technology and mathematics
  - c. Developing the use of IT to modernize the process of education
  - d. Emphasizing on spiritual values and behavioral morals, as well as enhancing the sense of tolerance and openness to the rest of the world.
  - e. Creating a floor for developing creative talents.
3. Each school will have a governing body that is assigned by the Minister of Education and is to be valid for three consecutive years. Each school will also have a board of trustees regulated as per the ministerial mandate no. 289 of year 2011 for reforming the board of trustees, parents, and teachers.

4. The school governing body will have the following responsibilities:
  - a. Setting a strategic plan and action plan with regards to the administrative, technical, and financial aspects that supports creative talents and develops their skills.
  - b. Ongoing assessment of the performance inside the school.
  - c. Improving the teaching frameworks inside the school to facilitate mental stimulation and creativity for students.
  - d. Providing modern technical equipment and relying on modern technology for delivering information.
  - e. Handling the financials of the school, including exempting students from paying for fees, additional services, accommodation and food.
  - f. Designing framework to facilitate the achievement of the smart school goal, i.e. promoting innovation and creativity, and drawing networks with national and international STEM-relevant research centers.
5. The Ministry of Education is responsible for the monitoring and evaluation of the whole learning process, including examinations and student affairs, as well as endorsing the certificates issued by the schools as per the ministerial mandates.
6. Admission for these schools is restricted to outstanding students, who successfully completed their secondary school education at any school throughout the nation as per the set prerequisites by MoE. Applicants must pass the assessment tests taken during the selection process.
7. The maximum number of students per class cannot exceed 25 students.

8. Teaching at STEM schools will follow the regular class-day, and additional classes.
9. These schools follow special curricula approved by MoE and are to equivalent to the national curricula. This is the responsibility of the specialized committee formed by MoE as per the ministerial mandate (no. 235) of year 2011 with regards to the rules and regulations to operate schools with special curricula.
10. The continuity of students at STEM schools is preconditioned by outstanding academic performance. The school holds the right to move under-performing students to another national or experimental language school, after receiving approval from the administrative board.
11. The fees and costs for additional services, as well as the expenses for food and accommodation, are to be collected based on the yearly regulations set by the administrative board. The administrative body and the board of trustees hold the responsibility of building networks with civil society, and public and private institutes to secure financial coverage that enables the school to achieve its goals.
12. Based on the set regulations by the administrative body, the board decides on the channels of expenditures in return to the services students receive in addition to donated funds by NGOs and other supporting institutes.
13. This is to be announced to the public and to be active from the date of announcement.

Another ministerial decree (no. 202) was published on 21<sup>st</sup> of April, 2012 to clarify the legal stand of the STEM high school certification.

1. STEM school graduates receive an equivalent high school certificate that is considered equivalent to the national ‘thanaweya amma’.
2. This is to be announced to the public and to be active from the date of announcement.

On the 2<sup>nd</sup> of October 2012, the MoE issued a longer and more detailed decree (no. 382)<sup>1</sup> classifying the STEM curricula. Under this decree, MoE specified that the schools target students who are gifted in the STEM subjects and who can pursue their potential by focusing their high school studies on the scientific fields. Additionally, it describes the varying nature of learning methodologies implemented in STEM schools and how they use modern teaching techniques to achieve integrated learning to build bridges between the taught science subjects. As a USAID funded project, English is the official teaching language. The decree also details the admission criteria and process to enter a STEM high school, and the times of the year where the application is open, namely over two weeks in June. After specifying the entry score and tests (subject knowledge and IQ), the decree states the parties involved in the process, from government officials, subject experts, and the school boards.

The calculation used for admitting the best students goes as follows:

$$\frac{(S1*40 + S2*40 + S3*20)}{100}$$

100

S1: Final score in preparatory school,

S2: Scores in assessment tests,

<sup>1</sup> The full decree is described in detail under appendices.

S3: Personal interview results confirming applicants do not suffer from any psychological instability;

where the highest scoring students receive an acceptance letter by post and are announced on the MoE STEM page by the first of September. Students must pass the minimum final score each year to remain in the STEM system; otherwise underperforming students are moved to another experimental national school. The minimum required score is 60% in science subjects, where the final exam accounts for 30% of the total grade, the capstone project 60%, and the overall performance. The decree further determines the final STEM certification to allow students into national and international universities.

Amongst the duties of the school principle lies the assessment of school needs in terms of staffing, equipment, and soft material, whereas requests are expressed to a committee of MoE representatives, school administrators, and consultants. The committee is responsible for approving the requests and taking them further to purchasing, building, or hiring, including the appointment of the school principals; and for building networks with public, private, and donor organizations. Here, the decree specifies the requirements for admitting staff, in terms of teachers and lab assistants, who must be coming from a national experimental school, be proficient in English, and open to modern teaching techniques. Selected teachers receive trainings by experts to adapt to the different nature of STEM teaching. Another crucial role of the governing body is the financial decision making; they decide on whether or not students need to pay fees and on the money allocation based on the priority needs of each school.

Lastly, the decree details the subjects to be taught in each of the four high school years. Arabic language, English language, second foreign language, and religion are cross cutting throughout all years. For science subjects and mathematics, the topics vary from one year to another and depend on the choice of specialization of the student. Additional, more specialized classes, are added at later stages for students who wish to learn more outside official classes, such as engineering design statistics in the third year or earth and space science in the final year. The number of classes vary between 35 and 39, depending on the year and additional enriching classes. Furthermore, there is the capstone course, where students get to integrate all their learning for a final project, that is worth more than half of their final grade.

#### 4. Chapter 4: The Study Methodology

This chapter outlines the methodological framework used in conducting the study. It starts by describing the overall methodological approach, including the research goals and the interview guide preparation, moving to the set site and population for data collection. Then, it moves to stating the methods of data gathering and the procedures undertaken for data analysis. The researcher goes on explaining additional measurements taken to ensure trustworthiness, ethical and political consideration in this study; as well as pinpointing the limitations faced while conducting this research.

Researchers discussed the difference in methodological approaches (quantitative and qualitative) and the use of each according to the type of data required for the respective study. In this research, the researcher uses qualitative methodologies. Marshall and Rossman (2006) argue that the interpretation of both types of methodologies (quantitative and qualitative) is a complex process of “bringing meaning to raw material”, in attempt to put it in a written report that can be comprehended by future readers. As defined by Silverman (2005), a methodology describes the data gathering and analysis tools used to study a specified case.

Choosing a method over another does not make it better or worse. It is just a matter of which better fits the nature of the undertaken study and the hypotheses to be tested (Silverman, 2006). As stated by Denzin & Lincoln (2005), qualitative studies cover various tools, including case studies, interviews, observations, and interpretive analysis; i.e. it reflects a reliance on empirical data collection based on life stories, observations, and personal experiences exposed through interviews and focus groups. Qualitative research tends to answer the how aspect of the study at hand. (Denzin and Lincoln, 2005)

Marshal described this approach as an ‘analytic study’, where the researcher shifts emphasis and develops deeper understanding of emerging ideas along the way; hence, it involves a process of continuous cross-checking the information received.

Guided by the methodological approach designed by Rossman, the researcher is following the below structure in tackling the methodology of the study:

- A. Overall approach
- B. Site or population selection
- C. Data gathering methods
- D. Data analysis procedures
- E. Trustworthiness
- F. Personal biography
- G. Ethical and political consideration
- H. Research limitations

#### **4.1. Overall methodological approach**

It is not necessary to decide on the final methodological framework before starting the research, as it is an unfolding process where in-depth understanding of the research question emerges throughout the process (Denzin and Lincoln 2005). Nonetheless, the researcher shall start by looking at the “relevant historical evidence”, which will guide him/her in understanding the underlying theories that the study is derived from (Silverman 2006).

Following Patton (2002), the researcher started by conducting desk research to gather available data on the subject matter. This covers the review of previously

published literature on implemented STEM systems around the world. As a second step, the researcher gathered background information on the donor organization (USAID) and published regulations by the Egyptian Ministry of Education with regards to the administration of STEM high schools in the country. Secondary data were collected using trustworthy online journals and official websites. With regards to the STEM-specific regulations in Egypt, further documents are collected from the Ministry of Education and the school administrations, after attaining the required governmental permissions and the informed consents of the officials, as primary sources.

By looking at these documents, the researcher identified the main themes and concerns faced internationally and locally to design the questionnaire accordingly. Questionnaires were used in interviewing key informants, who have been reached out to through personal or professional connections. The data represent a single study, namely the Egyptian case, and not a global representative population of STEM regulations worldwide. In primary data collection, this study relies on qualitative methods due to the limited number of key informants and the nature of required information, as this is an unfolding study. Hence, the researcher will draw linkages and derive common thoughts throughout the analysis stage to come up with solid conclusions.

#### ***4.1.1. Research Goal***

To start with, the researcher specified the purpose of the study. Following Patton's (2002) list of identified study purposes, this research is "descriptive" as it aims at stating the way STEM schools in Egypt are governed. Studying STEM is originating from the researcher's passion for studying education and interest in improving the quality of school education in Egypt. Whereas STEM education is a relatively new policy

worldwide, no previous research has been conducted on the administration of the STEM schools in Egypt. Hence, the contribution of this research to the literature is manifested in covering the policy implementation of this new system in a new country. The data gathered will be from a different group from the ones of previous papers. Hence, the researcher will ensure to cover the same themes identified in previous work on STEM schools' policy and administration. As a result, the researcher will come up with recommendations for policy developments that are mainly tailored on improving the Egyptian schools, but may also be adaptable elsewhere. In terms of social benefit, the paper will shed the light on the additional benefits these schools provide, compared to other national schools following other educational systems, which will benefit those who wish to benefit from the program in the future (Patton, 2002).

#### ***4.1.2. Preparation of the Interview Guide***

Following Patton's ideology, the designed questionnaires shall lead to the attainment of "accurate, relevant and reliable information" (2002). This study follows an open-ended format, as it gives space to the interviewees to freely share their own views with regards to discussed elements (Silverman, 2006).

### **4.2. Population and Site Selection**

- Population

The main players are identified through stakeholder mapping. Key stakeholders are split into administrators and beneficiaries. The administrators, who represent the school governing body, cover representatives from all involved parties including:

USAID, Ministry of Education, and school directors. Students are the main and direct beneficiaries, while parents and the broader community fall under the indirect category.

- Site

The research covers various sites, as per the involved key administrators:

1. USAID Office in Cairo
2. MoE – STEM unit in Cairo
3. Two established STEM schools

There are currently nine STEM schools around Egypt, out of which two are based in Cairo. These two are the oldest and the ones with graduate records. One school is a boys-only school while the other is a girls-only school. Therefore, the researcher will study both simultaneously. As for the other seven, they are located in seven other governorates around Egypt. These schools have only been opened in October 2015 and are therefore not yet fully operational. Accordingly, this research will shed the light on the two schools that are established, and will serve the purpose of this study.

#### **4.3. Data gathering methods**

Whereas it is possible to apply just one tool, a mix of tools adds breadth, depth, and richness to the study (Denzin and Lincoln, 2005). As described by Silverman (2006), using multiple means in gathering data, known as ‘triangulation’ enhances the quality of the research. Denzin & Lincoln (2005) point out that the quality of data lies at the heart of this approach. The scholars identified several tools as qualitative research strategies, such as interviews, focus groups, case studies, participant observation, testimonials and life history, and action/applied research (Denzin and Lincoln, 2005). In this study, the

researcher gathers information through desk research, in-depth interviews, and focus group meetings. These are perceived as the most suitable for the study, considering the limited number of key informants and the political consideration of their relationships with each other. Following the same line of thought, a case study, in this case the selected schools for the study require analysis of available historical documents, too. This will enable the researcher to examine the issue at hand in depth and detail, as s/he will understand the development of the program over the years; and hence why certain modifications were implemented. Choosing an approach here facilitates the evaluation process (Marshall & Rossman, 2006). Audio and video recording was not used, in respect of the confidentiality and anonymity measurements taken to motivate the participation of key informants.

Qualitative methodology also includes discovering more stakeholders, events, and datasets along the research period, which helps the researcher draw linkages and reveal the causes of the study; a process that eventually allows him/her to develop logical sub-themes for the topic, which helps them well structure their study (Marshall & Rossman, 2006). In this unfolding approach, the key informants are involved in the research progress and may even redirect the focus. Also, it leads to the identification of common beliefs and repeated ideas/issues; thus, the researcher will be enabled to categorize the gathered information by themes to structure his/her paper in an argumentative intellectual manner. As Patton (2002) described it, this approach represents an “inductive analysis” where themes, patterns, and categories unfold throughout the data gathering (Marshall & Rossman, 2006).

The researcher gathered two types of data:

- Review of existing data

As mentioned in the overall approach, secondary data is gathered through desk research. Also, the researcher used the physical library of the American University in Cairo to look for relevant books and the school-owned virtual databases for the same purpose. After identifying useful sources, including books, journals and articles, the researcher went through them to extract relevant information, which were grouped by theme. Extracted information was then tailored to be placed in the literature review.

- Primary data

This study relied on qualitative tools in the primary data gathering. In particular, the researcher used face-to-face in-depth interviews and focus group meetings for data collection.

After finalizing the literature review, the researcher conducted field observation to gather first-hand information about the topic in a natural setting (Silverman, 2006). This took place on the selected school premises, where the infrastructure, teacher-student relationship, and students' attitude towards the system were the focal points. The following activity started by conducting a stakeholder mapping to identify the main players involved in the policy formulation and administration of STEM schools in Egypt. Accordingly, participants were selected using purposive sampling, i.e. the researcher selected the key players to obtain meaningful information. Selected candidates were asked to participate in the study.

- Four main administrators (including school administrators, donor officials, and governmental officials from the Ministry of Education) were asked to attend face-to-face interviews.
- Graduate students were asked to partake a focus-group discussions. The researcher resorted to the graduates who entered the American University in Cairo after graduating from the Egyptian STEM high schools. Two focus groups were conducted, one for males and another for females as both genders were placed in two different school buildings. One group consisted of 3 students and another consisted of four; a small size was kept to maximize depth and effectiveness of the focus groups results.

To begin with, participants were briefed on the objectives of the study, the interview length, and the covered topics. Individual interviews lasted for 60 minutes and focus groups took up to 90 minutes. Interviews with the administrators took place in their offices. Focus groups with the students were conducted in the AUC campus for their convenience, as they reside at the on-campus dormitory. The researcher took quality control measurements, such as monitoring the discussion and ensuring the non-diversion from the main discussion to maximize response rate and obtain highly accurate and relevant information. Accordingly, the researcher decided on the key topics and was well prepared with a guiding document that covered the broad areas to be discussed beforehand. Following an open-ended format allowed the interviewees to share their perceived views on certain regulations and results more specific questions that evolved throughout the discussion. Hence, the aforementioned guide was arranged to proceed from general to more particular queries. Additionally, questions were phrased in a sort,

simple and precise manner, asking for only one piece of information at a time. Responses were documented electronically, in a way that makes them easy to understand, manage, and analyze at a later stage.

#### **4.4. Data analysis procedures**

A qualitative researcher shall be able to collect and analyze artifacts, documents, records and other sets of obtained information. S/he shall master the task of interpretation and textual analysis. (Denzin and Lincoln, 2005) As Marshall and Rossman (2006, p. 154) wrote “whether the researcher prefigures the analysis before collecting data, begins analyzing while collecting, or collects first and analyzes later depends on the qualitative genre and assumptions of the study.” Here, the researcher collects information on field, after which s/he tries to explain the findings, connect the dots, and draw objective conclusions respectively.

Nonetheless, before starting on the analysis, the researcher shall first revise the ‘piles’ of data collected and organize them by “dates, names, times, and places where, when and with whom they were gathered” (Marshall & Rossman, 2006). Hence, at this stage the researcher may also undertake data cleaning, where s/he extracts the useful and relevant content from the gathered information to the research question to put in the final report (Marshall & Rossman, 2006). As per Denzin and Lincoln (2005), the analysis process includes analyzing the set policies, setting criteria for judging adequacy, and considering the roles of the informants and underlying politics in the interpretation.

As mentioned above, the researcher will start by analyzing secondary data. This will serve the purpose of identifying the main topics to be covered during the interviews.

Hence, the questionnaire will be developed accordingly. As a second step, primary data will be collected from key informants who represent the administrative body of the STEM schools in Egypt as well as graduate students who can share their experience of living in STEM schools in Cairo. The researcher will take notes during the interview. Afterwards, she will organize the information based on the themes or issues to be tackled in the paper. Common notes on the same issue, which have been shared by more than one interviewee, will be grouped together. They will be pointed out in the discussion and analysis, as these will reflect strong standpoint with regards to the system that are agreed upon by various parties. Objective conclusions can then be drawn and recommendations can be driven in response to the discussed topics accordingly.

#### **4.5. Trustworthiness**

Considering the nature of the research, the researcher ensured the cross-checking of primary and secondary data collected. The primary data was cross-checked from other key informants. The researcher drew linkages and identified similar answers in this regard. Secondary data collected from the ministry's website and the USAID booklet were double checked with the corresponding key informants. This was particularly important as the secondary data may have not been up to date, whereas set policies and regulations could have been alternated.

#### **4.6. Ethical and political consideration**

The researcher ensured ethical consideration through various precaution measurements. The study aimed at applying high ethical conduct including impartiality, no conflict of interest, transparency, reliability, anonymity and confidentiality. These

criteria represented an ethical guidance for evaluation and the researcher ensured the documentation of any ethical issues that came across throughout the study duration, especially during the primary data collection phase.

This included the development of the informal consent form that states all benefits and risks to the participants, and ensured confidentiality of participant's anonymity. Hence, the researcher obtained the IRB approval to undertake this study. No children under the age of 18 were asked to participate in this research. Additionally, due to the sensitivity of the positions of most key informants, all interviewees are held anonymous in the report. Data safekeeping is another vital aspect; all data collected is stored and maintained in a safe platform that only the researcher has access to, in order to maintain the right of confidentiality to the participants.

As stated by Silverman (2006), the researcher must put into account the political sensitivity of the study. Hence, in this study, before starting the interviews, the researcher ensured the confidentiality of the discussion and collected their consent, which they may have chosen to submit verbally, if they did not feel comfortable with signing the consent form. In case the participants did not wish to sign the form, they were still given a copy for the sake of transparency and to reassure them that there are no foreseen risks in their participation to this study. Also, the form clarified that there are no tangible or financial benefits in that regard to set participant's expectations.

#### **4.7. Limitations of the research**

Patton (2002) identified some common limitations that qualitative researchers usually come across, which are also valid for this study, namely “ (i) access to data, (ii)

receiving conservative ‘safe’ answers from officials, (iii) going through long bureaucratic procedures, (iv) limited availability of secondary data, and (v) studying a relatively new project.

- i. When it comes to research on national-related topics, it is quite challenging to find published research on the country or key informants who are willing to participate in the study giving honest answers.
- ii. It is challenging to rely on information from key informants, especially when it comes to governmental officials. Many are not willing to participate in studies that criticize governmental policies.
- iii. Being a national school program under the MoE, governmental permissions must be obtained, before conducting any fieldwork, which may take quite long time or even be never received, if the required networking does not exist.
- iv. It is generally hard to find secondary data on issues related to the Egyptian government due to the restrictions on publications.
- v. Speaking of national regulations is a sensitive topic. Many officials try to remain diplomatic/politically correct in such studies. Hence, getting information from pertinent officials may not yield transparent results.
- vi. STEM is a relatively new policy move, especially in the country of study with no previous published research tailored to it.
- vii. The study is on a small scale, hence its statements, findings, and recommendations are only relevant in the Egyptian context.

## **5. Chapter 5: The Experience of STEM in Egypt**

This chapter presents the study findings and analyzes the collected data. As a qualitative study, there are no set interview questions. It is more of an unfolding study, where questions were developed throughout the fieldwork phase. Therefore, the researcher started with a pilot interview throughout which some guiding interview questions were developed, whereas further questions evolved while conducting the actual study. Accordingly, some key stakeholders were interviewed more than once to complete the missing data.

The discussion contributes to answering the research question stated in the introductory chapter of exploring the governance structure of STEM schools in Egypt. Therefore, the key decision makers were identified for the policy formulation and implementation; and which international models the formulated strategies are guided by. Additionally, the researcher shed the light on school regulations governing teachers and students.

### **5.1. Study Findings and Analysis on the Policy Process**

For this component of the study, the discussions with participants evolve around the themes stated earlier under the conceptual framework, namely:

- Reasons behind initiating the STEM project in Egypt
- Identifying the key decision-makers and their specific roles
- The rules and regulations governing the STEM project in Egypt
- The implementation plan for the STEM project in Egypt
- The monitoring and evaluation scheme set for assessing the project outcomes

Guided by Cochran & Malone (2005), studying the policy process shall provide information on the decisions taken by the state to govern the implementation of a desired program in attempt to achieve a set goal. In this case, the research describes the action plan and the objectives.

### **5.1.1. The Reasons behind Initiating the STEM Project in Egypt**

National school education in Egypt is known for its poor quality. The donor representative shed the light on the students' low scores in the international competitions, whether on science knowledge or cognitive skills, which reflected the poor quality of traditional education in public schools:

“The idea came as a result of the poor TIMSS results of Egyptian students in international competitions in the years 2003 and 2007. As a result, MoE did random sampling and tested 50,000 students from different governorates in elementary and secondary grades, where they used the CAPS test for critical thinking and problem solving to assess their performance in Arabic, mathematics, and science. That was in 2010, in collaboration with the ‘National Center for Examination and Educational Evaluation’ (NCEEE). The results were still very bad. Moreover, the national indicators report for 2000-2010 developed by USAID backed up this finding” (donor representative, interview, March 2016).

According to Todd (2010), Egyptian students in the eighth grade were of the lowest scoring countries in the TIMSS (Trends in International Mathematics and Science Study) tests in both, mathematics and science. Believing in the role of quality education in the country's development, STEM schools were initiated in attempt to raise the level of public school education. Following the global notion of raising technologically advanced

individuals (Marginson, 2014), who can secure the economic development of the country, the STEM project came into play. It is meant to combat the public notion of memorization and substitute it with a school system that is mentally stimulating and encourages innovation (Rollins, 2011).

Looking at the “Condition of Education in Egypt”, reported in the “Report on the National Education Indicators” (OECD, 2010), only one third of secondary school students chose to continue with a science high school, and most of those were females. Feeling threatened by these results, the donor organization has chosen to adopt the STEM schools’ initiative in Egypt:

“If Egypt is to follow this notion, there will be no doctors or engineers in a few years. These results were based on solid data only; it did not include any data that is not backed up properly. For instance, the literacy rate was excluded from the study sample to ensure its accuracy” (donor representative, interview, March 2016).

The research results presented in the OECD report (2010) were the main trigger for the donor organization to support STEM education for Egyptian talented kids, when it came to implementing a new project related to the enhancement of public school education. As the model was meant to focus on the science-gifted students only, it started on a small scale, providing just two schools nationwide (donor representative, interview, March 2016).

As the idea was put on the donor’s agenda, the organization worked in collaboration with MoE on studying the American model to be imitated and preparing individuals for the implementation progress, as described by the donor representative:

“Key players visited the United States to see the model in practice and learn from the hands-on experience. Following this visit, the first school in Greater Cairo was prepared to become a technical school, and started operation in September 2011. The second school in Greater Cairo was established a year later and started operating in September 2012” (donor representative, interview, March 2016).

It is no secret that national educational system in Egypt is suffering (Álvarez-Galván, 2015). It has been discussed in previous literature and is a main area of work for many international donors, just like USAID, the sole sponsor of the STEM schools in the country (“Basic Education”, 2017). USAID has a long history with funding less privileged Egyptians to receive quality education, which confirms their realization of the importance of the role of education in achieving sustainable development. A tremendous number of young talents lose the opportunity of making the most out of their gifts to the inefficient national system that does not allow them to develop their skills and challenge their minds.

Egypt, like many other countries, is facing the same issue of the diminishing number of students interested in science and technology, whereas the world is in need of more technological experts. Hence, when it came to funding a new educational project, together with MoE, USAID has taken this initiative to invest in the gifted students and give them the opportunity to achieve their scientific potential, which is the key for future development. Both entities were committed to implementing the project, even though it was initiated at a critical time, stated a school administrator:

“It is worth acknowledging that STEM schools were able to survive within the critical-political stage the country was facing upon their establishment in 2011-

2012, which means that the government was keen to apply this educational reform. None of the coming and going ministerial officials expressed interest in not wanting to continue with the STEM schools project” (school administrator, interview, April 2016).

STEM schools were initiated during the Arab Spring phase of 2011-2012; a state of political and public unrest (Lagi et. al, 2011). This was quite a challenge, especially with the abandoned first school location that made students and their parents feel unsafe to be at (school administrator, interview, April 2016). Though, the schools were initiated and started operation regardless of the surrounding atmosphere, which reflects a high level of commitment on the side of the respective and continually changing governmental officials. This proves the state’s dedication to improve education on a higher level, a vision shared by all those who played a key role in the matter.

### **5.1.2. The Key Decision-Makers in the Egyptian STEM project and their Roles**

The governance structure of STEM schools in Egypt integrates staff for MoE as a state actor, and human resources from the USAID as a donor organization, as well as individual board members consisting of representatives of the different stakeholders including parents, teachers, administrators, and those with expertise in the public educational sector in the country. Yet, the stakeholders are mainly there to receive the board decisions and implement them. The actual decision making lies in the hands of the two in power, namely MoE and USAID, as stated by a donor representative:

“The STEM project is a co-led program by the Ministry of Education and the USAID as a donor organization. MoE is responsible for most operational

elements, whereas the role of USAID is more about providing soft skills” (donor representative, interview, March 2016).

It is apparent that details on the roles of the key players is a sensitive topic to discuss as public interviewees refused to expose information in this regard and labelled it as ‘confidential’; particularly when it comes to the governmental contribution and financial issues. This is no surprise: gaining data on governmental entities in Egypt is always a challenge. Governmental officials have a tendency to keep their work secretive, especially junior staff who fear to share any information that may upset their supervisors. It is more of an organizational culture that is transferred from one generation to another, that reflects the level of corruption occurring in public offices (Lipset & Lenz in Harrison & Huntington, 2000). Likely, public employees who work on STEM were not cooperative in this research, most probably as per the orders given to them by higher authorities. They refused to share any information on the governance structure, on their role in setting regulations and managing the schools, and on the ministerial mandates of the recent years that have not been published on the website. They even refused sharing information on the role of the USAID as a donor, when their agreement will come to an end, and how they plan to sustain the project afterwards.

MoE initiated a division particularly to handle the management of STEM schools. This unit works together with specialized agencies to handle its responsibilities towards governing the STEM project, said a public official:

“The technical body STEM Unit, established by MoE, is the department responsible for issues regarding the STEM schools. The Unit works in collaboration with the curriculum center, NCEEE, national center for educational

research, the office of subject-experts, the school principal or deputy principals. Those are the ones responsible for designing the curricula and examinations so they must be present in every governorate. Additionally, MoE definitely covers more than 50 percent of the total expenses. They finance the school buildings and infrastructure, such as classroom desks, labs, library, etc. They are also responsible for the operational expenses in terms of teachers' and other personnel salaries, dorm supervisors and maintenance, food, and transportation. The ministry even started paying for the Internet bundle in 2015, which was earlier financed by the donor organization. Details on the timeframe of the donor's involvement and their budget are confidential. Yet, our strategy is to have minimal dependency on any donor should be minimal; therefore, more and more financial responsibilities are handed over to the Ministry" (public official, interview, February 2017).

The STEM Unit is in charge of setting the curricula and exams, in addition to recruiting teachers and supporting staff, and keeping the school infrastructure in a good condition. As the staff working under the unit does not have the expertise that covers all these functions, they collaborate with consultants and other institutes to fulfill their tasks.

Between the division of responsibilities between MoE and the donor organization come the financial matters. Operating STEM high schools in Egypt entails various expenses, some of which are covered by the donor and most of which fall on the state, said the donor representative:

"As a donor, USAID is financially responsible for providing soft skills. This includes the science and fab labs, the laptops given to each student upon their

admission into the school, the trainings given to teachers during recruitment and throughout the year, and setting the curricula and assessment plans. The USAID fund is limited, yet subject to renewal every four years, which in fact presents a threat of funding consistency” (donor representative, interview, March 2016).

As a temporary funding source, USAID ensured to put the higher burden of operational expenses on MoE, as an approach to ensure the sustainability of operating the schools in terms of infrastructure and staffing. As a governmental school, this approach partially integrates running STEM schools into the national budget allocated for education, which indicates the state’s commitment to maintain the project on the long run. Nonetheless, running public schools put a high financial burden on the state, while maintaining its quality makes it a critical public issue (Hanushek, 1986).

The role of USAID comes more in developing the soft skills and bringing in international best practices, in addition to providing the promised monetary support, added the donor representative:

“Whereas the quality of teaching is a main factor contributing to the quality of education in STEM schools, it is worth noting that it depends merely on the trainings given by USAID and the educational trips to the US financed by the donor, where teachers learn from experts in the field” (donor representative, interview, March 2016).

It is not guaranteed that MoE will be able to maintain this quality of knowledge transfer once the fund ends, especially that it is becoming more expensive to travel abroad due to the current fluctuation in the Egyptian pound and the increase in travel expenses; even getting international experts from abroad to conduct sessions in Egypt will be costly.

Consequently, MoE may have to depend on those who have attended USAID training in transferring their knowledge to new staff. Nonetheless, not having enough qualified staff members was an expressed concern by most interviewees, whereas the qualified minority would leave for a better opportunity. Accordingly, sustaining and enhancing the quality of STEM teachers and administrators is threatened.

Both entities, together with other high ranking professionals build the national board, which is supposed to be the main entity taking regulatory decisions with regards to running the schools. Nonetheless, the board has been inactive, mentioned a school administrator:

“The National Board consists of a former Minister of Higher Education, MoE, Ministry of Academic Research, and Chair of Misr el Kheir. Misr El Kheir was presented on the board as it was going to puts a trust in the name of STEM schools so that the interest can be used for covering the operational expenses, but this sponsorship did not go through. The board has also not met for around three years now due to the continuous changes in the ministries” (school administrator, interview, February 2017).

Ever since the Arab Spring, the board has been inactive, as some officials were frequently replaced. As a result, the schools lost a potential trust that was going to be put in the name of the school by the local NGO Misr el Kheir and giving MoE the sole power to set policies and implement them; a great financial opportunity that was not made use of.

Recently, a board of trustees has been established to involve a higher number of stakeholders in the decision-making process and has been active, the school administrator added:

“The board of trustees is based on the educational law 155 of 2007 or 2008 and has a strong role to play in the new schools. The board consists of parents elected by the community, civil society representatives, teachers elected by the teaching body, and the executive representative the school principal, whose function is mainly to implement decisions made by the board” (public official, interview, February 2017).

As the board became effective only recently, their attention was given to the newly established schools, mainly because they started operating before being fully established in terms of infrastructure. So, the first two schools in Cairo did not yet encounter changes as a result of the role played by the board of trustees (school administrator, interview, February 2017). It is the role of the board to identify the priority needs of the schools and to come up with alternative solutions to address them (Pecen et. al, 2012). The main struggles faced in the new schools are the ones faced in the STEM project as a whole. Hence, suggested solutions will impact the overall program, including the old and the new schools.

### **5.1.3. The Egyptian STEM High School Certification**

STEM students graduate with a special kind of high school certificate, whereas STEM exams are also guided by the SAT, following the adopted American model, said a school administrator:

“The STEM high school certificate is equivalent to the American SAT. It is named a ‘specialized thanaweya amma’” (school administrator, interview, April 2016).

As a USAID funded project, STEM is an imitation of the American Diploma with some modifications to fit the national system policies and restrictions, especially when it comes to funds. So, it ended up being a degree of ‘specialized thanaweya amma’, mixing the American system with the Egyptian national one, to qualify its graduates for admission to national and international universities. The drawback, however, is that STEM students have limited places in each university; hence, they compete against each other for the most demanded ones; a not necessarily fair system. For instance, if medicine school takes five STEM graduates, the top 5 applicants get in, whereas others who applied and were not admitted may have scored higher than those graduating from other national schools with the regular ‘thanaweya amma’ certificate and are eligible for getting into medicine school, explained a former STEM school student (interview, September 2016). Same concept applies to all national schools. As for the private universities, there is no limit for how many STEM graduates can be admitted, but there is a limited number of available scholarships for them, whereas it is too expensive for many of these students to pay for their own education in a private school (STEM school graduate, interview, September 2016). Abroad, the USAID has secured a number of scholarships in some of the universities in the United States, added the donor representative (interview, March 2016). There are not the top ranked, but they are renowned ones. It is the dream of many students to continue their studies in the US. Those who get a partial scholarship only, think of alternative funding options, like getting a part-time job, to not waste this opportunity.

#### **5.1.4. The Rules & Regulations Governing the STEM Project in Egypt**

##### *The Admission Process for Students*

Students who wish to join STEM schools go through a selection process that is stated in the ministerial decree, published on the ministry's website. A public official explained it as follows:

“Students who are interested in moving to STEM in high school go through the following selection criteria:

- First of all, the student must have achieved a total grade of 98 percent in the secondary school.
- The student must have achieved a full grade on the final exam in two of the following subjects: English, math, and science.
- MoE sends letters to those parents whose children are qualified to apply for STEM schools based on their secondary school grades to encourage them to apply.
- Interested students register on MoE's website.
- Applicants must then sit for aptitude tests that are taken online through MoE's website. This includes the IQ test, as well as tests in macro science and in English. MoE designs those assessment examinations in collaboration with NCEEE.
- Those who pass the exams are supposed to sit for interviews, but these do not take place. Hence, the highest (150) scoring students on the aptitude tests get admitted for STEM schools.
- Accepted candidates are announced on the ministry's website
- Students are to print out their acceptance and take it to the school for placement.

Originally STEM was meant for students from the national schools only. Now, those studying in private schools are also welcomed to apply, if they sit for the

‘equivalence’ exam that compares to the secondary school national examination. However, the school is not popular amongst those just yet” (public official, interview, February 2017).

STEM as a concept goes against any learning solely based on memorization. Yet, the mere selection of students to enter STEM high-schools in Egypt defeats that purpose. First of all, only those who score highest on their final secondary school exams are eligible to apply; the exams that assess how much they memorized from the books and not what notions they comprehend (Álvarez-Galván, 2015). So, STEM takes in those who know how to learn by hard the most; then ask them to forget all about this mindset and start making sense of the subject matter to pass in the new school. In return, some students drop out on their first year as they fail to adjust and cannot take not being top of their class (school administrator, interview, April 2016). Also, the secondary school examinations are prepared on a governorate-level. So, the exam differs from one governorate to another, i.e. students in one governorate might take an exam that is harder than those in another governorate (donor representative, interview, March 2016). Accordingly, those who sit for the hard one may end up with lower grades, not because they are less capable to excel, but rather due to their lack of luck to sit for the easier examination. Likewise, exams are graded by various teachers, who can depend on a subjective grading grid. Even students in the same class can be graded by two different teachers. When it comes to parts with no clear right or wrong answer, like essays, the same piece can be graded differently depending on the perception of its grader. So, if the student is lucky his/her paper will be given to a teacher who perceives their answers as sufficient.

MoE sends letters to the parents in the post informing them that their children are eligible to apply to STEM; a rather inefficient system as it is likely that the letters get lost in the post, in which case the respective student will never find out about this opportunity, unless he/she is lucky enough to have a friend who received the letter and informs them about it. Nonetheless, a donor representative explained how corruption is limited in the admission process of STEM high schools:

“Due to the minimal interference of humans in the selection criteria, relying on ‘connections’ does not exist. Hence, STEM schools give equal opportunities to gifted students, without prioritizing those who have contacts/networks to get into the school even if they are not the best” (donor representative, interview, March 2016).

As a unique system and an outstanding opportunity, targeting especially underprivileged students who are stuck in the poor national schooling for lacking the funds to enter a private school, STEM schools shall be promoted throughout the year to students and their parents, to ensure that everyone knows about it and has an equal opportunity to join. Also, MoE shall have an efficient channel to address any concerns that students or parents might have and to give students the chance to prepare for the entrance assessment tests early on. The last step, which may be the most critical one in assessing applicant’s cognitive abilities, namely the interview, is currently abandoned (school administrator, interview, April 2016). Nonetheless, avoiding human interference in the selection process may minimize the well-known ‘wasta’ concept, where students who have connections pass even if they are not necessarily the worthiest of this opportunity. In total, the admission process has a lot of space for improvement. The assessment shall reflect

scientific knowledge and the understanding of concepts to reflect the idea behind the system and ensure the selection of the most compatible individuals.

### *Student Dismissal Policy*

Students work hard to be of the few selected to enter STEM high schools. As a public school, they just need to pass the minimum score and adhere to the rules to retain their place. A school administrator talks about dropouts rather than dismissal as it is more common:

“The dropout rate is less than ten percent. This is not necessarily a reflection of low performing students or those who get expelled. Students must attain a total score of at least 60 percent to pass, which is not challenging considering the high level of cognitive skills for our students. Some students choose to leave STEM schools because they could not cope with the distinctive system. This includes the nature of learning methodologies relying on open research rather than studying from a book and memorizing the subject matter, as well as the idea of living in a dormitory away from their families at a young age. Therefore, during the first year at STEM high school, administrators make sure to cover the material that is taught in the other national schools, so that those who chose or are forced to transfer do not have to repeat a year” (school administrator, interview, April 2016).

STEM is a struggle for most students due to its different nature, especially at the first year, due to its different nature: academically and uniformly. On the academic level, STEM students come from an educational background, where memorizing the book was the key for success (Álvarez-Galván, 2015). In fact, it is those students who excelled at

memorization that scored high in their preparatory-level final exams and got qualified to apply for STEM. Yet, in STEM they are asked to abandon this ideology and start using their cognitive skills to research different topics (Rollins, 2011); a learning process with no limits. On a different note, STEM is the only school where students are obliged to live on campus. It is very uncommon for children this age to live away from their parents in Egypt. Hence, most newcomers feel homesickness (Duffell, 2000). There are those who handle being independent and make an alternative family of friends, and others who fail to manage living on their own even if this means giving up on such a unique opportunity. These are the two main triggers behind dropouts. Whereas the percentage does not exceed ten percent, fifteen spots are lost hereafter; Fifteen other young talented Egyptians could have benefited from this opportunity. The school administration accounts for such incidents; and hence ensures to cover the same topics as other national schools, so that those who chose to not proceed in STEM can get admitted to another national school without having to repeat the year. This encourages students, who get accepted but are hesitant, to give it a try.

#### **5.1.5. The Implementation Plan of the STEM project in Egypt**

The STEM project was envisioned to gather all scientifically-gifted young Egyptians and provide them with the necessary environment to grow their talents. Starting in 2011, STEM schools were implemented one after the other, described a public official:

“The initial plan was to establish around five schools in the first four years. We started with two schools in Greater Cairo that are now well established and fully operating. The nine other schools that were established in 2015, are not yet well

operating. They opened all at the same time and the financial capacity to provide all the required infrastructure was limited. For instance, in some schools the housing is still not ready, so MoE had to sometimes pay for renting external housing. As an alternative, some schools resorted to using the upper floor classrooms as rooms” (public official, interview, February 2017).

Not only did the first schools of Cairo start operating on time, but even the expansion plan was carried out according to the set time schedule. Nonetheless, many of the schools in other governorates started operating, whereas the required infrastructure and material were not yet fully present. Students suffered on their first year; especially those who had no laptop to conduct their research, i.e. studying, on. Therefore, MoE has thought of introducing an “Executive Committee”, independent from the STEM Unit, to carry out the responsibilities of providing the schools with quality infrastructure and resources (Request For Proposal, 2017, p. 13).

Due to the fact that the new schools were not fully furnished and ready for students to not just study at, but also reside in, some classes had to be used as rooms for students to reside at until the housing is ready for them to move in (donor representative, interview, March 2016). Nonetheless, the donor representative viewed it as an opportunity that could have been missed otherwise:

“This is a moment of opportunity. If those schools had not opened at this time, it may have ended up with the death of the project. Now that the schools are opened, all involved parties are committed to make them operate and operate well. We are working in collaboration with the Ministry on introducing a research model in secondary schools to introduce students to the idea of conducting

research at an earlier stage. This model was implemented in 140 schools and was proven to be successful in teaching students to do scientific research and think critically. The long-term plan includes the introduction of E-STEM to secondary schools as well, to allow students to build their language skills early on and focus their time in high school on scientific research and innovation. This is planned to start in the next few year until a proper reform of secondary schools' assessments take place. The main goal here is to get students to love sciences early on" (donor representative, interview, March 2016).

Opening the other nine schools around the different governorates before they were fully ready to operate may have been a rushed move. STEM high schools in Egypt are all about providing quality education, which is reflected in the capabilities of its educational personnel, but also in the surrounding learning environment (Lunenburg & Ornstein, 2008).

The lack of governmental fund to fully furnish the schools exposed the incompetency of MoE to take over the financial responsibility of STEM schools in Egypt, and their lack of strategic management. Here comes the long-term plan for expanding STEM and quality school education in Egypt. A donor representative stated that there is no vision of providing STEM education except in high schools:

"There is no plan to expand STEM schools vertically, i.e. adding secondary or elementary schools to the system at this stage. Yet, there is a plan to expand the schools vertically by having a total of 18 schools around Egypt by 2018. The ultimate goal is to have a STEM high school at each Egyptian governorate" (donor representative, interview, March 2016).

Whereas the horizontal expansion is going according to plan, the vertical expansion does not solve the root issues behind the poor quality of education. Still, students must first enter a regular national school and be exposed to the traditional system; and excel at it to be eligible to apply for STEM high schools after they finish their secondary education.

It is quite a challenge for the Egyptian government to depend solely on itself in funding STEM schools, especially with the current crisis facing the economy of the country and the lack of public funds. Also, the state cannot put the burden of funding on the students, or else it will turn into a private school available for only those who can afford it, making it inaccessible for many brilliant minds. Additionally, sustaining STEM quality is necessary, otherwise it will just turn into a poor national school like the others, offering no quality learning to its students. In STEM, it can be even worse, as there is no book to study from and no after-school private classes to rely on. Accordingly, students will feel lost and the lack of guidance will result in a serious deficiency in their learning outcomes. In attempt to secure financial flow, MoE can engage the civil society, particularly the private sector. One way can be to rely on Corporate Social Responsibility (CSR). As a vital part of big businesses, MoE can have a long-term agreement with corporates to fund STEM schools as part of their CSR activities (donor representative, interview, March 2016). For the corporate, it can use this opportunity to promote itself as an active player serving the civil society through supporting quality education. As a bi-product, they will also be creating public awareness on STEM schools and enhancing the status of STEM students. Accordingly, more students will be competing to enter those high schools, more parents would be interested in sending their children there, and graduates would receive better job offers.

While industrial contribution may offer a consistent and sustainable solution for the funding issue, MoE thought of asking students for a small monetary contribution to cover its operational expenses. A school administrator said:

“In terms of sustainability, the board has thought of generating revenues to partially cover the school expenses. Starting 2015, students are asked to pay EGP 1,000 as fees that are collected at the beginning of each year. Additionally, EGP 2,000 is collected from each student upon their admission as insurance for the laptops, lab equipment and so on. Those students who prove to come from poor families that cannot afford to pay are exempted from the fees. Also, MoE is taking more and more financial responsibilities from USAID. For example, the Ministry is now responsible for providing the laptops to the students in the new schools” (school administrator, February 2017).

This approach is not sustainable. First of all, the small contribution of students will not cover all of the operational expenses; in addition, unprivileged ones are exempted from the fees, making this source of revenue even less, bearing in mind that STEM students come from public schools, which reflects that their families were not able to pay for private schooling, i.e. are poor. Hence, it is likely that a large number of the students will be exempted from the school fees, making it basically unreliable income. Of course, these are not enough to cover the staff salaries, but they contribute to minor expenses such as books and food. Secondly, the idea of making students pay does not go with the state policy of providing ‘free education’, creating a new notion towards eliminating this ‘free service’. On a different note, USAID is working with MoE to improve national education at an earlier stage by familiarizing secondary school students with the research-based

learning approach, so that it becomes less challenging for them to transfer to STEM high schools. Nonetheless, this move will require a change in secondary school curricula, which is a massive move if applied to all national schools. Not only will it be challenging on the students' side, but also it means that all national school teachers must be trained to teach using research rather than the ancient books they memorized by hard. This ideology will take years to achieve, considering the large number of teachers, students, and schools.

#### **5.1.6. The Monitoring & Evaluation Scheme for Measuring the Success of the STEM project in Egypt**

The STEM initiative is meant to be all about providing quality education to the less privileged, yet academically talented, youth. In line with this, subject experts are consulted to develop assessment test that mirror this ideology:

“Student examinations are designed in collaboration with NCEEE. In attempt to provide STEM students with the best teachers and curricula, professional organizations provide trainings and curriculum expertise following USA models. These include: (i) Ties (Teaching Institute for Excellence Study), (ii) 21st PSTEM, and (iii) Franklin Institute” (school administrator, interview, February 2017).

The exams are designed by the NCEEE, which is specialized in exam preparation. However, the experts in this institute are not STEM specialized but rather general (donor representative, interview, March 2016). Hence, they do not necessarily develop the most applicable exams for these schools. The assessment is yet to be enhanced. These exams shall be unified amongst all STEM schools around the country to have the same

assessment for all STEM students. This is particularly important because STEM students in Egypt compete amongst each other for national and international university placements. So, it would be unfair to have different exam questions in the different schools (STEM school graduate, interview, September 2016). Nonetheless, this also requires ensuring that all teachers are of equal teaching quality and cover the same material. Hence, the teacher selection and training is critical.

The USAID and MoE have been working together on networking activities to develop partnerships and collaborations with professional institutes to train the staff, develop curricula and examinations, as well as for students to participate in international science and mathematics competitions. A school administrator explained that:

“Egyptian STEM schools are engaged in a number of national and international competitions. Every year STEM students participate in Intel-ICEF and I-Sweep. Students also participated in the mathematics and physics Olympics in Italy. STEM students excel at these competitions and continuously achieve top ranks. For instance, last year a group of students won the third place in the physics Olympics in Italy” (school administrator, interview, February 2017).

The competitions, whether national or international, are funded by the respective organizations and only require innovative ideas by the participating students (school administrator, interview, February 2017). So, no occurring cost falls on the state or the donor, which means maintaining them is not an issue. STEM Egypt has had a significant record participating in such competitions and winning first, second, and third place awards. Consequently, students gain a good reputation between those organizations and their participation in more competitions becomes easier, if not even demanded.

Additionally, it gives students the exposure to other countries and allows them to learn from the teachers and students they encounter throughout these competitions.

## **5.2. Study Findings and Analysis on Teacher Compatibility**

### **5.2.1. The Recruitment and Selection of STEM Teachers**

As described in chapter two on the global experience of STEM education, having competent teachers in STEM schools is a worldwide dilemma. STEM Egypt is no different; the whole process of finding, training, and retaining proficient teachers is a major challenge. Going through the cycle from the start, the first issue lies in the recruitment. A school administrator explains the following when talking about the hiring procedure of teachers for STEM high schools in Egypt:

“The selection criteria for teachers are posted in the online recruitment ad. However, in practice it does not work exactly as stated in the ministerial mandates. Supposedly, a committee that is formed from USAID, school administrators, and MoE representatives selects the teachers. But in practice, the only entity involved in selecting STEM teachers is MoE, who refers to the office of subject-experts for feedback on applicants. The selection occurs through the following process:

- Openings are announced online on the platform of the teachers’ academy
- Requirements include being a national school teacher, comprehensive knowledge of the teaching subject(s), good knowledge of the English language, and previous teaching experience in national high schools. Applicants must not have a master degree as stated in the ministerial mandate mainly due to the lack of competent applicants.

- Applicants sit for an English writing and reading test. Those who pass take a second English test assessing their English language speaking and listening skills.
- Those who pass the language assessment tests, sit for an exam in their teaching subject” (school administrator, interview, February 2017).

First of all, relying solely on an online ad for recruitment may not reach out to a wide base of teachers, which makes the number of applicants limited; hence, joining STEM schools becomes less competitive. In fact, STEM teaching opportunities shall be promoted for widely, even at teaching colleges, where teacher-students are yet to choose their subjects of specialization (Hubbard et. al, 2015).

Additionally, the pool of selecting teachers is restricted to national schools only. This is due to the fact that STEM teachers are paid by the government; hence, they need to be registered under MoE. The STEM high schools’ teacher recruitment in Egypt does not allow for teachers working in private schools to apply, as stated by a school administrator:

“Teachers who work in private schools are not eligible to apply to STEM, whereas those may be a better fit to the system considering their background of international exposure to different curricula, which may be more intellectually stimulating than the national ones” (school administrator, interview, April 2016).

Private school teachers in Egypt are usually better caliber compared to the national school ones. They are exposed to different teaching methodologies and school systems, such as the American, the British or the French, Hence, they may be better fit for STEM tutoring compared to the national school teachers. Although the ministry has come to this realization and started opening the floor for private school teachers to move to STEM

schools (school administrator, interview, April 2017), the teachers themselves are not showing any interest in moving due to the low compensation offered there. Whereas private schools pay more than public, including STEM, even those of public schools are discouraged to move to STEM because they complement their low ‘official’ salary from the government by private tutoring. Working for national schools, they basically do not need to attend formal classes at school, as all students and teachers rely on private tutoring (Hammad, 2010). Nonetheless, if they move to STEM they will have to commit to the formal classes scheduled by the school and even expand their teaching services to students after school hours with no additional financial compensation, confirmed a school administrator. Hence, from an economic point of view, teaching at STEM is a losing deal for both private and public school teachers.

### **5.2.2. The Personal Development of STEM Teachers**

STEM teachers are not used to the nature of the STEM system that is based on research rather than a single book with set topics presented in chapters. Hence, applying teachers must undergo several trainings to understand how STEM functions, aside from the multiple written examinations, explained the donor representative:

“Teachers who pass through the recruitment exams and face-to-face interviews, must take STEM teaching trainings before they start educating students” (donor representative, interview, March 2016).

Training teachers and changing their instruction mentality is not an easy task (El-Bilawi & Nasser, 2015). Whereas the number of teachers required in STEM schools is considered minimal compared to the total number of national school teachers, competent teachers are the most challenging factor facing efficient STEM schooling, which shows

how big of an issue it is on the national level. It is a vicious cycle: those teachers learn in schools since their childhood that they must memorize the subject matter to pass; teacher-colleges only focus on their selected subjects, where they only need to be aware of the book content for their selected subjects of specialization; and then they graduate and are licensed to teach with no practical experience. Hence, they pass on their know-how using the same methodology they were personally taught in, namely merely memorizing the book content, which is basically what examinations assess. Accordingly, the next generation is educated in the same way.

To break the cycle, the state needs to work on both teachers and students. It is not sufficient for teacher-students to get the required academic background to be certified as teachers. They must receive trainings on using intellectually stimulating and various teaching methodologies inside the classroom before attaining their university degree (Hubbard et. al, 2015). Accordingly, they will perform better when leading a class. Only then will the issue of incompetent teachers fade away; only when the state works on embedding intellectual teaching techniques into the system on a macro-level. Consequently, there will be more caliber qualified to teach STEM in Egypt, without the need to completely shift their teaching mentality, which many are resistant to. The donor, USAID, has recognized this as a main challenge negatively impacting the STEM project in Egypt. Therefore, in their updated strategy, they aim at introducing a “STEM Teacher Education and School Strengthening” program (Request for Proposal, 2017, p. 13)

### **5.2.3. The Compensation and Retention of STEM Teacher**

Governmental compensation for teachers in national schools are lower than those offered in private schools. Usually, it is perceived as not sufficient for teachers to have a

decent living, forcing many to resort to private tutoring for extra income. As mentioned by a public official, this is one major factor demotivating competent teachers to apply for STEM high-schools:

“The number of applicants is limited because the financial incentive is not very high, whereas teachers are required to spend much time with students, which takes away from their available time for private tutoring that yields higher financial rewards. Additionally, teachers interested in STEM learning must take trainings to adjust their teaching techniques to the new system” (public official, interview, February 2017).

In Egypt, there is a huge issue with the governmental salaries in general; a problem facing STEM teachers as well. The recent devaluation of the Egyptian pound and the continuous inflation in basic goods prices, has made a living in Egypt challenging for even mid-class citizens. Committing to STEM will require its teachers to give up their private tutoring, which yields higher income (Sobhy, 2011), i.e. they must be accepting lower salaries to live on; a rather unlikely move. Teacher packages have a major role to play in their recruitment and retention strategies (Allen, 2005).

Moreover, other countries who wish to start the STEM initiative would be ready to offer better financial compensations to the few qualified STEM experts Egypt has (school administrator, interview, April 2016). Hence, those who get a better opportunity abroad will definitely go after it, as it will guarantee a better living standard. Hence, whereas finding compatible teachers is a concern, losing the few existing qualified ones is a threat:

“STEM schools require more effort and time of its teachers to be spent with students in the classroom and afterwards ‘without extra pay’. Economically, it is not an attractive package for excelling teachers, whose reputation brings a vast number of private classes, that they will need to sacrifice” (school administrator, interview, April 2016).

STEM is becoming more demanded globally, as more and more countries are realizing the deficiency of tech-oriented youth and the need for them in the future economy (Drew, 2011). Furthermore, the issue of finding teachers who are capable of adjusting to this exceptional system is faced by many other countries, whether on a small or on a large scale (Rollins, 2011). Even more, some Arab countries, such as the United Arab Emirates, are currently considering initiating this schooling principle in their countries. As they do not nationally have the caliber to initiate the project, there can be a tendency of bringing the highest qualified and well trained Egyptian teachers and administrators to give them a head start until they train their own people (school administrator, interview, April 2016).

#### **5.2.4. The Student-Teacher Interaction**

Believing in the importance of the student-teacher interaction during the lecture, STEM high schools have a strict limited number of students per class; unlike other national schools. This allows for higher and better interaction, as teachers can dedicate more time to each individual student and create participatory lectures. In fact, the relationship between students and teachers in STEM is a strong trigger in growing the students’ talents. Hence, students appreciate those who encourage a deep learning curve, explained STEM high school graduates:

“We respect all our teachers, of course, but those who encourage us to learn openly mean more to us, i.e. our relationship to the teachers vary with their degree of commitment to the program. For instance, there are teachers who cannot really adjust to the STEM learning technique and insist on limiting their teaching to certain topics; those have a formal relationship with us that does not go beyond the lecture. On the contrary, there are teachers who feel committed to enhancing our individual scientific gifts and encourage us to dig deep in their area of interest, even if it takes the teacher to do his own research; with those we have a stronger bond” (STEM graduate, interview, September 2016).

Due to the different nature of STEM, its teachers require a different level of subject knowledge. They cannot rely on their understanding of the national school books only, but need to have the willingness to personally learn more about topics of interest to their students. Here, they shall be able to understand their students’ academic needs, teach them to benefit from each other, encourage in-class participation, and relate theories to real life experiences (Noam & Bernstein-Yamashiro, 2013). The teacher role is to resolve students’ confusion and explain unclear concepts, as well as encouraging them to use their imagination and be innovative. Accordingly, teachers would be effectively contributing to their students’ development, while maintaining their respect and interest in the subject matter.

#### **5.2.5. Teaching Tools & Methodologies**

While the quality of teachers defines the level of knowledge they deliver to students, the teaching techniques and methodologies used helps them better fulfill their job in an exciting manner. Hence, utilizing the tools available in and out of the classroom

can enhance the student learning experience. STEM calls for an integrative learning environment, where students are encouraged to make sense of the theories they learn and draw linkages between them, explained a school administrator:

“Each semester has a common theme that is covered in different subjects from different angles and feeds into a capstone project. There is a high level of integration between all science subjects that serves the theme of the capstone project/subject. For instance, if the project is on water filtration, students cover water molecules in Biology. For an energy theme, students research light in physics about Light and look for relevant chemical equations in Chemistry, etc. The integration does not necessarily happen across all subjects; sometimes it only covers a couple as needed. Also, each student is requested to write an individual journal, that s/he submits once every second week. This journal is guided by a set of integrative questions that assess students’ learning curve from working on the capstone project” (school administrator, February 2017).

STEM high schools in Egypt follow a strategy of diversifying in their teaching techniques. The tools used vary based on the subject. In more theoretical subjects, like English, it is more of an in-class lecture, led by the teacher and entailing some interactive questions for the students (school administrator, interview, February 2017). Yet, the donor organization has been working on making an online platform available for students to build on their English language from, which complements the offline learning in a modern way (Turney et. al, 2009). Language may not be the main concern of STEM schools, but it is of importance for students for various reasons. First, they can refer to English online publications in their studying. Secondly, it is crucial for their participation

in international competitions. Thirdly, it helps them pass the English placement exams required to be admitted to private universities in Egypt or abroad universities in the US (STEM graduate, interview, September 2016).

Nonetheless, as a science-based school, special attention is given to scientific classes. Science subjects are usually integrated in the sense that each semester a singular theme is covered in the different subjects from different angles. Then, students have to reflect on the broader picture in their homework on an individual basis in the journal; and develop a prototype in their capstone class as a group.

In sciences, students do not just stay in class. They have a lab for each subject (biology, chemistry, physics, etc.) to conduct their experiments. Then, there are the field trips to gain real life insight and comprehend how to apply theory in practice, mentioned a school administrator:

“The school can provide one field trip per week where students get to visit a research lab, a university, or a relevant firm to their scope of work. For example, if students are working on water purification, the school arranges a visit to the Water Research Laboratory. Currently, field trips do not occur every week, as they are not needed that frequent; although officially, the school provides one trip every two or three weeks. Although the groups work on different projects, each grade develops a prototype concerning a common ‘theme’; hence, the trips are offered per grade. But, we allow the individual groups of students are granted the freedom to arrange their own visits if it serves their project. For instance, if a group of students is working on a construction building, they may pay a visit to the desert research center” (school administrator, interview, February 2017).

It is unfortunate that the fieldtrips do not take place as frequent as stated in the school mandate. Fieldtrips have various benefits. They do not only help students make sense of the theories they study, but also foster their relationship with one another and with their teachers (Gee, 2012). Hence, the administration needs to put more effort in developing partnerships with more respective institutions or industries, whether private or governmental.

#### **5.2.6. The STEM Teacher Assessment**

Whereas teacher training programs help enhance their performance, there must be a way to assess how good the teaching staff is. Hence, a school administrator described the assessment grid used in measuring STEM high school teachers' performance:

“We use the set national grid<sup>2</sup> that is distributed to the schools by the Ministry of Education. Based on that grid, teachers receive a score out of a 100 that reflect their yearly performance. Accordingly, their continuity in the school, salary increase, and bonuses are determined. This sheet is filled in by the school principal and the deputy principal, who base their evaluation on in-class teacher observations” (school administrator, interview, April 2017).

Relying solely on MoE's assessment may not reflect the overall performance. On the one hand, STEM schools require more than a lecture. In attempt to enhance students' learning, teachers are required to spend a lot of time with the students out of class (Turney et. al, 2009). Accordingly, their contribution to the learning process in after-class hours must be taken into consideration as well. On the other hand, terminating a contract of a governmental employees is a complicated procedure that barely happens (school

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<sup>2</sup> The grid template is attached under appendices.

administrator, interview, February 2017). Knowing that, teachers may not be putting their best in not just transferring their knowledge to students but comprehending that in STEM students co-create the subject knowledge. Hence, teachers must be self-motivated to perform well. Such passion for the job must be also taken into consideration when it comes to the yearly evaluation.

### **5.3. Study Findings and Analysis on Students' Governance**

#### **5.3.1. The Class Size**

Due to the increase in population, the number of students per class in the Egyptian national schools has been on the rise. Adding to that the disorganization and chaotic environment in the schools, it has become hard to control those children in the classroom. STEM has tackled this issue by limiting the number of students per class, said a school administrator:

“The number of students per class cannot exceed 25 as indicated in the ministerial decree. Currently, there are 6 classes for each grade at our schools, i.e. a total of 150 students per grade. The whole school holds 450 students” (school administrator, interview, April 2016).

STEM is adapting the ideology of focusing on a few and making the best out of them. Hence, the school administration has ensured a fair number of students in each classroom, by limiting them to a maximum of 25 students. Mainlining a small number of students, not only leads to a better quality of learning, but also saves on the educational expenditures related to the school (Muenning & Woolf, 2007). Teachers are enabled to be more in control of the in-class activity and to give enough attention to each student.

Also, they would have more time to correct the student's homework, sit with them for a constructive feedback, and follow up on their individual progression. Realizing that there was only one school for males and another for females nationally, with a total number of 450 students each, made it a highly competitive school (school administrator, interview, April 2016). For the state, it was an experiment of giving scientifically gifted students an outstanding opportunity to reach their potential. Hence, it was important to give enough attention to each of them. Now that this investment yielded positive results, more schools were opened around the different governorates, giving the opportunity to more gifted children, while maintaining the teacher-student ratio, in order not to harm the educational quality (donor representative, interview, March 2016).

### **5.3.2. The Provided Tools for Enhancing the Learning Process**

STEM applies a mix of individual and group work to deliver the subject matter, as part of delivering quality education is using tailored and modern tools in and out of the classroom. Here comes the role of the donor organization in introducing soft skills to the teachers and modern material to the students, as stated by the donor representative:

“Students study mostly through online research. Hence, aside from providing teachers with trainings, the boarding body is currently working on granting STEM students access to university-level sources to enhance their research progress” (donor representative, interview, March 2016).

In their learning process, students rely heavily on digital sources. To start with, every student receives a laptop on their first year that belongs to them throughout their four years of high school. This is crucial to the learning process of STEM, as most of the learning is based on the student's own research on the subject matter. In fact, the school

relies heavily on self-learning, where students spend most of their time gathering information from the Internet (STEM school graduate, interview, September 2016). Along comes also a wifi connection with good speed, bearing in mind that the students live in the school housing; i.e. study there all day (school administrator, interview, February 2017). With respect to that, there is also a computer lab room, that students can resort to in case of emergencies, for instance, if a personal laptop broke down (school administrator, interview, February 2017). Studies have shown that students prefer having online platforms that complement traditional lectures to help them study (Peroz, 2009). There is also a library room, where some academic books in different subjects are made available, even if not so big (donor representative, interview, March 2016). Although students cannot only rely on the library in mastering the subject matter, it is of use for a smooth transition to those who prefer studying from a book rather than the internet. Instead of getting lost in online data, those students can start with looking into the available book and focus their online research on specific terms or principles, until they get acquainted with the digital world.

Instead of studying from a set book that contains all what examination will be about, STEM students must rely on open source research for studying. Some students feel lost when they have to google a theme in an unlimited manner, not knowing where exactly to stop or how deep they must go to cover what they will be examined on. Bearing in mind that all students who get admitted to STEM high schools in Egypt, excelled in secondary school, those students encounter a major challenge moving to STEM. Here are two types of students as explained by a school administrator:

“There are those who struggle in adjusting to the system and may end up dropping out as they are no longer on top of their class, whereas the system is very competitive. Conversely, there are those students who find the opportunity to follow their passion of digging deep into scientific research by entering STEM schools. Those feel that they are set free, that they are finally allowed to be creative and innovative” (school administrator, interview, April 2016).

In fact, STEM schools are meant to be for the smartest. In Egypt, top students managed to excel at international competitions due to their inventive minds (school administrator, interview, April 2016). Nonetheless, students sometimes reach a level of deepness that exceeds the teacher’s knowledge. If they are lucky they will find support by the teacher who uses the opportunity to develop his own knowledge while helping students out. The teacher perception on the cognitive skills of STEM students does impact their learning curve (Tofel-Grehl & Callahan, 2017). Hence, when teachers discourage students by telling them that their research went beyond the subject matter and do not care to answer their questions, the non-comprehended parts remain inconceivable.

### **5.3.3. The Maintenance of Material & School Equipment**

As a research-based study concept, the STEM model entails handing students a laptop to study on throughout their high school years. The school asks students to return the laptops at the end of their study period, so that they can hand them over to the new comers. Yet, usually these laptops are not used again, explained a school administrator:

“Students are supposed to be giving back their laptops after finishing their three years of high school, so that they are handed over to the newcomers. However, most laptops are fully depreciated after the three years. Therefore, they cannot be given to

new students, although the school resorts to this solution in times where there is a shortage in laptops, he added. But generally, schools go for buying new laptops each year for their new students, stated another administrator” (school administrator, interview, February 2017).

Most laptops are depreciated after being used for four years. Additionally, the models probably get old. Hence, the school needs to buy more updated ones for the new freshmen students, making no use of the old ones, unless they need to resort to an old one for replacement in case a student’s new laptop broke down (school administrator, interview, February 2017).

It is not only the laptops that are not dealt with effectively, the administration of material, tools, and equipment generally seems to be one area that needs improvement in STEM schools, especially when it comes to the maintenance of the science labs, described a school administrator:

“For the lab equipment, it is taken care of by the lab assistants, who are hired by MoE. When one assistant leaves, the hiring process takes some time, throughout which the labs remain unattended. A lack of their presence results in abuse of equipment and material, which in turn affects the availability of necessary learning tools; hence, the related learning outcomes of the students. As for the books, they are imported from the US and are stored in the school library. The main challenge here is receiving the books in time before the start of the academic year” (school administrator, interview, April 2016).

First of all, obtaining materials like books that come from abroad take time to reach the school (donor representative, interview, March 2016). Hence, they may not be ready at

the beginning of the school year, making students benefit less from them, if at all. Secondly, maintaining the lab equipment is lost if a lab assistant is missing, whereas if one left it takes MoE some time to hire a new one. Throughout the bureaucratic procedure of hiring, the labs remain without supervision, which may result in loss of tools (school administrator, interview, April 2016). In this case, again it takes time to replace or fix them and throughout this time students cannot conduct related experiments. Thirdly, there is no efficiency in storage. In fact, there is no set criteria to refer to. For instance, books are kept in the library, but there is no follow up on their presence and condition (school administrator, interview, April 2016). Hence, some books may be abused or taken out of the library by students and not returned, making them unavailable for the coming generations.

#### **5.3.4. The Curricula Setting**

STEM by nature is not based on a set of topics to be covered, but rather a general theme that students can go as deep in as they wish into. Hence, there is no specific book for students to study from, but rather a library full of resources and internet access that opens the gate for unlimited information. Additionally, the committee of setting national school curricula in Egypt is used to the mainstream system that has not been adjusted for years; the updates evolve around the same topics with only few adjustments every now and then. Therefore, settling on what to be taught in each school year (Wolven, 2013) for STEM subjects is challenging. A public official stated that they rely on subjects experts and the American model as a guide:

“A handbook published on the school website represents the ideal model. The curricula are set by a committee that consists of consultants, as well as

representatives from the office of subject experts and the curriculum development center. As a US funded project, this committee refers to the American STEM high school models as guidance in formulating the STEM curricula for the Egyptian schools” (public official, interview, February 2017).

Here, the role of the donor comes into play. Firstly, because it is an American funded project, it is following the curricula set by American experts in the United States; and secondly, the donor organization is the responsible partner of the soft skills, including curricula development workshops for the respective personnel from MoE (donor representative, interview, March 2016). Whereas the curricula committee depends on the models used in STEM schools in the United States when setting the STEM school curricula in Egypt, it may not be necessarily be suitable to copy the western model in our schools. Curricula must be developed with respect to the specific needs and set objective of the respective school and country (Wolven, 2013). The different academic and cultural background have to be put into consideration. Hence, a mere imitation of the American model does not necessarily result into equal success of the system. The respective officials must develop a system that supports the transition of students from the regular national system, where the assessment is based on mere memorization from assigned books, to the research-oriented open study.

### **5.3.5. The Languages Taught**

Not just do students need to adjust to a new learning system, but also to a foreign teaching language. Although English is taught in national schools as a second language, many students are not good at it, especially that they only need to memorize the vocabulary in the book only for the examination in other national schools. Therefore,

students struggle at the beginning of their STEM school years, said a STEM school graduate:

“We must be good in English in order to pass the admission tests. However, conducting scientific research in English is a different story. It is challenging to many of us at the beginning because other language schools do not offer quality language classes. But, we are glad to improve our English at STEM as it helps us get into top private universities in Egypt and even abroad later on” (STEM graduate, interview, September 2016).

Those who excel in the English language at a young age, whereas they attend a public school, usually go the extra mile of learning the English language on their own. This could be through reading books, watching movies, or participating in international programs. Nonetheless, merely relying on the school book and school teacher is not enough to achieve the level of English language competency required to pass the assessment test to join the STEM school. In attempt to solve this dilemma, the donor organization has initiated E-STEM, where STEM school students can continue studying online after class hours to strengthen their language skills; hence, be more capable to fit into the English research-based learning system (donor representative, interview, March 2016). However, what is required is more than that. Some scientific gifted students lose the opportunity of moving to STEM due to their insufficient English language scores as they missed a strong base. Generally, studying in a foreign language prepares multi-lingual globally-qualified competitive caliber (Rhodes, 2014). Hence, the state must introduce stronger English language classes for younger children in elementary and secondary schools; or E-STEM can be made accessible for all national school students, so

that those who wish to build on their language skills by themselves have an academic reference to resort to.

Realizing that English is the most important language globally for studying and later on for working, STEM puts most emphasis in teaching language skills on it. However, the school administration also acknowledges the benefits of having a second foreign language in today's job market. Hence, they offer French and German classes, confirmed a STEM school graduate:

“The study of a second language adds to our certification, especially for those of us who look into applying for universities abroad” (STEM graduate, interview, September 2016).

Students are to choose between the two foreign languages based on their own preference. The selection of German and French are based on the common foreign languages taught in Egyptian schools, whether public or private. In fact, the mainstream schools in the country are either English, French, or German. Nonetheless, as in other public schools, STEM students graduate with minimal knowledge of the second foreign language. Learning English is easy, as it surrounds them. They can watch movies or series, read books, and even do their studying in English. This all helps them improve their language skills. Conversely, the second language is usually just a class. They study few vocabulary and grammar rules for the exams, and afterwards they forget all about it; especially if they do not use it after high school; i.e. in university or at work. It is tis wrong way of teaching, that makes learning a foreign language a struggle for students, although being proficient in various languages is associated with a high educational level (McLaughlin, 2012). Therefore, finding a student really interested in the second language and putting

more effort to learn it, is most probably linked to an internal motive. For instance, if they are planning to study in Germany or France or if they are passionate about the language and would like to pursue a related career, which is highly unlikely in STEM students, considering their science orientation.

### **5.3.6. The Student Assessment Criteria & Grading System**

Due to the distinctive nature of STEM education, it seems that the school system is more challenging than other national schools. Accordingly, STEM high schools in Egypt have their own scoring criteria and passing grades. A school administrator explained is as follows:

“Students must achieve a total score of 60 percent to pass each year. This percentage is considered much higher performance, compared to the same score attained in other national schools. For instance, a total of 86 percent qualifies students for medical colleges, whereas ‘*Thanaweya Amma*’ students much achieve over 98 percent therefore. The total score is calculated as follows:

- 40 percent is on the subjects
- 60 percent is on the capstone project, which entails:
  - The individual assignments: including the bi-monthly journals and the portfolio, which presents the student’s progress over the year.
  - The group assignments: including the posters presented at the end of the year together with the prototype exhibition” (school administrator, interview, February 2017)

A total grade of 86% qualifies STEM students to get admitted to medicine school, whereas 'Thanaweya Amma' graduates need at least 98% to get into the same university (school administrator, interview, February 2017). However, STEM varies in calculating the score itself. While other public schools focus all the attention on the midterm and final exams, STEM puts into consideration attendance, assignments, in-class performance, and the capstone project that combines the learning of all subjects together. This entails grading on the drawn linkages between the subjects and the understanding of concepts (Rollins, 2011), rather than the memorization of book content. These are aspects of quality education that develop and assess cognitive advancement (Lloyd et. al, 2003)

In fact, more than half the grade comes from the capstone performance, putting less focus on the written examinations. Also, it reflects the learning outcomes of the integrative approach that STEM is promoting, explained a school administrator:

“Students work in groups on the capstone project. Hence, they spend a lot of time in peer learning, which is highly facilitated through the in-school residence facility” (school administrator, interview, February 2017).

The grading system of STEM high schools changes the prevailing behavior of students in public schools, where they do not even care to go to school, as they do not benefit from the official classes during school hours, and must compensate for that by paying for private tutoring (Sobhy, 2012). In STEM, teachers and students are obliged to make use of the scheduled classes. Also, as a boarding school, students remain on campus all day, while teachers are required to provide additional tutoring hours without asking students to pay for it (school administrator, interview, February 2017). Moreover, this assessment introduces students to the concept of teamwork, as their capstone projects are done in

teams. So, they must cooperate and share their ideas to come up with the best outcome; and push each other to do their best since each one's performance affects the grades of other team members. Hence, when students enter university, they already know how to work in a group.

### **5.3.7. The Residency Requirements**

STEM high school in Egypt attempt to provide a unique learning environment. Following the selected model of American STEM schools, in Egypt they are also designed as boarding schools, where students stay all week long. This was particularly suitable considering the first school premises located 'out of the city', said a school administrator:

“STEM students must reside at the in-school housing facility. The idea of boarding started due to the far from the city downtown location of the first school location, which is also why it was made into a boys-only school with an in-school residence. Consequently, when the second school in Cairo was established, it was turned into a girls' only school, with in-school residence, too. Also, considering there were only the two Cairo schools until last year, many students came from other governorates, i.e. they had to live away from home, and the school residence made their move smoother, as the parents feel a sense of security, knowing their youngsters are being watched and have company. Yet, the boarding concept remained with the following schools around Egypt as it became part of the STEM project identity, but not the segregation. New schools were established to host both males and females. In-school living facilitates peer learning and allows for spending more time on group projects after class hours. Considering the high

workload of STEM subjects, this facility contributes to better learning outcomes. On weekends, some students from other governorates travel to visit their parents. They leave Thursdays and return Saturdays” (school administrator, interview, February 2017).

Interviewees meant that the abandoned location is the main trigger for making it a boys-only school. Nonetheless, the housing facility shall have compensated for that. Since students reside on campus and are supervised by specialized personnel; and only leave in school buses, there is no risk for either gender (donor representative, interview, March 2016). Girls would not have to be on the road to and from school on a daily basis. Hence, it would have been possible to make it mixed gender. With the gender separation comes the threat of not giving enough attention to females, following the societal belief that female career progression is less important than this of males (Trafzer et. al, 2006). Moreover, boarding schools are not common in the Egyptian culture. Many gifted students or their parents do not consider the school for this specific reason, while others drop out because they cannot take living away from home at this young age. Homesickness is a common phenomenon when it comes to boarding schools (Duffell, 2000). Furthermore, a second school had to be established in Cairo to take the science-gifted girls. Accordingly, double the effort had to be done and double the personnel had to be trained. Realizing the challenge faced in finding compatible teachers and administrators, this issue doubled as well.

As students are obliged to stay in the school residence throughout the academic year, the school administration has special arrangements to provide for their welfare.

Students are provided three meals per day that is timed based on their classes schedule, noted a school administrator:

“In the housing, students are offered three meals that are planned for an hour each: breakfast is scheduled from 6:00 am to 7:00, i.e. before classes start; lunch is from 3:00 pm to 4:00 pm; i.e. after the official school day ends; and dinner takes place from 9:00 pm to 10:00 pm” (school administrator, interview, February 2017).

For each meal, they have one hour. Breakfast is served early morning before schools starts from 6:00 am to 7:00 am; lunch is at 3:00 pm, which is right after they finish a regular school-day; and dinner is scheduled from 9:00 pm to 10:00 pm, so before they go to bed. On the one hand, strict meal hours teach students discipline. On the other hand, these youngsters may be bothered by the unusual inflexible eating hours and their lack of choice when it comes to what they are offered to eat (Duffell, 2000). Additionally, the housing provides a counselor, whose main job is to watch students’ psychological wellbeing. The counselor is there to help with the smooth transition of the students’ from living at home with their families to living in the school residence with peers, possibly they have not known before.

#### **5.4. Graduates’ Opinion**

When asked about their opinion, the sample STEM graduates (interview, September 2016), who are currently studying at the American University in Cairo, agreed that the school provided them with a unique learning opportunity that allowed them to study at top universities in Egypt and abroad afterwards. Students expressed how their first year was the most challenging considering the switch from the regular national

system to STEM; yet, this system gave them the space to get creative and follow their passions, as a result of the open research teaching technique. Explaining their daily routine, students said that they wake up at 6:30 am for breakfast, and then start their school day at 7:00 am. At 7:20 am everyone has to be in line. Missing the morning line is same as missing a class, “a treatment that makes us feel in elementary school” said former STEM student. Classes start at 7:30 am and finish at 3:00 pm. Then they have an hour for lunch from 3:00 pm to 4:00 pm. Every student has to attend after school English classes twice a week, either from 5:00 pm to 7:00 pm or from 7:00 pm to 9:00 pm as per their individual preference. The day ends with dinner that is scheduled from 9:00 pm to 10:00 pm. Although they were told at first that they would have field trips every Tuesday, these did not always take place. In fact, the attention given to this activity varied based on how important it is from the principle’s point of view.

When asked about the main flaws of the system, STEM graduates complained about their set quota in joining Egyptian national universities. They explained that the admission based on a ‘flexible percentage’ works as follows: students express their universities of interest then the total number of students is divided by the number of the universities of interest. For instance, if the percentage is 6 out of 2000, then each university accepts six STEM graduates. Hence, the highest six regardless of the final score get accepted. If one student wants to study art, then Art College goes on the list and more students end up there even if they preferred another discipline. As for private universities in Egypt, students get to fill in an application with five preferences, out of fifteen private schools in the country. These are covered by a number of scholarships, especially when it comes to science-focused colleges such as Zoweil and Nile

Universities, where most STEM applicants get full scholarships. The national NGO Misr El Kheir also provides fund for STEM students that vary from 50 percent to full fees. Problem is, the amount given by Misr El Kheir is in Egyptian pounds (EGP), hence its value has decreased with the devaluation of the EGP making it less likely for students to cover the rest of their abroad college expenses. Also, there is El Ghoreir Foundation that provides scholarships to STEM graduates applying for the American University in Cairo. Usually, the competition on college admission takes into consideration the top scoring students from the boys and the girls together. But sometimes universities request a certain number of males and females, so they compete separately. For instance, last year, the Arab Academy for Science and Engineering opened its gates for fourteen STEM graduates. However, they requested to have seven boys and seven girls.

Students complained about the inefficient universities' admission system that currently takes place through the STEM Unit under MoE. Students submit an online form through the Ministry's website stating their college preferences. "The Ministry can take up to three months to get back to us, which makes us feel lost, not knowing where we will end up, until the very last moment", said male STEM graduate. Also, students cannot address the universities individually as the system is still considered new and is not yet well marketed for. Therefore, the Ministry of Higher Education nominates the top-applying students to each university. However, STEM graduates who apply for universities abroad, in the US particularly, are luck enough to avoid that. Since most of them graduate with a GPA of 4.0, they are always eligible for at least a merit scholarship, which removes part of their fees. However, this comes for as suspicious to the abroad universities seeing every applicant holding a GPA of 4.0, which reflects a deficiency by

the school administration in calculating the American GPA. USAID and MoE jointly collaborated with universities in the United States, such as the Florida Institute of Technology, Evansville University, and the University of Rochester where some STEM graduates are currently studying. The merit scholarship leaves around \$20,000 of school expenses that the students need to make on their own, as they mostly come from families that cannot afford such cost. Hence, most students who study abroad with partial scholarships look into part time jobs at the university and elsewhere.

As for the assessment system, students expressed another dissatisfactory aspect. Explaining the grade division, students clarified that in grade ten and grade eleven they need to achieve a final score of at least 60 percent on each subject to pass, whereas there are around eight subjects each year. The issue here is that 60 percent of their total grade comes from the capstone course, which consists of the poster and prototype (70 percent) and the journals (30 percent). Students find it unfair that a single question here can result cost them half a percent from the total score, which makes a lot of difference at the end. In grade twelve, ten percent goes to student adherence to school rules and regulations, twenty percent on the capstone, forty percent on the URT exam, and the remaining thirty comes from the performance on each subject. The URT exam is the final exam equivalent to 'Thanaweya Amma', and is based on the 'American College Test' (ACT). "This makes the pressure of performing on the capstone course less and lets us give more time and attention to the different subjects", argued a male STEM graduate. Although some teachers are good and capable of stimulating the young minds, some questions from students can be challenging for their teachers to answer, especially when students' research goes beyond the teacher's knowledge. In some cases, when feeling stuck,

teachers simply tell the students that their question is not included in the curriculum; hence, they do not need the answer. Some teachers misunderstand the STEM ideology as not having to explain anything, letting students rely fully on their own research to comprehend the subject. In better scenarios, the teacher looks for the answer and gets back to the student with it. Putting the exams is another challenge for teachers who do not have full comprehension of the STEM system. As a result, they use online questions for their examinations and students study online, so they may come across the exam questions. “One time in geology, our exam was copied from a preparation document that we all prepared beforehand. Out of 50 questions, 25 were copied into the exam”, said a STEM graduate.

Moving to their opinion on the on-campus residence, the students expressed advantages and disadvantages. Students said that living in the school taught them to live independently, as they no longer have their parents to depend on. Additionally, it allows them to develop close friendships with their fellows. “We spend all our time together, eating, playing volley ball, and studying every day”, said STEM graduate. Also, they benefited from being around their peers all the time, as they studied together and could help each other out. A former student even said, “We learned to not leave anything broken or malfunctioning. For example, one day the heater was not working in the bathroom; my friends and I took it down and opened it to see what was broken and fixed it. We did not resort to reporting it and waiting for a plumber to come and fix the issue. In fact, we find pleasure in fixing things like that.” Nonetheless, being in the school the whole time also has its disadvantages. For instance, the Internet on school premises is restricted. Social websites like Facebook are only accessible from 9:00 pm to 10:00 pm,

which students find frustrating. “We will not study by force because we don’t have access to Facebook. There is always a way to get what we want around the rules”, argued a former student. Also, the Internet speed is quite slow, except for seven selected “IT gurus”, who receive high speed Internet as a prize.

## **6. Chapter 6: Conclusion & Policy Recommendations**

This chapter presents the concluding remarks from the data collection and the analysis presented in the previous chapters. In drawing conclusions, the future perspective of the global STEM education globally are taken into consideration. After summarizing the Egyptian case, the chapter goes more into detail for each of the three research components, namely policy-process, teacher compatibility, and students' governance. This is followed by the identified main challenges facing the STEM schools' initiative in Egypt and the recommended policy solutions to tackle those challenges. The recommendations are based on the learned lessons from international best practices as well as reflecting on the information gathered from the key decision makers. They are meant to add to the effectiveness of administrating STEM schools in Egypt.

### **6.1. Conclusion**

As stated by Rollins (2011), in order to make students strive for being part of STEM colleges and careers, the respective government shall provide an inspiring learning atmosphere at the early stages of schooling. Therefore, it shall be a state priority to fund reform programs and provide the necessary technical support to widen STEM-related preparation in all educational levels (Rollins, 2011). Required investments do not stop at the curricula design, but must expand to the preparation of high-quality teachers who master their subjects in content and corresponding teaching skills (Rollins, 2011). Moreover, working on the teachers' compensation system is necessary to retain the best teachers that were invested in (Rollins, 2011). There is no doubt that relying on technology has a major role to play here. On the one hand, it is to be used in designing innovative curricula based on massive data usage; on the other hand it presents a solid

ground for crafting assessment tools and highly skilled teachers (Rollins, 2011). Furthermore, STEM education has to go beyond classroom learning. The system should involve on-ground field visits to boost students' learning excitement and ambition. Student whose intellectual level goes beyond the set curriculum shall also be encouraged to engage in advanced courses (Rollins, 2011).

The underprivileged majority of the Egyptian population has no other option but to study at a public school, as they cannot afford expensive private international schooling. Those proceed with national schooling only to end up attaining a high school certificate that is a prerequisite for a University degree. Hence, all they care about is doing well on the final exams; the whole scoring is based on. But, trying to make sense out of the books or even attending school is least of their concern. It is only a few who are an exception to this rule and get themselves out of that poor system, by working on their own self development and seeking scholarships to receive higher education at renowned universities. But a lot lose their potential of fulfilling their targets to the lack of quality teaching and guidance. In response to this dilemma, the project of STEM was initiated. It is definitely a step forward in improving the Egyptian national education. The teaching, the administration, and even the buildings themselves tackle various defaults in the traditional system and help in its students' developments.

STEM introduced a new ideology that combats the biggest issue facing the traditional national schools, namely developing children's cognitive skills. The research-based teaching technique encourages students on self-learning, whereas teachers are there for broad guidance and further elaboration. Also, the curriculum tries to link the subjects together and give students real-life examples, so they can relate what they learn in the

classroom to everyday situations. Surely, going beyond theory helps students retain the information and even encourages them to learn more. Yet, as a high school, STEM students are still not brought up since their childhood to be intellectually challenged. They spend two third of their school years following memorization-based learning, to be faced with this different ideology in high school and be asked to adapt to it. This is without doubt challenging for most of the students at least at the beginning. Hence, they try to find a trend for examinations from the elder generations and focus their studying on these questions that are repeated over the years, following the memorization notion. It is even worse in STEM schools as students do not have a book to study from; hence, rely solely on what previous students tell them to study. Still, as an experiment it was proven beneficial to the few who manage to make use of this distinctive opportunity and succeed at it.

Students who have been admitted to STEM realize that they got lucky to be part of this project. They acknowledge that the school gave them an opportunity for a brighter future in a scientific field, as it allows them to get creative and gives them the space to dig deep in their topics of interest. In fact, it also gave them the prestige of being one of a few who made it to this highly competitive one of a kind school in the country. Although not all the teachers are as supportive as they should be, as some simply cannot cope with the different nature of STEM schooling, but the students are thankful to the ones who push them forward and help them achieve their potential. More fieldtrips would certainly add to that. They also appreciate the scholarship opportunities that the school offers them in and out of Egypt at renowned university, that they would not be able to apply to otherwise, and they would not afford to study at without a scholarship. Nonetheless, they

find it unfair that their slots in the public universities are limited and that they have to compete amongst each other to get in; particularly, that even if they score higher in relation to graduates from other national schools they would not be able to be admitted if they are not the highest scoring STEM students. This is the one aspect that puts the highest stress on students and raises their sense of competition rather than cooperation.

STEM system is not just challenging for students, but also for the parents. The whole concept is foreign to the Egyptian culture and is resisted by older generations, particularly those who are not open to change. It has become a norm, especially amongst poorer families, that children must memorize hard from the given books to excel in the exams, so they get top scores, hence, qualify for the top universities of medicine and engineering and become the pride of the family. So, on the one hand, parents themselves may transfer their dissatisfaction of the research-based intellectually challenging learning and assessment technique to their children, making them scared of taking this move. On the other hand, there are parents who do not accept the idea of their children living away from home in the school housing, so they do not agree to their kids applying to STEM schools in the first place. It is uncommon in the Egyptian culture that students live away from their families at this young age. Parents may perceive it as a threat to their upbringing, especially when it comes to girls, who need to be always ‘supervised’; others may see their children incapable of handling their own life at this young age in terms of washing their own clothes and cleaning after themselves. As a result, some gifted students may lose the opportunity to develop their scientific skills and reshape their future.

Still, many students are happy to live together and learn from each other. They use the opportunity of being under the same roof to share their experiences. As each person has his strengths and weaknesses, students group together to study after school and each of them transfers his area of understanding to his peers. Additionally, they learn to be independent and to take care of themselves and of each other. Hence, when they go out of the country or even to a different governorate for college, they already have some background on how to handle their own living. Also, in the housing they feel excited to take care of the maintenance. Instead of waiting for the maintenance guy to fix an arising issue, they step in analyze and try fixing it themselves. If they succeed, they feel a sense of achievement and proud of themselves. It is unlikely that they fail as they learn to use help from the internet if they cannot spot what is wrong on their own. Thinking together they can then come up with an analysis and solution. This allows students to gain experiences beyond the classroom, which develops their personalities in a way that is not available in other Egyptian schools. Additionally, they come out with strong friendships that continue in university. However, students complain about the restrictions imposed on them as part of the dorm life, which makes them feel imprisoned. For instance, the fact that they have limited access to social media websites like Facebook.

Both parents and students face some difficulty adjusting to the STEM school system. Academically, many students suffer on their first year trying to figure out how to study and what online pages to get reliable information from. In the Egyptian culture, some parents interfere in the study patterns of their children. So, it is also a struggle for the parents, who cannot follow up on the study progress of their kids as there is no specific material to finish in a set timeframe. This fact even worries some parents to the

extent that they do not let their children move to STEM in the first place. There is also the issue of the residence. While it may be more difficult for the girls, here again parents may not approve sending their children to STEM as they do not accept them living away from home. This is particularly problematic for the girls. As part of the conservative Egyptian culture, some parents do not trust the peer effect on their children, whereas the parents will not be able to monitor their kids after school, as they do not go home. They fear that their girls misuse the freedom of living independently and abandon the principles their parents raised them to believe in. Likewise, there are those kids who are attached to their parents in one way or another and cannot take living on their own at this young age. This varies from depending on their mothers in cleaning after them, washing their clothes, preparing their food, or even studying with them.

#### **6.1.1. Policy Process**

As stated by Hill (2013) in the policy process, the researcher must take into consideration the power of the decision makers. In Egypt, the governance structure of the STEM project involves various players. On the one side, there is the Ministry of Education, the governmental umbrella under which falls the control of all school education in the country, particularly national schools. Therefore, MoE has the power of dictating its mandates on the established STEM schools in Egypt. On the other hand, there is the donor organization, USAID, which plays a vital role in providing funds and soft skills. Moreover, there is the board that entails representatives from both the above-mentioned stakeholders, in addition to key officials in the field of education and experts in science subjects. The involvement of various entities makes the decision-making process slow and complicated, especially with the current inactive state of the board. The

most critical issues currently facing STEM schools are: (i) devising sustainable revenue streams to ensure covering the operational expenses independent from donor support, (ii) raising competent teachers who comprehend their subjects and know how to follow the disparate teaching technique, (iii) continuously advancing the school curricula and assessment tools to keep up with the rapidly global technologies, and (iv) and sticking to the American model as per the donor's identity even though it is not recognized globally as the most successful one.

Following Birklands model (2015), the evaluation of the policy process exposed funding as the biggest challenge threatening the continuity of the STEM project in Egypt. The whole idea started with the help of USAID, whose fund will end sooner or later. Whereas MoE is the main entity responsible for sustaining the operation, running those schools is costly, compared to other national schools in the country. Firstly, every student must receive a laptop as it is the main tool for researching, i.e. studying. Secondly, students reside in the on-campus housing, where the school is responsible for their food and the maintenance of the building. This is accompanied by supervising and cleaning staff, who receive salaries from the ministry. Thirdly, as a science school, labs are critical. They must be preserved in good condition and always entail the necessary tools and equipment for students to conduct their experiments. Fourthly, STEM teachers receive higher salaries compared to other national school teachers, and so do its administrators; and still a raise is to be considered. Lastly, STEM personnel receive professional trainings by international experts, and sometimes they are required to travel to the United States to attend those trainings and visit American STEM models to follow back home, a cost currently covered by the funding entity and will be transferred to MoE

eventually. With the expansion of STEM schools around various governorates, these expenses are multiplying. too. Hence, MoE must be proactive and set a long term strategic plan to tackle this issue and ensure the full coverage of the schools' operational expenses to sustain its quality of learning and infrastructure. One efficient way is to have a trust in the bank in the name of the school, that generates monthly interest, such as the one that Misr El Kheir was considering to put. This approach may be the best to secure continuous availability of cash. Otherwise, the financial burden will fall on the state; when the public funds are not available, the quality of education offered in STEM will be harmed.

In its long-term plan, decision-makers must take into consideration the industrial role, as well. Whereas businessmen can help with the funds, their role goes beyond funding. The point of STEM is to raise future generations of scientists and technologist who can benefit their home-country later on. Unfortunately, most science-related excelling individuals are taken abroad, as they lack the opportunity in Egypt. This starts with scholarships to study at the top world universities where they can receive top education by the most competent experts in the field; and is followed by tempting job opportunities at worldwide institutes that offer them high financial rewards while providing them with the needed tools to complete their experiments, and ending with those other countries taking credit of the scientific inventions and allowing them to benefit from its trade and grow economically. So, if outstanding STEM graduates do not find a compatible local demand, those calibers will end up moving to the west, just like previous famous scientists, to continue their research. As a result, Egypt will lose its investment in those students and the state's economy will not benefit from their major

scientific inventions. Here comes the more important interface with businessmen, who shall invest in providing competitive job opportunities for STEM graduates. It is also the role of the big research institutes to provide the science-gifted minds with laboratories equipped with the required tools to serve STEM experiments and motivate researchers to fulfill their work, through financial and emotional support.

### **6.1.2. Teacher Compatibility**

Falling under the governmental command gives poor youngsters, who have a scientific talent, yet lack the funds, to join one of the renowned private international schools, the opportunity to receive quality education at a public school for minimal fees. Nonetheless, the state control also has its flaws; most importantly the selection and retention of proficient teachers and other school personnel. As the ministry mandates, STEM teachers must be coming from other national schools and continue to receive governmental salaries. This excludes a remarkable number of well-acquainted teachers who are hired by the private international schools, which offers them much higher salaries and a more prestigious social stand. Even public school teachers are not motivated to move to STEM, as their supplementary incomes from private tutoring still beats the STEM compensation, while in STEM teachers are requested to dedicate time after class hours for explaining unclear material and providing students with the necessary guidance and support to reach their potential, without any extra payment. Adding to that the long hiring process, which leaves a gap in some positions in the case of someone's sudden departure and waiting for the new appointment. Overall, being ruled by various bodies puts a lot of restrictions around the system that prevent its quick and timely advancement. Nonetheless, STEM teachers and school administrators are invested

in more than other national school staff. Whereas the state and the donor offer workshops to train teachers on adapting to this new ideology to enable them to better transfer their knowledge and expertise using proper and modern techniques, it also develops the teacher's personal and professional skills. Throughout these trainings, STEM teachers attain a competitive edge in receiving job offers abroad for better living standards - a double-edged sword. Teachers may sign up for STEM and sacrifice some of their income on the short term, with the ultimate goal of leaving for a better position later on.

### **6.1.3. Students' Governance**

In terms of the passed laws that govern students within the school premises, the board has taken various precautions to ensure delivering and maintaining quality education. This includes the limitation of the number of students per class to only 25, ensuring that each student actually benefits from the officially scheduled classes that take place during the school hours, and abandoning the culture of after school private tutoring. Besides, E-STEM is being introduced to allow students to develop their English language skills online; hence, be able to make better sense of their researched content. Furthermore, each student is provided with a laptop to ensure that they all have the necessary tool to study 'online', whereas the school secures a proper Wi-Fi connection at all times. Most importantly, STEM works on relating the study subjects to real life by building connections between the different subjects and sending students on fieldtrips to see the application of their taught concepts. Even the assessment depends highly on integrating the learnt concepts through the assignments and the final project.

Not only are STEM schools sponsored by the state, but are also meant to provide students with a supportive environment and well-equipped buildings to pursue their

prized scientific research In terms of infrastructure, STEM buildings are of the very few public schools that are well maintained, not only the classrooms, but even the laboratories, and of course the in-school housing facility. In many Egyptian national schools the desks and chairs are broken and the labs are not functioning as they lack equipment and supervision. So far, STEM has managed to keep its classrooms in good shape, in terms of walls, windows, desks, and boards. Additionally, the labs are always taken care of, as they are vital for the students' learning process, although they are at a threat in the absence of a lab assistant. STEM students have a higher sense of ownership to the school compared to children in other schools; this could be due to the fact that they live on campus, which makes the school feel like home and makes the students feel the sense of responsibility of always keeping it clean and in good shape. STEM schools also have the library room and the computer lab, which would not survive long elsewhere. But, it is also due to the fact that the ministry is giving special attention to these schools as the donor organization as well as high-level officials are closely monitoring them.

## **6.2. The Challenges and Recommendations**

### **6.2.1. The Challenges Facing STEM Egypt**

- “The most critical challenge threatening the success of STEM in Egypt now is finding qualified teachers to apply the un-usual curricula”, said a public official. “Teachers have to change their teaching mindset to be able to teach in STEM schools”. Although teachers who apply to join take ICDL in the selection phase, this issue is not yet effectively solved. In attempt to prepare competent personnel, teachers receive various trainings during their selection and afterwards. Some applicants realize their failure to fit into the system throughout this process.

- As part of MoE, only teachers from national schools can apply for STEM schools. “Those who teach in private schools are not eligible”, said one key official; whereas another stated that recently the application was opened for all certified teachers, but those of private schools were not interested to apply due to the poor compensation.
- One school administrator assessed the teachers’ compensation to be four to five times more than the teachers’ payment in other national schools as an incentive to make up for their loss of time otherwise dedicated to private tutoring, another interviewee meant that the payment is doubled which is not enough to compensate for the lost private classes; hence, many highly qualified teachers are not willing to belong to the STEM schools.
- A school administrator elaborated that teachers’ wide knowledge and deep understanding of the subject matter is critical, whereas many Egyptian teachers are not used to think beyond their assigned books, making it a struggle to find good caliber. As stated by the administrator, “Teachers must be able to challenge students mentally, as they are dealing with geniuses.” Hence, it isn’t just about the degrees they have, but also their comprehensive knowledge of the subject, which is not necessarily measured by a degree. For example, a teacher may have a PhD in Biology but his deep expertise is limited to a very specific area, while he does not know much about the rest of the subject.
- Many students (and teachers) cannot adjust to this type of schooling, due to its different nature. The research-based learning and the idea of not having a book to study from is challenging for students who came out of a system that assess their

performance through memorization, as well as for teachers who are only knowledgeable about the book content of their subjects. (donor representative, interview, March 2016)

- A school administrator here said that many parents get worried about sending their kids to a boarding school, something that is not common in the Egyptian culture. However, this issue is diminishing now that a couple of classes have graduated and had scholarships to enter some good universities in and out of Egypt, encouraging more parents to take that risk.
- Another main challenge facing STEM schools in Egypt is the language. Coming from national schools, many students do not have strong English language skills that allows them to browse science-related topics and comprehend the findings. Therefore, E-STEM was introduced; online English courses that aim at enhancing the students' language skills, especially with scientific terms. Yet, this made the language labs a necessity, which is now a tool that needs to be applied. (donor representative, interview, March 2016)
- The selection criteria are not efficient and entail unfairness: the secondary school final exams are designed on a governorate's level; i.e. not all students around Egypt take the same exam. Some may be harder than others, resulting in an unequal grading base; hence, unequal opportunities for interested students. (donor representative, interview, March 2016).
- Funding is one major challenge, as explained by a public official. STEM lack competitive compensation packages to attract top teachers. Also, the capstone projects are costly, which is also the case with operating the science labs,

- providing good speed internet, introducing the language labs for E-STEM, and giving a laptop to each student.
- As part of the sustainability plan, the donor organization wants to enable Egypt to design its own ‘SAT-equivalent’ exams with the same quality, as the cost of paying for each student to take the international exam test is very high and cannot be covered by the Egyptian government. (donor representative, interview, March 2016)
  - Funding cannot be solely based on governmental sponsorship (donor representative, interview, March 2016). Civil society has to play a role; “Industrial contribution is vital for sustainable funding”, added donor representative. “Yet, the role of business men is not just financial, they can also provide students with internships, whereas universities shall open their labs for STEM school research”, answered a school administrator. Also, they may help keep outstanding students in Egypt by promising them with jobs in the future; otherwise, they will find better opportunities abroad and leave the country, he pointed out.
  - There is a threat of taking the outstanding caliber of teachers and principals abroad, expressed a key official. For instance, “when representatives from the Arab Emirates visited the school, they showed interest in initiating STEM schools in their own country; and because they do not have the caliber to run such schools, they were ready to offer the Egyptian teachers, who have taken the required trainings and proved to successfully implement this teaching technique, higher living standards to move to their country and run their schools. Of course,

if the Egyptian government does not provide competitive packages to those teachers, they will go for the better standard of living abroad”, argued STEM school personnel.

- On a micro level, a school administrator talked about internal matters. This includes how students feel lost at first for not having a book to study from, as they are used to a system where teachers spoon-feed them the information. Also, in the residence they face maintenance issues where students and parents are not cooperative. For instance, when they faced a water cut there was a lot of complaints from the parents and a lot of pressure from the students.

### **6.2.2. Recommended Solutions to Encounter the Challenges Facing STEM Egypt**

Whereas STEM has offered a great contribution to the enhancement of school quality of education to the young bright Egyptian minds, the system still has a number of factors to develop in order to improve this project. The following recommendations were developed based on the global best practices referred to in the second chapter on the Global Experience of STEM Education:

1. As much as there are improvements following the rise of STEM schools in the country, it still has its drawbacks and areas of improvement. While some are universal issues facing STEM as a new notion worldwide, others are country specific due to the surrounding political environment.
2. As a USAID funded project, it was enforced to follow the American STEM model. Yet, as shown in the literature, this is not necessarily the most successful

- one to adapt. Also, it is worth noting that cultural and environmental variables play a role; i.e. what works in one country does not necessarily work in the other. Therefore, it would be beneficial to study STEM application in different countries and apply different techniques coming from the best practices based on trial and error, until Egypt develops its own model that best fits with its circumstances.
3. Funding is a critical point concerning the sustainability of the school. The small contributions from the students are not dependable. Neither can the state at this critical economic stage carry that burden. Hence, it must be the number one concern for the STEM Unit under the Ministry of Education to secure a long-term flow of fund for when the support of the USAID ends. The best alternative would be to have a permanent flow that comes from either a trust or the interest of owned assets.
  4. Businessmen can have a great contribution. On one side big corporations can fund STEM as part of their CSR activities: a win-win situation. On another side, they can contribute to making the most out of STEM graduates in order to benefit their own country. They can offer them internships and later on work opportunities for competitive salaries; and they can sponsor them to fulfill their scientific experiments and complete their innovations, whether it be through funding them to attend conferences abroad or providing them with the necessary space, equipment and guidance.
  5. Likewise, the government has to secure the continuity of soft skill development for STEM teachers and administrators, beyond the aid of the donor agency. To be cost-efficient, the government can build its own team of trainers, who then

transfer their expertise to the upcoming personnel. Those can be considered as an alternative investment to sending teachers to the United States, in which case they must be offered attractive compensation packages to secure their continuity under MoE and not to leave as soon they get a better opportunity. Otherwise, it will be a wasted investment.

6. STEM is introducing an intellectually challenging curriculum, which is a great addition to the national education in Egypt. Nonetheless, it is only a high school, which means that its students grow up memorizing anyway; and then it becomes challenging to change their mindset. The schools need to expand vertically, as much as they are horizontally. The more years students spend under this system, the higher is personal growth and benefit out of it.
7. With a target of keeping up with the modern world, the state must find more efficient and developed ways to inform the families of eligible students of the STEM opportunity. Sending a letter by post can encounter various flaws. In a world of technology, the Ministry of Education shall develop a better way to ensure the delivery of the message. They can resort to phone texts or emails; but having an online platform can be easiest. MoE would just need to create public awareness on the existence of STEM and that eligible students are announced online through the specific page. Then keen students will check if their names are on the list online.
8. The issue of teachers is another major one that must be tackled as a priority. The whole cycle needs improvement; whether selection, training, or compensation. The school administration must open the floor for private school teachers to apply

- as they may be a better pool to select from. In turn, the state must offer competitive salaries in comparison with the international private schools to be able to attract their best caliber. Then, there shall be a growth potential so as to maintain those teachers who have been invested in.
9. Housing was initially thought of as a solution to the distant school location and due to the fact that there is only one school in Greater Cairo, while many students come from different governorates. Now, that there are schools around the different governorates, a residence may not be necessary. There will be a higher number of students whose families live nearby. Hence, its need shall be reevaluated. Downsizing or eliminating the housing facility will save money and reduce operational expenses, too.
  10. Settling on a curriculum is an ongoing dilemma. There are too many parties involved in the matter. On the one hand, USAID interferes as the donor and the one responsible for the soft skills. On the other hand, MoE relies on NCEEE as its representative and gives them the power of the final say. After all, the curriculum has to be approved by the state for STEM to be a certified Egyptian national school. Whether NCEEE or USAID, these shall rather be consultants or advisors, and the curriculum should be the responsibility of a specialized committee with international expertise.
  11. Just like the curriculum, the assessment tests are still to be settled on. Using the SAT as guidance can be useful, but copying it is definitely a loss, especially that students get the SAT exams online. STEM schools need to be capable of developing their own tailored exams, and the teachers must be trained how to

train the students to excel at these exams. Here again, specialized international experts have a role to play.

12. As the STEM project was born during a politically critical area, a lot of governance issues remained unsolved. Most importantly, the freezing of its governing board. The board needs to be active again. A lot of the issues facing the system have to do with the multiple authorities, each with their own agenda, and where decisions get lost. Hence, the board shall have representatives from all stakeholders and be then the sole entity in charge of major decision-making and fund generation.
13. It is quite a challenge for students to switch to STEM learning ideology from the traditional national system. Hence, there shall be a transitional stage. For instance, the summer before the first year in STEM can be used for training to understand how it all functions. This training can extend to not only include students, but parents as well, so that they all feel acquainted with the academics and atmosphere in the STEM school, especially that it is a boarding one.
14. The teaching language is another critical point. STEM students must invest a lot of time learning English as their studies depends highly on their proficiency of the language. Therefore, USAID can invest in a related project, where it offers supporting English language courses online to secondary school students and have it accessible to all national students. Accordingly, students will have an early preparation with regards to the language. Where they save time spent on studying English during high school, they can invest more time on scientific studies.

15. Not only do students need to be prepared for STEM, but even parents. To combat the parental concern on sending their children to a boarding school, possibly in a different governorate, MoE shall invest more in promoting STEM to the parents and creating public awareness on its uniqueness. This campaign can emphasize the possible advancements children can achieve when they finish school, including the study opportunities at top universities and abroad and the bright career opportunities.
16. The students' participation in international competitions is one of the biggest things students look forward to when they join the school. USAID and the school administration can help taking it a step further by securing those students who achieve top ranks further opportunities. This can be in the form of a college scholarship or a research institute to sponsor their experiments.
17. STEM admission is to be improved. The selection needs to reflect cognitive skills rather than basing it on the secondary school exam scores. A full grade on one subject in the national curriculum does not reflect high intellectual capabilities, but rather high memorization skills. Hence, the admission process shall not be limited to the highest scoring students, but rather give all students the opportunity to take the placement tests and select the highest scoring students thereafter. Then, through the interview, the admission board can select those who have the greatest potential to excel in the system.
18. Likewise, admitting STEM students into Egyptian universities needs to reflect a fairer opportunity. Instead of giving STEM students limited slots, where they have to compete together on, their final score can be diverted into a total score

that is comparable to graduates of other national schools, so they can end up study what they want. Those students were meant to proceed with science-related studies to start with, hence, they shall continue being supported to pursue their studies and career of choice.

19. Following the concept of offering online classes for students to help them study beyond the classroom through E-STEM, MoE can start making more academic sources available for STEM students. This can happen by developing partnerships with universities in and out of Egypt to provide STEM students such as access their online libraries. The state can ask for instance for collaboration from the universities that offer STEM students scholarships for undergraduate classes.

20. Likewise, MoE can enhance the learning of the second foreign language by offering E-STEM in French and German in addition to the English. Hence, students will get to develop a second language skill beyond the classroom, if they wish. It will be of great use for those who wish to continue their studies in German or French speaking countries, plan to use either in their work later on; or even wish to read books and expand their research by reading online papers in those languages.

21. As per the graduates' response, they found the field-study of great benefit and would have preferred to have more during their school years. Accordingly, the school administration may reconsider having the trips on a weekly basis as per the initial plan. Also, it does not have to stick to institutions that are of relevance to the capstone course. Students may have other interests that the trips can help them develop beside their current area of study.

22. As the laptops reach their maturity by the end of the four years, the school administration may think of alternatives to collecting them back from the students. Instead, they can offer the students to take them and pay the depreciated rate. That would also be a source of cash generation. In addition, it may be costly for students to buy new ones, especially if they come from unprivileged families. So, paying a small amount in turn of keeping their school ones will be beneficial for both parties.
23. It has been a trend that a percentile drops out on their first year. Due to the limited number of students, the school may consider admitting extra students respectively. For instance, if statistics show that every year around ten percent drop out, it could take extra ten percent, so that they run on full capacity the following years. This will ensure that no opportunities are lost when students drop out, while others would dream of getting in.
24. The housing seems to have a lot of restrictions that students are unhappy about. For instance, there is the matter of closing access to Facebook except for one hour per day. As students still have access to it on their phones, this does not limit their access in practice. Hence, it is kind of useless. Also, providing only one hour for food is tight. The school administration may consider extending the lunch and dinner to two hours instead of one. Also, lunch can be offered in a break instead of after the school day. Students have breakfast before they start early in the morning, which results into a big gap to the next meal.

### 6.2.3. Main challenges and recommendations summarized

Reflecting on the above, the below table summarizes the most critical challenges facing the STEM schools' initiatives in Egypt and the derived policy recommendations to combat those challenges:

Challenge	Recommendation
Sticking to the U.S. STEM Model with its flaws, due to the fund coming from the American donor organization	STEM Egypt shall consider other international successful models and adopt what fits in the Egyptian culture and can benefit the program.
The heavy reliance on the donor organization in developing the soft skills for STEM teachers and administration	MoE shall work on raising its own STEM subject and system experts that are independent from the donor.
The admission criteria based on the final national secondary school examination results	STEM high schools may consider disregarding the reliance on the national preparatory-level final exam results and give access to all students for taking the assessment tests. Those who pass shall then sit for the interview, which is mentioned in the ministerial decree but does currently not take place.
The lack of preparation for students before getting into STEM high schools	The schools may use the summer before the first academic year to present the system to students and their parents through workshops. Additionally, STEM may expand vertically to

	address the root causes of poor education in Egypt.
There is a lack in qualified STEM high school teachers in Egypt	The state can work on advocating for STEM and enhancing the prestigious stand of STEM teachers, allow private school teachers to apply for STEM high schools as they may have higher qualifications than public school teachers, raise the teacher's compensation packages to substitute for private tutoring and attract the best caliber, and enforce long-term contracts to retain the STEM-trained teachers.
The biggest concern threatening the sustainability of STEM quality education is the long-term availability of funding	STEM administrators may put into consideration the industrial role and resort to businessmen, who can contribute to the financing of the schools' operation. This can be in the form of putting a trust fund in the name of the program or funding assets to be owned by the initiative for consistent cash generation.

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## Appendices

### 1. Ministerial Decree

Decree no. 382, issued by the Ministry of Education, on the 2<sup>nd</sup> of October 2012:

1. STEM high schools are high schools with distinctive curricula that aim at the following:

- a. Supporting students who are gifted in sciences, mathematics, engineering, and technology and developing their skills.
- b. Emphasizing on the role of sciences, mathematics, engineering, and technology in the Egyptian education.
- c. Spreading a new educational system, STEM, in Egyptian national schools.
- d. Encouraging the majority of students to specialize in sciences.
- e. Implementing modern and innovative curricula and teaching techniques relying on integrated learning approach.
- f. Developing the interests and skills of students, as well as increasing their interaction and passion for sciences and mathematics.
- g. Drawing relationships between sciences, mathematics, engineering, and technology to show the linkages between these subjects and provide a comprehensive curriculum, in order to prepare a student capable of innovation and analytical thinking.
- h. Teaching students about cooperative learning.
- i. Preparing competent and knowledgeable youth for higher education and research institutions.

2. Students who successfully finished their preparatory school at the same year from all around Egypt can be admitted to STEM schools, considering the following:
  - a. Having a final score of no less than 98%.
  - b. Getting a full grade on at least two subjects of the three: English, Mathematics, and Sciences.
  - c. Passing the medical check ups of the corresponding governorate.
  - d. Passing the assessment tests in sciences, mathematics, engineering, and technology.
  - e. Passing the IQ assessment test.
  - f. Passing the personal interview.

(The board of each school holds the right to adjust the entry requirements based on the needs of the respective school alone at each academic year, after getting approval from the Minister of Education.)

3. The call for applications starts at the end of June each year and remains for two weeks. Interested applicants shall fill in the application form available on the Ministry's website, have it validated from the educational administration and submitted to the respective educational directorate.

Applications for STEM schools are revised by the student affairs of each educational directorate in respect to the final scores of preparatory schooling and the above-mentioned prerequisites. Results are submitted to the central department of secondary education at the ministry no later than 25 of July of each year.

4. A committee is to be formed as mandated by the Minister of Education to accept new students. The committee is to be headed by and having the following members:
  - a. Head of central department for high school education
  - b. General director of high school education
  - c. Science consultant
  - d. Mathematics consultant
  - e. English language consultant
  - f. School board representative
  - g. School principle

The committee is responsible for the following:

- Setting the date and time for the assessment tests and personal interviews and informing students with it.
  - Conducting the personal interviews for new students, as well as forming committees for conducting and correcting the assessment tests mentioned above, in collaboration with the national center for examination.
  - Certifying the final results of the assessments and interviews and admitting new students.
5. The national center for examination is responsible for preparing a number of tests to assess the creative talents and personal characteristics of applicants. These are delivered to the head of the admission committee in a sealed envelope no later than first of July of every year, including the following:

- a. A test assessing diverse knowledge in sciences, mathematics, engineering, and technology.
  - b. IQ test
6. The above mention assessment tests in science, mathematics, engineering and technology, and the IQ test mentioned above are to be taken by applying students to enter STEM schools under the supervision of the national center for examination within the first week of august, complying by the minimum requirements mentioned in point 2.

Applicants who pass the tests are to attend the personal interviews with the admission committee, mentioned above in point 4., within ten days of taking the examinations.

7. Acceptances go to the highest scoring applicants, adhering to a maximum of 25 students per class. Hence, numbers depend on the availability of classrooms in each school. Scores are calculated based on the below equation:

$$\frac{(S1*40 + S2*40 + S3*20)}{100}$$

S1: Final score in preparatory school

100

S2: Scores in assessment tests

S3: Personal interview results confirming applicants do not suffer from any psychological instability.

8. Results of accepted students to STEM schools are announced on the first of September of each year on the MoEs website online; and a hard copy is sent to the educational directorates to inform the parents.

9. Students who did not get accepted can petition to student affairs of their respective educational directorate within 10 days of the announcement day.

A committee, decided on by the Minister of Education, is to be formed to assess the petitions and informing the students with the results within 10 days of submitting the petition.

10. The principle decides on the school needs, taking into consideration teachers, administrative staff, laboratory supervisors, and others, with the first week of June of each year. It is to be presented them to the administrative body of the school for approval and sent to the central administration of high school education no later than the last week of June to ensure provision of needed material before the academic year starts.

11. Committees headed by the head of public education, established by the Minister of Education, are to be formed. The following members are to be on the committee:

- a. Chairman of the professional teachers' academy
- b. Chairman of the central administration of high school education
- c. Representative of school administration
- d. Subject consultant
- e. School principle

The committees are responsible for appointing the teaching body in the different specialties in STEM schools through announcing the vacancies for a yearly contract subject to renewal.

12. Selected personnel, whether for teaching, lab supervision, or administration for a yearly contract at STEM schools must meet the following requirements:

- a. Have experience in attending educational conferences abroad; and have been exposed to modern teaching techniques.
- b. Have a master or doctoral degree, are registered as teachers under the MoE, and are faculty in Egyptian universities.,
- c. Have teaching experience in experimental language schools.
- d. Have high knowledge of the English language; and preferably took English language placement tests.

13. New teachers are trained on a learning ideology based on projects, collaborative learning, and integrated learning, known as capstone, in English.

14. A committee established by the Minister of Education is to be headed by the head of public education, and includes the following members:

- a. Chairman of the professional teachers' academy
- b. Chairman of the central administration of high school education
- c. Representative of school administration
- d. A university professor with expertise in administration affairs
- e. One of the STEM school principles

The committee is responsible for appointing STEM school principals through a public announcement to recruit outstanding competencies in sciences, mathematics, and English language for one-year contract subject to renewal; preferably with a master or doctoral degree in sciences or mathematics or engineering or technology.

15. All school personnel are to be evaluated at the end of the academic year as per the evaluation criteria set by professionals in the academy for teachers and experts in the subject matter. The contracts are renewed based on the evaluation of a specialized committee that is formulated as follows:

- a. For the school principle: the formed committee entails the chairman of the central administration of high school education, an expert nominated from the professional teachers' academy, and a member of the school trustees.
- b. For the teaching body: the formed committee entails the school principle, the subject expert, a nominated expert from the professional teachers' academy, and a member of the school trustees.
- c. For staff members: the formed committee entails the school principle, a nominated expert from the professional teachers' academy, and a member of the school trustees.

Outcomes are to be presented to the administrative body, as well as the head of the public education in the Ministry to take the final decision.

16. The continuity of students at STEM schools is preconditioned by outstanding academic performance. The school holds the right to move under-performing students to another national or experimental language school at the end of the year, after receiving approval from the administrative board and informing the parents once a semester through the registered email.

17. The learning at STEM schools is based on developing projects and integrative research of the topics taught.

Curricula are decided on according to national and international STEM standards.

STEM curricula are equivalent to the ‘thanaweya amma’ curricula (as per the attached timetables).

The governing body holds the right to propose additional enriching topics and activities, after presenting them to the Minister of Education.

18. The teaching body of each subject is responsible for setting the topics to be taught in alignment with the yearly curricula. Same rule applies to the projects that are then submitted to the school principle and revised by the administrative board for approval. In this regard, every student receives a brief of the requirements at the beginning of the school year, in addition to the projects brochure including the assessment criteria, in order to plan out their work over the weeks.
19. Projects of all subjects are compared to each other in order to find the commonalities out of which the critical ideas for the capstone (main) project evolve. Additional ideas that will benefit the students may be integrated.
20. The school is to provide a variety of materials in the library and online to support students’ learning. Additionally, they are to have access on scientific research and Egyptian universities.
21. STEAM teachers are to rely on investigative learning that is based on integrated projects through teamwork of small groups (each to be assigned a specific project), in addition to online learning that is made available by handing a laptop to each student in the school.
22. The teaching ideology at STEM supports activities in relevance to the research projects, which occurs through offering fieldtrips and educational visits to universities and research institutes on a weekly basis.

23. Students are regularly assessed, on a weekly and a monthly basis, based on the nature of the subject matter and the undertaken projects in the labs and classrooms. Results are to be kept in the file of each student.
24. Students' assessment follows the below criteria:
- First: exam (30%)
- Second: Projects and learning outcomes (60%)
- Third: students' performance throughout the year (10%)
- Students must exceed a total score of 60% in science, mathematics, technology, and engineering in order to pass.
25. Final grades must be out no later than May of each year; and students have the right to petition exam results within ten days from the grade release date. Petitions are submitted to the school that then submits it to the central administration of high school education.
26. The head of the public education sector forms a committee to evaluate the students' petitions and answer them within fifteen days of the date of submission.
27. The administrative body of each school is to decide on the membership fee to be collected from the students in return to the provided services to students, including accommodation and food. The board of directors and the board of trustees are responsible of networking with Non-Governmental Organizations (NGOs), as well as public and private organizations for collecting funds that allows the schools to achieve its goals.

28. The official language of teaching science, mathematics, technology and engineering is English. The schools are responsible for enhancing the English language skills of the students.

29. The ministerial decree no. 290 of year 2012 is cancelled.

30. This is to be announced to the public and to be active starting the school year 2012/2013. Any contradictory announcement is cancelled.

The subjects to be taught to students in grade ten (sciences to be taught in English)

	Subject	Nr. of basic classes	Nr. of enriching classes
1	Arabic Language	5	-
2	Religion	1	-
3	First Foreign Language	4	2
4	Second Foreign Language	2	-
5	Mathematics (Algebra, Trigonometry, analytical geometry)	4	2
6	Sciences (Chemistry, Physics, Biology, Geology)	6	2
7	Sociology (History, Geography, Citizenship)	2	-

8	Multimedia Technology	-	2
9	History of sciences, engineering, and technology	-	2
10	Educational activities (artistic, musical, sports, etc.)	1	-
11	Hydraulic	-	2

- Number of classes: 37
- Subjects that are not counted in the final score: religion and educational activities
- Project subject (capstone): 3 classes per week
- Students are to spend one day per week in universities and research institutes

The subjects to be taught to students in grade eleven (sciences to be taught in English)

	Subject	Nr. of basic classes	Nr. of enriching classes
1	Arabic Language	5	-
2	Religion	1	-
3	First Foreign Language	4	-
4	Second Foreign Language	2	-
5	Mathematics (Algebra, Differentiation, Trigonometry)	4	2

6	Sciences (Chemistry, Physics, Biology, Geology)	6	2
7	Scientific Research and Scientific Thinking Skills	1	1
8	Citizenship and Human Rights	1	-
9	Engineering Designs Statistics	-	2
10	Information Technology	-	2
11	Philosophy	1	-
12	Educational activities (artistic, musical, sports, etc.)	1	-

- Number of classes: 35
- Subjects that are not counted in the final score: religion, educational activities, and Citizenship and Human Rights
- Project subject (capstone): 3 classes per week
- Students are to spend one day per week in universities and research institutes

The subjects to be taught to students in grade twelve (sciences to be taught in English)

(The path of basic and medical sciences)

	Subject	Nr. of basic classes	Nr. of enriching classes
1	Arabic Language	5	-
2	Religion	1	-
3	First Foreign Language	4	-
4	Second Foreign Language	2	-
5	Biology	3	2
6	Physics	3	2
7	Chemistry	3	-
8	Citizenship and Human Rights	1	-
9	Capstone	-	3
10	Earth and Space Science	0	2
11	Educational activities (artistic, musical, sports, etc.)	1	-
12	Technology (industry, agriculture, management) and students selects one subject	1	1

- Number of classes: 36

- Subjects that are not counted in the final score: religion, educational activities, and Citizenship and Human Rights
- Students are to spend one day per week in universities and research institutes

The subjects to be taught to students in grade twelve (sciences to be taught in English)

(The path of mathematics and engineering)

	Subject	Nr. of basic classes	Nr. of enriching classes
1	Arabic Language	5	-
2	Religion	1	-
3	First Foreign Language	4	-
4	Second Foreign Language	2	-
5	Mathematics 2	3	2
6	Physics	3	2
7	Geology	2	1
8	Citizenship and Human Rights	2	1
9	Capstone	1	-
10	Citizenship and Human Rights	-	3
11	Human Automation	-	2

	Engineering		
12	Electronic Engineering	-	2
13	Educational activities (artistic, musical, sports, etc.)	1	-
14	Technology (industry, agriculture, management) and students selects one subject	1	-

- Number of classes: 39
- Subjects that are not counted in the final score: religion, educational activities, and Citizenship and Human Rights
- Students are to spend one day per week in universities and research institutes

## 2. Teacher Evaluation Form

Assessment Criteria	Max. Score	Direct Supervisor		Governorate's Director		Top Manager		
		Letters	Numbers	Letters	Numbers	Letters	Numbers	
Firstly, Work performance & level: Quantity of work								
Quality of work								
Secondly, administrative & artistic skills: involvement in improving school performance								
Degree of follow up on teachers' performance								
Ability to lead and guide								
Certificates & Educational								

Level & Trainings								
Thirdly, Behavior with school administration & educational administration								
Discipline at work								
<b>Total Score</b>								
<b>Score Rating</b>								

### 3. Interview Guide

Policy-related
1. Where did the idea of STEM come from?
2. Where do the funds come from?
3. What is the application procedure? How are students selected?
4. How are teachers selected? What are the eligibility criteria?
5. Why is STEM in Egypt a boarding school?
6. What curricula are applied?
7. What is the expansion plan?
8. What is the long-term sustainability plan?
9. What are the main challenges facing the system now?
10. What collaborations (academic and professional) do the schools have?
11. What certificate do STEM students graduate with?
12. What is the governance structure?
Administration-related
1. Which entities are involved in administering the schools? What is the role of USAID and what is the role of MoE?
2. Are students required to pay fees?
3. What assessment tools are used to measure students' performance?

4. What assessment tools are used to measure teachers' performance?
5. What is the maximum number of students per class?
6. What is the methodology used in teaching for each subject?
7. What is the out-of-classroom learning?
8. What is the relationship between the students and their teachers?
9. How are the material and equipment stored and sustained?
10. What is the percentage of dropouts?
11. What are the offerings for the 2 <sup>nd</sup> foreign language?
12. How is the residence regulated?