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Case Studies on Hands-on STEM Program in Chemical Engineering for High School Students

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Ali Gharib is a current undergraduate student at The University of Texas at Austin, where he is pursuing his bachelor's degree in chemical engineering. He has an in-depth history of active involvement in STEM education, outreach and workshops both nationally and internationally from the years 2014 - 2021. He participated in many robotics Olympiads representing Qatar internationally in his early years. Also, he was an active participant in STEM and outreach programs at Texas A&M University at Qatar. Continuing on, he is now involved with membrane and sustainability research his university where he is immersed in the field of materials at the center for Materials for Water and Energy Systems. Ali is especially passionate about science and engineering and has been persistent about his passion of ensuring STEM access and outreach for all and building the frameworks for its successful implementation.

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Abstract

High school students nearing the end of their secondary education often come up against the frightening task of selecting their major for the next 4+ years of their academic instruction. The intimidation is only amplified in engineering disciplines with a lack of awareness of what each major entails and what students can expect in the field. Chemical engineering, in particular, is one such field not generally explored within high school classrooms and is surrounded by a significant shortage of accessible information for both students and educators alike.

This paper presents the potential of a pre-collegiate chemical engineering oriented program that aims to increase familiarity with this field of engineering by examining specific case studies previously conducted within summer camp programs for high school students. The program exemplifies a STEM education approach for engineering outreach through two unique examples of chemical engineering projects in water desalination and fuel cell applications. The insight obtained from these case studies showcases how high school students' understanding of chemical engineering can be built upon through immersive programs and projects. Each of the two case studies presented were designed with the purpose of bolstering student interest in learning about chemical engineering concepts through project-based learning while exposing students to broader engineering and chemical concepts such as the engineering design process, fuel cell evaluation, cost-effectiveness comparison, distillation processes, power generation methods, photovoltaic cells, water filtration systems, and safety assessment. Additionally, this program engaged students to apply such skills in real-life contexts and challenged them to consider the relationship between what they learned and pressing global issues. These connections not only prompted students to consider the future possibilities of a chemical engineering education but also put in motion a lifelong learning motive, imparting new curiosity regarding the field.

In the presented case studies, through a series of short lectures, laboratory demonstrations, and hands-on experimentation, the program’s main objective of allowing students to explore fundamental chemical engineering concepts was achieved. Six students from grades 9-11 spent various amounts of time discovering chemical engineering through a mixture of guided and

independent instruction. Along with a final review and discussion, students were instructed to create presentations showcasing what they had learned. Project assignments were also utilized, with students allocated resources and a timeframe to produce small-scale demonstrations that showcased specific chemical engineering processes.

The programs presented in this paper aimed to ease students' uncertainty by providing a window into the world of chemical engineering. Students were able to present what they learned at the end of each case study, demonstrating a great understanding of engineering challenges and building bridges toward a brighter future for young chemical engineers. The details of this novel program are presented in this paper, including the content, preparation, materials used, and the resulting learning outcomes.

1. Introduction

In the past few decades, the field of education has seen a popular rise in a term coined as STEM education. STEM education came into play as a response to a world that faced vast technological change and advancement that showed both professionals and educators alike that in order to keep this pace of development up, there will have to be a dedicated and structured focus applied to the topics of Science, Technology, Engineering, and Math (STEM) and how students are introduced and exposed to these fields. STEM education has and continues to serve the crucial purpose of preparing future generations to solve real-life problems. The effects of STEM education have been recognized as primary contributors to economic productivity, societal well-being, and the development of innovative solutions and advanced technologies in countries all across the world, especially when interdisciplinary approaches are applied [1, 2].

As the complexity of systems we rely on increases and technology reliance increases over time, so does the need for capable professionals to solve the equally complex problems that appear with this advancement. This surge in demand highlights the importance of STEM education at all levels of learning.

Texas A&M University at Qatar recognizes students as future leaders and has committed to fostering STEM education for high school students aiming to pursue careers in engineering or STEM disciplines. Through programs that preview engineering careers, the university encourages students to engage in self-guided discovery, innovation, and lifelong learning. These initiatives have been devised to encourage young students to excel in their educational journeys, paving the way for careers in science and engineering that support Qatar's transition to a knowledge-based economy.

Expanding K–12 STEM programs in fast-growing countries like Qatar is essential for addressing significant national challenges [3, 4]. While numerous STEM initiatives have been established across various engineering disciplines, it is uncommon to find such programs in the field of chemical engineering, as detailed in the next section, which briefly surveys the existing body of work regarding such programs. In this paper, the proposed program stands out for its innovative design and implementation, which have proven effective in engaging students, including those with limited initial interest in chemical engineering.

1.1 Existing STEM Programs in Chemical Engineering

K-12 STEM workshops are often taught using traditional methods. While science education was once predominantly theoretical, hands-on learning is now being increasingly adopted. This shift has been facilitated by the availability of safe, nonhazardous materials and other improved capabilities, particularly in chemical engineering programs. Studies have previously demonstrated that practical and experiential learning significantly enhances students' interest in STEM fields [5].

Chemical engineering STEM programs are a specific facet of STEM education that this paper focuses on. Chemical engineering is a field that is known to extend into so many other avenues of science and technology due to the breadth of content covered by chemical engineering studies. From the numerous intersections of physics with chemistry to the complex mathematics used for modeling reactor systems to even the biological knowledge needed for devising pharmaceutical and medical devices, chemical engineers are prepared with a thorough interdisciplinary skillset that equips them to solve the toughest of challenges. As such, there has been a growing need in the 21st century for students to be prepared to delve into the complex world of chemical engineering through STEM education.

Works such as that of Ross and Bales (2003) have presented a STEM program focusing on integrating high school students with undergraduate chemical engineering instruction, where undergraduate students from Northwestern University developed interactive presentations and delivered them to an audience of high-school students in their science or math classes. These interactive presentations included a variety of hands-on demonstrations and tasks related to a variety of engineering concepts. This program concluded that outreach programs such as these increase high school students' interest in STEM fields while giving them the hands-on experience to know if the field suits them, consequently making students well prepared for choosing their field of work [6].

Similarly, in the work of Stanley and Ymele-Leki (2017), the authors presented a STEM program focusing on engaging middle and high school students from Washington, D.C., through chemical engineering laboratory experiments. During the four-day program, the students were introduced to scientific methods, laboratory safety, and some fundamental concepts in chemical engineering. After that, the students did hands-on experiments using the ThermoHue app to measure and correlate color changes in thermochromic solutions with temperature. They also conducted a number of different experiments that included fundamental topics in chemical engineering. The students hypothesized, performed calibration and kinetics experiments, analyzed data, and presented their findings to their peers [7].

Despite chemical engineering being a broad field that extends into many industries and applications, there is a distinct lack of previously established works that specifically focus on chemical engineering STEM engagement. Thus, STEM programs in chemistry have proven to be a valuable resource in the search for past works that have pertinent elements to the topic of this paper. The following are STEM-related works found in Chemistry with relevant elements to the work presented in this paper.

For example, in the work of Bell et al. (1980), the authors presented a STEM program focusing on giving high school students hands-on chemistry laboratory work through experiments such as titrimetry, chromatography, and gravimetric analysis while attending seminars about the field of chemistry and undergraduate programs at Lebanon Valley College [8].

In the work of Stepek et al. (2019), the authors presented a STEM program called “Make a Molecule,” which focused on synthetic organic and medicinal chemistry, where a group of high school students were tasked with hands-on chemical synthesis and testing of bioactive molecules. Over the two laboratory sessions, the students conducted undergraduate program-level laboratory work where they synthesized peptides using a process called “synthetic fermentation”, tested their anti-bacterial properties, and learned advanced concepts such as pharmacophores [9].

In the work of Long et al. (2012), the authors presented a STEM program focusing on improving the standard of chemistry education in underfunded high schools through the Chemistry Outreach Program (ChOP), which was developed by Virginia Tech. This program featured a ground-breaking Mobile Chemistry Laboratory, which was a 78-foot-long trailer that was fully equipped with advanced chemistry laboratory equipment and instruments. The Mobile Chemistry Laboratory would travel to underfunded schools and would provide students with the opportunity to perform hands-on experiments and lab work using high-end pieces of apparatus, including spectrometers, pH probes, and chromatographs [10].

In the work of Schmidt et al. (2020), the authors presented a STEM program focusing on improving students’ interest and self-efficacy in STEM fields through a chemistry course called “Chemistry 1898,” which was conducted by Tulane University. This program paired undergraduate students from Tulane University with students from public schools in New Orleans, where they conducted hands-on chemistry demonstrations and had discussions about STEM education. This, paired with self-reflection activities, helped students think and plan for their future in STEM fields, and this is especially impactful given that they were in the k-8th grade age [11].

In the work of Tomat (2020), the authors presented a STEM program focusing on inspiring the next generation of STEM workers called “Chemistry Discovery,” which was a service learning outreach program that was conducted by undergraduate students from the University of Arizona. During the program, the students aged between 11-14 years old watched live demonstrations of reactions such as the clock reaction and luminol glow to explain reaction kinetics and chemiluminescence and conducted some experiments such as using red cabbage as a pH indicator to test the acidity of household items [12].

1.2 The Proposed STEM Program in Chemical Engineering

This paper aims to present and detail two distinct case studies of chemical engineering projects devised to draw high school students into the world of chemical engineering. Chemical engineering is a highly specialized field of engineering that simultaneously extends into many different focuses and applications that may be inaccessible for high school students to learn about. As such, there was a clear and pressing need for an initiative to make the rich field of chemical engineering accessible.

The presented case studies in this paper were part of the Summer Engineering Academy (SEA) program at Texas A&M University at Qatar. Within the Summer Engineering Academy, two distinct roles were needed for the successful implementation of the academy. There was a specialized team of faculty and staff that oversaw all the logistical aspects of the program for incoming students, from informing them of expectations to creating timetables to overseeing the overarching success of the students. In addition to this, chemical engineering professors and instructors from Texas A&M University at Qatar were involved in the dissemination of course content and teaching the students in the program all the knowledge absorbed over the course of the ten days of the program's duration.

Each case study presented is from a different year of the program and is conducted with a distinct focus on a selected topic in chemical engineering. In case study I, the project was based on an exploration of desalination through a variety of different methods. In case study II, the project was based on an exploration of alternative fuel sources utilizing fuel cells.

Given the purpose of this paper, the following organizational structure is adopted: Section 2 briefly details the structure of the overarching program these case studies were presented within and the appropriate logistic description for program delivery. Proceeding to Section 3, Case Study I is presented with the accompanying results. Following this is Section 4, which presents Case Study II and the results. Lastly, Section 5 concludes the work.

2. Program Structure

Texas A&M University at Qatar's Summer Engineering Academy was developed to immerse participants in applying scientific and engineering principles to practical, real-world scenarios. Through this hands-on approach, students acquire essential knowledge and sharpen their critical thinking abilities, thereby supporting them in attaining their goals. Each year, the academy accepts 24 individuals who receive instruction from four academic departments within Texas A&M University at Qatar. Over ten days, each department accommodates six students for daily sessions running from 9:00 a.m. to 3:00 p.m. This initiative has consistently recorded a full attendance rate. The program’s schedule and learning objectives are as follows:

- Day 1: Provide an overview of what chemical engineering is. An introduction to the chemical engineering program at Texas A&M University at Qatar and outlining and introducing the project.
- Days 2–5: Cover the fundamentals through laboratory experiments and activities that students actively learn from and note for future applications.
- Days 6–8: Actively work on the research project, applying principles and lessons to the project creation in a team setting.
- Day 9: Finishing touches are added to the research project in addition to poster and presentation preparation and rehearsal.
- Day 10: Finalize the presentation and poster and carry out the final presentation and demonstration.

3. Case Study I: Water Desalination Project

3.1 Background

Water is considered the most vital commodity for life, with no life to exist without it. Although 70% of the Earth's surface is covered by water, only less than 1% of this water is accessible fresh water suitable for domestic consumption, 97.5 % as saline water [13]. Accordingly, water desalination has been adopted worldwide to provide a sustainable freshwater supply to communities with no access to freshwater supplies. Water desalination has been practiced since 1950s, with thermal desalination technologies, then innovated by developing membrane desalination technologies in the 1970s, with a current desalination capacity of about 100 million m^3/day from about 16 thousand desalination plants, with membrane technology accounting for about 75% of desalination capacity and 85% of the number of desalination plants [14]. However, the main challenge with desalination is the high energy consumption along with carbon emissions, among other environmental impacts such as the discharge of high salinity brine [15].

3.2 Objective

The main objective of this specific case study was to introduce the students to core topics of water resources, in general, and water desalination, specifically as a reliable water supply for areas with limited access to freshwater resources. The discussion has been extended to "Clean Water and Sanitation" as one of the United Nations Sustainable Development Goals UN-SDGs, Goal # 6: Ensure availability and sustainable management of water and sanitation for all [16]. According to the UN, 2.4 billion people live in water-stressed countries, hence the importance of water desalination.

In this project work, a team of high school students has been asked to study and practice desalination of synthetic seawater (3-4 % NaCl solution) using both membrane (Reverse osmosis RO) and thermal (double-effect evaporator DEE) technologies. The experiment involved the calculation of water recovery for each technology at different operating conditions.

3.3 Experimental Procedure

The desalination experiments were carried out using a lab-scale RO membrane desalination system (see Fig. 1.a), which is equipped with a 2.5" 21" seawater RO (SWRO) membrane element connected to high-pressure (HP) pump capable of delivering up to 70 bar. In the RO system, the feed is drawn from the fed tank, pressurized to the test pressure and fed to the membrane element. The students varied the feed pressure for two different solutions of 3 and 4% NaCl and measured the flux of product water (as the volume of water produced per unit membrane area per unit time, i.e., $m^3/m^2.h$ or m/h).

(a) (b)

Figure 1. Laboratory desalination systems: (a) RO membrane desalination, (b) double-effect evaporator

The double-effect evaporator (see Fig. 1.b) is equipped with a pressurized water heater, able to supply heat up to 130 ^{o}C, along with preheater for the feed stream able to heat up to 70 ^{o}C. The vapor from the first effect is used to heat up the second effect, hence increasing the energy efficiency of the system. Finally, the combined condensed vapor from the first and second effects is combined with the brine and sent back to the feed tank. Students are to explore the effect of feed flow rate, single vs double, and the effect of pressure and feed preheating on the amount of water produced. Both systems run in closed-loop circulation mode; hence, no waste streams are generated as the product streams are mixed back.

3.4 Results and Conclusion

The students started the work by preparing synthetic seawater solutions of different salinity, i.e., 3 and 4 % NaCl in distilled water. The solution was then used as feed for both membrane and thermal desalination systems.

For the SWRO membrane desalination system, the feed pressure was varied in the range of 35-60 and 45-65 bar for the 3 and 4% NaCl solutions, respectively. It is worth mentioning that feed pressure in SWRO systems has to exceed the osmotic pressure of the feed solutions (which is directly proportional to the salinity of the feed).

Figure 2 shows the flux as a function of feed pressure for the 3 and 4 % NaCl solutions. It is clear that there is no water flux at pressures lower than 30 and 40 bar for the 3 and 4 % NaCl solutions, respectively. Also, Fig. 2 shows that the flux of product water is directly proportional to the feed pressure, as outlined in Eq. 1.

$$J_w = A\ (\Delta P - \Delta\pi) \tag{1}$$

Where, J_w is Water flux through the membrane (m^3/m^2.h), A is Membrane permeability coefficient (m^3/m^2.h.bar), $\Delta P \approx P_F$ is the Hydraulic pressure of feed (bar), and $\Delta\pi \approx \pi_F$ is the Osmotic pressure of feed (bar).

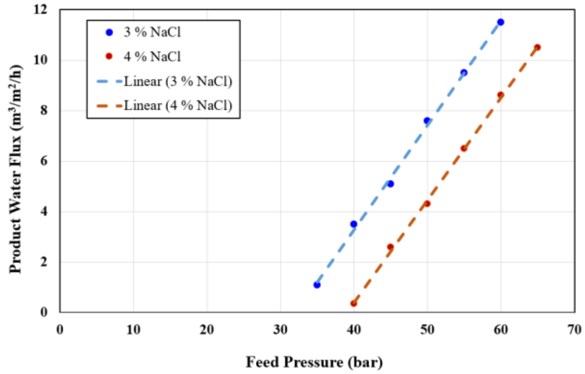


Figure 2. Water flux through SWRO system

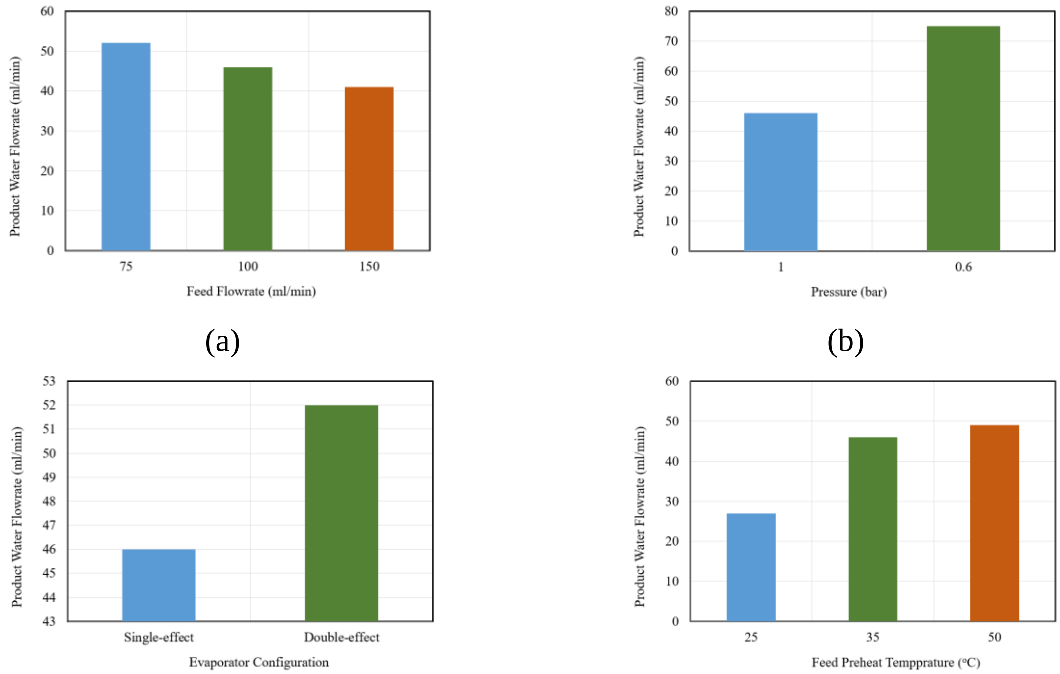
For the thermal desalination using a double-effect evaporator, the students have compared the water productivity at different feed flowrates of 75, 100, and 150 ml/min, evaporator pressure, the productivity of single-effect as compared to double-effect, and feed preheating temperatures at fixed heat supply.

Figure 3 shows the results obtained with the base case taken as pressurized hot water at 130 ^oC, feed flowrate of 100 ml/min, and feed preheating at 35 ^oC in a single effect evaporator. The results obtained show that at fixed heat supply, water productivity decreases with the increase in feed flow rate, as shown in Fig. 3.a. This is mainly because the higher the feed flow rate, the more energy is required to obtain the same productivity or less product water will be produced. Also, Fig. 3.b shows that working under vacuum increases the water productivity, as the boiling point decreases from 100 ^oC at ambient pressure to about at 85 ^oC at 0.6 bar, hence more water is evaporated. Figure 3.c shows that the productivity of double-effect evaporator is almost 10-15% more as compared to single-effect, as the heat recovered from the condensation of vapor produced from first-effect provide additional heat, which helps to evaporate more water in the second-effect, hence increasing overall water productivity. Finally, Fig. 3.d, shows that feed preheating from 25 (ambient temperature, i.e., no preheating) to 35 ^oC has substantial effect on water productivity, increasing by almost 70%, while that from 35 to 50 ^oC, did not show significant increase.

The performance of the thermal desalination system in the double effect evaporator can be easily explained by performing simultaneous mass and energy balance on the system. This calculation enable the determination of the water produced for a certain amount of energy input.

Material balance: $\sum Mass\ flowing\ into\ the\ systems\ = \sum Mass\ flowing\ out\ of\ the\ systems$

Energy balance: $\sum Energy\ flowing\ into\ the\ systems\ = \sum Energy\ flowing\ out\ of\ the\ systems$



(a) (b) (c) (d)

Figure 3. Water productivity in double-effect evaporator

3.4 Learning Outcomes

The case study was formulated and designed to achieve a set of learning objectives, which can be summarized as follows:

- Acquire knowledge about water resources and challenges faced to provide clean water supplies.
- Explore desalination technologies that help to produce clean water from saline water as reliable water resources.
- To design and perform experiments to deeply study water desalination technologies.
- To gain practical and technical skills in performing lab studies.
- To work effectively and cooperatively in teams.

4. Case Study II: Fuel Cells Project

4.1 Background

The race to develop sustainable and renewable energy sources has become a very hot topic over the last few decades. This is mainly due to the severe environmental impacts of the currently heavily utilized fossil fuel resources such as Coal, Oil, and Natural Gas. Additionally, the conversion of chemical energy into electrical energy, as currently practiced for power generation, is subject to many thermodynamic inefficiencies, with an overall efficiency of less than 30%, as commonly known within the energy industry.

Fuel cell (FC) stands as a very promising power generation technology, as it enables the conversion of chemical energy directly into electrical energy, hence higher overall efficiency, especially when utilizing hydrogen as a clean future fuel, i.e., hydrogen FC, hence a much lower environment impacts as compared to conventional power systems [17].

4.2 Objective

The main objective of this specific case study was to introduce the students to core topics of energy resources, in general, and sustainable energy resources, specifically for futuristic energy supply. The discussion has been extended to "Affordable and Clean Energy" as one of the United Nations Sustainable Development Goals UN-SDGs, Goal # 7: Ensure access to affordable, reliable, sustainable, and modern energy for all [16]. According to the UN, 0.7 billion people still live in the dark, and energy efficiency has to be doubled.

In this project work, a team of high school students have been asked to study and practice the operation of two different types of fuel cells, i.e., hydrogen FC and Ethanol FC. The experiment involved calculation of power produced by each over time, hence assessing its stability for power supply.

4.3 Experimental Procedure

Figure 4 shows a simple schematic diagram for a typical hydrogen FC, in which H_2 is reacting with O_2 from air at the cathode surface to produce electrical current, and H2O is the only product; hence, there are no carbon emissions as compared to using fossil fuels. Additionally, the reaction takes place at ambient temperature. Hence, there are no thermal losses, which further increases the efficiency. The reactions taking place in the hydrogen FC can be summarized as follows:

Cathode: $4e^- + 4H^+ + O_2 \rightarrow 2H_2O$

Anode: $2H_2 \rightarrow 4H^+ + 4e^-$

Overall Reaction: $2H_2 + O_2 \rightarrow 2H_2O$

Ethanol FC working principles are very similar to that of Hydrogen FC, with the only difference of using ethanol as fuel instead of hydrogen hence the cell reactions can be summarized as follows:

Cathode: $12e^- + 12H^+ + 3O_2 \rightarrow 6H_2O$

Anode: $C_2H_5OH + 3H_2O \rightarrow 12H^+ + 12e^- + 2CO_2$

Overall Reaction: $C_2H_5OH + 3O_2 \rightarrow 3H_2O + 2CO_2$

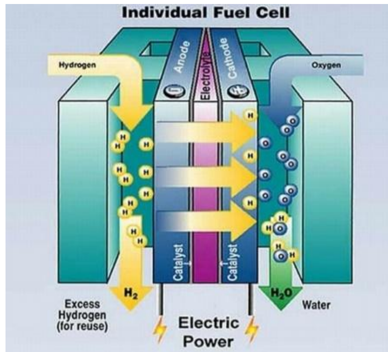


Figure 4. Simple schematic of hydrogen fuel cell [18]

4.2 Experimental Procedure

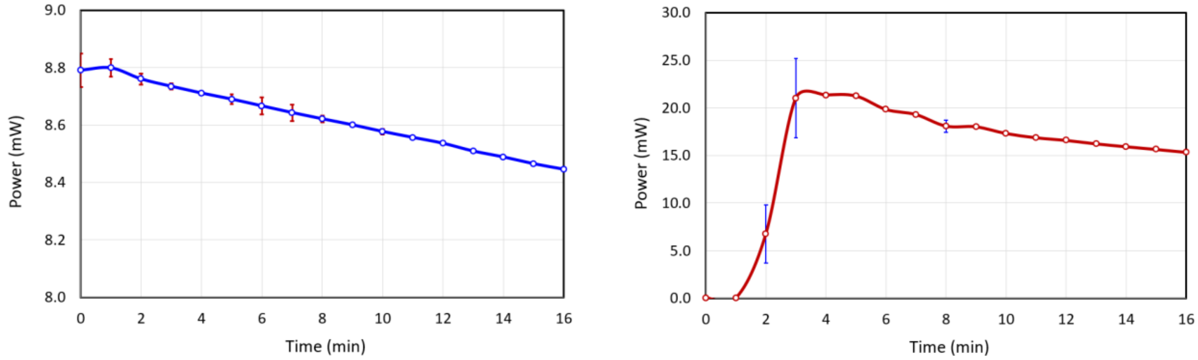
A commercial lab-scale hydrogen fuel cell was readily acquired, as shown in Fig. 5 (Electrode Area: 16 cm²). In this experiment, pure hydrogen was supplied to the FC to react with air. Students were asked to run the FC over a 16-minute time period to study the stability of power generation. The values of electrical current and voltage were measured using a multimeter to calculate the power generated (where P = IV. P is the power in W, I is the electrical current in A, and V is the voltage in Volts).

(a) (b)

Figure 5. Lab-scale hydrogen fuel cells: (a) PEM fuel cell (model: FCSU-012-1) [19]; (b) Ethanol fuel cell (model: 67130014) [20] (C) Schematic diagram of Fuel Cell

4.3 Results and Conclusion

Students operated the FCs using pure hydrogen feed and 3% ethanol with air over a period of 16 minutes and reported the power generated. Figure 6 below shows the power generated vs time. The results obtained show a very stable power generation from the hydrogen FC within the range of 8.5-8.8 mW. The figure shows clearly that the power generated by the ethanol FC is much higher than that of hydrogen FC, reaching 21.4 mW as compared to 8.6 mW for the latter. However, the figure shows that ethanol FC takes about 3 minutes to start generating such significant power as a start-up period. Additionally, the power generated is not stable and declines, reaching about 15 mW after 16 min. The higher maximum power of the ethanol FC can be mainly attributed to the higher number of electrons involved in the cell reactions, i.e., 12 electrons, as compared to only 4 electrons for the hydrogen FC. Meanwhile, the decline in power generation can be attributed to the consumption of the ethanol fuel in the cell.



(a) (b)

Figure 6. Power generated by (a) hydrogen fuel cell; (b) ethanol fuel cell

4.5 Learning outcomes

The case study was formulated and designed to achieve a set of learning objectives, which can be summarized as follows:

- Acquire knowledge about energy resources and challenges faced to provide affordable and clean energy supplies.
- Explore newly developed energy conversion systems that help to generate clean and sustainable energy from renewable resources.
- To design and perform experiments to deeply study energy conversion technologies.
- To gain practical and technical skills in performing lab studies.
- To work effectively and cooperatively in teams.

5. Conclusion

This paper aimed to present a novel STEM program meant to bolster interest from and inform high school students about the field of chemical engineering through several case studies facilitated by the two-week Summer Engineering Academy. This program, developed by Texas A&M University at Qatar, delved into the real-world chemical engineering challenges faced by the world, and a hands-on STEM program approach was applied to involve students in the solution to these challenges. In this paper, the details of the program structure and the research projects conducted have been described in the form of two case studies. These case studies illustrate the ways that hands-on application of theoretical knowledge in an unfamiliar field can lead to great outcomes in STEM education, building on student knowledge and providing them with valuable experience to draw from in the future.

The projects undertaken in this study were carefully designed to meet four primary goals: (1) introducing and familiarizing students with chemical engineering as a major, (2) cultivating critical thinking through in-depth, research-centered tasks, (3) reinforcing a culture of safety, and (4) improving students' soft skills, such as teamwork and effective communication. The program outcomes indicate that participants gained a comprehensive grasp of essential chemical engineering concepts, demonstrating their ability to integrate new knowledge into practical applications. Over the duration of the program, students received guidance on identifying important research questions, conducting scientific research, designing and executing experimental work, and analyzing the subsequent results. These outcomes sparked a high level of enthusiasm among the students and motivated educators to continue developing similar learning experiences, which is commensurate with the goal of this paper. By outlining the methodologies, challenges, and successes observed within these case studies, this paper aims to offer a valuable model for instructors interested in designing and delivering similar educational initiatives in chemical engineering.

Publishing the program in the local news significantly boosted its popularity in Qatar, making it highly competitive in applications [21-23]. Admission reports revealed that 20% of students who participated in the program chose Texas A&M engineering as their field of study at the university level.

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ALI GHARIB

Ali Gharib is a current undergraduate student at the University of Texas at Austin, where he is pursuing his bachelor's degree in chemical engineering. He has an in-depth history of active involvement in STEM education, outreach and workshops both nationally and internationally from the years 2014 - 2021. He participated in many robotics Olympiads representing Qatar internationally in his early years. Also, he was an active participant in STEM and outreach programs at Texas A&M University at Qatar. Continuing on, he is now involved with membrane and sustainability research his university where he is immersed in the field of materials at the center for Materials for Water and Energy Systems. Ali is especially passionate about science and engineering and has been persistent about his passion for ensuring STEM access and outreach for all and building the frameworks for its successful implementation.

AHMED ELSAID

Ahmed Elsaid is a current undergraduate electrical engineering student at Eindhoven University of Technology, Eindhoven, Netherlands. Ahmed has a strong interest in STEM, Electronics, and Robotics. His early passion for robotics and programming started early during mid-school participating in the National Robotic Olympiad (NRO) in Qatar 2015, winning the third place. His passion for STEM has driven him to participate actively in various programs, where he has shaped his technical and problem-solving skills. Also, he was also an active participant in STEM and outreach programs at Texas A&M University at Qatar during the high school study, which allowed him to gain hands-on experience and connect with experts in the field.

ABDULLA AL-DABBAGH

Abdullah Al-Dabbagh is a current high school student at Qatar Academy for Science & Technology (QAST) in Qatar. He has a strong interest in STEM, Robotics, and Mechatronics. His passion for STEM has driven him to participate actively in various programs and research projects, where he has honed his technical skills and problem-solving abilities. Also, he was also an active participant in STEM and outreach programs at Texas A&M University at Qatar, which allowed him to gain hands-on experience and connect with experts in the field. In addition, he was a member of Qatar Teams that participated in SeaPerch ROV Challenge and First Global Robotics Challenge in 2022 and 2024, respectively.

NAYEF ALYAFEI

Dr. Nayef Alyafei received his Ph.D. in Petroleum Engineering from Imperial College London in 2015. He was a faculty member at Texas A&M University at Qatar from 2015-2022. Currently he is an associate professor at Qatar University. Dr. Alyafei is known for his passion for teaching with a unique teaching style. He received several teaching awards such as the Teaching Excellence Award 2019, Faculty of the year 2019, and the Distinguished Achievement College-level Award for Teaching. In addition, Dr. Nayef has recently launched his educational YouTube channel Petrohow, along with his textbook on Fundamentals of Reservoir Rock Properties.

GHADA SALAMA

Ghada Salama is an Instructional Associate Professor at Texas A&M University at Qatar in the Chemical Engineering Program at Qatar. She teaches freshman Engineering introductory courses, and chemical engineering courses of different levels. She is a strong advocate and believer of student engagement and conducts interactive classes to support and encourage the learning process. She has published and presented at numerous conferences sharing her experiences in engineering education.