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Interventions to Improve Mentoring Over an Eight-Session Out-Of-School Workshop for High School Students (Work in Progress)

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Introduction

Schulich Ignite is an out-of-school program where undergraduate engineering students teach computer programming to high school students [1]. The goal of the program is to recruit and prepare high school students for an engineering program. A pillar of the program is formal mentorship that helps students realize their potential as engineers. The program was moved online in 2020 to address limitations imposed by physical distancing mandates and reach more students outside of the city.

Literature Review

Youth Mentoring

Youth mentoring practices have been steadily increasing as more evidence emerges about the positive effects mentoring can have, such as improved academic achievement, physical wellbeing, resiliency, and pro-social activity [2] - [4]. Although there is no single definition of mentoring, a broad description is a practice where a mentor provides guidance and support to a younger person, often mediated through an emotional connection [5]. Mekinda and Hirsch created the "Revised Framework for Investigating Mentoring Relationships in After-School Programs" [6], [7]. The Framework considers factors unique to after-school programs, such as the characteristics of the environment, individuals, and mentoring relationships. Within the mentoring relationship, potential mentoring behaviours are listed: emotional support, guidance/teaching, sponsorship/advocacy, and learning/collaboration. The Framework then looks at the experience and outcomes to the youth and staff related to the mentoring relationships. The Framework helps practitioners assess mentoring programs and find areas for program development.

Mentoring in Engineering Outreach

In university outreach activities, mentoring has been employed to attract a wider diversity of students to the engineering and science fields [8] - [10] and improve mentors' professional skills, such as leadership and teamwork [11] - [13]. The research involves a breadth of approaches to assessing programs, like Bandura's self-efficacy model [12], [14], [15], Bloom's taxonomy [16], and engineering competence development [15], to name a few.

Objectives

This research seeks to find opportunities in virtual engineering outreach programs where mentoring can increase the program's positive outcomes. We hope to answer the questions: (RQ1) *what are the program's current outcomes?* (RQ2) *Can existing theory for youth mentoring be applied to engineering outreach programs?* And (RQ3) *what characteristics of the engineering outreach program have the most potential to improve outcomes?* To answer these questions, we look at the activities and outcomes of the Schulich Ignite program and discuss these results in the context of existing theories.

Methodology

Mentees received surveys pre- and post-program. Questions (see Table 1, below) measured program outcomes (the use of programming skills and ability to see oneself majoring in engineering) and mentoring behaviours (learning/collaboration, sponsorship/advocacy, emotional support, and guidance/teaching) explained in mentoring theory. Mentees answered questions on a five-point Likert Scale [17]. Respondents could also choose unable to answer, which was then treated the same as a non-response and excluded from the analysis.

The end of the survey contained open-ended questions about what mentors did to help mentees create a digital product or see themselves as engineers. Furthermore, two voluntary mentees participated in follow-up interviews. Responses from the open-ended survey questions and transcribed interviews were analyzed and coded. Codes were then grouped into themes and confirmed using a thematic analysis approach [18]. Using these themes, we compare the qualitative data to youth mentorship theories to find the highest potential areas for improvement.

Results

The results from eleven survey questions appear in Table 1. The questions measure current outcomes of the program as well as mentoring behaviours.

In the qualitative data, the dominant themes that emerged were knowledge and relationship, followed by activities, and lastly, atmosphere.

Knowledge

The theme of knowledge included such activities as explaining, describing, guiding, and answering questions. These activities are distinct because they involve the passing of knowledge from a mentor (or lecture lead) to a mentee. This finding demonstrates that one of the program's primary functions—as perceived through the mentee experience lens—is instructional and is further supported by the quantitative survey results. Most respondents agreed that the mentor helped them create a digital product (SQ2: $\bar{x} = 4.3$) and respect their mentor's ability to teach others (SQ11: $\bar{x} = 4.9$).

Relationship

The relationship theme refers to activities like encouraging, motivating, helping, relating, appealing to interest, and sharing. The distinction with this theme is that the activities necessitate at least two people interacting beyond merely sharing knowledge. Activities under the relationship theme tend to bring mutuality and empathy, which Rhodes theorizes is foundational for a robust mentoring connection [19]. Here, mentees and mentors discussed interest and experience in engineering. In one interview, the mentee fondly recalled the experience of hearing about and seeing examples from her mentor’s engineering classes.

In the survey, the participating mentees expressed that they saw their mentor as a friend (SQ10: $\bar{x} = 4.2$). In interviews and open-ended responses, only one survey respondent noted that a mentor had empathized with a personal frustration. The lack of responses concerning emotional

relationship building is, perhaps, not surprising as Rhodes asserts that "adolescents on the brink of adulthood may be less interested in establishing emotional ties with mentors, instead gravitating to peers and vocational skill-building activities." [19]. Therefore, we have drawn no significant conclusions about friendship's function in the program given the data collected.

Table 1: Survey Questions (SQ) and Responses

Survey Question	Sample mean	Standard deviation	Number responses	Percent agree
Learning/Collaboration and Cognitive Development				
SQ1. Before enrolling in the Ignite program, I had created a new digital product from scratch.	$\bar{x} = 2.7$	$s = 1.4$	$n = 55$	40%
SQ2. My mentor helped me to create my own digital product from scratch.	$\bar{x} = 4.3$	$s = 0.8$	$n = 20$	80%
Sponsorship/Advocacy, Vocational Support, and Identity				
SQ3. Before enrolling in the Ignite program, I could see myself majoring in engineering at University.	$\bar{x} = 3.6$	$s = 1.4$	$n = 56$	58%
SQ4. My mentor discussed applying to a University engineering program with me.	$\bar{x} = 2.9$	$s = 1.1$	$n = 19$	42%
SQ5. My mentor discussed studying engineering at University with me.	$\bar{x} = 3.3$	$s = 1.4$	$n = 19$	53%
SQ6. My mentor discussed working as an engineer.	$\bar{x} = 2.1$	$s = 1.1$	$n = 19$	11%
SQ7. The mentor helped me to see myself majoring in engineering at University.	$\bar{x} = 3.4$	$s = 1.3$	$n = 20$	60%
SQ8. The mentor helped me to see myself as an engineer.	$\bar{x} = 3.3$	$s = 1.1$	$n = 20$	50%
SQ9. After the Ignite program, I could see myself majoring in engineering at University.	$\bar{x} = 3.9$	$s = 1.0$	$n = 19$	84%
Socio-Emotional Support				
SQ10. I consider my mentor to be a friend.	$\bar{x} = 4.2$	$s = 1.1$	$n = 15$	67%
Guidance/Teaching				
SQ11. I respect my mentor's ability to teach others.	$\bar{x} = 4.9$	$s = 0.5$	$n = 15$	93%

Activities

The theme of activities came up only in the interviews. The mentees interviewed described several instances where they pursued challenges, created a project, and accomplished a goal. These activities were mostly led by the mentee, with collaborative support from the mentor. Both interviewees mentioned their final projects in the interviews. One interviewee stated that the final project was a highlight of the program and explained that "what really stood out about Schulich Ignite for me was how they constantly love to challenge me."

The survey data supports that activities were a large part of the program, seeing that mentors helped 80% of survey participants create a digital product from scratch (SQ2: $\bar{x} = 4.3$).

Atmosphere

Finally, the theme of atmosphere refers to mentions of comfort and fun that did not fit into other themes. These are distinct because they are beyond the participants' immediate control (e.g. mentor-mentee ratios, parental factors, the ease with using cameras and microphones on the platform, and the program's approachability in general). Without much data in this category, it is not easy to fully articulate how this theme moderated the experience. This theme presents an area for further investigation.

Discussion

Program Outcomes

In response to our first research question, *what are the program's current outcomes?* Our data show that the most significant outcome of the program is the use of programming skills. Qualitative and quantitative data support this finding. We also see that students who enroll in the program already have an interest in engineering and maintain this interest. Some mentors provide vocational support in this regard by talking about their studies and sharing their projects.

Fit with the Youth Mentoring Framework

We now look at how these results hold to Mekinda and Hirsch's "Revised Framework for Investigating Mentoring Relationships in After-school Programs" [6] to test if the Framework can be applied to an engineering outreach program (RQ2).

Individual characteristics in the Framework show up in the atmosphere theme found in the qualitative data. These characteristics (notably, gender) were alluded to in some open-ended survey responses, mainly by female mentees about comfort. As noted, there was limited data in the research conducted here. The individual characteristics, or atmosphere, are essential to consider as they can set the tone for the mentoring relationship and thus need further investigation beyond this study's scope. Mekinda and Hirsch note that these characteristics can help to build rapport [6]. This and other researchers say that shared characteristics help build relationships but are not as important as shared interests [2], [20], [21].

The activity theme relates to environmental characteristics and learning/collaboration behaviour. Mentees were mostly unaware of deeper organizational structures that would fall under the Framework's environmental characteristics. Nonetheless, activity offerings were often successful and highlights of the program.

The characteristics of the mentoring relationship set out by the Framework can be found in this study's relationship theme (emotional support and learning/collaboration) and knowledge (guidance/teaching behaviour). The survey data reveal that some sponsorship/advocacy is offered (SQ4-SQ8), but it does not appear to be offered by all mentors. The only vocation-related question where more than 50% of respondents agreed with the statement was SQ7: *The mentor helped me to see myself majoring in engineering at University* ($\bar{x} = 3.4, \%agree = 60\%$).

Qualitative data also reveal that mentees enjoyed when the mentoring arrangement took on a more collective approach. One mentee stated, "I wished that the mentors would actively engage with other participants." Another mentee showed appreciation when they got to meet other

mentors at the final gala event. An advantage of the collective arrangement is that mentees can seek support from mentors (and even other mentees) that share their interests.

In answer to our second research question, *can existing frameworks for youth mentoring be applied to engineering outreach programs?* The "Framework for Investigating Mentoring Relationships in After-School Programs" has proven helpful for identifying areas for further research (individual characteristics of participants and mentoring arrangements) and an opportunity for development (sponsorship/advocacy). However, the Framework lacks a place to incorporate program-specific goals into the early framing of the relationship. For instance, assessing the program's goal to help students realize their potential as engineers through skill-building and identity development occurs in the latter part of the Framework. We believe it should appear earlier (perhaps more clearly as part of environmental characteristics) to help determine the appropriate characteristics of the mentoring relationship. Secondly, while some of the data from the atmosphere theme supported individual characteristics, there is no area in the Framework to consider the factors beyond the participant's immediate control that affect the mentoring relationship. Especially in hands-on engineering outreach, space, tools and the emotional atmosphere are essential to program success.

Improving Outcomes and Further Research

From this analysis, we can address our third research question (RQ3): *what characteristics of the engineering outreach program have the most potential to improve outcomes?* We have found two areas for further investigation as well as an area for program development.

The individual characteristics of participants need further exploration. Setting the right tone for the mentoring relationship is necessary for reaching further gains in the program.

The mentoring arrangement could also take more investigation. Some data indicate that moving towards a collective arrangement could be of value to mentees.

While the program does very well in instructional support and activities, an opportunity exists for mentors to provide more vocational support to the mentees through conversations about university. This opportunity could appeal to mentees' interest in engineering, which could also help to strengthen the mentor-mentee relationship. Furthermore, these conversations could help to shift mentee’s perceptions of themselves as engineering students. More development and research are needed.

Conclusion

In this study, we analyzed the behaviours and outcomes in a virtual engineering outreach program. We applied an existing mentoring framework from social sciences to the engineering outreach program. By doing so, we framed the program's outcomes and defined areas for further research and development. In particular, we have identified three areas that present opportunities to improve the program: individual characteristics that could improve relationships, mentoring arrangements, and vocational support. We hope that with more research and development, the program's outcomes will continue to improve and provide insight for similar engineering outreach.

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