

Examining the Influence of a Professional Development Program on High School Counselors' Practices Regarding Engineering

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Abstract—This Work-in-Progress paper details the innovative practice of providing high school counselors with a hands-on engineering professional development (PD). Prior research shows that counselors are often unprepared to advise students about engineering pathways. This is primarily due to the lack of information and training provided to counselors about engineering. A PD was designed to educate high school counselors about engineering education and the overall engineering profession. A total of 15 counselors completed the five-week PD online during the summer of 2020. A subset of participating counselors ($n = 5$) was interviewed six months after the PD to examine how their practices had changed following the PD experience. Initial findings suggest that counselors changed how they viewed engineering as a more inclusive field beyond just a discipline for those who excel in math and science. This led to adjustments in their counseling and recommendations regarding engineering to ensure that any student with an expressed interest would be aware of the opportunity.

Keywords—*pre-college engineering education, high school counselors, professional development, qualitative research*

I. INTRODUCTION

The fields of science, technology, engineering, and mathematics (STEM) have made notable progress but continue to have underrepresentation of women, Hispanics, and African Americans [1]. The root cause of the dilemma starts in pre-college education. The issue is partially due to the minimal attention given to pre-college engineering education. In a 2009 report by Katehi, Pearson, and Feder, K-12 engineering education can not only increase the awareness of engineering and engineering opportunities, but also increase interest in the pursuit of an engineering degree and career [2]. Early intervention in the educational system is vital in order to influence career choices focused on STEM [3]. One way to achieve this goal of getting a more diverse population interested in engineering is through education of school counselors.

School counselors play a major role in students' course selections and future educational pathways [4]. Oftentimes when a student is unsure how to proceed with their academic future, they will consult a counselor. It is pivotal that counselors have the ability to give an accurate representation of engineering to any student who may be interested.

It has been shown that most counselors are unprepared and have had little to no training on advising students, specifically minority students, about engineering pathways [4-5]. Most counselors lack any engineering experience, which makes it difficult for them to portray what engineering is really all about. Increasing counselors' knowledge of engineering, as well as equipping them with essential tools in order to be able to effectively inform students, has the potential to broaden both the awareness and participation of those who have not previously been presented with or interested in engineering pathways.

A five-week, online professional development (PD) was created to educate counselors about engineering. This work was taken up under a bigger project called Engineering for Us All [6]. A total of 15 counselors completed the program in July 2020. The PD aimed to provide learning opportunities for counselors with a focus on encouraging greater participation in engineering. This was accomplished using informational sessions and collaborative, hands-on, engineering design activities aimed to educate counselors about the broad nature of engineering, and to show that engineering can be for anyone. Activities included discussing the impact of stereotypes and implicit bias that often influence who pursues engineering education and careers, engaging in engineering tasks (e.g., spaghetti tower, building a rain shelter out of newspaper, and constructing a robotic arm), and dialoguing with university representatives about different engineering majors. Each activity required the counselors to use engineering-oriented skills, such as problem-solving, creativity, and critical thinking, to display that engineering is much more than just math and science. The PD also allowed participants to work with other counselors to get an understanding of the cooperative, teamwork aspect of engineering, as well as to share useful information with each other. Overall, counselors were provided with the tools they needed to effectively engage students in conversations about engineering. Counselor practices were examined to see if the PD influenced their abilities to convey educational and professional aspects of engineering, and the opportunities associated with it, to students. This paper analyzes changed practices as a result of counselor participation in the program, not the evaluation of the PD itself.

II. GUIDING THEORY

This work is being guided by the Diffusion of Innovation (DoI) theory [7]. DoI is the process by which an innovation is communicated, by means of certain channels, over some length of time among members of a particular social system and adopted in practice [8]. DoI allows for practical analysis into the process of social change [9]. For this study, innovation is the new knowledge and techniques (e.g., information about engineering as a discipline of study and profession) that counselors obtained from an engineering PD experience. DoI suggests that the decision process that leads to the sustained use of an innovation occurs in five distinct stages: knowledge and awareness, persuasion, decision, implementation, and confirmation [8]. The stages must occur in that order because each successive stage builds off the prior.

The first stage of *knowledge and awareness* occurs when individuals go through the process of learning about the innovation. It is critical that potential adopters understand both how and why an innovation is used in order for them to effectively progress to the subsequent stages. Knowledge and awareness stage provides the foundational building blocks for the remaining stages. The second stage of *persuasion* occurs when an adopter is convinced by peers, or convinces themselves, that an innovation has inherent value and is worth adopting. Potential adopters weigh the possible advantages and disadvantages that they are presented with during this stage. Individuals are often faced with arguments as to whether the innovation provides sufficient improvement to justify the effort required to adopt it [10]. Adopters who are successfully persuaded shift to the third stage of *decision* where one must choose whether to adopt a certain innovation based on previous information. Individuals tend to explore how effective an innovation may be before they decide to either accept or reject it [10]. The fourth stage of implementation is where adopters implement the innovation they have decided to adopt. Usually, there is a plethora of different ways that an innovation can be implemented. The final stage of *confirmation* is where the adapters seek affirmation in regard to whether or not their decision and implementation were successful.

The duration of these stages is unknown because it is common for some individuals to adopt an innovation much more readily than others [7]. The time that it takes for adopters to progress through the innovation-decision process varies. The described stages provided the basis for our analysis with expected variation in regard to where each counselor was at in the innovation-decision process.

III. METHODS

Counselors were recruited five months after the PD for interview sessions to understand how their counseling practices had been altered as a result of the PD. Five counselors volunteered and were interviewed via Zoom during approximately 30-minute sessions. Of the participants, 3 were female and 2 were male. Years of counseling experience of the participants ranged from 3 to 30 years. Participants worked at public and private high schools across the United States. All but one of the male participants are white.

The counselors were asked how the PD influenced their professional practice, and what they found useful from the PD specific to engineering-related counseling. Interview transcripts were analyzed using two rounds of coding [11]. In the first round, excerpts and data units were partitioned into five code categories based on DoI stages [7]. In the second round, data units under each of the five DoI stages were further analyzed for similarities and differences across participants. Table 1 provides a short description of each code, the percentage of excerpts evidenced under that code, and an example statement made by a participant.

TABLE 1
RESULTING CODES

Code	Description	% Evidence	Example
Knowledge and Awareness	Counselors learning and gaining knowledge about engineering and engineering education	57	"I got a lot out of the summer PD, because it really was an opportunity to revisit a lot of the research and rationale behind engaging young people in engineering. All those bedrock, foundational elements of why this is critical."
Persuasion	Counselors convincing themselves to adopt the strategies learned in the PD	7	"Over the summer PD, having a chance to hear from colleagues...having that chance to sort of compare notes about challenges, strategies, just to sort of get energized and recommitted from other people was really worthwhile."
Decision	Counselors making the decision to implement information and tools learned from the PD	7	"I've been toying with using the tower building activity, or one of the other pretty accessible activities as just a hands-on intro for students."
Implementation	Specific implementations of gathered techniques from the PD utilized by counselors	26	"We're creating sort of a STEM certificate program. Making sure that students are exposed to engineering is one element of that. I have a way to do that and people enlist as allies in that."
Confirmation	Affirmation by counselors that the changes made are an effective improvement	3	"I've been pretty successful in talking to students about that engineering class and there's a little bit of enthusiasm about it. We've had elective courses that have gone okay for a while and then just kind of disappeared. I don't foresee that happening with engineering."

IV. RESULTS

A. Knowledge and Awareness

Over half of the codes under the knowledge and awareness category suggested that counselors acquired a good amount of useful information from the PD. As stated by one of the counselors in response to what they found helpful from the PD, "...a lot of the things that we talked about just equity and thinking about minority students and students of color, kids that we don't typically think about for higher level classes and all that. I think that was very pointed and definitely is in the forefront of my mind." One of the major focuses of the PD was inclusivity and emphasizing that engineering can be for anyone. Gaining confirmation that information on those topics stuck with a counselor and got them to really think about it as they work with students gives a glimpse at the progress towards one of the overall goals of broadening participation in engineering.

Counselors shared information about specific experiences they acquired and can now draw on from the PD. For example, one counselor detailed that, "having a way to really access very readily the experience of students in intro level engineering activities, I think has really just deepened my knowledge base and enabled me to be a better ambassador." In reference to the hands-on engineering activities that they participated in during the PD, they expressed how such activities allowed them to better connect with students and accurately relay information to students in regard to what engineering is really all about. This furthers the progression of another overall goal of explaining that engineering is about being creative, problem solving, and much more than just math and science.

Counselors were also asked about what resources they think would be helpful to them, but that they did not gain from the PD. One of the counselors mentioned that "we didn't get too much into this. But I'm aware that there are scholarship opportunities within engineering." They additionally noted that, "I find students are always receptive to areas of study where they realize that there's some scholarship funding available, especially for underserved groups, women, and beyond..." Part of the reason some students may seem hesitant to pursue engineering is because it may seem daunting financially and/or academically. When students are presented with scholarship opportunities that would grant them funding, it might make them more inclined to consider an engineering pathway. This is particularly important for female or minority students receiving opportunities specifically for their demographic, which could help to encourage them to pursue engineering. Providing counselors with these resources would in turn allow them to share that information with students, and ultimately increase the likelihood of more students participating in engineering.

B. Persuasion

An important part of the PD was that counselors had the opportunity to communicate and work with other counselors. Interactions with others allowed participants to see how the PD was being perceived by their peers. As one of the counselors mentioned, "...just being able to connect with other people who have the same passions, but also challenges or frustrations can be helpful." They described how they found it valuable to be able to connect with other counselors in a unique environment. Having the ability to hear the opinions from people in the same

profession allowed the counselors to evaluate the impact that the information they gained from the PD may help not only with their jobs, but also have a positive impact on their students.

C. Decision

Preliminary data suggests that counselors would like to further the awareness of engineering opportunities to their students and were considering ways of enacting. It can sometimes be difficult for an individual to actually take the steps to implement a certain innovation, especially if they are unsure exactly how to go about it. A counselor explained, "I've been toying with using the tower building activity, or one of the other pretty accessible activities as just a hands-on intro for students." Counselors acknowledged that it would be very beneficial for their students to be able to learn more about engineering through a tangible activity, like the one they had participated in during the PD. Counselors also stated they will make an effort to implement the activity as a part of a larger engineering experience program at their school.

D. Implementation

The second highest percentage of evidence came in the implementation category of coding. Many counselors explained how they directly implemented what they learned from the PD into their work with students. One of the participants described how "counselors are somewhat involved in the course selection each year, particularly when it comes to elective type classes and the engineering class is an elective class. So we're able to recommend, when kids have openings on their schedule...by the end of the [PD], we still had a good 30 or 40 kids that had not registered for classes we were working with in the counseling office. And, since there was still room in the engineering class, it ended up being a full class." They explained how they were able to pull information learned from the PD in order to get undecided students interested in engineering offering.

Counselors also described certain challenges of implementing some of the knowledge and information they had gained from the PD. For example, a counselor detailed, "we do something called a boot camp with [students] where we're kind of introducing them to tasks that center, in some way mimic what, or relate to what they might ultimately be doing in research...it also could work in a team context...but with masks and social distancing, it's really hard to get the same kind of hands-on involvement that we typically might have." Counselors had wanted to implement certain activities that they had accomplished during the PD into the boot camp so that those experiences could be shared with the students, however, they ran into issues due to the pandemic forcing everything to be virtual. This hopefully temporary setback made it difficult to accurately portray what engineering is really about without being able to tangibly design a solution.

Some counselors also expressed that some ideas had yet to be implemented because of reasons such as time restrictions, pandemic complications, and lacking a clear opportunity for implementation. One counselor explained, "I'm trying to think if there's a way to have, not necessarily a video or something like that, but even a handout that 'Did you know that it's an engineer that did this, or this, or this?' So that they could look at it as 'Oh, gee, it's more than, building bridges', or whatever you would think a normal engineer would do. It's like 'Wow, I

never thought that that was part of engineering and that's something I like, so..." The counselor explained that it could be beneficial for students to be able to see engineering in action, rather than simply being told about it. Initial findings suggest that oftentimes counselors acknowledge improvements that can be made but are limited in making those improvements due to resource constraints.

E. Confirmation

Smallest portion of data-units were found under the confirmation stage. However, limited data suggested that counselors are gaining confirmation that the information they applied from the PD is beneficial to students. One of the counselors described, "what I've been using is all the knowledge that I gained from going through the class series, and the notes that I took. I had no idea how wide open the engineering field is, and so I was actually really encouraging a lot of students to take AP Physics 1 their sophomore year...and after those conversations, so many of them switched over to AP Physics..." They explained that by utilizing techniques and information they had learned from the PD, they helped a number of students realize the course sequence that would be more beneficial considering future higher education pathways. In particular, counselors applied their knowledge of how broad engineering is to introduce engineering to students that they likely would not have considered to be interested in engineering prior to taking the PD.

For this Work-in-Progress, we primarily looked for themes under the broad heading of DoI. However, we also found additional themes. Primarily, we observed that counselors expanded their conception of engineering beyond just math and science, to include creativity, teamwork, and problem solving.

V. DISCUSSION & FUTURE WORK

School counselors are trained to help students develop their skills and interests into academic pathways, and ultimately the workforce [12]. However, a large majority of them struggle to relay accurate information to students regarding engineering due to a lack of experience and understanding of what engineering is really all about [5]. Data suggests that the PD provided counselors with the knowledge that they needed in order to effectively advise students on potential engineering opportunities. Counselors described how the experiences and information that they acquired from the PD aided them in their interactions with students. In particular, the PD provided counselors with relevant understanding that engineering is not exclusively for those who excel in math in science, but rather for anyone who has a desire to be creative, problem solve, and cooperate with others. Numerous counselors detailed how they were able to use the information learned to introduce engineering to students they previously might not have considered. Whether the student ends up becoming interested in engineering or not, it is important that they are at least presented with an accurate portrayal of what it truly is all about.

Participants described how the PD not only allowed them to gain a better understanding of engineering, but how it encouraged them to share the experiences with students and implement ways for students to attempt those activities themselves. Providing students with such opportunities will

help them be able to really gauge whether engineering is something they desire to pursue. Such efforts have a strong potential to get more students to become interested in engineering, which can broaden participation. Overall, results suggested that connecting counselors with others in their profession through such PD opportunities is pivotal to their understanding of engineering and their progression through the DoI process. Peer education is often a valued aspect of such PD opportunities in pre-college settings [13-14].

Although the DoI framework was primarily utilized in this paper, as we collect more data, we plan to look at other inductively emerging themes [12] and potential frameworks, including Community Engaged Learning. Continued research will need to be done to ensure that counselors are fully equipped with all the tools they need to effectively portray engineering to their students [15]. It will be important to obtain feedback from more counselors, to get a broader understanding of how the PD has helped them with their work, as well as what can still be improved. It will also be beneficial to conduct further interviews to see if implementations have succeeded or not, and to find more evidence of counselor progression to the confirmation stage. More interviews are being conducted, and supplemental data will be collected at the end of the school year to further assess the changes counselors made based on what they learned from the PD. Future work may also include more quantitative analysis, with a larger number of participants. Despite difficulties from the COVID-19 pandemic that counselors faced when attempting to implement what they learned from the PD, it is reassuring to know that they have applied some of the knowledge gained from the PD and that more students are being presented with an accurate understanding of, and opportunities to learn about, the true nature of engineering.

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