



## **The STEM Loop: Undergraduate Engineering Students Create a STEM Children's Book**

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# The STEM Loop: Undergraduate Engineering Students Create a STEM Children's Book

## Abstract

This paper documents an innovative project in which undergraduate mechanical engineering students created and produced a children's book about combustion engines. Funded through a grant provided by Texas A&M University at Qatar, students researched, designed, and wrote a children's book intended to promote interest in STEM fields. The book, written in both English and Arabic, will be used in Qatari public schools and in the Texas A&M University at Qatar's STEM Outreach Program. The interdisciplinary project was co-led by a mechanical engineering professor and an English professor. Students gained valuable transferable skills while working on this project including creative thinking, audience awareness, teamwork, technical writing, visual design, and communication. The authors of this paper, who include the students that worked on the project, aim to promote and encourage the idea of undergraduate students actively engaging and creating STEM programs and initiatives for K-12.

## Introduction

The idea of STEM education has been around since the early 1900's. Originally called, SMET (science, mathematics, engineering, and technology), educators focused on instructing students in skills that would benefit their future societies<sup>[1]</sup>. The idea of enriching these fields by creating students well versed in them quickly gained popularity. Currently, STEM education is recognized in many countries as a way to raise educational standards and produce a generation of ingenious individuals. In the Middle East, where this study was conducted, STEM education and engineering programs specifically, are currently the fastest growing majors. Professionals in engineering and science are in high demand in the region as countries like UAE, Qatar, Kuwait, and Saudi Arabia use their abundance of petroleum revenues on State development and new technologies.<sup>[2]</sup>

Texas A&M University at Qatar offers engineering programs for Qatari and international students. The university advances STEM pedagogy and incorporates transformative educational experiences into its curriculum. These efforts correspond to the current belief that engineering education is outdated and does not prepare students for the challenges they will face in industry. David Goldberg in his book, *A Whole New Engineer*, suggests that current engineering education is misaligned with 21<sup>st</sup> century needs. He argues that change in engineering education "can't be accomplished in the old paradigm under the old assumptions about how education change happens, but in the right atmosphere, the change flows organically from the students themselves"<sup>[3]</sup>. It was this kind of thinking about a new way of educating future engineers that spurred the idea for this project.

The idea to create a children's book came from a discussion that took place in the spring of 2015 in a Business and Technical Writing course at Texas A&M University at Qatar. The discussion centered on a student's prospective audience for his upcoming descriptive paper. The student jokingly suggested creating a pop-up book on combustion engines for an audience of children. This remark resulted in a discussion about the possibility of doing a children's book series focused on engineering concepts that would inspire children to enter the engineering field.

English professor, Dr. Leslie Seawright, partnered with a mechanical engineering professor, Dr. Ibrahim Hassan, to pitch the idea to the administration of the university. They were awarded a Transformational Education Experience grant of \$12,500 in order to produce a children's book on combustion engines.

### **The University and Students**

Texas A&M University at Qatar (TAMUQ), is an international branch campus more than 8,000 miles away from the main campus of Texas A&M University in College Station, Texas. Despite its location in the Middle East, students at TAMUQ are required to complete identical coursework as their peers on the main campus, including courses on American politics and American history. The student body is comprised of students from around the world, but primarily students come to TAMUQ from the Arab Gulf region and Asia. TAMUQ offers Bachelor of Science degrees in chemical, electrical, mechanical and petroleum engineering. The university maintains an enrollment of around 550 students, of which 58% are male and 41% are female<sup>[4]</sup>. Nearly all of the students at TAMUQ speak English as their second or third language. The faculty of the university is as diverse as the students, with faculty from the United States of America, Jordan, Lebanon, Egypt, Greece, France, and elsewhere.

TAMUQ is located in Education City and funded by the Qatar Foundation, a non-profit organization founded in 1995 by the then ruling Emir of Qatar, Sheikh Hamad bin Khalifa Al Thani. Education City hosts the branch campuses of five other American universities, including Georgetown School of Foreign Service, Carnegie Mellon University, Northwestern University, Virginia Commonwealth, and Weill Cornell Medical College. Education City is a bustling community of students and faculty in all disciplines<sup>[5]</sup>.

### **The Project**

Once Drs. Hassan and Seawright received the grant for the children's book, they went to work finding students for the project. Since the assignment was not part of a class, the students voluntarily committed to the project and spent time outside of class to work on the book. Many of the students came from the mechanical engineering program, though not all. Of the ten students involved in the project, six were in mechanical engineering, two in electrical engineering, and one each in petroleum engineering and chemical engineering. The project not

only had program diversity but gender diversity as well, as four of the students in the project were female along with one of the project's advisors, Dr. Leslie Seawright.

The students and advisors meet weekly starting in the Spring semester of 2016 to discuss ideas for the children's book. Many important challenges and opportunities were discussed and debated in these project meetings. The first decision to be made was the target audience and the main character of the book. Other decisions such as narrative style, illustrations, number of pages, type of book paper, and other fundamental aspects of the project were raised. Mohammad AlGammal, a technical laboratory coordinator, agreed to tackle the precise mechanical drawings necessary for the book. Two students volunteered to create and draw the main character and background. In addition to the students and advisors, two students were hired as part-time workers for the book project. These students communicated and planned the student meetings, worked with publishers to obtain quotes for various types of children's books, and collected data on the project.

The division of labor and scope of the project was decided by the students themselves. They divided into two groups: an illustration group and a dialogue/text group. Despite these divisions, the students actually met as a whole on most occasions and discussed the book project as a team. As the students reached the mid-point in the semester, it became clear that the book would not be accomplished using only student art. An illustrator was hired in order to take the students' concept drawings and turn them into the actual book pages.

## **Findings**

This project was funded through a Transformative Educational Experiences Grant awarded by Texas A&M University at Qatar. The idea of transformative educational experiences (TEE) has been adopted by many colleges and universities in order to encourage undergraduate research and meaningful student-centered work. These types of experiences are especially meaningful for engineering students, as their future careers will require them to work in teams and think critically about project decisions. Equally as important are the children that these engineering students hope to reach. As Carlson and Sullivan note, "Preparing children with the skills necessary to flourish in an increasingly technological world becomes more challenging every day...engineering is about building things to help people and society."<sup>[6]</sup> This project allowed engineering students to reach out to young primary school children and encourage them to learn more about the field of engineering.

The first decision to make was the type of children's book and the target age group. The students and advisors brought in books and discussed the options. It was decided that the group would like to make a book with flaps on each page in order to make the book more interactive for children. The students were adamant about wanting to connect with the children reading the book, and they also discussed the possibility of adding QR codes, videos, and an app connected

to the book that could provide additional information. Ultimately, the students had to discard these ideas as the short time span of 5 months simply wasn't enough to incorporate all of their ideas. Even the flap idea had to be abandoned after the students discovered that the flaps nearly doubled the cost of the book and created complications related to illustration and design. The students struggled with the decision to drop the page flaps for several months. Their decision to move on with a more traditional-style children's book was driven by time and money concerns, both issues they will face again and again as engineers. The real-world scenario of book production forced them to make hard decisions that affected their overall design and aspirations for the book since these goals did not correspond to the amount of time and money available.

The age range for the children's book was set at 6 to 10 years old. This decision was made by studying the book industry and the common age ranges for children's books. While it appeared a minor decision to make, the students soon realized that this factor would ultimately affect the vocabulary, style, illustrations, and organization of the entire work. As the dialogue group began writing the story, they often thought about the words and examples children 6 to 10 would know and understand. Also, this age group created a dilemma in thinking about the level of writing that should be used. Should the book be able to read by 6 year olds, making it very simple and perhaps too childish for the 10 year olds, or should it be written at the top end of the age group challenging the 10 year olds and requiring an adult or sibling to read it to the 6 year olds? The students decided to aim for the upper end of the age range in regards to reading level. This decision would allow the book to "grow" with the 6 year olds and be informative and challenging for the 10 year olds.

The creation of this children's book also required a great deal of care in the selection of the main character, plotline, and gender/culture/language considerations. The students agreed in the first meeting that the main character of the book should be female. When the advisors asked them why they decided to make the main character female, several students explained that boys would be immediately drawn to the idea of a book on combustion engines while a girl may not. They wanted to encourage female readers to learn about combustion engines by having a female lead character. This impressed the advisors, as the majority of students in the group are male but the students all quickly decided that females should be encouraged to enter STEM fields and the creation of a female lead character was one way to do this. What should she look like? How old should she be? What should she wear? The students spent several minutes discussing the main characteristics of the female character. One student suggested that the girl be a bit older than the 6 to 10 age range because children look up to older children. The students decided that she would be 12 or 13 years old. They chose her name, Sara, because this is a name found in both English and Arabic-speaking regions of the world.

The advisor, Dr. Seawright, reminded the students that it was important how they chose to dress and characterize the girl. The students quickly agreed that she should have black or dark brown hair and wide anime-style eyes. The eye selection was driven by the student illustrator who

preferred this style and by the fact that anime is an Asian art style. The students felt that this style would speak to the children in the Qatar region, as anime is popular in the region. The character's clothes were also discussed in several meetings. Students wanted the girl to look comfortable in a story about combustion engines. The initial sketch was of the girl in a pair of mechanic's overalls and a baseball hat. In the Middle East, Muslim women commonly cover their hair in order to respect their cultural and religious beliefs. The girl was given a hat in a nod to this tradition. Later, however, the sketch was changed and the girl had her shoulder length hair down. This was done in order to make it more believable that she had just removed her go-cart racing helmet (a plot detail). The student illustrator (a female) explained that the girl in the story didn't need to cover her hair because she was 1) young enough to not have to cover and 2) had short hair so it was not necessary to cover it in the student's opinion of her own culture and religion. The students and advisors agreed with this new choice.

The plot remained the most important part to work out in terms of getting started with the book. By this point, the students had decided on the age range, the number of pages, and the main character's details. One student suggested that the girl ask her father while riding in a car how the car's engine worked. The advisor pushed back asking the students to help the girl feel empowered in a journey to discover more about combustion engines. Soon the students were excited by the idea of the girl as a go-cart racer whose engine has broken down. The story of how combustion engines work evolves as she tries to find out what happened to her engine. It was important for the students and advisors that they give the girl agency in researching combustion engines.

Several weeks into the project, it became clear that student-only illustration was not going to be possible. None of the advisors or students had experience illustrating and producing a children's book, so an artist was hired to illustrate the book based on the conceptual drawings for each page and the character sketches of the main figure. In addition to the illustrator artist, a publishing expert was used to put together the final pages of the book combining the art, mechanical drawings, and text into one cohesive document. While students had initially wanted to produce two completely separate books, one in Arabic and one in English, they ultimately had to settle for a book in English in the first half and Arabic in the second half. This was done in order to cut costs and production time. The benefit of having the two languages in one book will also help young children learning to read in both languages, a common situation in Middle Eastern countries like Qatar.

The idea for this children's book came from a student and became a student-led project. An ethic of selflessness was prevalent throughout the project. Brainstorming, writing, and designing were all done in a team environment that sharpened students' skills in critical thinking, writing, designing, and working as a team. Because students were in charge from the beginning, they felt an immediate sense of responsibility and commitment. Many of them now claim that because they were allowed primacy in decision making, they felt more dedicated to this project than their

required coursework. The students saw the children's book as something they had ownership in, something they had created rather than an assignment they simply completed.

## **Discussion**

ABET requires engineering students to be competent in writing, communication, presentation, and cultural awareness in order to be truly competitive and ready to perform as engineering professionals<sup>[7]</sup>. The students involved in creating this children's book were actively acquiring these critical skills while building cultural and gender awareness. At each phase of the process, students were grappling with creating a complete picture of the audience in order to select appropriate vocabulary and analogies. Developing audience awareness is one of the central aspects of all good technical writing pedagogy. This is a difficult skill to teach, however, because in nearly all cases students are merely writing for their teacher and trying to figure out what one person requires of their writing. In this project, students had to write for a real audience of potentially thousands of children with varying English abilities, nationalities, and scientific knowledge. In addition, the engineering students had to select a plot, illustrations, and scenarios to best fit the needs of their readers. The development of presentation skills resulted from the decisions the students had to make in regards to illustration style, color saturation, text fonts, and other choices.

Perhaps the most interesting ABET requirement achieved in this project was cultural awareness. Students developed a deeper understanding of their own (mainly Arab) culture while reaching across boundaries to better understand other cultures. The students discussed customs, styles of dress, architecture, cultural norms (especially those related to gender) of their own and other cultures in order to create a book that could be easily accepted by many cultures and peoples. This is a skill that is difficult to teach and difficult for students to acquire in more traditional engineering courses.

It is the hope of these students and faculty advisors that this project will turn into a book series. Each year a new group of students could explore a new topic and create a children's book that fits within the book series. These books could then be distributed to local Arabic and English schools, as the book is printed in both Arabic and English. Engineering students at TAMUQ could also invite local primary students to campus in order to engage them in the stories and lead them in hands-on engineering activities.

Allowing students to lead this project was challenging and rewarding in many ways. If faculty can find ways to let students come up with projects and support their implementation, they can begin to change engineering education one project at a time.

## References

- [1]"STEM EDUCATION: Preparing Students for a Growing Field", *connectionslearning*, 2016. [Online]. Available: [http://www.connectionslearning.com/Libraries/PDFs/STEM\\_Primer\\_PreparingStudents.pdf](http://www.connectionslearning.com/Libraries/PDFs/STEM_Primer_PreparingStudents.pdf). [Accessed: 16-Apr-2016].
- [2]A. Durrani, "Arab Region Engineering Degrees Address Industry Demands", *US News & World Report*, 2015. [Online]. Available: <http://www.usnews.com/education/best-arab-region-universities/articles/2015/07/07/arab-region-engineering-degrees-address-industry-demands>. [Accessed: 19- Apr- 2016].
- [3]D. Goldberg, M. Somerville and C. Whitney, *A whole new engineer*.
- [4] "Enrollment Profile Fall 2015," Texas A&M University, Nov. 2015.
- [5]R. Hamilton, "After 10 Years in Qatar, A&M is Ready for 10 More, by Reeve Hamilton", *The Texas Tribune*, 2016. [Online]. Available: <https://www.texastribune.org/2012/05/25/after-10-years-qatar-m-looking-forward-10-more/>. [Accessed: 19- Apr- 2016].
- [6]L. Carlson and J. Sullivan, "Int. J. Engng Ed", *Hands-on Engineering: Learning by Doing in the Integrated Teaching and Learning Program*, vol. 15, no. 1, pp. 20-31, 1999.
- [7] "Criteria for Accrediting Engineering Programs, 2016 – 2017," *ABET Criteria for Accrediting Engineering Programs 2016 2017 Comments*, 16-Oct-2015. [Online]. Available at: <http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2016-2017/>. [Accessed: 17-Apr-2016].

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