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Fostering Giftedness and Creativity: Implementing Engineering by Design in Kuwait

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feature article

fostering giftedness and creativity:

implementing Engineering byDesign™ in Kuwait

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by Nathan Mentzer, DTE, Philip A. Reed, DTE, Meshari Alnouri, and Mohammad Barbarji, DTE

In 2010, the Kuwait Foundation for the Advancement of Sciences (KFAS) founded the Sabah Al Ahmad Center for Giftedness and Creativity (SACGC). The Center supports Kuwait's Strategic Development Plan and the country's commitment to nurture gifted and talented youth. The Center also supports the work of talented adult inventors and entrepreneurs by providing financial support and facilities to assist with product development and the patent process. In early 2015, the International Technology and Engineering Educators Association (ITEEA) was approached by General Manager Dr. Omar Al-Bannai and Curriculum Coordinator Mr. Meshari Alnouri from the SACGC after reviewing other comparable programs to support innovation and design education at the Center. ITEEA, through the implementation of the Engineering byDesign™ (EbD™) curriculum, has since partnered with SACGC to further the mission of the SACGC: Contributing to build a Kuwaiti society that fosters giftedness and creativity. Prior to this partnership, technology and engineering education was not a part of public primary or secondary education in Kuwait. Kuwait teacher education programs do not prepare technology and engineering teachers. The relationship between the SACGC and ITEEA has founded technology and engineering education as a discipline in Kuwait and has drawn math and science teachers together in partnership to implement integrative STEM education for the first time.

ITEEA's STEM Center for Teaching and Learning™ (STEM CTL™) conducted an on-site visit in July 2015 to provide facility evaluations, staff professional development, implementation strategies, and recommendations for curriculum modifications (Mentzer, Harms, & Reed, 2015). The ITEEA consultation team (Dr. Nathan

Figure 1a. Neusaiba School (Al Asma 2015).

Figure 1b. Hallima School (Jahra 2015).

Mentzer, Mr. Henry Harms, and Dr. Philip Reed) toured the Fab Lab Kuwait (http://fablabkuwait.sacgc.org/) and six middle schools: two in Kuwait City (Neusaiba & Abdulla Hassan), two in Ahmadi (Sawda & Ahmed Meshari), and two in Jahara (Halima & Abdullatif). The tours included one school for boys and one school for girls in each location. The schools that were visited were comprised of basic rectangular classrooms with individual desks and chairs as well as a mixture of projectors, LCD panels, and whiteboards (Figure 1b). Each site also contained one or two computer laboratories with approximately 20 PCs, projectors, and a SmartBoard. The Neusaiba girls' school had the unique opportunity of utilizing a science laboratory including six lab benches with water, gas, and electrical utilities as well as storage cabinets and a mixture of supplies for Earth science, physics, and biology instruction (Figure 1a).

During the 2015-2017 site visits, the team was hosted by Mr. Meshari Alnouri, who facilitated the implementation and upkeep of the Engineering byDesign™ curriculum for the SACGC. The STEM CTL™ team met with SACGC administrators and English, science, and mathematics coordinators. The six subject supervisors reviewed the curriculum and shared examples of similar technological design activities that had recently been conducted within the gifted program. The SACGC administrators also spent a considerable amount of time educating the STEM CTL™ team on Kuwaiti cultural and traditional values. The ITEEA consultation team drew many parallels to the middle school *Exploring Technology* and *Inventions and Innovations* courses through tours around town to view architecture and discussions on water, utilities, solar energy, climate, and technological and engineering challenges that impact Kuwait. Discussions with the program administrators, as well as the mathematics and science supervisors, confirmed that these topics should be contextualized in these EbD™ courses.

EbD Implementation in Middle School: Planning and Professional Development

ITEEA's STEM CTL™ utilized the information from the July 2015 site visit to establish an aggressive EbD™ implementation plan

Figure 2. 2016 EbD™ *Technological Systems* (Grade 8) Professional Development Summer Institute. A pair of teachers (top) present design work to the group; (middle) a team of teachers works on a design problem; and (bottom) a team of teachers collaborates.

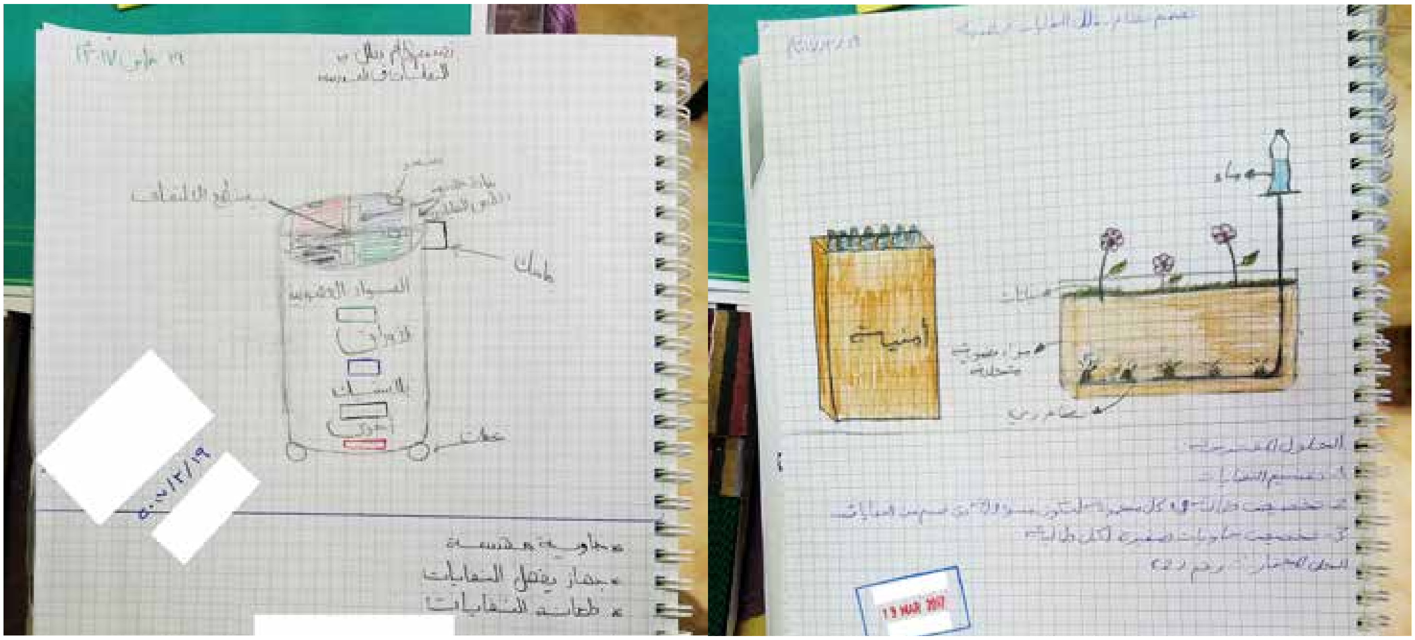

Figure 3. Example of design journal work of a passive watering system for gardening and type of recycling system.

with the SACGC. In September 2015, less than one month after the site visit, a 10-day professional development course was provided for SACGC teachers by an ITEEA EbD™ National Teacher Effectiveness Coach (NTEC), Mr. Henry Harms, for *Exploring Technology* (Grade 6) and *Inventions and Innovations* (Grade 7). A five-day professional development opportunity was provided for the *Technological Systems* course in September 2016 for 23 SACGC Grade 8 teachers and supervisors by NTEC Dr. Nathan Mentzer (Figure 2).

During the on-site visits, the ITEEA team met with SACGC administrators and teachers, and toured facilities. These interactions helped leverage the standards-based nature of curriculum to deliver a culturally relevant pedagogical approach. As one example, water is a critical resource, and water towers are a cultural icon. Structural design challenges in the U.S. are often focused on bridges. In Kuwait, we focused structural challenges around water towers. As another example, traffic in Kuwait City is an issue. The Grade 8 technology course has a significant focus on systems—traffic systems become a rich, relevant system to contextualize the lessons. Additionally, SACGC administrators (Sadeq Qasem and Meshari Alnouri) met with ITEEA staff in Reston, VA as well as during the 2017 ITEEA conference. Online meetings and email correspondence also helped during the initial implementation of EbD™ at the middle school level to provide support for teachers and administrators.

In the program's initial implementation, there were a few challenges that were identified and resolved in the first year. The main challenge was that the curriculum was written in English. All the Grade 6 and 7 EbD™ curriculum was translated to Arabic very quickly over the summer of 2015. The next challenge was the co-teaching taking place within each EbD™ class. Since there were no technology education teachers in the gifted program (or the public schooling system in general), it was decided that having a mathematics and science teacher in the classroom at the same time would facilitate implementation. This would allow the teachers to contextually navigate the material along with support from Mr. Meshari Alnouri, who assisted when clarification was needed. The last, and smallest, challenge was the teachers' inexperience with tools and machines. Few, if any, teachers had experience with power or bench tools and needed training to give them confidence prior to expanding beyond middle school curriculum.

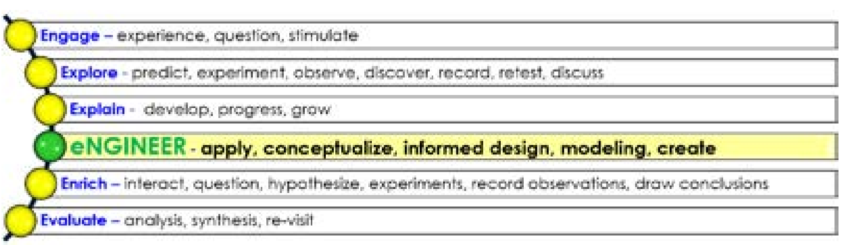

Figure 4. ITEEA's 6E Learning by Design Model.
www.iteea.org/STEMCenter/6ELearningbyDeSIGN/49882/49885.aspx

Programmatic Evaluation

In March 2017, the fourth on-site visit was conducted by Dr. Philip Reed to provide a program review and recommendations during the second year of SACGC implementation of Engineering byDesign™ in Grades 6-8 (Reed, 2017). The program review included class observations, discussions with teachers, meetings with administrators, and facility tours. The classrooms observed contained dyads of teachers, one mathematics and one science, who had received the proper EbD™ course training and support materials. Classes were capped at 20 students, but most classes had 12-15 students. All students had design journals and access to tablet computers (Figure 3).

Our observations showed that all instructors used the EbD™ 6E lesson planning model (Burke, 2014; Figure 4) to deliver their lessons and effectively keep students engaged (Figure 3). Teachers used a variety of instructional strategies, including videos, projected notes and illustrations, whiteboards, and journals, among others. The Sawda Girls School, for example, used the jigsaw group strategy where students worked with multiple groups to conduct research, add journal entries, and then combine thoughts in order to present a group brief to the entire class. The EbD™ teachers all had students use their design journals, work in groups, and provide oral feedback to their classmates. Student engagement was apparent by the range of participation in discussions, hands raised, and attention to the instructors. Several students elected to present their journal reflections and/or comments in English. It was clear that the teachers observed were comfortable using instructional technology as well as a range of instructional strategies.

Facilities

The on-site visit in March 2017 revealed impressive new facilities based on STEM CTL™ recommendations and ITEEA facility standards (ITEEA, 2013). The middle school facility observed (the SACGC Academy) consisted of technology laboratories with tables or science laboratories with benches. All rooms contained a class set of tablets, whiteboards, and multimedia projectors. The SACGC has provided each laboratory (including the local middle schools and the academy) with a tool bench containing assorted hand tools and a storage cabinet complete with the supplies needed for the respective EbD™ course(s) taught in the facility (Figure 5). Additionally, each lab has been provided the following tabletop power equipment: drill press, scroll saw, combination disk/belt sander, band saw, and vacuum. The laboratory in the Boys Academy contains a side room for the power equipment (Figure 6).

The Boys Academy also contains a Fab Lab used for after-school activities that contains a CNC router, laser cutter, two 3D printers, a ceramics room, and several other rooms with modeling kits and additional equipment (Figure 7).

Additionally, there is a second staffed Fab Lab at the Boys Academy to help designers and entrepreneurs in the community. This lab contains three precision machining centers, a coordinate measuring machine, a food dryer, an extensive set of fischertechnik™ automation kits, breakout rooms, and an abundance of other tools and equipment (Figure 8).

Figure 5. Middle school classroom laboratory during professional development.

Figure 6. Middle school production equipment.

Figure 7. Fab Lab for student use after school hours. Top left: 3D printers; Top right: CNC; Lower: Collaborative spaces with prototyping materials.

Figure 8. Fab Lab for community and student use after school.

Kuwait SACGC Faculty Become ATECs in 2017

In the summer of 2017, under the guidance of Mr. Sadeq Qasem, Section Head of Program Curriculum Development at the SACGC, two EbD™ National Teacher Effectiveness Coaches, Dr. Nathan Mentzer and Mr. Mohamad Barbarji, delivered a two-week workshop for four teachers and one administrator to prepare them to be EbD™ Authorized Teacher Effectiveness Coaches (ATECs). In the workshop, we focused on three main elements: refining and mastering their pedagogical content knowledge; preparing them to teach other teachers; and team teaching. We began the workshop with a needs assessment that included discussion and our observation of a lesson delivery by the participants. Based on these data, we created a routine where we modeled delivering lessons to teachers, critiqued participants practicing the delivery of lessons, and reflection.

During and after each model lesson, we reflected with the teachers about the pedagogical decisions we (and they) were making and the rationale for making these choices. We assigned each of the teachers to focus on their specialization—one was going to become an ATEC for Grade 6, one for Grade 7, one for Grade 8, and one for Grade 9. The administrator had attended all the summer institutes to date, taught and coached other teachers on the curriculum, and had a Ph.D. in education. She had participated in supervising the EbD™ implementation, and as a result was able to demonstrate competence as an ATEC in all four grades.

Each participant taught three lessons during the workshop. During and after each lesson we reflected and provided direct and specific feedback. We noted strengths and opportunities for improvement and were very impressed with the participants' growth from the first to third lessons. Interestingly, we began to provide the critical feedback privately, but the teachers all wanted to hear our evaluation of each participant's teaching so they could collaboratively reflect, learn, and develop. One of the benefits of all five participants earning their ATEC as a collaborative team in four different EbD™ courses was that they were very attentive to vertical alignment between the grades. They learned what is happening in grades prior to theirs (for example, how the 6th grade will be implementing design journals and what explicitly should go in them) and what came after their grade level (for example, using CAD and 3D printing in the 9th grade builds on lessons on 2D and 3D shapes in the previous grades). Interestingly, we also discovered a few humorous translation issues along the way: EbD™ curriculum was translated literally word for word into Arabic by an expert linguistic translator rather than a conceptual translation done by an expert in the content area. As a result, one of the lessons called for "self-healing mats" (one student) to cut balsa wood on their desks with razor knives. The literal translation was "Band-Aids." We discovered this when one of the teachers was preparing to deliver the lesson and wanted to know why he needed 16 Band-Aids for the students. While a first aid kit is an essential part of the lab environment, we don't prescribe handing out Band-Aids as a proactive measure.

The third week of the 2017 summer professional development was a summer institute for the Grade 9 *Foundations of Technology* course. We were joined by a dozen more teachers, some new to EbD™, some new to the school and country—all preparing to teach in the giftedness program in the fall. During the week, we modeled lessons and engaged the teachers in the learning activities and reflection. As a capstone event for the ATEC participants from the prior weeks, we strategically identified lessons for them to teach, including how to use design journals, sketching, CAD modeling, tool and machine safety, as well as some of the *Foundations of Technology* (*FoT*) lessons.

Next Steps

A team comprised of Dr. Nathan Mentzer and Mr. Mohamad Barbarji has plans to go to Kuwait during the first week of April 2019 to review implementation and refine teachers' pedagogical content knowledge. We will collect evidence of teacher efficacy through a review of teacher and student artifacts (portfolios, design journals, video-recorded lessons, reflection, etc.). We plan to use these data to create an appropriate five-day workshop for the Grades 6–9 teachers that includes both whole-group instruction and grade-band-specific instruction.

Current middle and high school teachers are certified in mathematics or science education. These teachers have done an admirable job implementing the EbD™ curriculum because of the support they have received from SACGC (i.e., translation of materials, classroom and lab space, release time, professional development support, etc.), their networking, and their adherence to the 6E lesson model. The dyad teaching model works well because science educators are comfortable delivering lab-based instruction, and mathematics teachers ensure math content is developmentally appropriate and relevant. By planning together, the dyads are more efficient at assembling materials and providing lessons that offer differing perspectives, which is important for adding a Kuwaiti cultural context to the curriculum.

In conclusion, ITEEA's STEM Center for Teaching and Learning, in collaboration with the Sabah Al Ahmad Center for Giftedness and Creativity (SACGC), have done groundbreaking work to establish Technology and Engineering Education as a discipline in the country of Kuwait. Currently, implementation is flourishing in Grades 6–9. With the new Academy adding one grade each year, it is hiring new teachers and expanding its offerings into high school this year for the first time. Within the next few years, the goal is to offer Grades 6-12 and, based on the success in middle school, we hope EbD™ expands further into the secondary programs.

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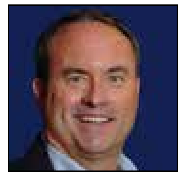

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