Egypt STEM School Project (ESSP)

FINAL REPORT

December 2017
This publication was produced for review by the United States Agency for International Development (USAID). It was prepared by World Learning.

Egypt STEM School Project (ESSP)

FINAL REPORT

August 2012 – October 2017

Cooperative Agreement No. AID 263-A-12-00005

CONTENTS

ACRONYMS

21PSTEM	The 21st Century Partnership for STEM Education
ACT	American College Testing (exam)
AIP	Annual Implementation Plan
BOT	Board of Trustees (school)
CA	Cooperative Agreement
CCIMD	Center for Curriculum and Instructional Material Development (MoE)
CDRS	Curriculum Design Review Studio
CMS	Content Management System
COP	Chief of Party
DEC	Department of Educational Computing
DCOP	Deputy Chief of Party
ESSP	Egypt STEM Schools Project
ESF	Education Support Fund
ELP	English Language Program
GILO	Girls' Improved Learning Outcomes Project (USAID)
GOE	Government of Egypt
GTM	GoToMeeting
HR	Human Resources
IAT	It's About Time
ICT	Information and Communications Technology
LO	Learning Outcome
MAP	Management Assessment Protocol
M&E	Monitoring and Evaluation
MoE	Ministry of Education
MOHE	Ministry of Higher Education
MSI	Management Systems International
NCEEE	National Center for Examinations and Educational Evaluation (MoE)
NCERD	National Center for Educational Research and Development (MoE)
PARLO	Proficiency-based Assessment and Reassessment of Learning Outcomes
PAT	Professional Academy of Teachers (MoE)
PD	Professional Development
PMP	Performance Monitoring Plan
QPR	Quarterly Progress Report
SCOPE	Standards-based Classroom Observation Protocol for Egypt
STEM	Science, Technology, Engineering, and Mathematics
STTA	Short Term Technical Assistance
TDC	Technology Development Center (MoE)
TIES	Teaching Institute for Excellence in STEM
TFI	The Franklin Institute
TILO	Technology for Improved Learning Outcomes (USAID)
TOT	Training of Trainers
WL	World Learning
URT	University Readiness Test
US	United States
USAID	United States Agency for International Development

Spotlight on Successful STEM Students: Mona Moawad

Mona Moawad is a 2015 graduate of the Maadi STEM School for Girls. Originally from the governorate of Daqahleya. Mona won a scholarship to study Chemistry at the Department of Chemical and Biological Engineering at Montana State University, College of Engineering. At Montana State University, Mona has impressed her professors with intelligence and hard work. She recently won the Department of Chemical and Biological Engineering Victor R. Thayer Memorial Scholarship for the 2016-2017 academic year. Mona reflects on her experience as a founding student in the Maadi STEM School for Girls and the impact this opportunity has had on her life in the following feedback:

"I am a dreamer. I have to dream and reach for the moon, and if I miss the moon then I grab a handful of stars. I believe that the beginning of a journey does not matter, nor its end! What really matters is what's in between. [Attending the] STEM school is what's in between the beginning and that unknown end of my journey.

The obstacle which changed my whole life was my father's death. With time, I started to move on…I started to achieve my dreams by studying very hard to make my father proud of me. The first step in achieving my goals was joining Maadi STEM School for Girls focusing on science, technology, engineering, and mathematics. There, I learnt how to think outside the box, conduct experiments, and work in teams. I was taught all the important skills to be a good leader and design solutions to my country's greatest development challenges. Joining STEM school turned me into an independent learner who is equipped with the 21st century skills of critical thinking and collaboration. In my STEM school, I did research on issues directly related to Egypt's economic growth.

Coming to STEM school was a turning point in my life. I went from memorizing every day at school to doing real research. In May 2014, I, and two classmates, traveled halfway around the world to compete in Intel's International Science and Engineering Fair in the United States (ISEF). We won the second place at Intel's national science fair in Egypt. And at the global competition in Southern California, we won third place in our category among more than 1,600 of the best and brightest students in the world. After the competition, I was honored by the Egyptian president, Abd El Fatah Al-Sisi, I took the accolade of excellence –second degree.

I want to leave a message to the new STEM school students – Don't give up! Don't even think that word. Life must have ups and downs and a bright side…and STEM is the bright side of your life!" – Mona Moawad

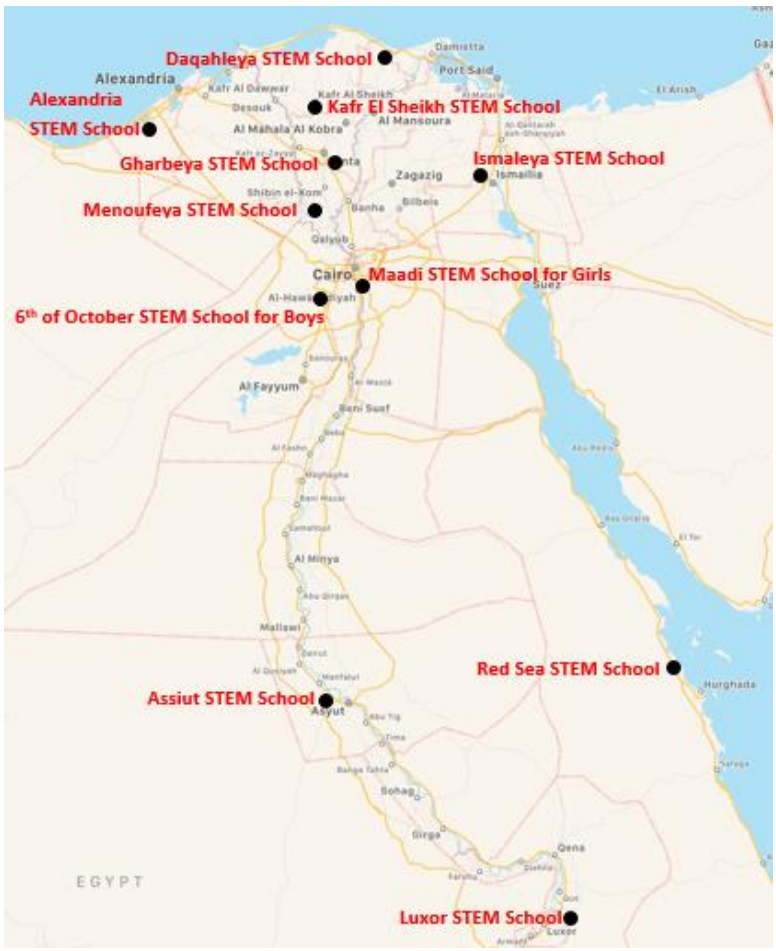
I won a [USAID-funded] STEP scholarship to Montana State University to study chemical engineering. It was hard at the beginning to stay at the top as I used to be in Egypt. I faced many problems such as the language, culture, weather, and homesickness. To overcome these problems, I remembered the promise I made to my dad when I was 13-year-old. The STEM school played a big role in that academic achievement [at university]. During high school, I learnt to be a self-learner, so I was able to understand the material myself and go to all the lectures prepared, which gave all my professors a good impression about me. Also, the material we covered in STEM school was very close to what I covered in my freshmen year [at university]. I am a junior this year and after my graduation in May 2019, I am planning in joining a graduate school for a PhD degree in chemical engineering. My dream graduate school is MIT so I am doing my best to achieve this goal."

I. Executive Summary

This is a final report to describe project successes and challenges, identify best practices for future projects, and communicate recommendations for continued success and sustainability of the progress achieved collaboratively between the USAID-funded Egypt STEM Schools Project (ESSP) and the Ministry of Education (MoE) in Egypt.

a. Project Overview

The Egypt STEM Schools Project (ESSP) is a $30 million, USAID-funded project to build a science, technology, engineering, and mathematics (STEM) model school network in Egypt. Since August 2012, ESSP has supported the establishment of 11 STEM public high schools across Egypt, educating students on essential knowledge and skills needed for a future in STEM jobs and establishing a system and supporting policies to sustain STEM education in Egypt by strengthening the capacity of the Ministry of Education (MoE).



Eleven STEM Model Schools were established throughout Egypt

The Egypt STEM School Model embodies best practices in STEM education that have been adapted and customized for the Egyptian context. This model embedded inquiry-based, student-centered pedagogy that integrates real world applications and critical problem solving into the Egyptian public education system. In doing so, ESSP has also helped the MoE institutionalize processes around STEM education, including policy reforms on student admissions, teacher selection and training, curriculum and assessment, and procurement processes for school needs. These systems improvements have laid the foundation for the MoE to be able to scale STEM education nationwide. Through ESSP, the MoE is equipped with the knowledge, skills, and systems to improve public school education in Egypt by ensuring students are prepared with 21st century skills needed to succeed in higher education and the workforce.

The original goal of the project was to support the establishment of three to five STEM model (high) schools in targeted governorates. These schools would serve as centers of excellence, contribute to workforce development, and allow enrollment to a range of gifted students regardless of their gender, social, or economic background. To do this, the project's objectives were to:

1. Increase student interest, participation, and achievement in science and mathematics

2. Strengthen the STEM school initiative by developing an effective model for specialized high schools;
3. Build the capacity of a highly qualified cadre of STEM professionals and provide opportunities for training and sustained, intellectually rigorous professional learning;
4. Strengthen MoE capacity at the systems and policy level to sustain and replicate these model schools; and
5. Support the MoE in upgrading science and mathematics curriculum standards, student assessments, and teacher preparation for mainstream schools.

Over the five-year duration of the project, ESSP progressively exceeded donor and host government expectations, founding eleven STEM schools supported by a national policy at the highest level (far exceeding the original target of five schools), and co-creating a blueprint for future STEM school development and system-wide improvements in public education in Egypt.

b. World Learning Partners' Roles and Responsibilities

As the prime implementing partner, World Learning has worked with a consortium of partners to implement the project, including: The Franklin Institute, 21st Century Partnership for STEM Education, Teaching Institute for Excellence in STEM, and later Management Systems International. The combination of these four partners along with World Learning leading the process created a unique and complementary synergy that provided the right expertise throughout the life of the project. A summary of each organization's leadership areas includes:

- **World Learning** led overall project management, Egypt-based operations and support to schools and the MoE, and ongoing needs related to equipment procurement, school support, and coordination. In addition, World Learning led all development of English for STEM programming for both students and teachers, as well as coordination with the MoE. In addition, they provided integrated technical assistance across project components as needed.
- **The Franklin Institute** (TFI), the oldest science center in the United States, provided leadership in teacher training and continuous professional development for teachers, school leaders, and MoE officials and also recommended viable co-curricular and extra-curricular activities. In addition, they provided integrated technical assistance across project components.
- **The Teaching Institute for Excellence in STEM** (TIES) provided leadership for school model network design, school leadership training and coaching, and technical assistance for capstones, Fab Labs, and the Blueprint (the online tool that houses all STEM School Network design documents, manuals, and resources). In addition, they provided integrated technical assistance across project components.
- **21st Century Partnership for STEM Education** (21PSTEM) provided leadership for the development of the STEM school curriculum, including focused training, coaching, and tools to support teachers and school leaders to implement the curriculum. In addition, they provided leadership on student learning assessments (formative and summative). They also provided integrated technical assistance across project components.
- **Management Systems International** (MSI) joined the team in the third year of the project (2015) for targeted development of the University Readiness Test (URT), the proposed alternative to the *thanaweya amma* for Egypt's STEM schools. MSI, in partnership with Egypt's National Center for Examinations and Educational Evaluation (NCEEE), developed a URT specific to Egyptian context that measures the students' readiness and aptitude to enter university following the completion of their STEM high school studies.

c. Summary of Project Achievements:

The following are highlights of the project's major achievements in each project objective.

Objective 1: Increase student interest, participation, and achievement in science and mathematics

- **Student Application and Enrollment:** Established 11 STEM schools that served 2,799 students (1,586 boys & 1,213 girls) by the end of the 2016/2017 academic year (Year 5 of the project).[1] Another major achievement was the substantial increased interest by prospective students leading to a 49% increase in student applications in just a two-year time span (1,589 applications in 2014 to 3,173 in 2016). (Related to Activity 1.1).
- **Graduation Rates:** A total of 458 students (294 boys, 164 girls) have graduated from the STEM schools. The first cohort of 85 students (from the 6th of October STEM school) graduated in June 2014, the second cohort of 182 students (from both the 6th of October STEM School and the Maadi STEM School) graduated in June 2015, and the third cohort of 191 students graduated in June 2016 from both schools. All graduates have been accepted into universities, mostly in private universities in Egypt and few in public universities. In addition, several female graduates received scholarships from USAID's STEP project to study in the U.S. as well as other scholarship funds (Related to Activity 1.3)

Maadi alumni exhibit the US colleges they are enrolled in at the entrance of their school

- **Preparatory School Outreach and Training:** To inspire student interest to enroll in STEM high schools and succeed, ESSP extended STEM teaching and learning to the preparatory school level. In collaboration with the MoE head counselors, ESSP developed and disseminated outreach and training packages for science and English targeting 54 preparatory schools (2 per each governorate) and trained 303 (57% men and 43% women) supervisors and teachers in science and English to expand to all preparatory schools after the life of the project. (Related to Activity 1.4)

Objective 2: Strengthen the STEM school initiative by developing an effective model for specialized high schools

- **IT and STEM Lab Equipment:** The project procured and provided training for all laboratory and IT equipment for five STEM schools in addition to supplementary material for 11 STEM schools to fit the learning outcomes outlined in the STEM curriculum. The equipment for the other six schools was procured by the Ministry using ESSP's standards and specifications. In addition, the project provided training for Fab Labs and related technologies in all 11 STEM schools and developed guidelines for safe lab management and maintenance. This procurement process not only developed specifications for such equipment, material, and tools, but also created a local market that now has local providers where specialized items can be sourced by the MoE. (Related to Activity 2.2)
- **Established Public Private Partnerships:** Established 18 partnerships with multinational companies that assisted the schools in creating better learning systems. Examples include Google and Microsoft, which offered to provide e-mails accounts, cloud space, and applications to promote innovations within the STEM Model. (Related to Activity 2.3) In addition, partnerships with Cisco, Boeing, and Injaz fostered extracurricular activities in schools and provided alternative learning experiences to students to improve and complement

[1] These figures do not account for the 2016/17 graduates nor 2017/18 newly enrolled students, as data was not available by the end of the project's period of performance.

their school experience. Also, students were exposed first through ESSP and later on their own to local and international competitions where they achieved advanced positions and won awards all over the world, including the high-profile competitions like Intel's International Science and Engineering Fair (ISEF). (Related to Activity 2.4)

Objective 3: Build the capacity of a highly qualified cadre of STEM professionals and provide opportunities for training and sustained, intellectually rigorous professional learning

- **Intensive Training and Professional Development:** Provided more than 106,000-person training hours in pedagogy, curricula, assessment, and leadership training for 640 teachers and 6,800-person training hours for 62 administrators. Also, provided 44,500-person training hours for 503 MoE, NCEEE, CCIMD, PAT, NCERD, and TDC staff.[2] Training resulted in qualified MoE trainers with the ability to sustain and scale the full STEM package including pedagogy, curriculum, e-STEM, assessment, capstone, fabrication labs, and lab practical. (Related to Activity 3.2)

- **English Language Training and Support:** Developed English curricula and e-STEM online platforms for STEM schools, providing the necessary support for students to improve English language fluency to be prepared to learn in English-medium schools. (Related to Activity 3.2)
- **Online Platform and Apps:** ESSP developed and introduced many innovative online tools to support collaboration and shared tools across the STEM School Network. The curriculum app allows teachers to access it from any connected laptop, phone, or tablet. The app is a new platform in Egypt, enabling teachers to contribute to lesson plans and collaborate in real-time, thus, feeling ownership of the curriculum itself. A related capstone app enables teachers and leaders to similarly collaborate and create new content. Finally, the English language outreach and e-STEM online for Grades 10 and 11 provide a platform for student-driven learning units to support STEM students as they improve their English language skills in a sustainable way. (Related to Activity 3.6)

Objective 4: Strengthen MoE capacity at the systems and policy level to sustain and replicate these model schools

- **Curriculum Development**: Developed and implemented a new transdisciplinary project-based STEM curricula that is approved and owned by the MoE and produced two compendiums of curriculum standards for STEM and Humanities subjects in very close collaboration with the MoE's CCIMD. (Related to Activity 4.1)
- **Improving Learning Assessment Systems:** Introduced a new assessment system that was approved by the MoE and tested and improved throughout the life of the project. This new system includes new methods to measure students' knowledge and depth of understanding by instituting the Test of Concepts as part of the assessment system for grades 10 and 11,

[2] These government agency full names are: National Center for Examinations and Educational Evaluation (NCEEE), Center for Curriculum and Instructional Material Development (CCMID), Professional Academy of Teachers (PAT), National Center for Education Research and Development (NCERD), and Technology Development Center (TDC).

developing end of year tests for each grade level, and developing a Grade 12 STEM School Exit Exam. A new system – PARLO[3] –is now functioning in all schools with capacity built at TDC and in schools through several training sessions to respectively manage it and proficiently use it. These achievements to improve school-based learning assessment were complemented by the development and approval of the University Readiness Test (with item bank) as the first alternative to *thanaweya amma* in Egypt. (Related to Activity 4.2)

- **Executive Leadership and Support within Government of Egypt:** ESSP enjoyed unprecedented government support during its implementation. Starting with the STEM National Board and ending with the Executive Committee at the highest Ministry level in addition to the establishment and institutionalization of the STEM Central Unit, ESSP continuously cultivated government capacity and enthusiasm to sustain the STEM School Network. In addition, the STEM School Blueprint provides an online one-stop-shop for all STEM school documents for Ministry officials to access, use, and improve (Related to Activity 4.3)

Objective 5: Support the MoE in upgrading science and mathematics curriculum standards, student assessments, and teacher preparation for mainstream schools

- **Support Policy Improvements to Establish STEM School Model:** Led the process of crafting and issuing new Ministerial Decrees based on international best practices for the establishment of a new STEM education system in Egypt including the central and local STEM units at the governorate level. (Related to Activity 5.1)
- **Support Policy Changes to Institutionalize STEM School Model:** Such ministerial decrees paved the way for CCIMD, NCEEE, and PAT to adopt new ways of doing business, such as CCIMD championing the production and adoption of new standards for STEM and Humanities subjects, NCEEE being part of and approving the STEM URT, and PAT adhering to new guidelines in recruiting and selecting STEM teachers at higher standards. (Related to Activity 5.2)

The core elements of the program's design – student interest and learning, curriculum and standards, assessment, equipment procurement, in-service teacher training, and MoE capacity-building efforts – were designed with buy-in from all stakeholders and contextualized to form Egypt's own STEM education model. Going forward, the foundational network of 11 STEM Model Schools will serve as a catalyst for change not only for future STEM schools, but also for system-wide math and science education reform within Egypt.

[3] PARLO is the Proficiency-based Assessment and Reassessment of Learning Outcomes, a program that enables teachers to measure and track learning outcome proficiency in real-time.

Spotlight on Successful STEM Students: Demiana Aiad Megala

On February 25th, 2014, Marwa Abd El-Raouf, Maiar Mosaad, and Demiana Aiad Megala won the local Chapter ISEF Competition for Cairo Governorate. Demiana was 17 years old, attending her second year at the Maadi STEM School for Girls, and the last thing she expected that day was for her team to win the first prize! Her comment, when she heard her project called out as the first prize winner, was as follows:

"I worked with my team on Seawater Desalination using Nano Technology. I was not expecting to win first prize in Intel ISEF. I want to thank our school who sponsored and financed our project and encouraged us daily telling us you will be able to build. Special thanks to USAID who funded and worked with us. Special thanks to the school principal who helped us, Mr. Mohamed Abdel Halim. The six of us worked every day on the project and stayed up long nights. We wanted to do something for Egypt. We know that Egypt will be built by us. God realized our dream. I hope we reach the finals and represent Egypt so that it gets built by us."

Demiana, who lives in Haram district in Giza governorate, graduated in June 2015 and is now in her second year at Nile University studying Business Administration. She reflects on her university experience by saying, "*I was studying dentistry at Faculty of Dentistry, Ain Shams University. After passing the first year and my father's death, I didn't find myself passionate about dentistry, so I shifted my career to study business at Nile University, majoring in Operations and Supply Chain, getting a scholarship from Bank Misr. From my experience as a STEM graduate, STEM is not only a school, but it is a way of thinking. Although I am studying business, I apply STEM concepts in my courses; as STEM taught me how to think in a certain way to solve a certain problem. Also, STEM helped me to get to know myself better and to find my passion.*

"A message to the new STEM graduates, it will be to FIGHT for their passion as life is not easy nor fair, however, a goal could be achieved by hard working, a positive mindset and having a detailed plan" – Demania Aiad Megala

As I am passionate about helping others, I am now the Community Service Representative of Nile University Students' Union and a member in Rotaract Cairo Royal Club; my role is to encourage the students to give back to society through making multiple activities. One of them is making educational sessions for students from low-income families and orphans. So, I am trying to widen the idea of STEM through studying in NU. When I graduate, I am looking forward to make my master's degree in Development and Sustainability and to work in NGOs or the UN; maybe as a project manager, to help in solving some of the community's issues."

Demiana was the master of ceremony at the STEM schools 2017 graduation. She was able to convey her message to the crowds of STEM students who attended and are embarking on their college education.

II. Project Accomplishments

The following is a more detailed account of the project's accomplishments achieved through five years of implementation (August 2012 – October 2017). These activity accomplishments are listed according to the project objectives.

Objective 1: Increase student interest, participation, and achievement in science and mathematics

Activity 1.1 Implementing an admissions system that is transparent, inclusive, and criteria-based

Prior to the start of ESSP, the Ministry of Education had just one open STEM school – the 6th of October STEM School that had 147 boys enrolled in Grade 10. To realize the shared goal of expanding the STEM School Model, ESSP supported the MoE to develop a more robust and transparent student application and admission process. This resulted in the ability of the MoE to keep pace with the increased demand for STEM education as more students and families learned about the new model schools. As demonstrated in the graph, student applications increased significantly in each year of the project. ESSP and the MoE kept pace with this demand by opening 7 additional schools in 2015/16 and two more schools in 2016/17.[4] In addition, there were a record 5,274 applications for the 2017-2018 academic year. The MoE is now fully managing this process and will need to continue to address the increasing demand with the number of STEM schools available (currently, just 11) and the increase in preparatory students' interest and preparation to enroll in STEM high schools.

Student Applicants, Enrollments and Acceptance Rate by Year

Academic Year	Number of Applicants	Increase in Applications	# of Enrolled Students	% Acceptance	Average Acceptance Rate
2014/15	1,589		657	41%	
2015/16	2,850	79%	1,468	52%	55%
2016/17	3,173	11%	2,341	74%	
2017/18	5,274	66%	2,753	52%	

To keep pace with the demand, the number of students enrolled in the expanding system has also increased each year. The average acceptance rate for the STEM schools is 55%. The total number of students increased dramatically starting from academic year 2015/16 due to opening 7 schools at once that year. However, in the two following years the dramatic increase in numbers of students enrolled subsided and aligned with the plateauing of new school openings. In the included tables, the total enrollment rates in each year are shown and the gender disaggregation is shown.

[4] The 11 STEM schools are located in the following areas: Giza, Cairo, Alexandria, Assiut, Luxor, Red Sea, Kafr El Sheikh, Dakahilya, Ismalia, Gharbia, and Menufia.

By the end of the project, girls' enrollment reached 46% of total enrolment. This was a notable achievement both because of the well-established gender gaps in STEM education and careers around the world coupled with the traditional gender norms in Egypt that make it difficult for many girls to pursue STEM fields or attend boarding schools outside of their communities. In addition to focusing on girls' access to STEM education, the school model also supported the enrollment of marginalized and underrepresented groups through targeted outreach and opening schools in governorates outside of greater Cairo to make STEM schools more accessible. This focus supported the MoE's goal to create a STEM School System that promotes academic excellence and achievement for all Egyptian students regardless of socioeconomic status.

Academic Year	# of Boys	# of Girls	% of Girls	# of Enrolled Students	% Increase in Enrolled Students by year
2011/12	147			147	
2012/13	243	119	33%	362	146%
2013/14	338	209	38%	547	51%
2014/15	357	300	46%	657	20%
2015/16	817	651	44%	1,468	123%
2016/17	1,292	1049	45%	2,341	59%
2017/18	1,486	1267	46%	2,753	18%

The total number graduated is 609 students including the number of graduates in 2016/17 (which is not included in our PMP since final data was not available at the time of reporting). At the time of this report, four cohorts have graduated from the 6th of October STEM School for Boys and three from Maadi STEM School for Girls. Since the schools add one grade level per year, the other STEM schools have not been open long enough to produce a graduating class.

Academic Year	October School Graduates	Maadi School Graduates	Number of Graduates	% Increase in Number of Graduates by year
2013/14	85		85	
2014/15	92	90	182	114%
2015/16	117	74	191	5%
2016/17	100	51	151	-21%
Total Graduates	394	215	609	

All graduates were accepted to universities and many succeeded in obtaining university scholarships either abroad or at many of the top private universities in Egypt, including Zewail University, Arab Academy for Science, Technology and Maritime Transport, Nile University, and the American University in Cairo (AUC). While the graduates show great promise, there have been challenges as the new education model has been introduced. As shown in the table, the Maadi STEM School for Girls has multiple students transfer out of the school (reducing the number of school graduates in each year) due to concerns about university acceptance and placement – especially in the uncertain time period when new STEM schools were opening, and parents feared that universities would not be able to accept all students from these new model schools. The Ministry will need to address the concerns of students and families and develop a clear plan with universities and the Ministry of Higher Education as the STEM School Network continues to grow.


Abdelrahman Mehina, class of 2014, at Illinois Institute of Technology in Chicago where he studies Biomedical Engineering

Activity 1.2 Preparing students for the rigors of STEM education and leadership roles

Throughout the course of the project, ESSP led Student Orientation and Leadership Summer Camps at STEM schools to prepare the new cohorts of Grade 10 students to succeed in STEM schools. This activity was essential to support students to transition to a very different type of learning environment from what they experienced in previous schools. Students spend two weeks away from home sampling the character and spirit of a STEM school for the first time and learn about the STEM education approach and its subjects. It is also a means to introduce new students to the use of the English language for STEM subjects and receive intensive English language courses that are tailored to their level of English fluency. The camp also provides presentations from STEM Unit members to explain the system and answer questions, and teachers introduce the importance of trans-disciplinary Capstone Projects and the assessment system. In addition, special sessions are dedicated to leadership and team building. These camps are also a good opportunity for students to decide if the rigor and alternative approach of the STEM schools are a good fit for their learning needs and goals (and indeed some students did withdraw their applications and move to other secondary education schools). Throughout the life of the project, ESSP worked closely with school principals, leaders, and teachers to lead the orientation process and to sustain it in the future.

Students attending summer camp at Ismaleya STEM School working on their Boeing Curiosity Machine project

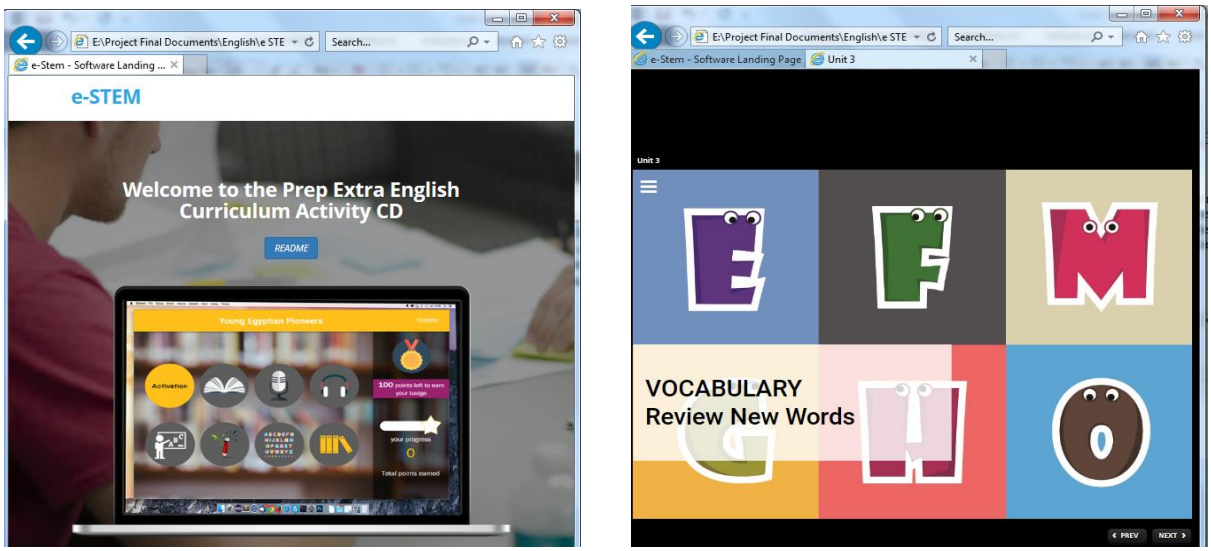
Activity 1.3 Outreach to Egyptian Preparatory Schools

ESSP developed extra- and co-curricular activities for preparatory students in Science, Mathematics, and English. It delivered Science Outreach activities "Developing Scientific and Technological Skills for Preparatory Students" to the Counselors of Mathematics and Science's offices, CCIMD, STEM Unit, and a group of distinguished MoE trainers who have previous experience in similar activities. This resulted in the development of a set of instructional activities including a teacher's guide, a set of resources for each activity, and a training guide for trainers for Grades 1, 2, and 3 of the preparatory stage. ESSP also developed a set of tools including a teacher observation rubric and a student assessment tool. The activities were piloted with all students in Grade 1 in 54 preparatory schools nationwide. Feedback was collected from teachers, supervisors, and other stakeholders who participated, and activities were modified accordingly.

In coordination between the Basic Education Sector, the Preparatory Education Department, the Counselor of Science and the head of the General Education Sector, the MoE approved the implementation of the outreach activities for two schools in one *idarra* in each governorate after the pilot. To support the rollout, ESSP held a planning workshop that was facilitated by a core group of master trainers in collaboration between the counselor's office, CCIMD, and PAT. To support the rollout as well, ESSP provided training and instructional material to all general and senior supervisors and all the trainers. ESSP also coordinated with the counselor's office and established a mechanism through which the senior supervisors delivered a soft and a hard copy to each school participating in rolling out the activities. The workshop resulted in an implementation plan for each governorate including specific details on how the teachers will be trained and how the activities will be implemented as part of the science curriculum

structure. ESSP supported the counselor's office in developing and implementing a follow-up plan to monitor the training of teachers in each governorate and visited sample schools to make sure that implementation is being carried out at the school level.

The English Outreach Program (e-STEM) was developed in ten units to cater to the English language needs of preparatory students to improve their ability to succeed in English-medium STEM high schools. The units were divided among the three prep grades and cover different English skills: listening, reading, writing, speaking, vocabulary and grammar to be taken at the student's pace as self-learning units. They were all developed on an interactive DVD, which provides students with immediate feedback for their listening, reading, and writing performance. Students can also elect to do self-evaluation for their speaking and writing, and are encouraged to seek support and more feedback from their English teachers on their writing and speaking output.



Screenshots of the Outreach English interface for preparatory schools

English supervisors and trainers-of-trainers (TOTs) received training and a manual on how to use the DVD and its content. Also, pre- and post-tests were developed and shared with the TOTs and supervisors to orient the English teachers to those tests and encourage them to use them in classrooms. A follow up plan was designed in collaboration with the English Counselor to get feedback from teachers and students on using the Outreach program throughout the 3 preparatory stages. A total of 55 supervisors and TOTs were trained receiving a total of 1,030 training hours; on average each received three days of training.

Objective 2: Strengthen the STEM school local initiative by developing an effective model of specialized high schools focusing on science, technology, and mathematics

Activity 2.1 Tailoring the STEM school to the surrounding community through school specializations

STEM School Boards of Trustees (BOTs) were established with support from the project in all schools. BOTs maintain a critical link between the students, their families, and the larger school community, providing insightful counsel to school leaders. ESSP focused on engaging BOTs with the STEM schools to increase their impact by having them focus on creating new

opportunities to strengthen school connections with local industries and businesses to enhance STEM learning and better the community. While the BOT structure is an established feature of public schools, some hurdles were faced in gaining full support and involvement of BOTs for STEM schools. These challenges included: several new schools that only had one grade enrolled were stopped from forming their BOTs until they are fully enrolled; and STEM schools, by MoE design, host students from across the region. Because their parents do not typically live in the same governorate, it is hard to assemble parents and interested stakeholders. To overcome these challenges, ESSP regional managers worked with the local MoE social workers to allow STEM schools not fully matriculated to form their BOTs and to hold BOT meetings at times when all BOT members can attend.


Luxor STEM students making good use of a BOT initiated partnership with the local youth center

ESSP trained social workers who in turn trained the BOTs on the importance of community assets and the asset mapping tool. This tool helps the BOTs and schools develop relationships with individuals and organizations who want to be involved with the STEM school in a variety of ways. The BOT training addressed: how to connect the STEM school to their community; plan for identifying potential partners, universities, and supporters; administer asset surveys; and work with STEM school social workers and leadership to transfer the work into learning opportunities for the STEM students. Understanding the importance of the STEM school's connection with the community, STEM school leadership prepared school improvement plans and action plans to include a section entitled "Community Engagement Plan" to guide outreach to local partners. Because of the training that took place in 2015/16, BOTs were able to secure community contributions to the school such as procuring some lab equipment and materials, printing paper, and photocopiers, as well as coordinating bus rentals for students' scientific trips.

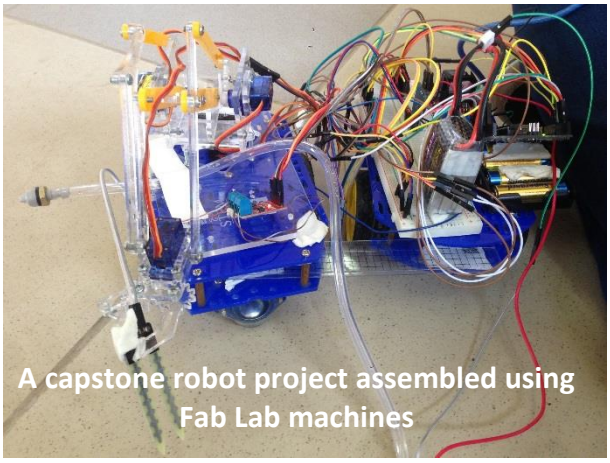
Activity 2.2 Providing essential educational infrastructure to support experiential classroom activities

During the project's life span, ESSP procured 11 complete Fab Labs with seven desktops for each lab. In addition, the project supported the schools with electricity infrastructure required for the installation process and required furniture for all labs. Five schools were provided with complete equipment and furniture for Physics, Chemistry, Biology, Earth Sciences, and Mechanics Labs, and the 6th of October STEM School was provided with missing items in its existing science labs. Furthermore, the project provided a total of 30,508 textbooks over the life of the project, and information technology infrastructure for the same five STEM schools to supply 18 classrooms (equipment included: data shows, desktop computers, and e-beams in each classroom; a printer on each of the school's three floors; all in one heavy duty photocopiers; and a number of access points, routers, and switches, along with network and


Daqahleya STEM School Science Lab

cabling, including fiber optics cables, according to the needs of each school). Finally, the project also provided a total of 1,854 student laptops for all schools.

As part of its curriculum design process, the project undertook a detailed process to identify the required equipment and tools to carry out activities and experiments according to the Biology, Chemistry, Earth Science, Physics and Mechanics learning outcomes. This process allowed the project to fully design a science laboratory commensurate with the science curriculum and resulted in the most efficient laboratory design. ESSP's procurement built interest among local vendors and distributors in the business opportunity these schools present and created a local market for school labs. It also standardized specifications that were adopted by the MoE to equip additional schools. Equipment was all purchased with a three-year warranty, and local suppliers are now more familiar with the equipment needed and are efficiently supporting lab maintenance locally.


A capstone robot project assembled using Fab Lab machines

Activity 2.3 Creating sustainable and mutually beneficial public private partnerships

Public-private partnerships (PPPs) were aggressively pursued throughout the life of the project. ESSP secured partnerships with local companies (i.e., the cement factory in Assiut and the Sokari mine in the Red Sea region) and national and multinational companies (i.e., Dow Chemical, Cisco, and Microsoft). Local partnerships helped in supporting the school's specialization, promoted primarily by ESSP's regional managers and the schools' BOTs, while the partnerships with multinational companies provided national notoriety to the schools, supported by ESSP's Cairo office. Additional partnerships were also facilitated by World Learning's home office with Boeing, Dell/EMC2, MoneyGram, and others. ESSP also successfully engaged several national and international partners in Egypt, such as e-Finance and the Schneider Group, to raise awareness about STEM schools and the school model, and several entities offered financial and in-kind contributions. Overall, the ESSP was able to forge partnerships between the schools and private partners and successfully meet the cost share obligations outlined in the Cooperative Agreement.

Activity 2.4 Organizing extracurricular activities that complement classroom content and school specializations

Extracurricular activities provide vital venues for the application of the skills and knowledge gained in STEM schools. In academic year 2014/15, ESSP organized 82 extracurricular visits for both Maadi and October schools after MoE approval. Students performed several visits including to universities such as Cairo, Ain Shams, AUC, British University in Egypt, Nile, and Zewail to receive support on their Capstone Projects. In 2015/16 ESSP organized 41 extracurricular visits for both Maadi and October schools after MoE


October STEM school students visiting Zewail University

approval. The Assuit, Alexandria, and Kafr El Sheikh schools organized 11 trips. ESSP supported the schools' BOTs at Daqahleya, Ismaleya, Red Sea, and Luxor to provide trips to local business to support student knowledge of STEM related jobs. In the 2016/17 academic year, the planning and organization of extra-curricular activities was fully transitioned to school leaders. In that year, ESSP organized only three extracurricular visits for both Maadi and October schools following MoE approval. The Assiut, Alexandria, Dakahlia, and Kafr El Sheikh schools organized 16 trips.

Also, from 2014-2017 students participated in eight competitions including ISEF, ISWEEEP, and the Genius Olympiad, in addition to Cisco International Day for Girls and many other local competitions where they gained national and international notoriety. Advanced positions were achieved for the first time in Egypt at Intel's ISEF, ISWEEEP, and Genius Olympiad, where STEM students participated and gained prizes, giving the students confidence in their studies and putting them on an international level with other international student peers.

Objective 3: Build the capacity of a highly qualified cadre of STEM professionals and provide opportunities for training and sustained, intellectually rigorous professional learning

Activity 3.2 Building teacher capacity to effectively implement STEM curriculum in the classroom

Based on a shared belief by ESSP, the MoE, and USAID of the importance of qualified teachers to the success of the STEM School Model, strengthening teacher capacity was one of the top priorities throughout the life of the project. ESSP held a series of intensive trainings paired with continuous coaching. The intensive training, termed the Professional Development Institute (PDI), was successfully conducted twice a year during the summer and mid-academic year break in each year of the project. The training included customized learning tracks for beginning, developing, and experienced teachers, school leadership, and MOE supervisors. The professional development trainings covered the full package of STEM training, which includes curriculum, assessment, pedagogy, capstone, Fab Lab, practical labs, the e-STEM program, and effective methods in coaching and mentoring.


Teachers during PDI lab practical training

PDIs include practical training for using laboratories, ensuring that teachers are able to understand and effectively implement practical laboratory experiments that serve the curriculum learning outcomes and to understand the potential role of lab-based inquiry in the curriculum. Such training will help teachers induct students into the culture of scientific inquiry with sound grounding in the practicalities of the laboratory. A total of 640 teachers[5] (73% male, 27% female) successfully completed in-service training of two days or more or

opment (CCMID), Professional Academy of Teachers (PAT), National Center for Education Research and Development (NCERD), and Technology Development Center (TDC).
the total trained per year is not the same as the total individuals trained.

received intensive coaching or mentoring over the past three years – this total exceeds the overall target of 450 teachers trained by 42%.

		Teachers Trained		
2014/15	Males	126	181	**640** *73% males and 27% females*
	Females	55		
2015/16	Males	210	289	
	Females	79		
2016/17	Males	348	470	
	Females	122		

The STEM training packages used during PDIs were certified by PAT. STEM teachers passed through these training packages to become PAT-certified STEM teachers. A total of 259 teachers are now fully certified by PAT (101 teachers certified in 2015/16 and 158 certified in 2016/2017) with more anticipated in the future as PAT continues to implement the PDI process.

Activity 3.4 Building school principals' ability to develop and implement strategic STEM action planning frameworks

ESSP supported school leaders in developing leadership skills that are unique to managing STEM schools in Egypt and beyond the normal expectation for a leader of a traditional public school. Unlike other public schools in Egypt, STEM schools typically have a school principal and an academic coach (deputy principal). While the former is responsible for the whole school operation, the latter is focused on the professional development of teachers, classroom observation, and providing technical support to ensure student academic achievement. In 2014/15, ESSP trained 27 principals and deputy principals but only 18 were hired by the MoE. In 2015/16, ESSP trained one group of 35 new leaders, and in 2016/17, 40 leaders were trained, making the total trained by the project to be 84 (some of the trainees were trained more than one time).

> "I worked in language schools for 17 years and in 2013, I moved to STEM. The experience of the past four years was more beneficial/rich to me than my previous years because I started seeing the education process and activities from a different perspective. Before, my concern was only my subject, and now it is the integration of all subjects and the Capstone Project. It is important now to be continuously updated, even the training provided is very important and beneficial." - ***Ahmed Abdel Maksoud, Principal***

ESSP US experts worked with school principals and deputy principals to develop School Improvement Action Plans. These plans provided a structured process for principals to reflect on the status of their schools and develop concrete steps to implement for improvements. All of the school leaders developed school-level action plans in the summer of 2016 during PDI and reviewed them in the spring of 2017 to see if they had achieved progress. Many schools, especially at the beginning of the academic year, witnessed the procurement of some lab equipment and materials, printing paper, photocopiers, and coordinating bus rentals for students' scientific trips as a result of these action plans.

Activity 3.5 Identifying and building the capacity of Master Trainers

ESSP not only prepared MoE officials and STEM unit members and built their capacity through PDI training activities, coaching and mentoring, but it also coordinated with PAT and the Central STEM Unit to identify and equip a group of additional trainers in the full STEM package of pedagogy, curriculum, e-STEM, assessment, capstone, fabrication labs, and lab practical. ESSP worked with PAT to update trainer certification requirements and standards,

and published the requirements on their websites. PAT announced the opportunity on its website, inviting candidates to apply for trainer capacity building workshops. Candidates selected the training areas they were interested in and submitted applications to participate. ESSP organized TOT events for the candidates, involving them in training material preparation, inviting them to assist trainers, co-facilitate, and facilitate training sessions with US experts. Over time, PAT Trainers started taking more and more responsibilities in delivering the training while US experts continued to coach and observe local trainers until the trainers were able to hold high quality training sessions independently. In addition to PAT trainers that applied to become STEM Master Trainers, ESSP also proposed (in collaboration with the STEM Unit and School Leaders) to PAT that the best performing STEM teachers would receive additional training to become PAT trainers. PAT reviewed trainer performance during the 2016-2017 academic year and reviewers wrote reports on each of the trainers observed to be added to their certification application portfolio.

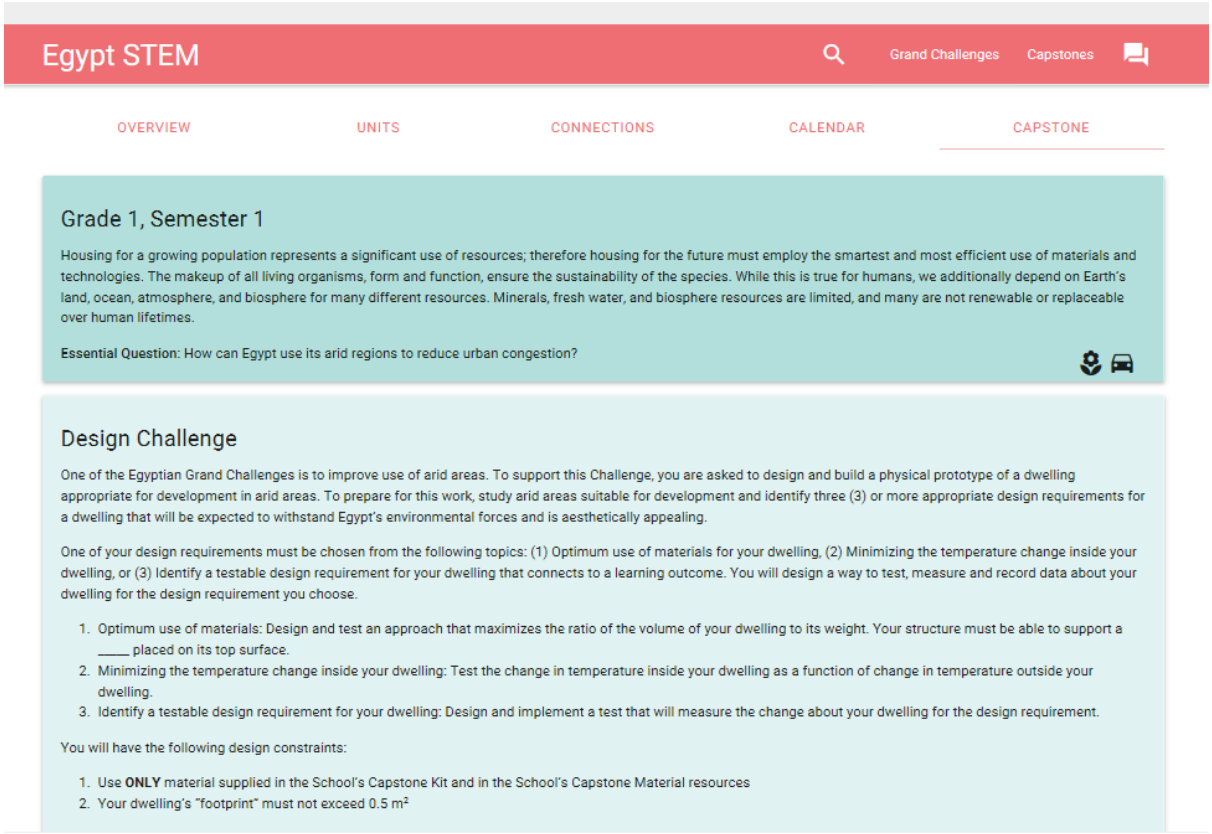
The project compiled a list of potential trainers in various topics who have the potential to carry out training in the future. A few of the trainers acquired the capacity to train in more than one topic. This table shows the number of trainers in each training topic. A total of 72 individuals from different governorates were trained by ESSP as trainers and will be an important resource for PAT and the Ministry to draw from to train new teachers in the full STEM package. In addition, 303 trainers were also trained for STEM science outreach to preparatory schools during 2015-2017. To ensure continuous support for local trainers, ESSP reviewed, finalized, and had PAT certify all training materials developed during the lifetime of the project. Complete sets of training material, including trainer, trainees, PowerPoint, and additional resources were compiled and classified by topic and target audience to facilitate its use by local counterparts. All materials were handed over to PAT and the STEM Unit and made available on the Blueprint for future use.

Training Specialty	# of Trainers
Pedagogy	12
Assessment	6
Capstone	7
Curriculum	17
Lab Practical	12
English	14
Leadership	4
Total	**72**

Activity 3.6 Creating a virtual STEM Professional Development Learning Platform

ESSP introduced several key innovations to support the establishment of the STEM model school network and to find easier and better ways for educators to work together and access knowledge and information. Notable innovations that were introduced include: 1) the curriculum app (which is featured under objective 4 below), 2) the capstone app, 3) the e-STEM Online English self-learning resources, and 4) the STEM School Blueprint. Each one of these innovations saved the project time and effort, facilitated the use of its resources, and made achievements more sustainable.

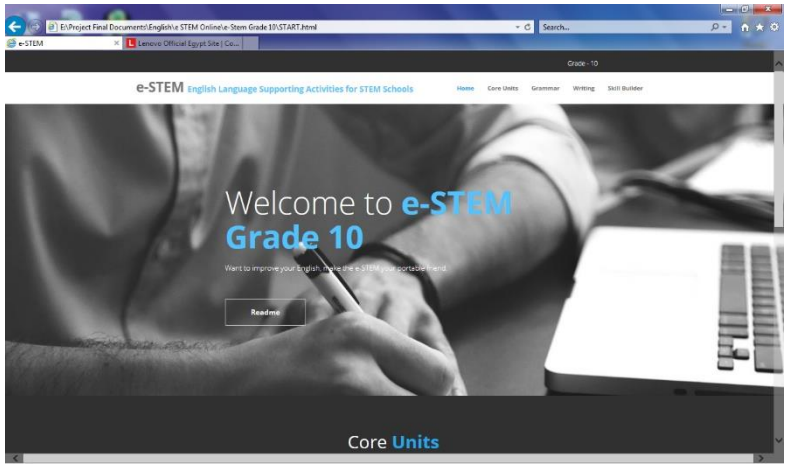
Capstone App: Capstones are trans-disciplinary projects that students complete in each grade level. The capstone app is used to post the capstone topics each semester and the essential learning questions the topics address, and it also describes the relation between the essential questions asked and the Grand Challenge (tying it to the STEM Curriculum and corresponding learning outcomes). The app also allows the students to access the cloud-based service app and answer capstone journal questions several times each semester to get their individual grade on the Capstone Project. The app enables students and teachers within each school to collaborate and also allows collaboration across schools, something that would not be possible without this tool. An example screen shot follows.

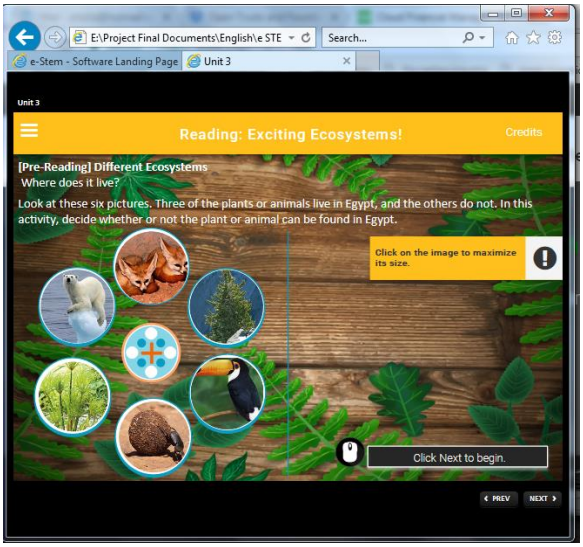


Examples of the types of Capstone Projects facilitated by the app include:

- The Grade 10 Capstone Project topic is sustainable housing. Through the project, students learn about the smartest and most efficient use of materials and technologies, especially in arid regions to reduce urban congestion.
- In Grade 11 students study how Egypt can address its water needs in a safe and environmentally responsible manner through the study of water's chemistry and physics, the students' use of water and the impact of the availability and quality of water to their health, reflecting on the social, economic and political systems around us.
- In Grade 12 students explore Communication through their Capstone Project with applications into electronic and electromagnetic communications among people.

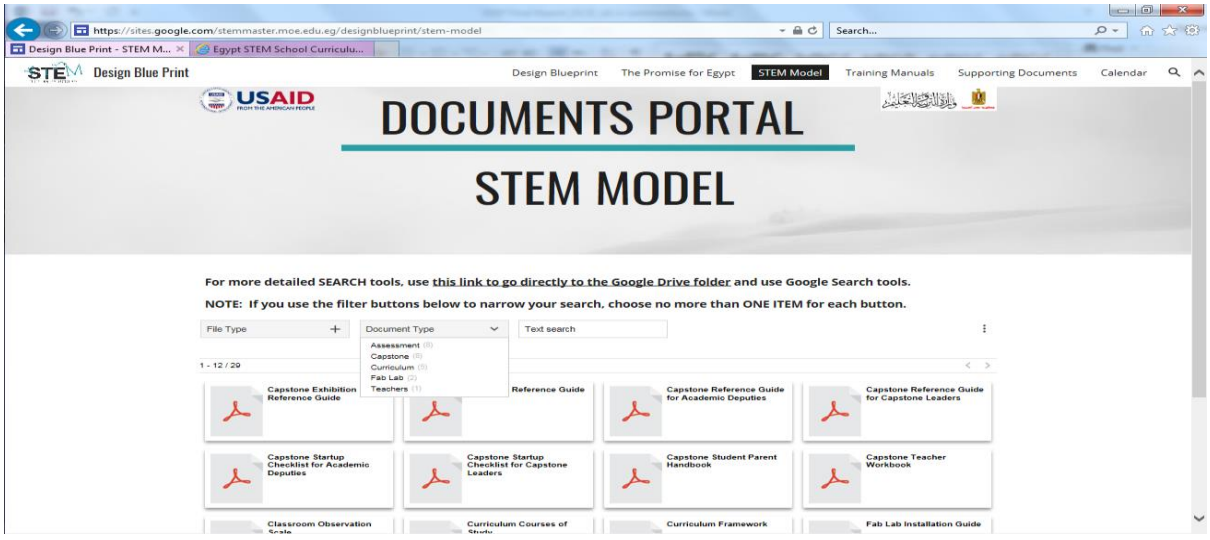
English Language Resources: The ESSP developed interactive English outreach content (available online and through an interactive DVD) that includes ten English language self-paced courses to help students in the preparatory schools improve their English language skills and qualify for STEM schools. Two other DVDs were produced by the project that include 20 self-teaching English skills lessons for Grade 10 and another 20 units for These units were supplemented with over 50 other mini-units that focus on certain in-demand topics, bringing the total number of learning units developed to over 100 units. With this compendium of English language resources, ESSP is leaving behind high quality material to support students to develop English for STEM language skills in STEM and preparatory schools.





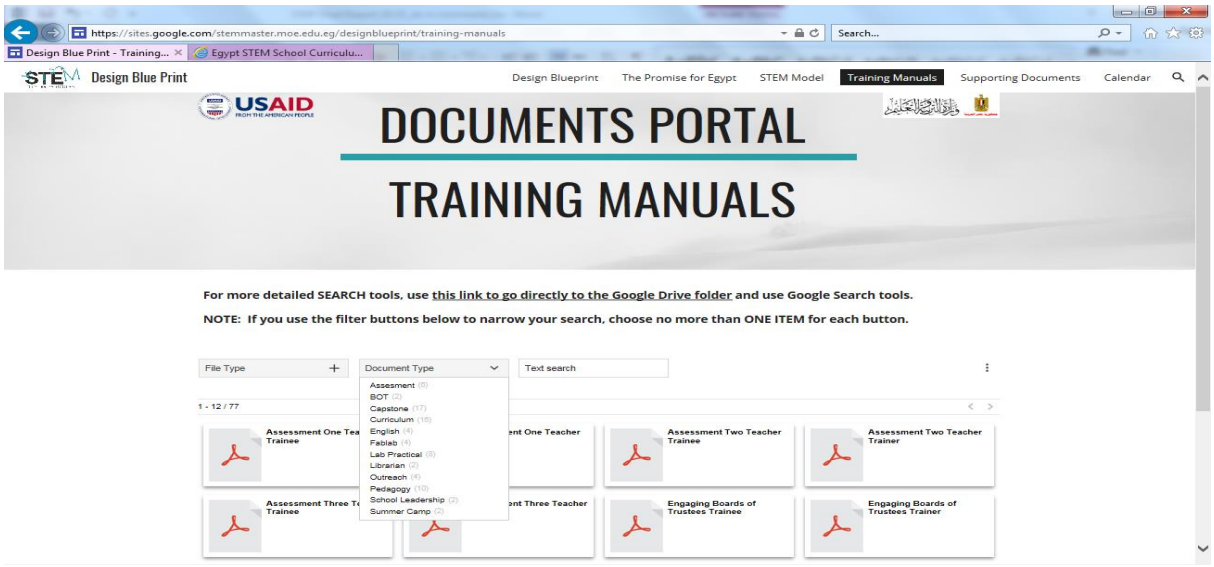
The snapshots above provide examples of the high degree of interactivity that results in students being more excited to learn and complete the units. To achieve this final product, ESSP tested different content and platforms, eventually employing several young Egyptian programmers who were able to deliver the level of quality and interactivity expected.

STEM School Blueprint: The Blueprint is an online resource designed to allow the STEM Unit, the Ministry, and its subsidiaries a platform to easily navigate and access the core design, training, and guidance documents for the STEM School Model. The goal of this platform is to create a single depository of information and documents for any Ministry official who wants to learn from what was done by the project, in order to expand the STEM model, replicate it, or add to it.



The Blueprint was developed to support the quality and fidelity of the Egypt STEM School Model as the MoE sustains current schools and opens new STEM schools in the future. It is expected that as new schools are added to the network, each will follow the same framework and curriculum as the 11 established STEM schools but with intentional school specialization processes that take advantage of local assets in each governorate.

Through a pull-down menu of choices, the user can search for the document, manual, or report they need and download it to examine its content and use it. The pull-down menu includes all the different sectors under which documents can be retrieved, such as curriculum, assessment, pedagogy, leadership, laboratory practical, English language, capstone, fab lab, etc. As the MoE continues to manage the Blueprint they will add new information, tools, or resources to maintain the central features of the model.



Objective 4: Strengthen MoE capacity at the systems and policy level to sustain and replicate these model schools

Activity 4.1 Designing school-driven curriculum

Designing and implementing the curriculum was critical to the success of the development of a sustainable and successful STEM School Model in Egypt. In Egypt, curriculum is typically based on a single textbook. However, diversifying student resources and encouraging internet-based research is one of STEM education's main principles, since it encourages students to access increased and more up-to-date and current information, and use a wider variety of resources for learning. This approach also offers the Ministry new possibilities to source its curriculum while still maintaining control over the common content that all students must master.

After a lengthy co-development process during the first two years of the project (which included live field-testing and refinement), the model's inquiry-based and transdisciplinary STEM curriculum was approved by the MoE in 2014. The curriculum was designed to prepare students with the intellectual and problem-solving skills to enter highly competitive universities throughout the world and ultimately to work toward solving Egypt's Grand Challenges. While this curriculum was fully customized to the Egyptian context based on the Egyptian curriculum standards, best practices such as the U.S.'s Next Generation Science Standards were used to ground the curriculum in a solid evidence-base for effective STEM teaching and learning. The curriculum consists of course descriptions that include: big ideas, learning outcomes, skills and concepts, instructional materials, typical evidence that would indicate student achievement of learning outcomes, connections to other disciplines, and connections to the Capstone Project of each semester. The STEM school curriculum contains 760 discrete learning outcomes across

three years that have been integrated, especially in the six STEM disciplines: biology, chemistry, physics, earth sciences, mechanics, and mathematics.

CCIMD established a STEM leadership team and specific discipline groups made up of university professors, STEM teachers, and CCIMD members. Through a collaborative effort with this MoE leadership team and ESSP, the *Egypt STEM Curriculum Framework* was developed. A process was then established for the discipline groups to receive training and to draft standards based on this framework. Standards were written by CCIMD through this process, reviewed by project experts, and revised as appropriate. In the final months of the project, CCIMD published the *Framework* and two sets of standards with indicators and links to the learning outcomes and the Grand Challenges for STEM subjects and Humanities subjects. The two curriculum standards books provide guidance to the Ministry for future improvement or expansion of the STEM curriculum.

Capstone Projects: Capstone Projects are the practical anchor to the STEM multidisciplinary integrated school curriculum, in which students apply concepts and skills from across the curriculum to real-world Grand Challenges with authentic assessments that focus on Capstone learning outcomes and the transfer of learning outcomes from other courses to the Capstone Projects. Capstones are Design Focused Learning, transdisciplinary curricula that use the Engineering Design Process (EDP) to engage students with real-world problems and issues. Projects more closely resemble the tasks and ambiguities inherent in real life and help to make schoolwork more relevant to students' lives, as well as more transparently linked to the skills needed to succeed in the working world, increasing the likelihood of the application of learning to new situations. Capstones allow students to integrate subjects and apply rigorous solutions that address real problems.

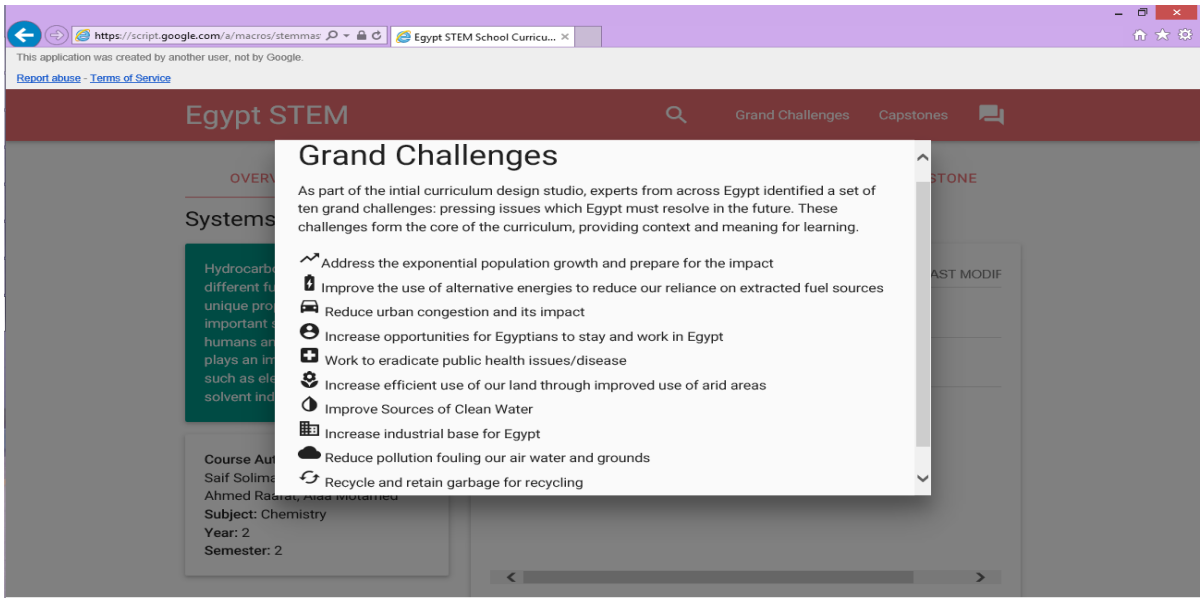
> "I was hesitant about joining the school but I learned more about the education system and that it has a Capstone Project and does not rely on memorizing, which I liked. The Capstone takes a lot of time and it applies all that we learn in all subjects. STEM opened, through the STEM community, a large number of competitions that I was not aware of, like the Math Olympiads where I travelled to Italy and achieved a bronze medal." - ***Mohamed Sameh, Student***

Curriculum Implementation and App: The STEM schools implement the project-based and integrated curriculum that provides practical resources to guide teachers to achieve learning outcomes through detailed lesson plans. CCIMD and the Counselors office, in addition to teachers in both founding STEM schools (6th of October STEM School and Maadi STEM School), were involved in the Design Studios and development of Curriculum 1.0 and its evolution into 2.0. This collaborative approach ensures that MoE officials can sustain, update, and improve the curriculum in the future.

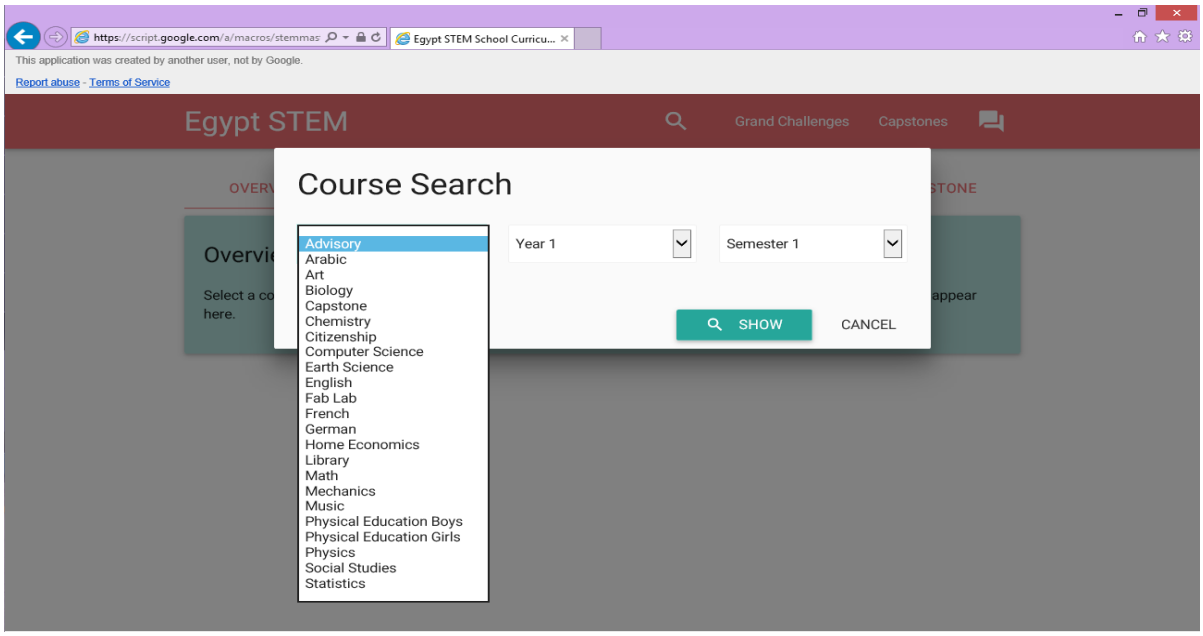
The project first piloted its Curriculum App in 2015, when it expanded its program to include seven additional schools. The cloud-based app is accessed by teachers using their mobile phones and handheld devices from anywhere whether in a STEM school or any other place where a cellular telephone connection is available. The Curriculum App supported wider and easier access to the curriculum available for all schools, simultaneously, regardless of their geographic location. It also allowed teachers to contribute to the content, by including an option to download and adapt, upload, and even comment on lesson plans, in addition to adding new ones. This approach supports the concept of peer-to-peer learning, enhances teachers

communicating with and learning from each other, and also professionalizes the role of teachers in actively framing what students will learn and how they will learn it.

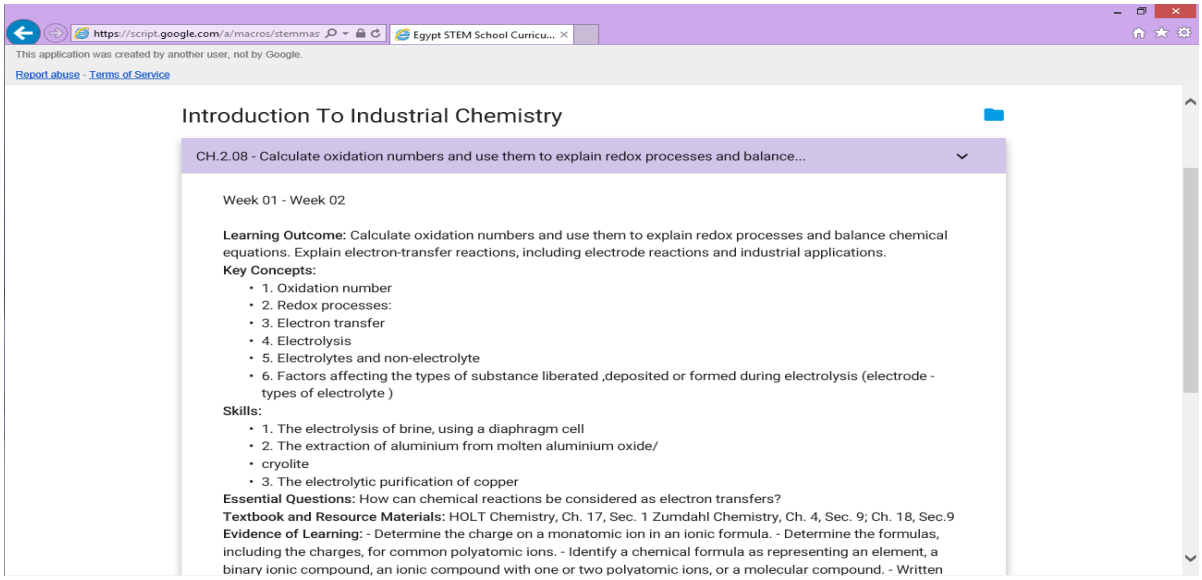
Although the use of a curriculum software often comes with challenges, using a cloud-based app not only provides a zero-cost alternative, it also creates the possibility to build up the app to cover more uses than curriculum. The project built another app for Capstone Projects; other apps also could be added on the same platform to interact with each other. Screenshots of different parts of the Curriculum App and a brief explanation are provided below:



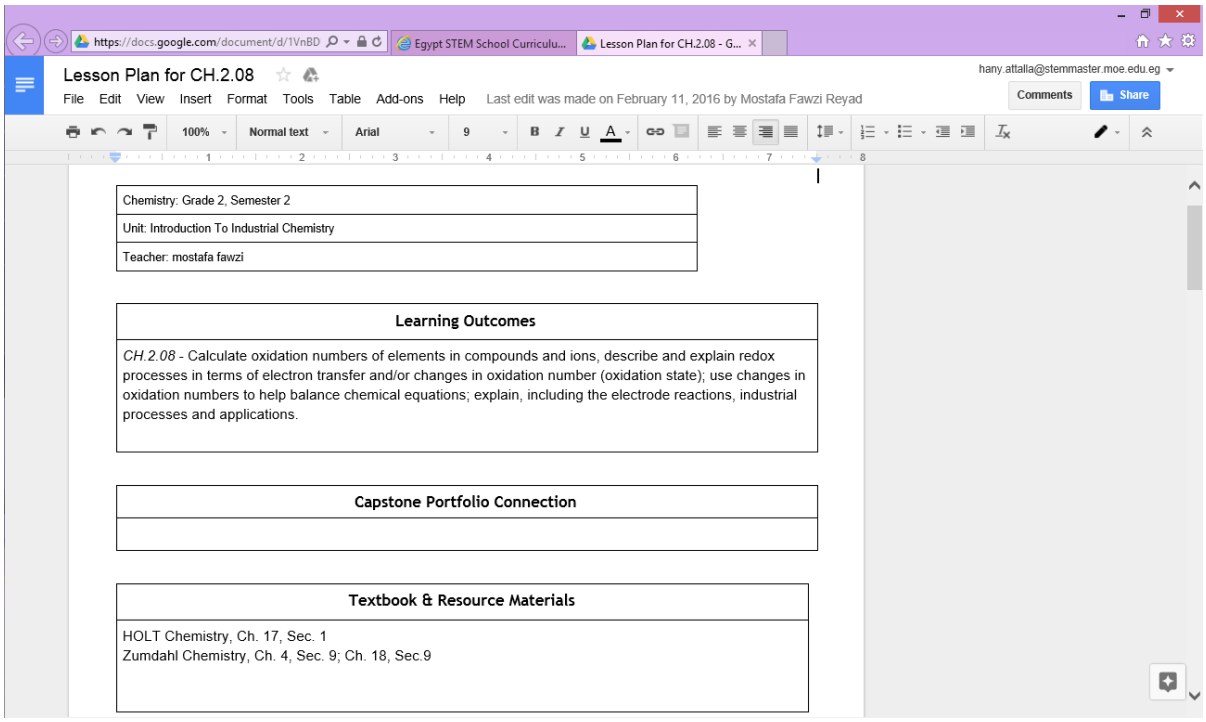
Based on the ten Grand Challenges facing Egypt, the curriculum challenges are listed on the curriculum app's first page with symbols indicating each one of them. These symbols are displayed on various parts of the curriculum app, indicating relevance.



By selecting the subject, year, and semester, teachers can quickly access the part of the curriculum they need.



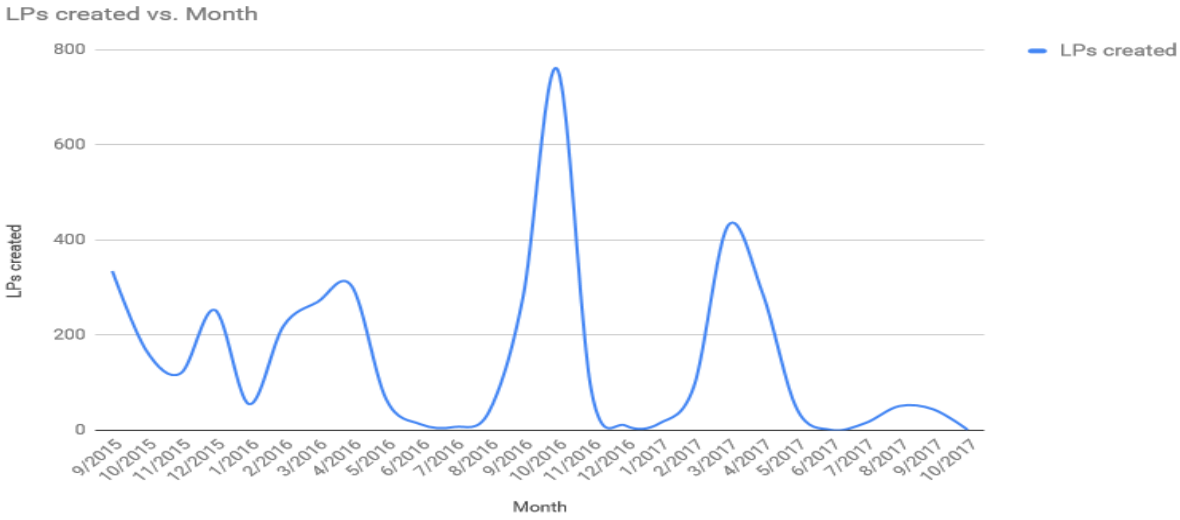
The lessons for each subject topic are listed. If a lesson is selected by the teacher, the curriculum app lists the key concepts of the lesson, the skills that need to be acquired, and additional resources.



Teachers notice the symbols denoting the Grand Challenges this lesson covers and view existing lesson plans or to author new ones. Teachers have a variety of lesson plans authored by other teachers to choose from and use in their classes, add input to, or just view in order to stimulate their own planning process. Each lesson plan includes the learning outcomes, the textbook references, and additional resources serving this lesson plan and the Capstone Project connection.

After the curriculum app was published at the start of the 2015/16 academic year, 1,846 lesson plans were created during that year, in all 24 subjects, at an average of 77 lesson plans per subject (average nine lessons per month). During the academic year 2016/17, 2,074 lesson plans were created at an average of 86 lesson plans per subject (average ten lessons per month). The following graph shows when lesson plans were created during the past two years by month.

It is evident that when the app was published at the start of the 2015/16 academic year and throughout its duration lesson plans were being created. During the 2016/17 academic year, the two spikes in lesson plan preparation were at the start of each of the two semesters. September and October are the months that witness the highest activity of teachers adding lesson plans, followed by March and April when the Spring semester starts.



Activity 4.2 Developing comprehensive national assessment instruments aligned to STEM curriculum

A major strategic objective of ESSP was to offer a viable alternative to the traditional *thanaweya amma* exam to certify student learning for college acceptance. In 2013 the MoE issued Decree 308, which established the Assessment Matrix. That matrix outlines multiple measures used to determine students' successful completion of Grade 3–including weighted scores for the university readiness test, the test of concepts, student performance in Capstone Projects, and student attendance. Securing approval for this alternative assessment approach at the highest levels of the Ministry of Education and relevant stakeholders was a major ESSP accomplishment. The University Readiness Test (URT) and Test of Concepts (TOC) both have been ensconced in MoE decrees outlining the STEM School Assessment System. Egyptian universities, including the most competitive programs of private universities, have accepted students into their colleges based on the new STEM School Assessment Matrix, which is now equivalent to the *thanaweya amma* exam. Even prestigious universities such as Zewail University and the American University in Cairo adjusted their student acceptance standards for STEM students, thus acknowledging that the URT is more valuable than the *thanaweya amma* exam.

University Readiness Test (URT): Since students in the STEM schools have different curriculum standards and learning outcomes from those implemented in the traditional Egyptian public secondary schools, it was imperative to develop an assessment system that is aligned with the new curriculum. ESSP developed the University Readiness Test (URT), a reliable, valid, and fair test for measuring students' aptitude and readiness to enter university following the completion of their STEM high school studies. Through several consecutive workshops starting in July 2015, MoE counselors in Science, Math, and English, in addition to NCEEE officials supported by project US assessment experts, were trained on the URT. The MoE Counselors produced approximately 1,780 items for the MoE's item bank (635 English, 425 Math, 185 Physics, 175 Chemistry, 185 Biology, 175 Earth Science items). The URT was

piloted at the end of academic year 2015/16 at the 6th of October and Maadi STEM schools, and adjustments were made to improve the test based on this pilot testing. Full implementation of the URT took place at the end of academic year 2016/17 at the same two schools (the only STEM schools that had Grade 12 students enrolled at the time).

While the NCEEE officials have been trained by ESSP and introduced to the URT process and its use, the MoE counselors of Science, Math, and English are the custodians of the item bank and the sole owner of its items due to the test's high security requirements. MoE counselors were also trained on FastTest and Iteman software packages to support their continued maintenance of the test and item bank. FastTest is a computer-based comprehensive and configurable assessment item banking and online testing ecosystem supporting reliability and validity, while Iteman is a software program that provides detailed item and test analysis reports to help testing programs evaluate the quality of test items, and tests as a whole. Along with the Remark Software package that was deployed by ESSP in all schools and at the Ministry with accompanied training, this package allowed schools to mark multiple choice question tests through scanning, which saved time and rendered accurate results to all tests used at the mid-term and end-of-term levels. The FastTest, Iteman, and Remark suite of software provided a complete computer-based solution to assessment to the Ministry and to the STEM School Model.

Test of Concepts (TOC): Students often come into STEM schools with a set of misconceptions, and as they progress through their STEM education such misconceptions are progressively built upon. To effectively teach science and math, it is vital to ensure that students' knowledge is sound and to modify any misconceptions that may compromise future student learning, following the logic that misconceptions lead to ever-increasing issues with learning as students continue to build their knowledge on common misunderstandings throughout their college education.

ESSP experts carefully reviewed existing concept inventories, the alignment between university level concepts required for success, and STEM school learning outcomes and agreed that Tests of Concepts (TOC) are the only means to detect common misconceptions and ensure that STEM students, during the course of their STEM studies, are able to correct them. TOCs also gauge the student's proficiency in specific science and math subjects, since the URT covers math and science generally. A Guide to Developing and Writing Test of Concepts manual was provided to the MoE. Training workshops were held to prepare Egyptian content and assessment experts to take over development and refinement of the TOCs. Training workshops were provided by ESSP US experts to the MoE's Science, Math and English counselors and NCEEE officials. Training workshops also included subject supervisors at the 11 *mudireyas* where schools are located to familiarize local authorities with the TOC and train them on how to prepare items.

> "Coming to the STEM school was a big move for me. We do not spoon feed information to the student but bring up the student as a researcher. Mathematics is the base of every science. I never saw the application of mathematics before in schools until I came here. Here is the first time for me to see a mechanics laboratory. I did not even see it in my university." - ***Bassem Mohamed El Desouky, Math and Mechanics teacher***

PARLO: The Proficiency Based Assessment and Reassessment of Learning Outcomes (PARLO) system, developed by 21SPTEM with funds from the National Science Foundation was leveraged for adaption by the MoE for use in STEM schools. Throughout the project,

ESSP US experts worked closely with the MoE to build their capacity to manage PARLO. Based on this training, Egyptian STEM school teachers and MoE officials can identify a set of high value learning objectives and determine learning measurement indicators and rubrics to determine when their students reach proficiency in each objective. The PARLO system improves students' performance and attitudes by providing students with high quality feedback and multiple opportunities to demonstrate mastery within a curriculum-independent standard-based assessment system. Through PARLO's teacher-friendly software tool, the "PARLO Tracker", students and parents are able to gain online access to student proficiency ratings. By providing these stakeholders with detailed information on the exact concepts and skills they are struggling with, they are able to work independently or with teachers to ensure mastery of those topics.

PARLO has also been deployed in all schools and the system uploaded onto the Ministry server so that the Technology Development Center (TDC) is able to manage and control its operation. PARLO is now functioning in all schools with capacity built at TDC and in schools through several training sessions to respectively manage it and proficiently use it. Finally, manuals have been provided to guide management and administration of the Tracker software and for school leaders and teachers.

Activity 4.3 Building the capacity of the STEM Model Schools National Board

ESSP started its work in close collaboration with the National STEM Board, which substantially helped the establishment of the STEM schools, pushing for their recognition at the Supreme Council of Universities and later for public acknowledgement and notification. Until early 2014, the STEM Board had best served the cause of the STEM schools and the project, but after the schools' anchored establishment it was clear that a technical arm within the Ministry needed to take charge of the schools to manage their activities and gain the know-how necessary for their technical operation and further support. In April 2014 the Central STEM Unit was established to assume this role. Later on, the Executive Committee within the Ministry needed to support the work of the Unit by taking important higher decisions to support its activities. During the last two years of ESSP, the Executive Committee provided tremendous support to ESSP and the STEM Unit to help sustain the STEM model and spread its expansion nationwide in 11 governorates.

The STEM Unit is made up of the three MoE counselors' offices of Science, Math, and English in addition to active representation from PAT and the MoE Centers of NCEEE, NCERD, and NCEEE. This unique union within the STEM Unit, supported by the Executive Committee at the highest level of the MoE, guaranteed the success of the model and its eventual spread nationwide. The Central STEM Unit played an instrumental role since its formation in 2014 in carrying out a number of key STEM tasks including capstone management, training, assessment, and follow up with schools. The Unit has a number of extremely qualified STEM experts who are now able to sustain the model beyond ESSP. Before the end of the project, ESSP coordinated with the MoE's Executive Committee to form a transition team including qualified experts who were part of the creation of the STEM model and representatives of the key relevant entities like PAT, CCIMD, NCEEE, and NCERD. This effort resulted in a new ministerial decree for STEM Unit structure and a smoother transition from ESSP to the Unit. The STEM Unit is now tasked with the responsibility of sustaining the STEM model within the Egyptian context and expanding the number of schools as per the request of the Ministry.

Objective 5: Support the MoE in the upgrading of science and mathematics curriculum standards, student assessments, and teacher preparation for mainstream schools

Activity 5.1 Capturing best practices in STEM education

ESSP drew upon international best practices to create a STEM model that integrates and builds on practices that have proven successful to advance STEM education. ESSP prioritized contextualizing these practices to the Egyptian context, the MoE structures and processes, and the local culture in order for the STEM model to become sustainable. To institutionalize this model, ten ministerial decrees and other Executive Committee orders were issued to establish policies to entrench STEM within the Egyptian public education system. For each of these decrees and executive orders, an adaptation of the existing system had to occur. These were done in addition to other executive orders issued by relevant governmental authorities such as the Supreme Council of Universities to allow for the students' acceptance in college or for PAT to certify trainers in the new approach. A summary of these decrees includes:

1. #369 dated 11/10/2011 for the Establishment of STEM Schools System.
2. #202 dated 21/4/2012 for Granting Egyptian secondary school certificate in science and technology to STEM schools.
3. #238 dated 3/7/2012 for High School Graduation Certificate for STEM schools (canceled and replaced later by #308).
4. #382 dated 2/10/2012 for Admission System to STEM schools.
5. #308 dated 27/8/2013 for High School Graduation Certificate for STEM schools.
6. #30 dated 16/1/2014 for the establishment of the STEM Board.
7. #172 dated 14/4/2014 for the establishment of the STEM Unit.
8. #313 dated 24/8/2015 for the establishment of Local STEM Units.
9. #219 dated 4/8/2016 to reduce STEM schools' minimum acceptance grades from 98% to 95% to expand the pool of STEM school applicants.
10. #136 dated 2/4/2017 to amend the Ministerial decree for a new structure of the STEM Unit.
11. And Executive Committee order dated 5/7/2015 for hiring teachers from outside the Ministry pool.

As listed, three decrees were issued before the official ESSP project started and during the previous technical assistance project implemented by World Learning and partners, and eight decrees (including an executive order) were issued during the life of the project.

Activity 5.2 Building the capacity of the CCIMD and NCEEE to apply Egyptian STEM best practices to mainstream science and math curricula

The CCIMD and NCEEE, in addition to other MoE entities like the science, math, and English counselors' offices, PAT, NCERD, TDC, and the STEM Unit, which is composed of members of most of these entities, have all been the main recipients of capacity building and know how transfer since the start of the project. ESSP trained 503 (341 males and 162 females) Ministry counterparts for a total of 44,564 hours.

CCIMD played an integral role in being the main counterpart for the curriculum development across STEM subjects, humanities, and English language. The CCIMD head championed, with ESSP US experts, the development of the STEM curriculum standards and issued two

compendiums to document the process and product. Not only will this product best serve the Ministry and the STEM Unit by providing guidance for any further improvement or modifications to the curriculum, but it will also serve as a reference for anybody within the CCIMD or the Ministry who is interested in transferring parts of the science, math, or English curriculum to the mainstream within the secondary stage education system.

The counselors' offices have been a main counterpart due to the head counselors' belief in STEM education. While the NCEEE has participated in the relevant training and workshops, they have not been a custodian of the STEM exam due to the concern for its test and item bank security. NCEEE, nonetheless, attended the assessment trainings and workshops and was made aware of ESSP's developments in the assessment of the STEM model. As a result, the capacity of the NCEEE and the MoE's counselors' offices are now built to the extent that allow them to not only fully implement the STEM model but to also take parcels of the STEM assessment system and adopt them for mainstream public schools using what they learned and the resources and software packages they were trained on during the project.

III. Project Monitoring and Evaluation

ESSP's Performance Monitoring Progress (PMP) includes indicators that monitored the implementation of key activities, outputs, and outcomes. ESSP's PMP is built on 20 indicators that correspond to the activities of the project's five objectives. ESSP met or exceeded the majority of its indicators; for the indicators where the project fell short of its target the margins were very small.

- Indicator 1-d: the percentage of students achieving minimum passing STEM grade. In this indicator, ESSP achieved 96% against a target of 98%.
- Indicator: 2-c: the number of sustainable and mutually beneficial PPPs created and approved by the MOE. In this indicator ESSP achieved 18 partnerships, and the target was 20 partnerships.
- Indicator 2-d: the number of extra-curricular activities organized to complement classroom content and school specialization. In this indicator, ESSP organized 171 activities and the target was 190 activities.
- Indicator 3-a: the percentage of STEM teachers hired according to teacher recruitment model. In this target, ESSP supported the MoE to establish the teacher recruitment model, but the MoE only achieved 53% against the target of 72% teachers hired according to the model.

For each of the indicators where ESSP was not able to achieve its target, the PMP explains the reasons and justifications in detail. A detailed description of final data can be found in ESSP's Year 5 Annual Report.

It is important to note that the project followed a different PMP in the first two years of the project. The first PMP was approved by USAID and collected data on a different set of indicators during that period, such as the number of STEM model schools effectively using reformed admissions systems and the number of students participating in English and Leadership Summer Camp, among other indicators. In fiscal year 2014/15, USAID asked for the project's PMP to be updated and to comply with USAID's Performance Indicator Reference Sheet. In collaboration with USAID, World Learning changed the indicators to be measure project progress. This put ESSP in a position where two sets of unrelated data were collected; however, the last data set is the one that witnessed most of the project achievements. This is why the data showed on the project's PMP and its final report cover only 2014/15 until 2016/17

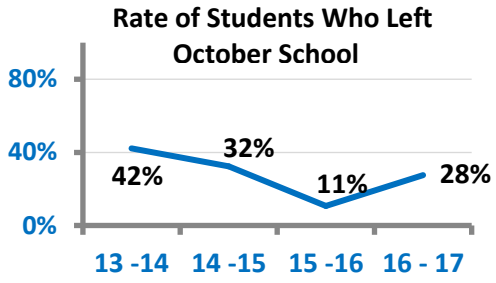
and not its first two years of implementation–because no relevant data was collected during that period.

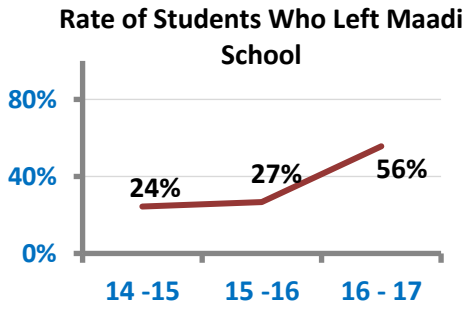
IV. Challenges and Responses

The ESSP project period between 2012-2015 was marked by the fluid political environment and continuous changes in Ministers because of changing presidential administrations. In addition, in Year 3 ESSP was instructed by USAID to wind-down activities and this resulted in a delay in implementation, but the project was able to resume activities and continue following this period. In addition to these events, the ESSP team encountered many challenges during implementation, but at each step the team was able to use a collaborative approach and emphasized open communications, primarily with USAID and the MoE, to identify solutions and collectively arrive at workarounds for the problems. Below is a list of some of the major challenges that will continue and recommended responses.

Challenge: Numbers of student applicants and enrolled students showed a steady increase and a particularly sharp surge when seven schools opened in academic year 2015/16. But in the same year a decline in Grade 12 enrollment in the Maadi STEM School for Girls and the 6th of October School for Boys started due to parents' and students' uncertainty of university acceptance after the number of schools increased.

Response: The Ministry should work with the Supreme Council of Universities to resolve this challenge and address student and parent's perceptions. This type of communication is needed to maintain the student and parent demand for STEM schools.





Challenge: The Central STEM Unit played an instrumental role since its formation in taking over the project's activities; however, the departure of a couple of its key members posed a challenge to the sustainability of the Unit's work. The Unit has a number of extremely qualified STEM experts who can help sustain the model if all expertise is harnessed within a stable structure that allows for the continuity of the Unit's services to the schools.

Response: ESSP coordinated with the Executive Committee to form a transition team including qualified experts who were part of the creation of the STEM model and representatives of the key relevant entities. The Executive Committee may again be sought to regroup the Unit and bring back essential expertise to its formation.

Challenge: Although the number of teachers applying to work in STEM schools has increased during the project period, the population of applicants has not always included an adequate number of the most needed specializations or met the higher required qualifications. The expansion of STEM schools from 2 to 9, and then to 11, increased the burden on in-service project training to help teachers reach the essential skills and knowledge needed to work in a STEM school.

Response: ESSP always provided emergency training to teachers who were hired at the last minute before the school year began because of a severe deficiency in teachers. ESSP continuously provided these teachers with on-site and virtual coaching in addition to including them in the regular PDIs during mid-year and summer breaks. ESSP also coordinated with PAT and MoE to spread the announcement of STEM schools and the need for teachers using various methods including websites, social media groups, and involving the local supervisors to encourage qualified potential teachers to apply. More efforts need to be exerted to ensure the availability of qualified teachers, especially when more STEM schools are opened in the future. In addition, continued attention to identifying and certifying a larger pool of qualified Master Trainers is needed to continuously provide support to STEM school teachers.

> "I was impressed from the start because as soon as I applied and was selected, I attended a training workshop and this was a surprise because the ten years I spent in public schools before, I never received any training. I took my move as a challenge; to move from an education system that is based on memorizing to a system that is built on students gaining skills that will help them for the rest of their lives. STEM education also introduced me to something that is very dear to me and that is my participation in the curriculum design workshops, which made me feel I am part of the curriculum and my opinion is heard." - ***Noha B., English Teacher***

Challenge: Since its start, the project has been managing the operating costs of the schools. This includes consumables for laboratories such as chemicals and glassware, as well as the administrative items such as toner, copying paper, and other stationery. ESSP has also been supporting the purchasing of raw material for Capstone Projects and the Fab Labs every semester for all schools. The transition of these services to MoE needs to ensure no interruption to these services to help continue with the schools' success.

Response: Making available a school budget is key in order to move requests for materials from the central Ministry to the school level, where possible delays can be better managed. Schools should have the budgets to make these purchases against preset guidelines and specifications set forth by the project.

V. Impact, Sustainability and Recommendations

Impact: ESSP succeeded in the main goal of introducing a quality STEM School Model into Egypt's public education system and building the capacity for the MoE to use the knowledge gained to improve mainstream science and mathematics education. Through the model a new curriculum and assessment design, practical extracurricular activities, and partnerships with private sector companies like Cisco, Intel, Google, and Microsoft were introduced as examples. In addition to these core deliverables, the impact of the STEM schools was also demonstrated in less measurable but no less important ways: by students from international schools applying to join the MoE's STEM schools; by Grade 10 STEM students entering international competitions and achieving advanced results; by Grade 12 STEM graduates being recruited by private universities in Egypt and being offered scholarships; by students applying to universities abroad and not only getting accepted but also advancing in their first years of college in the US and other countries; and by other MENA government ministers expressing

interest in the model for their own countries or interest in sending their own students to Egypt's STEM schools. The first cohort of STEM school alumni will graduate from college in the summer of 2018, and tracking their success and careers after graduation may offer a clearer idea of how these students will move on with their professional lives and how their STEM school education may affect their career choices and development.

Sustainability: Through concentrated effort and collaboration, the MoE has the policies, structures, and capacity to sustain and expand the STEM Model School Network. The MoE's passion and dedication for continued improvements will enable sustainability. A big part of the model's success relies on important elements like information technology and connectivity in schools, access to Fab Lab and Fab Lab managers' proficiency in using its equipment and teaching students, and the robust upkeep and access of the cloud service where the project resources like curriculum, capstone app, Blueprint, and PARLO reside on the TDC's server. Although ESSP trained MoE personnel on the maintenance of these systems, continuous support is required so that these systems do not suddenly cease providing the schools with the services they need. To maintain these established and operating systems, MoE will need to identify and support well trained and experienced personnel who can understand the systems' needs, troubleshoot problems before they occur, and make sure that their operations are reliable and responsive.

Recommendations:

- ESSP encourages the MoE and the STEM schools to track the progress of the students and maintain close relationships with alumni so that the full impact of the secondary STEM education is measured and felt.
- The turnover of some Ministry personnel trained by ESSP and the short duration of experience for some others leave information technology, Fab Labs, and cloud/server systems in jeopardy and may impede the proper operations of the schools and the STEM system. Project personnel proficient in these three systems were trained under the project and their expertise is now available after the project ended. We recommend that these personnel be part of the Central STEM Unit so that they can help the Unit supervise the schools' operations, provide support when needed, and resolve problems under the direction of the STEM Unit.
- To ensure the sustainability of the project and its outputs and the STEM Unit having continuous access to its resources, ESSP not only built the capacity of its various counterparts at different levels through extensive training, but it also shared its documents and manuals on the online Blueprint and in PDF format for all who have access to view and use the documents and manuals beyond the project life. Training workshops were held for MoE and STEM Unit personnel to proficiently use the Blueprint. Another editable copy of the documents, manuals, and project reports was also handed to the STEM Unit leadership in a soft format for the Unit members to edit and use as they see suitable. This will allow the Ministry to add and improve on the project's work anytime in the future using these documents as a base.

Spotlight on Successful STEM Students: Afnan

The win that Demiana and her team achieved at the Intel-ISEF 2014 competition opened the door for STEM students to participate in local and international competitions and win advanced prizes. Afnan, a colleague of Demiana, from Zefta Markaz in Gharbeya governorate, attended Maadi STEM School from 2012-2015. She presented her Capstone Project to the Conference of Arab Education Ministers in Sharm El Sheikh on January 28th, 2015. In her interview that day she was asked why she wants to participate in international competitions like ISEF, and she replied with the following:

"So, why we are in Intel, because Intel ISEF produces a large opportunity to spread our ideas all over the world and we hope that we will get a high place in our category. We believe that if you can dream with that you can believe it and you can do it. That is what we call "Day Dreamers" and it is the mission of our school, STEM school."

More than a year after Afnan's successful Capstone Project presentation, she was awarded a full scholarship by the USAID-funded STEP project to pursue her undergraduate degree in the United States. ESSP interviewed her and her colleagues that day, and Afnan stated:

"My name is Afnan, from Gharbeya governorate. I am going to study this August at University of Kansas. I will study engineering physics and specialize in electromechanical systems. I plan to finish my four-year bachelor degree there and return to work with a company in Egypt until I build my experience. Then I start my private business. God willing, I may be able to do something good for Egypt."