

## Chapter 61: Engineering Design in Science Class

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### 1 Introduction

I have taught science in Saudi Arabia elementary and middle schools for four years. Unfortunately, science instruction in Saudi Arabia is not as good as it should be. The focus is on memorization, and students are not interested or motivated. But science teaching does not have to be that way. In a United States' school, I observed an eight-year old student working on a project I had suggested -- to design and produce a 3D maze. This project is engineering with designing, building, and problem solving—real science at work. The student was excited and worked hard, creating excellent obstacles in his maze. When I started to connect the electrical circuit, he said, “I can do it because I learned how to do this pre-school!” I was shocked. In this American school, students were not memorizing. They were acting as young engineers, excited and curious. Saudi science education must change. Engineering design is important for students because they can learn science better (Cunningham, 2009). When students are asked to design solutions to problems in science class, they are going to apply their knowledge to the concrete solution. When the students build projects, they learn how to develop a plan to solve a problem, which motivates them to think deeper. Saudi science teachers must change their teaching methods and use engineering design methods in their curriculum to help students connect science knowledge with a real-life problems and solutions.

### 2 Context/Problem

My country, Saudi Arabia, has a vision to advance and modernize its educational system to bring students to higher levels of efficiency when they graduate. In my school in Saudi Arabia, the students learn science just through memorization without creating any projects that apply their knowledge. Another problem is students are not gaining the skills to prepare them for the workforce. In my school the content teachers do not have any experience in teaching engineering design. The other issue in my school is there is no classroom set aside for activities such as the engineering design or science clubs. In addition, the science teachers, schedule is so full now, there is no time to make changes. As a result, the students' science education is seriously lacking. Research has documented the benefits of studying engineering design. In a study published in the International Journal of Engineering Education, it was found that engineering design education improved student's motivation and thinking skill. It also satisfies three basic student's needs: “autonomy, competence relatedness” (Gero, 2016).

### 3 Solution Steps

Pre-planning Approval  $\longrightarrow$  Rules  $\longrightarrow$  Technology Revised  $\longrightarrow$  Provide Space

In the beginning, I will present my project “Engineering Design in Science Class” to the principal of education in my city. My project consists of changing the method that we teach the students in science class, to make the students participate in the class by designing a project related to the lesson. For instance, when I teach my students about simple machines, I

do not have to get them to repeat memorized information on a test. The modern way to teach science in the United States is to make the students build some machines with simple materials as a project for the topic of a lesson, in order to help them use the science knowledge in a design. When students build a project for any lesson they can think deeper on a solution, and work as a group, and they will have the ability to solve problems in a scientific way.

The next obstacles to conquer are the schools' rules about time and lack of facilities. For example, the rules in the schools don't allow the students to bring any device (iPad or cell phone) to use in the classrooms, so there is a solution for that, which is the students can bring the devices in the morning and put them in the manager's room until they need them. As for time we have one extra hour during the school day (activity hour); we can make a schedule for it to arrange the classes so that every class in the school can attend one time per week or per two weeks in the engineering design room. The second assistant principal is the school manager. He is the only person that can give funding, permission to do the workshop for the teachers, and can arrange a room for engineering design classes.

#### **4 Teachers**

In my interview with Dr. Trauth Senior Associate Director, Science Education Professional Development Center for Educators, University of Delaware, she suggested that the first thing that I need to focus on is the teachers' training on the method for engineering design. In order to accomplish this, she recommended that I conduct a workshop during the school day for the science teachers, and schedule with them a weekly meeting in the free time. But I believe I will clash with some teachers who will not agree with me. So, she advised me to tell them that everything is optional. There is a saying repeated by teachers in my school many times that the engineering design can be taught only by smart teachers with intelligent students. This is wrong. With a little experience and with practice, engineering design will become easier (Cunningham, 2009). I will present the idea to the Ministry of Education, and they will decide if it is going to be mandatory or not. If they decide that it will be mandatory, Dr. Trauth said I should do a workshop during the day and follow up with the content teachers until they know how to use this method. In my school, there are 7 science teachers, so I will work hard to convince them by different ways such as, showing them the result of the engineering design activities and showing them how the students work independently in the class. In the United States, the teacher just introduces the lesson and then the students work by themselves. After I convince the other teachers, we will work together as a group to divide the students in order to be sure that all the students in the school can build a project.

In order to do any activity in my school, I must be careful about the time it takes to complete it. Engineering design activities typically need a long time to finish, and we don't have a time in my school for this. One answer to this issue is to follow the suggestions of my host teacher. She recommended activities that can fit in my curriculum and can be finished in one class and gave me a website that she used to show me how it can be done in one class. So, the solution for the time is picking activities that do not take a long time. In addition, my host teacher divides the time, organizes the students in groups, and prepares a task list for the students. The host teacher was using the task list for everyone to be sure that every student did something in the class, so it is a way to focus on many students, and she used the

engineering design as competition to encourage them. Engineering design, when used in science teaching, will certainly change the way teachers are teach from a traditional way of "remembering" to a more creative way.

(Cunningham,2009)

## 5 Students

Students in Saudi schools do not have the ability to design a project because they are not taught how to do it in school. I believe that it will not be easy for me to establish the engineering design tasks in the schools because the students don't have any ideas about it. I will start easy and slowly with them as I observed in my school in Newark, Delaware,]. The host teacher usually starts any activity with students gradually. For example, she uses a story or scenario to get the students' attention and encourage them to build the project. Some activities may need a technology inside the classroom such as iPad or laptop. In this case, I can ask the students to bring any device they have after I take permission from the principal. It is important to start using the easy problems to reduce potential problems. The EIE (Engineering design is

Elementary) foundation says, "Educating a generation that understands what engineering and technology are and their importance to our society and our world will require the energies, creativity, and talents of teacher educators, teachers, engineers, parents, and children". This is all we aspire to, that our students become creative using scientific methods, engineering designs and technology as well. Elementary students are smart and have the abilities teachers not expect. In a study conducted for students in the primary stage of engineering design, the result was that they saw an unexpected interaction of students according to their age. (Cunningham,2009). When I come back in the first year, I will be teaching students about the engineering designs and then in the following years, we will focus on the design quality, because if the design is efficient it will reflect on the educational environment as well as on the student's output. In order to achieve this, I have to complete three things, according to a DBSL curriculum (design-based science learning) study, where the writer said "it was found that the crucial aspects for the success of the design were the students' understanding of (1) the science phenomena, (2) the operational principle behind the ice cream making device, and (3) the design criteria. These claims needed to be further explained".

## 6 Science Curriculum Limitations

In every lesson and unit in the science curriculum, we will find some goals that focus on memorization only, so in my project, I would like to have students participate in the class in small groups to connect the knowledge they are learning with a design project. Dr.

Zoubeida Dagher, Professor of Science Education in the School of Education at the University of Delaware, said in an interview that lessons just focusing on memorization will not support students in real-life because such lessons do not promote understanding and application of knowledge. It appears that EIE curriculum and DBSL agree engineeringoriented curriculum in the US encourages the students to use the knowledge they learn in the lesson to solve problems. In my project, I am planning to fit some design activities into our curriculum without changing the curriculum because every science teacher in my country is expected to teach the entire curriculum. However, the question must be

asked, how can I fit in engineering design and meet the expectation of the curriculum? Professor Dagher suggested first identifying an engineering design activity that builds on the curriculum content that I teach and that can be completed in one class. She also advised choosing the right time to implement the activity, making your students familiar with it, not giving a grade for the final project in the first year. The professor said that doing these things is a way to encourage students and to reduce the chances of unexpected problems. If time spent in science class is not enough to do the activity, I can use the extra activity hour in the school day.

## 7 Conclusions:

The Ministry of Education in Saudi Arabia is working hard to develop education, and my presence here to take the experience and teaching methods in America is an example of the Ministry's work to develop education. The development of science education is one of the requirements of Vision 2030, so I chose the engineering design that will help in teaching science better.

## Implementation-chart

In the following chart there will be information about the action plan for my project Engineering Design in science class.

Step	goal	when	who	Limitations	Impact evaluation	Who and When
1	Get Approval	March 2019	Principal	Time to meet, Time in the curriculum, getting teachers to agree	Get approval	The principal, March
2	Develop Engineering Design lesson details and method of giving students feedback/grades	April 2019	Me	Funding, Space, Materials for Projects, Technology availability	Send to Professional from US program for feedback	A Professional in my Major
3	Make a schedule of projects	August 2019	Me Supervisor	Making decisions about: Which lesson is first, second, third...? How to do the lessons, Classroom space availability	After the first project, Reevaluate the schedule's success and effectiveness considering time, Organization, fit with the	Me Supervisor

Step	goal	when	who	Limitations	Impact evaluation	Who and When
					curriculum, etc.	
4	Implement first project	In the beginning of September 2019	Me & Students	Time with the curriculum, and cell phone usage approval, Students interest must be developed,	Pretest for the activity, Observation or students survey?	Me and students, after the lesson
5	Implement 2 <sup>nd</sup> project	By the end of September 2019	Me Other teachers observing	Time with the curriculum, and cell phone usage approval, Students interest must be developed,	Teacher observation question. Are they on task?	Content teachers
6	Teacher development workshop on Engineering Design	Nov 2019	Teachers	Participation with the goal of getting teachers familiar with Engineering Design and to get them to join my team	Survey	Me and content teachers
7	Teachers sign up to join the Engineering Design team with a start of Jan 2020 as the goal	Nov 2019	Content teachers	How many going to join in Engineering Design team	Survey	Content teachers

## References

- [1] Cunningham, C. M. (2009). Engineering is elementary. *The Bridge*, 30 (3), 11-17. <https://bit.ly/2EhuYiL>
- [2] Vaino, K., Vaino, T., & Ottander, C. (2018). Designing an ice cream making device: A designbased science learning approach. *Science Education International*, 29(3). <https://bit.ly/2Ehu99F>
- [3] Gero, A., & Danino, O. (2016). High-school course on engineering design: Enhancement of students' motivation and development of systems thinking skills. *International Journal of Engineering Education*, 32, 100-110. <https://bit.ly/2zVCpcK>
- [4] Dankenbring, C., Capobianco, B. M., & Eichinger, D. (2014). How to develop an engineering design task. *Science and Children*, 52(2), 70. <https://bit.ly/2BgcmN0>