Title: Enhancing chemical engineering identity in young women with a low-cost biomedical polymer outreach activity

Authors: Jessica E. Torres and Julie C. Liu

Affiliation, Address and Contacts:

Torres: Purdue University, Davidson School of Chemical Engineering, West Lafayette, IN 47907

torre161@purdue.edu

Liu: Purdue University, Davidson School of Chemical Engineering and Weldon School of Biomedical Engineering, West Lafayette, IN 47907

julieliu@purdue.edu

Author Biographies

Jessica E. Torres is a PhD candidate in the Davidson School of Chemical Engineering at Purdue University. She received her B. S. in chemical biological engineering from the Massachusetts Institute of Technology in 2016. She received a 2019 National Science Foundation Graduate Research Fellowship to support her studies. Her research focuses on the development of protein-based biomaterials for biomedical applications including tissue sealants and adhesives and in vitro tissue models for drug delivery. ORCID: 0000-0003-0480-6098

Prof. Liu received her B.S.E. in chemical engineering from Princeton University. She was awarded a Whitaker Graduate Fellowship for her doctoral research at the California Institute of Technology. She received an NIH postdoctoral fellowship for her research at the University of Massachusetts Medical School. She is an associate professor of chemical engineering and biomedical engineering at Purdue University. Her research interests include biomimetic materials, tissue engineering, stem cell differentiation, and surgical adhesives.

Abstract.

To increase interest in chemical engineering and introduce non-traditional chemical engineering fields to high school women, an outreach activity focused on the biomedical applications of polymers was developed. Surveys given to students before and after the activity demonstrated greater agreement with the statements "I am interested in chemical engineering" and "Chemical engineers help people" after the activity. Additionally, there was better alignment between students' aspirations and chemical engineering as a result of the activity.

Keywords P-12, Outreach, Diversity, Laboratory.

INTRODUCTION

Although more women obtain bachelor's degrees overall, women received only 32% of bachelor's degrees awarded in chemical engineering in the United States in 2018.[1] Government entities recognize the need for a more diverse science, technology, engineering, and mathematics (STEM) workforce, and legislation such as the CHIPS and Science Act Title V seek to identify and lower barriers experienced by women and other underrepresented groups in STEM.[2] Lowering the barrier for women to receive a chemical engineering education involves establishing an understanding of and connection to the profession before students select their college major. Secondary education does not typically include concepts, such as design and data analysis, that are central to engineering curricula. Thus, the only opportunity for students to learn about chemical engineering is through experiences outside of the classroom. For many, those experiences come from parents – one survey found that 63% of undergraduate engineering students had at least one family member who was an engineer.[3] For others, extracurricular programs offer the only opportunity for students to learn about engineering before college.

The professional identity, or sense of self and belonging within a professional community, of a high school student impacts selection of a major in college.[4] Extracurricular programs can contribute to the professional identities of engineering in young women at an early stage to better prepare them to choose chemical engineering as a major in college. For this study, we investigated chemical engineering identity in terms of three components: academic identity (self-beliefs as students), occupational identity (self-understanding of an occupation), and engineering aspirations (self-goals of becoming an engineer) introduced by Capobianco et al.[5] Together, these components can paint a picture of how likely students are to pursue chemical engineering in college.

The purpose of this manuscript is to outline a low-cost, short activity that showed measurable influence on chemical engineering identity. The activity centered around a biomedical application of a common polymer, sodium polyacrylate. The focus on biomedical applications serves two purposes. First, biomedical applications can emphasize the communal goals of caring for and working with others, which are attributes women favor in a profession.[6] Secondly, this focus highlights a core future direction of chemical engineering put forth by the National Academies: engineering targeted and accessible medicine.[7] The activity described in this manuscript seeks to elucidate and influence elements of chemical engineering identity of early high school women to increase representation of women in the chemical engineering discipline at all levels.

SUMMARY OF ACTIVITY

The activity described in this article was part of Introduce a Girl to Engineering Day (IGED) hosted by the Women in Engineering Program at Purdue University.[8] This day-long program is for female students during their freshman and sophomore years of high school. Advertisements for the program are sent to local high schools, through list services, and via news releases. The high school attendance of 2022 IGED participants was collected by the program coordinator. From the list of schools, we determined the location, school type, and demographic make-up based on Common Core Data collected from the 2021-2022 school year.[9] Students participated from various states including 83% from Indiana and the remaining 17% from Illinois, Ohio, and Kentucky. Most participants (95%) attended public schools, and the remaining 5% attended private religious-affiliated schools. Participants attending schools from rural, town, suburb, and city locales were 12%, 7%, 53%, and 28%, respectively, whereas the nationwide percentages of students is 24%, 12%, 34%, and 29%, respectively.[10] There was an overrepresentation of students from suburbs and an underrepresentation of students from rural and town locales. Students attended schools with varying levels of racial composition. Only 31% of participants attended schools in which the population of white students was less than that of the general population (58.9%).[11] The National Center for Education Statistics uses the percentage of students eligible for free and reduced lunch as a means to measure the concentration of low-income students in a school,[12] and this definition was used to classify schools. Students from low, mid-low, mid-high, and high poverty schools, as defined by the National Center for Education Statistics, composed 47%, 41%, 11%, and 1% of participants, respectively, compared to 24%, 29%, 22%, and 21% in the general population.[12] Students attending IGED from low-poverty schools were more than double that in the general population.

In their application, students self-select into the following thematic tracks: Healthcare, Technology, Future City and Environment, and Space. The chemical engineering activity is a part of the Healthcare track and the Future City and Environment track. At the start of the program, all students are given an introduction to engineering and have the opportunity to ask questions to a panel of engineers with industrial positions. Then, students attend three sessions based on the track they chose. In each session, an engineering discipline, such as chemical engineering, civil engineering, or mechanical engineering, hosts a hands-on activity. For the past ten years, our lab led the chemical engineering activity for IGED, and, in 2021 and 2022, we developed a polymer-based activity to design a hydrating patch for burn victims. This manuscript describes the full chemical engineering session, which includes an introduction presentation, pre-survey, three-part activity, and post-survey, and shares lessons learned based on survey data. The 2021 session was remote, and the 2022 in-person session refined the activities and collected the survey information presented here. Copies of the handout used in this laboratory are posted online at https://engineering.purdue.edu/LiuGroup/outreach.[13]

Chemical Engineering Session Introduction

Before the activity, a PowerPoint presentation that described the chemical engineering profession was delivered to participants. The presentation was interactive and meant to prompt students to consider how they view chemical engineering. In the presentation, we introduced areas that employ chemical engineering professionals. We intentionally included fields, such as biomedical and clean/alternative energy industries, that are not classically considered as applications for chemical engineers. We provided a brief introduction to polymer science and discussed how polymers can have several unique material properties. Then, we introduced the main material used in this study, sodium polyacrylate, a super-absorbing polymer.

LABORATORY ACTIVITIES

Participants worked in teams of two to four under the guidance of graduate or undergraduate chemical engineering mentors. Graduate and undergraduate mentors facilitated the activity and answered questions about their chemical engineering experience. Each mentor worked with two teams of students, and two facilitators led the introduction of activities and group discussion. Together, students worked through a series of engineering challenges related to using sodium polyacrylate as a component in patches designed to aid burn victims. Each activity was introduced by the session leader on a PowerPoint slide, and students had worksheets that corresponded to each engineering challenge. Table 1 provides time allocated for each activity.

TABLE 1
Time allocation for each Engineering Challenge

Engineering Challenge	Allocated Time
1	10 minutes
2	20 minutes
3	10 minutes

Materials

This activity requires the use of no specialized laboratory equipment. The directions below assume that beakers, measuring spoons, containers, and stirrers are readily available for the laboratory. Additional materials and estimated prices per student are shown in Table 2.

TABLE 2
Materials for Engineering Challenges

Material	Amount	Example Product	Estimated cost per student
Sodium polyacrylate	Approximately 0.8 oz per group	Science Gone Fun 30dp1lb	$0.30
Gram weight set for material stiffness measurements	One set per two groups (reusable in each session)	Learning Resources LER4292	$0.90
Micro petri dishes for material stiffness measurements	One dish per group (reusable in each session)	VWR 10799-192	$0.12
Sodium chloride salt for body fluid simulant in the third engineering challenge	Approximately 5 g per group	VWR 470302-522	$0.04
Nitrile gloves for safety	One pair per student	VWR 40101	$1.87
		Total	$3.23

Engineering Challenge One

The first engineering challenge was intended to familiarize students with the testing procedure. They made two different materials: the first material was made by mixing 1.25 mL water with 1.25 mL of the sodium polyacrylate polymer (1:1 volume ratio of water to polymer) and the second material was made by mixing 250 mL water with 1.25 mL of the polymer (200:1 volume ratio of water to polymer). Students were asked to calculate the water ratio of the materials as defined in Eq. 1.

$$water\ ratio = \frac{volume\ [mL]\ of\ water}{volume\ [mL]\ of\ polymer} \tag{1}$$

The water ratios of the first and second materials were 1 and 200, respectively. Before making the materials, students were asked to form a hypothesis about the resulting physical appearance and mechanical properties of each mixture. The first material was powdery and solid-like, whereas the second material was flowing and liquid-like (Figure 1). The participants were then tasked with measuring the stiffness of the material by increasing the weight placed on top of the material until it failed to hold the weight up. The stiffness rating of the material was calculated using Eq. 2.

$$stiffness\ rating = mass\ [g]\ held\ before\ sinking \tag{2}$$

The more solid-like the material was, the more weight it would hold. The first material with a water ratio of 1 was able to hold the heaviest weight of 100 g, whereas the second material with a water ratio of 200 was not able to hold the lightest 1-gram weight. This measurement was intended to simulate unconfined compression measurements of stiffness. The material stiffness was proportional to the stiffness rating, or the mass held before failure. Students were then asked to reflect on their hypothesis. This engineering challenge was the first opportunity for students to work with their teams and mentor. Students shared their observations with the full session group.

Engineering Challenge Two

The second engineering challenge was intended to engage participants with engineering materials for a specific application and creative problem solving. The ability of sodium polyacrylate to absorb large volumes of water made it an attractive candidate as the basis of a patch that hydrates the skin of burn victims to promote healing after injury. Participants were tasked with designing a material out of sodium polyacrylate and water that could serve as a patch for burn victims recovering from a fire. The material needed to be both hydrating and able to maintain its structure to function as a burn patch. Participants needed to hypothesize a ratio that would have enough polymer to maintain its shape when applied and enough water to be hydrating. After selecting a ratio with their partners, students made the material, tested its stiffness, and plotted their results on a blackboard to compare with the rest of the students in the session. Materials with water ratios between 25 and 50 were stiff enough to hold their shape, had a stiffness rating around 50, and maintained large volumes of water to meet the design constraints. Figure 1 illustrates differences between the materials created in engineering challenges one and two.

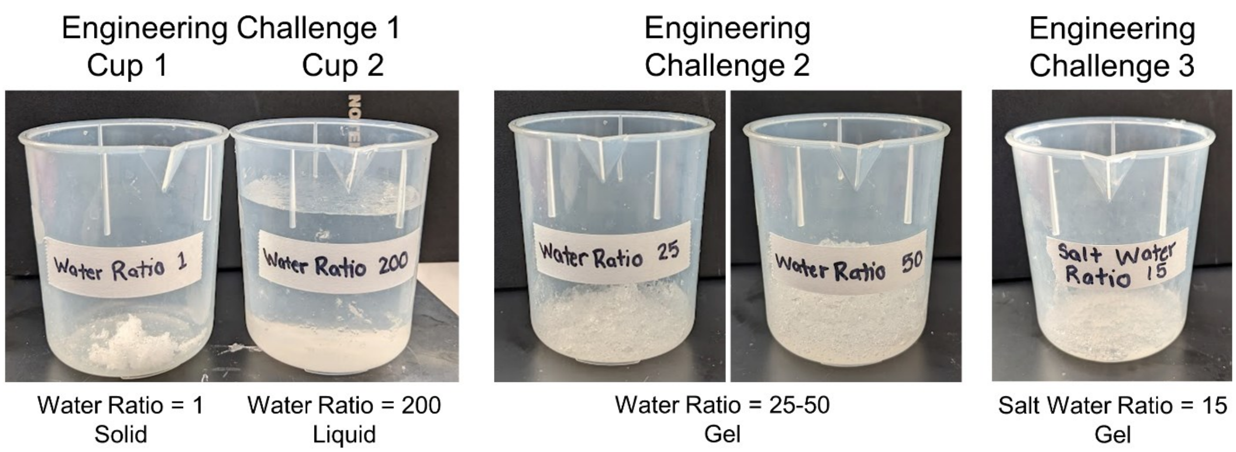

***Figure 1**. Materials from Engineering Challenges 1, 2, and 3. In Engineering Challenge 1, materials had water ratios of 1 and 200 and were solids and liquids, respectively. In Engineering Challenge 2, a water ratio between 25 and 50 produced a gel that met the design challenge criteria. In Engineering Challenge 3, a salt water ratio of 15 produced a gel that met the design challenge criteria.*

Students shared their observations with the group and together they evaluated trends in the data. In each session, the group results demonstrated that increasing the amount of water decreased the stiffness of their material. We noted that students enjoyed connecting their observations to their prior knowledge. For example, when describing their burn patch material, one group observed it felt "like aloe vera."

Engineering Challenge Three

The third engineering challenge was intended to encourage groups to think outside the box, adapt to new challenges, and get more creative in their problem solving. Participants were tasked with adapting their product to use a salt solution, which simulated a buffered system that balances pH and salt concentration to help prevent pain and dryness upon application. Thus, we replaced the water the students used to make their material with 3 wt% salt water. We explained that salt disrupts the water-absorbing ability of sodium polyacrylate. Students would need more of the polymer than in previous challenges to maintain structural integrity and absorb the salty water, but they were given no information to guide their selection of how much more polymer would be needed. In their groups, they had to figure out a method to achieve the new criteria. Some groups started with polymer and added small amounts of the salty water until they assessed that the material met the design challenge criteria. Other groups added the salty water to materials they made in previous challenges to see how it impacted the absorbency. Materials with salt water ratios around 15 were both stiff enough to hold their shape and still maintained large volumes of water to meet the design constraints (Figure 1). During this challenge, we observed that the language shifted in the groups from passive observation to active participation. Creativity phrases such as "we should try" were common during this challenge.

RESEARCH DESIGN

Research Questions

The goal of IGED is to increase interest in engineering among early high school female students. To gauge the effectiveness of the chemical engineering session at increasing interest among participants, surveys were given to the students both before the introduction presentation and after the activities just before departing. In addition to measuring the change in interest levels in chemical engineering, we wanted to evaluate which components of the activity contributed most to those changes. Students were asked the extent to which they agreed with statements relating to activity components concerning helping others, teamwork, and creativity.

Survey Overview

The surveys were designed to gauge the impact of the session on students' engineering identities. Participants received a series of statements shown in Table 3 and were asked the extent to which they agreed or disagreed based on a Likert-type scale in which a 1 indicates they strongly disagree and a 5 indicates they strongly agree with the statement. The majority of statements were given in both the surveys before and after the session. The last five statements were only given in the post-survey and were intended to evaluate the effectiveness of different components of the activity. Several questions within the survey probed different aspects of helping others, teamwork, and creativity. These questions were asked with respect to the participant's interest in a future profession (e.g. "I want to work with others in my future profession."), their thoughts about chemical engineering (e.g. “Chemical engineering is a profession where you get to work with others.”), and, in the post-activity survey, how well the participant enjoyed those aspects of the activity (e.g. “I enjoyed working on a team to solve a problem.”). Based on the framework outlined by Capobianco et al.,[5] statements around participant perception of their abilities were considered “academic identity,” interest in a future profession were considered “engineering aspirations,” and statements involving participants’ thoughts about chemical engineering were considered “occupational identity.”

RESULTS

Table 3 summarizes the percentage distribution and average score of the pre- and post-survey questions. All questions received 40 responses, except “I am interested in chemical engineering” and “I enjoyed learning about polymers” in the post-survey, both of which received 39 responses. All average scores in the post-survey were equal to or higher than those in the pre-survey.

TABLE 3
Pre- and Post-activity survey results show changes in engineering identity as a result of the activity

Chemical Engineering Identity	Statement	Survey	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Average score[a]
Academic Identity	I am interested in chemical engineering.	Pre	5.0%	12.5%	42.5%	37.5%	2.5%	3.2 ± 0.9
		Post	0.0%	7.7%	25.6%	51.3%	15.4%	3.7 ± 0.8
	I think I can be a chemical engineer.	Pre	5.0%	12.5%	40.0%	35.0%	7.5%	3.3 ± 1.0
		Post	2.5%	10.0%	22.5%	50.0%	15.0%	3.6 ± 0.9
	I am good at solving problems in math and science.	Pre	0.0%	0.0%	27.5%	37.5%	35.0%	4.1 ± 0.8
		Post	0.0%	0.0%	14.6%	41.5%	43.9%	4.3 ± 0.7
Engineering Aspirations	I want to help people in my future profession.	Pre	0.0%	0.0%	0.0%	12.8%	87.2%	4.8 ± 0.4
		Post	0.0%	0.0%	0.0%	17.5%	82.5%	4.8 ± 0.4
	I want to work with others in my future profession.	Pre	0.0%	2.5%	20.0%	32.5%	45.0%	4.2 ± 0.9
		Post	0.0%	5.1%	12.8%	33.3%	48.7%	4.2 ± 0.9
	I want to be creative in my future profession.	Pre	2.5%	0.0%	7.5%	30.0%	60.0%	4.4 ± 0.8
		Post	2.5%	0.0%	5.0%	22.5%	70.0%	4.6 ± 0.8
Occupational Identity	Chemical engineering is a profession where you get to help people.	Pre	0.0%	2.4%	19.5%	43.9%	34.1%	4.1 ± 0.8
		Post	0.0%	2.5%	2.5%	17.5%	77.5%	4.7 ± 0.6
	Chemical engineering is a profession where you get to work with others.	Pre	0.0%	2.4%	22.0%	36.6%	39.0%	4.1 ± 0.9
		Post	0.0%	2.5%	12.5%	30.0%	55.0%	4.4 ± 0.8
	Chemical engineering is a profession where you get to be creative.	Pre	0.0%	9.8%	17.1%	26.8%	46.3%	4.1 ± 1.0
		Post	0.0%	5.0%	7.5%	20.0%	67.5%	4.5 ± 0.8
Activity Components	I enjoyed learning about polymers.	Post	0.0%	2.6%	12.8%	38.5%	46.2%	4.3 ± 0.8
	I enjoyed creating a material to help treat burn victims.	Post	0.0%	2.5%	10.0%	20.0%	67.5%	4.5 ± 0.8
	I enjoyed working on a team to solve a problem.	Post	0.0%	2.5%	5.0%	25.0%	67.5%	4.6 ± 0.7
	I enjoyed designing a new material.	Post	0.0%	0.0%	5.0%	20.0%	75.0%	4.7 ± 0.6
	Overall, I enjoyed participating in this session.	Post	0.0%	0.0%	0.0%	17.5%	82.5%	4.8 ± 0.4

[a]Average score is reported as the mean ± standard deviation

Two response averages were statistically higher after the activity than before the activity: "I am interested in chemical engineering" and "Chemical engineering is a profession where you get to help people." Students were more confident in their ability to solve math and science problems than they were about being a chemical engineer as evidenced by responses to statements related to academic identity. This discrepancy could be a result of the disconnect between the engineering profession and the coursework students learn in high school.

When comparing the pre-activity and post-activity survey results across the three identity factors, we observed a larger impact of the activity on participants' academic identity and occupational identity compared to that on their engineering aspirations. There was a slight increase in the statement "I want to be creative in my future profession," but the other two engineering aspirations statements remained unchanged in their average and standard deviation.

In the post-activity survey, we asked several statements about how much participants enjoyed certain aspects of the activity. Overall, the responses were positive with average scores >4. The final statement of "Overall, I enjoyed participating in this session" received the highest positive value with the lowest standard deviation. The statement "I enjoyed learning about polymers," received the lowest score. All three elements were rated a 4.5 or higher on average by participants. Therefore, incorporating aspects of helping others, teamwork, and creativity into chemical engineering outreach activities can increase effectiveness in reaching early high school women.

To evaluate possible disconnects between participants' career goals and concepts of chemical engineers, differences between engineering aspirations and occupational identity as a result of the activity were also investigated in Table 4 using Eq. 3.

$$Difference = Engineering\ Aspiration - Occupational\ Identity \tag{3}$$

Differences were calculated within a single participant's response in either the pre-activity survey or the post-activity survey, and all response differences were averaged together. If the difference was positive, the participant wanted the attribute in their future career but did not think that chemical engineers used that attribute in their profession.

TABLE 4
Differences between engineering aspirations and occupational identity decrease after the activity

Data represented as difference between responses to the statements of "I want to X in my future career," and "Chemical engineering is a profession where you get to X."

Help People		Work with Others		Be Creative	
Pre-activity	Post-activity	Pre-activity	Post-activity	Pre-activity	Post-activity
0.7 ± 0.9	0.1 ± 0.7	0.1 ± 0.9	- 0.1 ± 0.9	0.3 ± 1.1	0.1 ± 0.8

This comparison was intended to determine if there was a disconnect between what students want to do in their future professions and if they think chemical engineers do those things. When asked before the activity if participants want to help people, work with others, and be creative as statements related to their engineering aspirations, most students strongly agreed. However, fewer students thought they could do these things as chemical engineers as evidenced by lower average responses in statements related to participant occupational identity. After the activity, the difference between engineering aspirations and occupational identity decreased or became negative. The highest numerical decrease in these identity differences was between the statements "I want to help people in my future career," and "Chemical engineering is a profession where you get to help people."

In the post-activity survey, there was a short response section for participants to answer with four sections:

1. Did you learn anything new about chemical engineering from this session? If so, please explain.
2. What did you like most about the session?
3. What did you like least about the session?
4. Additional comments or suggestions for improvement.

This section of the post-activity survey had a varied number of responses. The questions received 37, 37, 34, and 17 responses, respectively. Responses to the first question were split between learning about polymer science (15 responses), learning about different applications of chemical engineering (13 responses), and learning about design (8 responses). Students who commented about polymers either generally remarked that they learned about polymers or more specifically about different characteristics they observed about the polymer used in the activity such as water absorbency or the impact of salt on polymer absorbency. Responses related to applications of chemical engineering commonly remarked on the broad range of applications chemical engineers focus on in their profession or on specific applications the participant learned chemical engineers work with. One student remarked "I learned that chemical engineering has medical applications (I knew nothing about it before)." The design-focused responses mentioned aspects of creativity and problem solving involved in chemical engineering. Developing specific skills such as applying trial-and-error and translating designs into real-world applications were mentioned as well.

Responses to the second question of what students liked most largely centered around the experimentation and design process (14 responses). Many of the responses indicated enjoyment of engineering challenges two and three in which students tried their own ratios and creative thinking to get their material to work. Eight responses mention "playing with" the material and the hands-on component of the materials design process. Notably, helping others, teamwork, and creativity of the activity were specifically mentioned in four, six, and six responses, respectively, for this question.

The third and fourth sets of responses related to what students liked least and suggestions were helpful in providing feedback for future iterations of the activity. Eleven out of 34 of responses of what students liked least related to the messiness of the experiment. Ten responses related to having to calculate ratios and filling out the activity sheet or survey. One response specifically mentioned "I'm not a big people person, but it was fun" and also scored the statement "I enjoyed working on a team to solve a problem" a two out of five indicating they disagreed with the statement. Three responses mention adding in color as the polymer itself is white when dry and clear when hydrated. Others mention wanting to take their material home with them as bags were not provided for all students. Three participants mentioned they did not like the time constraints and lack of participation. Six out of 34 of the responses mention nothing was their least favorite, and 12 out of 17 responses to the feedback question stated they had no suggestions.

DISCUSSION

The outlined activity enabled participants to learn about polymers, simulate compression measurements of biomaterials, critically think about materials design parameters, and design and prototype unique biomedical materials. These fundamental materials design and characterization skills were developed without the need for costly lab equipment. The activity cost only $3.23 per student, and several of the materials are reusable for future sessions and would further reduce the cost. Originally, this activity was designed for a fully remote IGED chemical engineering session so the materials are shippable and non-toxic, and the activity can be performed at home or in a remote setting if needed. However, the teamwork component led to rich discussions amongst the students and were absent when the activity was remote. The outlined activity led to an increase in interest of early high school women in pursuing chemical engineering as a career as indicated by a statistically more positive response to the statement "I am interested in chemical engineering" after the activity. This increase in interest was correlated to demonstrating that the chemical engineering profession can provide service to the community as indicated by a statistically more positive response to the statement "Chemical engineering is a profession where you get to help people," after the activity.

The academic identity, engineering aspirations, and occupational identity of students impact whether they choose to pursue chemical engineering as a profession, and each component was impacted differently by the activity. Academic identity demonstrates whether the student believes herself to have the technical and emotional skills to pursue a career in chemical engineering. After the activity, fewer students held negative views of their academic identity related to chemical engineering. There was a notable disconnect between ideas about the chemical engineering profession and science and math coursework that persisted after the activity was complete. Participants indicated they on average were neutral or agreed with the statement "I think I can be a chemical engineer" even after the activity was complete, whereas students agreed or strongly agreed with the statement "I am good at solving problems in math and science" (Table 3). The disconnect between math and science skills and engineering abilities is strong motivation for greater investment in incorporating engineering skills into early high school curricula. Future iterations of the activity could emphasize the connection between math and science skills and engineering abilities by explicitly mentioning the connection during discussions after each challenge and discussing the skills the students gained as a result of the activity at the end of the session.

The engineering aspirations of students remained largely unchanged as a result of the activity (Table 3). Engineering aspirations demonstrate whether the student has interest in the attributes of the profession. In this study, service to the community, teamwork, and creativity were the attributes of the chemical engineering profession measured, and participants agreed or strongly agreed on average with wanting these attributes in their future profession. In particular, service to the community had the highest level of agreement with the smallest standard deviation, which aligns with studies that suggest women are more attracted to professions with social impact.[6] Interest in these three attributes was not expected to change as a result of the activity because participants likely encountered these attributes in their lives and formed their perceptions before the activity. However, although not statistically significant, participants rated wanting to be creative in their profession higher after the activity. Also, fewer participants held neutral views of these attributes after the activity compared to before, and this result suggests the application of these attributes in problem solving challenges allowed students to develop more informed opinions.

Occupational identity connects the attributes of service to the community, teamwork, and creativity to the chemical engineering profession, and responses to occupational identity questions were expected to change as a result of the study. The perception that chemical engineering is a profession that provides service to the community was more positive as a result of the activity (Table 3). This measured increase is beneficial given the importance participants placed on having a profession in which they help others. Therefore, as a result of the activity, there was an increase in the alignment of participants' engineering aspirations and the occupational identity of chemical engineers. In addition, participants from underrepresented communities can benefit from the emphasis of this activity on the communal aspect of chemical engineering.[14]

Alignment between engineering aspirations and occupational identity can increase the likelihood of these young women to pursue a chemical engineering profession; however, there are other attributes and factors not measured in our survey that likely contribute to whether or not participants will pursue a chemical engineering degree in college. These factors include having female role models who pursue chemical engineering,[15] general exposure to the field,[4] and real-world experiences in the field.[16] Our activity addressed some of these factors by having graduate and undergraduate mentors serve as active role models and by exposing and educating the students about chemical engineering; however, more sustained exposure in K-12 curricula would be a more effective, long-term method for students to develop a chemical engineering identity. In addition, a majority of participants attended schools with low poverty, with above average white populations, and in suburban communities. As a free program, IGED has the opportunity to make engineering more accessible with better recruitment of participants from high-poverty areas.

Overall, the design of this biomedical polymer activity was aimed at increasing young women's interest in chemical engineering. To effectively reach young women in early high school, it is important to keep the activity fun and engaging and allow ample time for creativity in their designs. However, it is easy to foster immediate enjoyment in a fun activity but sustaining those positive attitudes toward chemical engineering is more difficult and is essential for long-term retention of women in STEM fields such as chemical engineering. To sustain interest, engaging hands-on activities such as this one should be made available regularly to students, and secondary education should invest in incorporation of engineering design into curricula.

CONCLUDING REMARKS

A simple, low-cost activity was designed to increase interest in and awareness of the chemical engineering profession among female high school students. The short activity impacted participants' academic and occupational identities and led to better alignment between the engineering aspirations of participants and the occupational identity of chemical engineers. These results motivate the need for application-oriented design-focused chemical engineering activities for high school women. Overall, this study determined that emphasis on helping others, teamwork, and creativity can positively influence the chemical engineering identity of early high school women and has the potential to increase representation of females in the chemical engineering profession.

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