Perceived Influences in High School of Undergraduate Engineering Students' to Pursue Their Major

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Abstract

Several factors are present in high school leading to students pursuing engineering majors in college. Currently, the only research on this subject has been conducted through participants that participated in engineering courses through high school (Batts et al., 2009; Glenne et al., 2019; Al-Qahtani, 2009). As Singapore American School does not have any engineering course structure in place, qualitative interviews were conducted amongst SAS engineering undergraduate alumni to explore how SAS students were influenced differently from these previous studies. The codified interview data revealed that SAS students were influenced most from robotics courses and extracurricular activities. Also revealed was the lack of foundational understanding of engineering disciplines and career applications. Having knowledge regarding these career applications was the highest measured influence from previous research (Batts et al., 2009). This suggests many beneficial improvements could be of a result of integrating engineering education in high school. This study also implemented analysis of parental influence to further isolate these high school factors (Siregar et al., 2019). Further exploration of how curricular changes could be implemented from this data are also outlined.

Keywords: engineering, education, STEM, influence, high school, interdisciplinary, perceived, international, college major

Introduction

There is a problem with applying Science Technology Engineering and Math (STEM) concepts through engineering in K-12 education. STEM is the integration of science, technology, engineering, and math concepts (Sevda & Ahmet, 2015). Despite engineering professions applying STEM concepts every day, traditional schooling often lacks the direct application of concepts needed to become an engineer. This problem has negatively impacted aspiring engineers because they do not have the skills needed to successfully practice engineering. A possible cause of this problem is the lack of training for both students and teachers as well as little focus in STEM areas in middle and high school settings (Cunningham, 2008; Cunningham, 2016; Lammi, 2018; Moore, 2014; Brockway, 2011; Glennie et al., 2019). Perhaps a qualitative study that looks at how students in high school are influenced to pursue engineering in college could signify ways that Singapore American School (SAS) can improve opportunities students have to pursue engineering.

Influences Affecting a Student's Engineering Pursuit

Firstly, as shown in research by Batts et al. (2009), students who participated in dedicated engineering programs were more likely to pursue engineering as a profession (Batts et al., 2009). Throughout the research, there were many studies related specifically to the integration of engineering courses into pre-university studies. Engineering courses are influential in teaching children and adolescents hands-on and problem-solving skills that are integral to cognitive development and real-world application (Cunningham, 2008; Cunningham, 2016; Lammi, 2018; Al-Qahtani, 2013; Brockway, 2011; Glennie et al., 2019). The traditional disjointedness of STEM subjects instruction gives students an unrealistic view of how engineering is applied as a

career which leaves them ill-prepared for real-world application (Batts et al., 2009; Al-Qahtani, 2013; Glennie et al., 2019). Many systemic changes can come from these programs as well. In Cunningham's 2016 article *Engineering is Elementary,* she identified many ways that teaching engineering concepts can impact elementary school students, including increased problem solving, breaking down gender and racial stigmas in engineering, as well as shaping their skillset to be adaptable in a workplace environment. In addition, Lammi (2018) found engineering education allowed students to problem solve collaboratively. This is directly applicable to the current research as these identified traits can be used when framing the interview methodology (Creswell & Creswell, 2018; Merriam & Tisdell, 2015; Zucker, 2009). Other prevalent influences found in literature will now be discussed.

Demographic Influences Students Face

Gender and racial stigmas are widely overlooked influences that could dissuade minority students from pursuing engineering. In a report by the NSF, minority postdoctoral fellows stated that African American students are often recommended to pursue athletics over academics. This stems from guidance counselors and teachers unknowingly providing negative reinforcement in pursuing STEM careers (National Science Foundation, 2007; Batts et al., 2009). Furthermore, women often are disproportionately less interested in STEM careers but perform equally academically (Blickenstaff, 2005; Cunningham, 2016; Adya & Kaiser, 2005). Blickenstaff proposed a lack of women role models in STEM careers leads to female disinterest in STEM subjects at a young age (Blickenstaff, 2005). In their study, Adya and Kaiser found that increasing the availability of technological infrastructure, both at school and at home, amongst students positively influences women to pursue STEM careers (Adya & Kaiser, 2005).

Extracurricular Influence

Another aspect shared amongst many of the researchers were extracurricular activities, clubs, and competitions related to engineering (Flowers, 2006; Cunningham, 2016). Flowers (2006), who founded FRC, one of the biggest high school engineering competitions worldwide, also advocates that the competitive hands-on experience is a driving factor for getting students interested in engineering (Flowers, 2006; Lammi, 2018).

Through FRC specifically, students are also encouraged to make technical and outreach presentations that are graded by competition judges. This structure of the competition not only gives students the ability to creatively explore engineering through the hands-on experience of designing and building the robot, but also gives them experience in expressing and explaining those ideas to others (Flowers, 2006). These interpersonal skills gained specific to engineering are integral when working collaboratively in a real-world environment (Flowers, 2006; Cunningham, 2016; Cunningham, 2008; Al-Qahtani, 2013; Brockway, 2011).

Synthesized Aspects from Researched Influences

A common theme in these studies is the many unforeseen positive influences as a result of these programs such as breaking down stigmas in the field or giving students heightened problem-solving and design thinking skills (Cunningham, 2008; Cunningham, 2016; Lammi, 2018; Al-Qahtani, 2013; Brockway, 2011). This demonstrates how, if engineering application opportunities are successfully implemented, they can not only increase skill sets amongst students but contribute to wider systemic change. Another emerging influence was that of extracurricular activities. This revealed that the influence in applying engineering does not have to be strictly academic. Furthermore, common negative influences that affect students' desire to

pursue engineering were also identified. Moreover, although no conclusive research has been conducted on the topic, Siregar et al. (2019) stated in a recommendation for future research, to investigate how parental influence plays a role in a student's desire in engineering.

Now that common influences have been identified through previous literature, they can provide groundwork for developing the qualitative methodology used (Creswell & Creswell, 2018; Merriam & Tisdell, 2015; Lopez, 2018; Zucker, 2009).

Beneficial Aspects of Engineering Education

From all influences found in existing research, SAS does not have any existing educational engineering opportunities present, it is important to identify the specific aspects present in this type of education that are most influential in students' engineering pursuit. Focusing on the curricular content of these engineering courses, the research of Moore (2014) and Flowers (2006) summarised core content that should be present in these programs to most benefit students (Moore, 2014; Flowers, 2006). As the researcher has personally participated in courses, clubs, and activities designed by Flowers (2006) the researcher has positive confirmation bias towards their effectiveness. Even though Flowers's (2006) is more focused on the FIRST Robotics Competition and university applications of such coursework, he provides a vast framework for general aspects to include when devising a curriculum.

It was also shown in these courses that many students showed increased desire for pursuing engineering when presented with the opportunity to complete hands-on work and learn applicable skills in engineering (Batts et al., 2009; Cunningham, 2008; Cunningham, 2016; Glennie et al., 2019). Some of these aspects include the engineering and design process, applications of physics and math into hands-on projects, and the implementation of robotics.

These ideas can help a school system when it comes to designing a curriculum that they could implement. Giving students a good foundation of basic engineering concepts is integral to understanding more specific subsets of the discipline (Batts et al., 2009).

Moore (2014) discussed in depth what content is integral to include. Through an in-depth analysis of government-provided proposed STEM curricula, Moore (2014) identified key concepts that should be included. These largely mirrored the conclusions of the other researchers (Moore, 2014; Flowers, 2006; Al-Qahtani, 2013; Glennie et al., 2019). As key aspects of these educational programs have been unanimously shared amongst this pre-existing literature, research can be conducted through qualitative interviews to determine if any participant experiences at SAS acted as an auxiliary to the benefits and influences stated above (Creswell & Creswell, 2018).

Conclusion of Literature Review

This study is formed around looking at the influences students face in choosing engineering majors in university. Through analysis of previous literature, three key influences emerged repeatedly amongst existing studies: academic engineering education, extracurricular activities, and gender and racial stigmas. Through this process, a gap in the research was identified by looking at student influences in high school to pursue engineering without the presence of structured academic engineering education. Much research has been previously conducted looking at these influences, namely Glennie et al. (2019), Batts et al. (2009), and Al-Qahtani (2013). However, these studies did so by looking at how students were influenced specifically as a result of taking structured engineering programs in high school. As the interview participants in this study never had that opportunity, through their experiences, perceived

influences may emerge that differ from previous studies. The data gathered will then be compared against results from these studies to identify any potential irregularities present in SAS graduates.

As many, more extensive studies, have been conducted on gender and racial stigmas as they relate to engineering and STEM, although these will be incorporated into this study, less emphasis will be placed to narrow the focus specifically on comparing SAS student influences from those in existing research.

Positionality

Finally, when analyzing these studies, the researcher encountered scenarios where their personal bias could have had an impact on the synthesis and research of the studies they chose. Having always enjoyed the field of engineering as well as participating in engineering-related clubs and doing personal STEM-related projects, the researcher would have confirmation bias towards a more positive outlook on many beneficial influences brought up by these studies.

Methods

In order to answer the research question, a qualitative phenomenological methodology containing online narrative interviews and codified thematic analysis was employed. Phenomenological research is a culmination of lived experiences as described by participants normally involving conducting qualitative interviews (Groenewald, 2004; Creswell & Creswell, 2018). This research focused on a phenomenological study of three SAS alumni who have gone into engineering majors in college. The phenomenological method was used to reveal personal nuances and experiences that are not normally exposed when taking a strictly quantitative approach (Mirriam & Tisdell, 2015; Lopez, 2018). Influences were thematically codified to

identify recurring influences and their relation to existing research. This approach of studying these influences through qualitative participant experience was successfully applied in a similar study by Lopez (2018). Finally, it is important to recognize that for this study an assumption is made that the participants did in fact face influences in high school that could have affected their desire to pursue engineering (Creswell & Creswell, 2018; Merriam & Tisdell, 2015).

Participant Prerequisites

This study was conducted amongst student alumni that have graduated from Singapore American School (SAS). An eligible participant from SAS must have enrollment or graduation with an engineering major when in university. The major is decided to be engineering based on how it is categorically defined by their university (Lopez, 2018). Although computer science and software engineering often fall under the category of engineering, the researcher omitted participants from these majors as SAS has curriculums in place for these disciplines unlike all of the other fields of engineering. As SAS does not have any interdisciplinary engineering courses, participants from SAS would have never had the opportunity to participate in engineering courses in high school. This study was limited to observing percienced influences only throughout high school education as there are few students who have attended SAS throughout their entire K-12 education and also meet the above requirements (Lopez, 2018). Many existing studies on the topic also were only conducted in a high school setting (Batts et al., 2009; Glenne et al., 2019; Al-Qahtani, 2009). Given the scale of this study, any participants who have taken engineering courses at a previous high school before coming to SAS were also omitted to prevent the influence of courses at previous schools (Lopez, 2018).

Methods of Gathering Participants

Due to the international nature of the school, alumni are located across the globe. With the current global COVID-19 pandemic, the researcher was unable to conduct in-person interviews with the participants of the study. As such, all of the participants from the study were gathered by contacting the SAS robotics coach for alumni nominations.

Out of the lists of 12 alumni provided by the faculty member, six alumni from SAS met the eligibility requirements for the study. The robotics coach at SAS personally reached out to the six participants to ask for them to participate in the study. This could possibly introduce bias as participants would be more likely to respond to faculty that they know. In these emails sent by the faculty member they were told to reach out to the researcher and that is how that initial correspondence was made with all participants. Out of those six participants, three responded and were able to be interviewed for the study. For context, a normal graduating class for any given year at SAS is around 300 students. Something important to note, although the participants were promised their names, genders, and identities not to be disclosed, taking the participant demographic as an aggregate reveals that many of the negative systematic influences discussed earlier may not be represented in the sample size used (National Science Foundation, 2007; Batts et al, 2009).

Ethical Considerations

When gathering the personal information from participants of the study the researcher was sure the intentions of the use of their information and the final research were communicated through text with a preliminary participation form with an attached waiver seen in Appendix A, as well as verbally in the scheduled interview (Creswell & Creswell, 2018; Merriam & Tisdell, 2015). The researcher then received written and verbal permission from the participants to use

their information in the ways that were outlined. They were also made aware, both written and verbally, that the verbal interviews were to be recorded and transcribed to be included in the research to which the researcher also received written and verbal permission for (Creswell & Creswell, 2018; Merriam & Tisdell, 2015). Participants were also made aware that when referred to in the study that their names, genders, and other personal information were to remain anonymous aside from their university of choice, accompanying major, and their qualitative responses (Creswell & Creswell, 2018). They were also made aware that all recordings, written transcriptions, and final research were to be made available to the participant at their choosing and they had the right to exclude any of their responses or information from the final research (Creswell & Creswell, 2018; Merriam & Tisdell, 2015). This study has also gone through a full IRB review process and was approved by *Research and Composition* course mentors: Kristoffer Munden, Mare Stewart, and Dr. Martha Began. Digital waiver forms were sent on official SAS letterhead and signatures were digitally typed and dated by all participants.

Methods of the Study

Foundationally, the methodology is a fully qualitative phenomenological study conducted through online interviews (Creswell & Creswell, 2018; Merriam & Tisdell, 2015; Groenewald, 2004). Once all of the participants had verifiable eligibility and gave the permission needed to conduct an interview, they were asked to join a short online verbal interview using the ZOOM voice chat platform. When in this interview, a series of qualitative questions were asked which were codified from similar research made by Al-Qahtani (2013) and Lopez (2018). The questions, seen in Appendix B, focused on the perceived influences affecting their choice of major (Lopez, 2018). Questions were also added to gauge parental influence on students as

suggested by Siregar et al. (2019). The underlying structure of these questions was successfully used in the past in a study by Lopez (2018) and was adapted for this study also including additional ones added by the researcher to get alumni feedback on what SAS could change regarding their engineering opportunities. There was no definitive structure to the interview and the researcher asked follow-up questions when appropriate unique to every participant's personal experiences and opinions. One potential drawback to this approach is that bias could arise in the answers of the participants as engineering is the main field of study for all of the participants as well as potential participants with a negative outlook on engineering not being as likely to participate in the study (Lopez, 2018). As the researcher also outlined to the participants what the purpose of the study was, they could be incentivized to have a positive outlook on their perceived influences (Alvarez, 2019).

Table 1.

Description of Participants

Pseudonym	SAS Graduation	College Major	College	Current Job Title
Participant A	2017	ME	Virginia Tech	Student
Participant B	2017	ME	University of British Columbia	Aerospace Engineer
Participant C	2012	ECE + CS	Duke University	Software Engineer

Note: ME = Mechanical Engineering, ECE = Electrical and Computer Engineering, CS = Computer Science.

Qualitative Analysis

For the qualitative analysis of the interviews, a set of preliminary *a priori* empirical codes had been developed based on qualitative studies by Lopez (2018) and Al-Qahtani (2013). Transcripts of the recorded interviews were then thematically codified using the *a priori* codes as well as extrapolating new overarching themes from participant perceived influences. This thematic codification process was documented digitally by selecting quotations from the transcripts to codify themes.

Participants in the study, although not directly incentivized, were also among the minority of the total alumni nominated to participate.

Findings

After the qualitative interviews were conducted with all three participants, the experiences of the participants on how they were influenced to pursue engineering majors in college were codified to reveal themes. To isolate these influences to a high school setting, questions were asked to gauge outside influence in their interest in engineering seen in Appendix B. This method of finding external factors that affect a student's interest in engineering was previously employed in a study by Lopez (2018) with research suggestions taken from Siregar et al. (2019). As the participants never could participate in these engineering programs, isolating external factors and influences is integral to identifying potential ways SAS student experiences differ from previous literature. These external factors were heavily focused on when identifying themes from their experiences.

Before moving to discuss the results of this thematic codification, the themes extrapolated from the data must be defined. From all three interviews, a total of seven themes emerged. These selected themes and given definitions are codified in the table below.

Table 2

Names and Definitions of Codified Themes

Themes	Definition
Outside/Parental Influence (*A Priori*)	Influence to pursue engineering from parents from external nonacademic sources. (Not including school affiliated clubs or activities)
Benefits (*A Priori*)	Positive influences, skills, or traits gained from engineering education.
Limitations (*A Priori*)	Limited engineering opportunities faced in high school.
Suggestions	Suggestions for what SAS could improve in regards to engineering and STEM activities.
Change in Interest	Influences that changed the student's interest in pursuing engineering.
First Exposure	When and how these students were exposed to engineering or STEM activities for the first time.
Wanting More	Participants were shown to be wanting more in terms of engineering education/infrastructure when in high school.

Results and key points from the three interviews are compiled below.

Table 3

Key Points from Each Interview with Corresponding Themes

Pseudonym	Key Points from Interview	Corresponding Theme
Participant A (Appendix C)	First real experience in engineering was from taking robotics science courses in grade 11.	First Exposure
	A deprecated lesson in robotics classes on computer aided design (CAD) by industry experts allowed them to go into college with a deeper understanding as opposed to their peers.	Benefits

	Application of engineering in SAS robotics courses was done with little rhyme or reason with no thought given to teaching engineering and design concepts.	Limitations, Wanting More
Participant B (Appendix D)	After coming to SAS, joining the MATE and FRC extracurricular competitions exposed and solidified their desire to pursue engineering.	First Exposure, Change of Interest
	Teaching higher-level math and science concepts and using those in application-based situations is a better way to apply to engineering than surface-level "intro" courses.	Benefits, Wanting More
	After completing both the intro and robotics science courses noted that having multiple courses would've been nice. This resulted in them taking the same courses multiple times.	Wanting More, Limitations
Participant C (Appendix E)	After exposure to robotics in grade 11, their interests changed to pursue engineering in college.	Change of Interest First Exposure
	Wanted more application-based stuff. As soon as they took science courses at SAS. Part of the reason they sparked the initiative to start the SAS robotics program senior year.	Wanting More
	They recognized college-level course that would be beneficial to SAS students as it covered Arduino[1], sensors, electronics, and soldering which allows students to develop problem-solving skills	Suggestions Benefits

As stated prior, three participants who graduated from SAS to pursue engineering were interviewed to give their personal perceived influences on what caused them to pursue engineering in university. As seen by the first column of Table 1, all participants' names were

[1] An Arduino is a programmable microcontroller device traditionally used for education and small scale electronic projects.

omitted to choosing instead to refer to them with pseudonyms. The respective appendices with the full codification of the interview transcripts are also included.

The second column in Table 3 outlines three key paraphrased points from the interviews focusing on the most exemplified themes for each participant. These points were taken from experiences that the participants had in SAS courses, extracurricular activities, and experience with the college-level application of engineering concepts. Some participants also based their experiences in contrast to peers in college that had differing engineering opportunities in high school.

In column three of Table 3, themes were assigned specifically to each key point or experience. As some of the points have multiple applicable themes they are listed in descending relevancy as they relate to the respective point. For example, the first key point by Participant C highlighted how after taking robotics courses at SAS their interests changed to pursue engineering in university and as a career path. The themes assigned therefore were “Change of Interest” as it highlighted the impact that the robotics courses had on switching their interest to an engineering field going into college, and “First Exposure” which highlights how the student was first exposed to engineering late in their high school career. In this example, “Change of Interest” has more of an influence on a student’s college major choice as it is directly related to what they chose to pursue going into university.

This table is effectively used as a way to condense the full narrative interviews given by the participants into influences the participants thought most had an impact on their college major choice while linking to their accompanying themes. Through its use, recurring themes can be recognized before in-depth analysis of the influences.

Analysis of Themes

Now as the themes gathered from the data, shown in Table 2, have been categorized through key experiences of the participants, recurring themes can be identified. As shown by Table 3, six of the seven themes occurred more than once across all participants. The theme of "Suggestions" was omitted as it was rarely present in the experiences of the participants and although helpful for recognizing where future improvements can be made, these suggestions have no way in retroactively affecting their choice of college major choices.

Recurring Theme 1: Outside/Parental Influence

With all of the themes shown throughout the interviews, "Outside/Parental Influence" is integral to address in order to isolate strictly a student's high school experiences. Outside influence, as defined by Table 2, is the influence to pursue engineering from parents or external sources outside of a high school setting. Gathering this data was used to address the possibility of parents or other external sources either discouraging the student to pursue engineering or overly encouraging it past the student's wants.

Parental Influence. In all three interviews conducted, all participants said that their parents had little to no influence on their choice to pursue engineering in college. However, one common influence that parents did have amongst two of the participants was discouraging their children from pursuing their careers. Although none of the participants' parents had engineering careers, it could have still been a possible influence on their college major or career. One example of this stated by Participant A when asked about the influence of their parents stated,

> They supported me, definitely. I wouldn't say they had any sway. They'd support me and pretty much whatever I ended up doing. But the only advice they gave me was just don't become a lawyer because they're both lawyers, but every other field was pretty open.

This also was a recurring theme amongst Participant C and their parents as well. Outside of this recurrence, all participants stated that their parents were supportive of their decision to pursue engineering in college with Participant C stating, "They both kind of encouraged me not to go into finance." Participant B stated, "They've generally been quite supportive of whatever I wanted to do." This shows that none of the participants recognized any influence that their parents had on their choices to pursue engineering. In a study by Siregar et al. (2019), they outline for future researchers to comprehensively evaluate students' parental support and motivation when evaluating the influences of these programs. This gap in their research was then synthesized in the interview questionnaire seen in Appendix B adapted from the Lopez (2018) study and addressed.

Outside Influence. Although parental involvement was the main focus when addressing possible external influences, some participants had other extraneous factors that they recognized could have influenced their pursuit of engineering. More specifically, when asked if participating in two-year mandatory national military service after high school had an influence on their decisions Participant B stated, "Yes, National Service highlighted to me that if I wasn't doing something I enjoyed. I should probably not do it." Although it was recognized as a potential influence in their decision making to pursue engineering, as the participant did not deviate from these interests after completing national service, it further exemplifies how passionate they were

in pursuing engineering in college. The only other participant who recognized an experience that could have influenced them was Participant C who stated,

> I had a twin brother in high school. And he got more interested more quickly than I did, especially in computer science. So when he applied to college, he applied specifically for computer science, he was coding applications and selling them in high school. And so I think that definitely gave me more exposure to it.

This is probably the largest outside influence that was discussed amongst any participant interviewed, as Participant C had a close relationship with a member of their family who attended high school at the same time. This could be a leading factor in their college major decision. However, an argument can be made that this influence took place in a high school setting.

Recurring Theme 2: Benefits

Through the experiences and discussions with the participants, they acknowledged the many beneficial skills and knowledge gained throughout high school and how applicable it was in college. Many of these alumni outlined benefits similar to pre-existing research on the effects of engineering education (Cunningham, 2008; Cunningham, 2016; Lammi, 2018) citing how interdisciplinary engineering courses allow students to understand how engineering is applied and develop problem-solving skills. Participant A recited an instance where, in the SAS robotics classes, they were given the opportunity to learn modeling software.

> They had a CAD[2] session using Autodesk Inventor[3], where they brought people from Autodesk and had them just go through the CAD software. The second I got into college,

[2] CAD or Computer Aided Design is the process of modeling parts or assemblies using a computer.
[3] Autodesk Inventor is an industry standard software used for CAD.

> it was like, Alright, here's Inventor, here's how you use it, and just having a little bit of pre-knowledge was very beneficial.

This aspect of the course was later deprecated and the teaching of these activities is no longer present. This highlights how seemingly simple activities and lessons can provide students with integral foundational knowledge going into college. Other beliefs are summarized by participants in Table 3 above. Nonetheless, although the SAS participants outlined benefits and influences mirroring that of previous studies, due to recent changes in the robotics course curriculum to be more self-led, many of the beneficial projects and activities discussed by the participants are no longer present.

Recurring Theme 3: Limitations

Now that the potential benefits have been defined, through the alumni experiences limitations of SAS high school engineering opportunities will now be outlined. Many of these limitations were taken through student high school experiences and what they think could have helped them transition into college. Aside from added general knowledge of conceptual engineering and design skills that could have been of help to these students in college, the most exemplified knowledge that the participants felt was missing was how engineering is applied in the real world. Many participants noted that although finding an interest in engineering while in high school through extracurriculars, they had little knowledge on what engineering major to choose or how engineering is applied as a career. As stated by Participant C,

> I applied for biomedical engineering, kind of just because that was the highest-ranked engineering major at Duke. And it was like if I get into that and decide I don't like it, it’s probably pretty easy to just switch to whatever else. And I switched after one semester.

This highlights how many of the students in high school know they want to pursue engineering but have no preconceived knowledge on how different disciplines of engineering are applied.

When it comes to the academic limitations of not knowing engineering concepts, many students highlighted how through the robotics program they participated in there was no structured way to learn about engineering. In the context of comparing the SAS robotics program to one of a similar school with a structured engineering program, Participant A stated,

> They used to go through the design process and the steps that would need to be taken before they even went into building the robot. Our program was kind of just "hey, look, the parts are here. Let's build the robot."

This shows how Participant A proposed that in comparison to other schools they were not offered the same opportunities to learn about the underlying design process of building a robot as the SAS robotics program as it was focused instead on surface-level self-led material instead of conceptual understanding.

Recurring Theme 4: First Exposure

In the interviews conducted, participants often stated that their first experience with engineering was midway through high school after taking the high school robotics courses and extracurriculars. This was in contrast to previous literature which implies students have an interest in these activities at a young age (Cunningham, 2008; Cunningham, 2016; Lammi, 2018). However, although unexpected, this further shows the impact influences can have on students in high school. As seen in Table 3 above, Participants A and B's first experience in applying engineering was through the SAS robotics program in high school. Participant C was motivated to pursue engineering through personal interest but wanted more hands-on experiences

at school which led them to found the extracurricular robotics club at SAS. They stated, “Getting involved with playing around with Raspberry Pi's[4] and starting to get interested in some coding. And then the year after that, I started working with my brother and Mr. Millar to start the robotics team.” Through these experiences, it is evident that many of these students’ first experiences in engineering and STEM were in high school.

Recurring Theme 5: Change in Interest

As stated prior, all of the alumni interviewed participated in the robotics club and/or robotics course structure present at SAS. In the qualitative interviews, the participants were asked if participating in these programs changed their interests to pursue engineering. Although the robotics program at SAS was not recognized as academic by the participants, it still serves as a metric for how hands-on experience in engineering can affect students’ college careers. As paraphrased in Table 3, Participants B and C both stated that robotics was the reason that either solidified or changed interests to pursue engineering in college.

Recurring Theme 6: Wanting More

As defined in Table 2 above, *Wanting More* consisted of participants highlighting what more they wanted in regards to engineering at SAS. In the interviews, participants were asked if interdisciplinary engineering courses were present while in high school if they would’ve taken them, and why. All of the participants said that they would have taken them as they wanted more experiential learning in engineering throughout high school. Participant B States,

[4] A Raspberry Pi is a cheap single-board computer often used as an educational and prototyping tool.

> I did the one-semester intro to robotics course, one semester of advanced robotics like some people do, and that was in junior year. Then in senior year, I was like, "Well, I guess I'll just do that again". So something else would have definitely been nice.

This quote exemplifies most how students at SAS who want more experiential learning in engineering are limited to taking the same classes over and over again. As stated previously, all participants interviewed did not view these courses as academic. The researcher, a student at SAS, has personally taken these robotics courses multiple times at SAS which could introduce bias into the interpretation of these statements. Even Participant C, the only person interviewed before the implementation of the SAS robotics program and courses, stated "I wanted more application-based stuff. Pretty much as soon as I started taking science courses at SAS, which was freshman year". This highlights the many ways in which these Alumni wanted more opportunities while in high school.

Discussion

From the results of this thematic analysis, recurring influences that these participants faced can now be categorized seen below in Table 4.

Table 4.

Key Influences Participants Faced Categorized from Themes

Influence	Associated Theme(s)
Participation in the SAS robotics extracurriculars or courses.	Benefits, First Exposure, Change of Interest
Limited knowledge relating to higher-level applications of engineering.	Limitations, Wanting More
Parental Influence to pursue engineering.	Parental/Outside Influence

Participation in the SAS Robotics Extracurriculars or Courses

Firstly, student participation in the SAS robotics program was by far the largest influence shown amongst participants in their choice of college major. Through their experiences, it was revealed that the SAS robotics club was participants A and B's first experience with engineering, and participant C founded the club. It was also revealed by participants B and C that the robotics club and course structure was influential in solidifying or changing their desire to pursue engineering.

The benefits of these STEM and engineering extracurriculars were defined earlier from previous research (Flowers, 2006; Cunningham, 2016). Although extracurricular STEM programs have shown to be beneficial, in a study *Factors Influencing High School Students Career Considerations in STEM Fields,* Batts et al. (2009) found through quantitative survey data that students were not influenced by extracurriculars to major in engineering. As their study's sample population was students enrolled in interdisciplinary high school engineering courses those could have overshadowed student experiences in extracurriculars (Batts et al. 2009). As this is in contrast to SAS student influences to pursue engineering, future implementation of interdisciplinary engineering education could influence students' choice of major more than the current robotics program. It is also important to note that due to limited data in the Batts et al. (2009), a proper comparison of each school's extracurricular infrastructure in engineering can not be conducted. This could also be a driving factor in the vastly different influences faced by the students.

Limited Knowledge Relating to Higher-Level Applications of Engineering

Limited knowledge of higher-level engineering applications was shown to be the largest negative influence SAS students faced when pursuing engineering. All students remarked that they had little knowledge and preparedness for how engineering is applied at a university and career level. Having a good understanding of how engineering is applied as a career is a large determinant of student interest in engineering (Glennie et al., 2019; Al-Qahtani, 2013; Brockway, 2011). This lack of knowledge resulted in participants unaware of different engineering majors and disciplines leading some participants to have to change engineering majors after not having a foundational understanding of the original one they applied for.

The SAS results are again in stark contrast to students that participated in engineering academically. Batts et al. (2009) measured student influences to pursue engineering as a result of taking interdisciplinary engineering courses. Students in this study answered a Likert scale rating five influences from 1-5. When averaging all influences these students faced, *Knowledge about Fields* was the highest-rated influence averaging at 4.16. *Knowledge about Fields* was also the highest-rated metric from each gender and racial category independently. The programs these students participated in throughout high school had a direct focus on teaching students how engineering is applied in post-secondary education and engineering careers. There was also course material present for learning different disciplines of engineering and how they are interrelated (Batts et al., 2009).

This highlights just how detrimental not having this education in place can be for students. This was something very unexpected as most of the research studying the benefits of engineering education focused on teaching engineering concepts rather than teaching what engineering is as a career.

Parental Influence to Pursue Engineering

Finally, the last influence that emerged was parental influence in their child's pursuit of engineering. Through all previous literature found, there are no related studies incorporating parental influence in their methodology. Siregar et al. (2019) outlined that when looking at the effects of STEM and engineering coursework studying parental influence on students should be heavily incorporated. As this was a suggestion for future researchers, an analysis of parental influence was added to this study to fill that gap.

From participant experience, parental influence on their decision to major in engineering was very negligible. All participants stated that their parents were supportive of them doing engineering. However, in research by Batts et al. (2009), parental influence played a bigger impact on the students studied. Perhaps a larger sample size could allow for further investigation.

Limitations

Throughout the research process, many limitations were encountered. This study does not include comparing qualitative data of student influences to pursue engineering from multiple high schools. Originally, the phenomenological method used included interviewing alumni experiences from SAS and another international high school with an extensive engineering program to compare differing experiences. Due to logistical and communication problems when arranging these interviews whilst in the COVID-19 pandemic, interviews from alumni from the second school were unable to be conducted.

Furthermore, originally this study incorporated a convergent mixed methodology where quantitative data would be collected on the distribution of engineering college majors for each school using the qualitative data as justification. After not enough quantitative data was collected

to provide any significance, combined with the logistical issues faced with the second school, this aspect of the methodology was omitted. Using mixed methodology in this way could be used for further justification of these influences in future research (Creswell & Creswell, 2018; Merriam & Tisdell, 2015; Lopez, 2018).

From the methodology conducted, the sample size of the students could have been affected the results, and having a larger sample size above three participants could have brought out new themes and experiences and further exemplify ones already present. Through the participant sampling method, although majoring in engineering was a requirement for participants in the study, because all participants were personally nominated by the SAS robotics coach, this could have introduced bias leading to the chosen participants possibly not being a representative sample of all SAS graduates that pursue engineering.

Although the implications of this study could help schools like SAS looking to implement these programs, Singapore American School is far from being a representative high school. It is an international high school with access to many resources, students from 56 nationalities, 96th percentile Advanced Placement education, and a 99% 4-year college matriculation rate (Singapore American School, 2020). This could inhibit the data and results collected from being generalized across a wide range of schools.

Finally, the positionality of the researcher could have impacted the interpretation and framing of the qualitative interview data. The researcher also advocates for the implementation of engineering education at SAS. Furthermore, the researcher also plans to major in engineering in college and has taken many of the robotics courses and extracurriculars at SAS.

Implications

This study has multiple implications for the future of the SAS high school curriculum. Firstly, these results show us that there is a want for engineering education using high-level STEM concepts in high school from the participants interviewed. This information is also useful for other schools looking to implement these programs as all previous studies look at students who were influenced by taking them. This study differs by looking at the experiences and limitations that students faced by not having the opportunity to take them in high school. This offers these schools qualitative experiences that are akin to their current graduates. This study also addresses an amendment of future research by Siregar et al. (2019) where they said that when performing qualitative research on the influences of engineering programs, in-depth analysis on the parental influence on students' pursuit in engineering is needed. Taking this into account, in the interviews, questions were added to gauge parental and other outside influences that might overstate their high school experiences seen in Appendix B.

Future Research

If future studies were conducted, sampling a wider range of more representative students could reveal more experiences and themes. Furthermore, in pre-existing research, gender and racial stigmas were amongst some of the biggest influences seen for pursuing an engineering major (Blickenstaff, 2005; Cunningham, 2016; Adya & Kaiser, 2005). However, due to the small sample size of participants in this study, many of those influences were not present in their experiences. Having a larger more representative sample including more demographics could alleviate this issue.

Additionally, the results of this study have identified several key aspects for improving engineering education at SAS. To investigate the applicability of these results Mattew Rodgers,

COO of Singapore American School, was interviewed. Rodgers graduated from SAS from the original campus in 1995 to pursue and complete an engineering degree. Shortly after his graduation the campus was renovated and relocated in 1997. Currently, Rodgers works at SAS and is one of many SAS faculty members involved in the upcoming campus redesign. Through his experiences at all three campuses along with his engineering background, he was asked to give insight into how the data gathered from this study could be implemented when designing new facilities and curriculums seen in Appendix F. When asked how these experiences could be integrated into the upcoming redesign he stated,

> I do feel comfortable walking into any of those design meetings with our architects and with some of our educators, and administrators and offering input based on that experience, not only with my engineering background but also with my first-hand experience with our own SAS Campus.

As SAS begins to go through this transition, future research can be conducted on how recommendations made by this study can be feasibly integrated into SAS.

Finally, when conducting future research, the qualitative methodology could be more aligned to that of pre-existing research. Due to the methodology change, questions that looked at gender and racial issues were not implemented. If these were added it opens up more opportunities to address one of the largest negative influences defined by previous research.

Conclusion

Several perceived influences in high school leading to undergraduate students pursuing their major have now been identified. Firstly, in the absence of structured engineering education, students were more influenced by extracurricular robotics activities. As engineering education

programs are not present at SAS the largest negative influence observed was the lack of knowledge surrounding how engineering is applied in college or as a career. These results were in opposition to previous research which found that knowledge of STEM career applications to be the highest influence in students' college engineering enrollment (Batts et al., 2009). These results highlight several changes that SAS can make to significantly improve student engineering opportunities. Through interviews with SAS administrators, the viability of future research in the implementation of these improvements was also identified. Finally, factoring the analysis of the parental influence on students allowed for further isolation of just high school influences (Siregar et al., 2019).

References

Adya, M., Kaiser, K. M. (2005). Early determinants of women in the IT workforce: a model of girls' career choices. *Information Technology & People. 18,* 230-259.

Al-Qahtani, H. (2013). An investigation into the preparation of high school students to pursue an engineering career. *In Procedia - Social and Behavioral Sciences.* https://doi.org/10.1016/j.sbspro.2013.10.749

Alvarez, E. (2019). The impact of high school science, technology, engineering, and mathematics (STEM) magnet programs on the academic performance of students. *ProQuest LLC.*

Batts, D., Kauffmann, P., Hall, C., Bosse, M. (2009). Factors influencing high school students career considerations in STEM fields. *American Society for Engineering Education.*

Blickenstaff, J. C. (2005).Women and science careers: leaky pipeline or gender filter?. *Gender and Education. 17,* 369-386.

Brockway, D. (2011). Measuring the impact of engineering design activities on student learning in high school biology and chemistry. *Stevens Institute of Technology.*

Chuang, H. M., Lee, C. C. (2020). Interactions of construal levels on programming ability and learning satisfaction: a case study of an Arduino course for junior high school students. https://doi.org/10.1371/journal.pone.0236500

Creswell, J. W. (2018). Research design: Qualitative, quantitative, and mixed methods approaches. *Thousand Oaks, Calif: Sage Publications.*

Cunningham, C. M., Science, M. B. O., Duschl, R. A. (2016). Engineering in elementary STEM education: curriculum design, instruction, learning, and assessment. *The Bridge.*

Cunningham, C., Knight, M. (2008). Integrating engineering in middle and high school classrooms. International Journal of Engineering. *TEMPUS Publications.*

Glennie, E., Mason, M., Dalton, B., Edmunds, J. (2019). Preparing students for STEM college and careers. *The High School Journal.*

Groenewald, T. (2004). A Phenomenological Research Design Illustrated. *International Journal of Qualitative Methods.* https://doi.org/10.1177/160940690400300104

Lammi, M. (2018). Search and review of the literature on engineering design challenges in secondary school settings. *Journal of Pre-College Engineering Education Research.* https://doi.org/10.7771/2157-9288.1172

Leo, L. (2016). Working principle of Arduino and using it as a tool for study and research. *International Journal of Control, Automation, Communication and Systems.* https://doi.org/10.5121/ijcacs.2016.1203

Lopez, M. (2018). A qualitative exploration of the factors that led Hispanic/Latina middle school students to select a STEM high school education in New York City. *Fisher Digital Publications.*

Merriam, B., Tisdell, J. (2015). Qualitative research : a guide to design and implementation. *San Francisco, CA.* ISBN: 978-1-119-00361-8

Moore, T. J. (2014). A framework for quality K-12 engineering education: research and development. *Journal of Pre-College Engineering Education Research.* https://doi.org/10.7771/2157-9288.106

National Science Foundation, (2007). Division of Science Resources Statistics, Women, Minorities, and Persons with Disabilities in Science and Engineering. *National Science Foundation.*

Sevda, Y., Ahmet, Ö. (2015). A content analysis study about STEM education. *Turkish Online Journal of Educational Technology.*

Singapore American School. (2020, June 22). SAS by the numbers. *Singapore American School.* https://www.sas.edu.sg/about-us/the-sas-story/by-the-numbers

Siregar, N., Rosli, R., Maat, Siti., Capraro, M. (2019). The effect of science, technology, engineering and mathematics (STEM) program on students' achievement in mathematics: a meta-analysis. *International Electronic Journal of Mathematics Education.* https://doi.org/10.29333/iejme/5885

Taherdoost, H. (2016). Sampling methods in research methodology; how to choose a sampling technique for research. *SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.3205035

Zucker, D.M. (2009) How to Do Case Study Research. *School of Nursing Faculty Publication.*

Appendix A

Interview Waiver Form

Consent to Participate in a Research Study

Title of Study: The Effects of High School Engineering Programs on Students' College Major Choices

Name Caden Kraft **Phone:** (+65) 87666554

Introduction

- You are being asked to be in a research study on the effects of high school engineering programs on students' college major choices.
- You were selected as a possible participant because you are an alumni from SAS (Singapore American School) who has gone into an engineering major.
- We ask that you read this form and ask any questions that you may have before agreeing to be in the study.

Purpose of Study

- The purpose of the study is to see the possible effects that these programs have and use the data taken from the study as a catalyst for the implementation of these programs at Singapore American School.
- Ultimately, this research may be submitted to College Board for an AP Research credit and published in a journal.

Description of the Study Procedures

- If you agree to be in this study, you will be asked to do the following things: The researcher will be conducting an online interview over ZOOM. This interview should not take more than 15 to 20 minutes. In this interview, a series of qualitative questions will be asked about how the implementation of these programs at SAS could have had an effect on you and any other opinions you may have on them.

Risks/Discomforts of Being in this Study

- There are no reasonable foreseeable (or expected) risks. There may be unknown risks.

Benefits of Being in the Study

- The benefits of participation is that the information gained through the interview could be used as a leverage point for the administration at SAS to implement these curricula.

Confidentiality

- This study is anonymous. We will not be collecting or retaining any information about your identity. The records of this study will be kept strictly confidential. Research records will be kept in a locked file, and all electronic information will be coded and secured using a password-protected file. Videotape recordings will be taken of these interviews. Only the audio of these recordings will be used to create a written transcript. Once this is completed the recordings will be securely deleted. We will not include any information in any report we may publish that would make it possible to identify you. When your responses are referred to in the study a pseudonym will be used.

Right to Refuse or Withdraw

- The decision to participate in this study is entirely up to you. You may refuse to take part in the study *at any time* without affecting your relationship with the investigators of this study or Singapore American School. Your decision will not result in any loss or benefits to which you are otherwise entitled. You have the right not to answer any single question, as well as to withdraw completely from the interview at any point during the process; additionally, you have the right to request that the interviewer not use any of your interview material.

Right to Ask Questions and Report Concerns

- You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research. If you have any further questions about the study, at any time feel free to contact me, Caden Kraft at kraft774144@sas.edu.sg or by telephone at (+65) 87666554. If you like, a summary of the results of the study will be sent to you.
- If you have any problems or concerns that occur as a result of your participation, you can report them to Caden Kraft at the number above.

Consent

- Typing your name below indicates that you have decided to volunteer as a research participant for this study and that you have read and understood the information provided above.

Appendix B

Interview Questionnaire

1. When did you first become aware/interested in engineering?
    a. How old were you?
    b. What grade were you in?
2. What were some of the ways that your family had an effect on your interest in engineering?
3. Prior to entering high school, were there any curricular or extracurricular STEM activities that you participated in?
4. Are you aware that currently at SAS there is currently no engineering program or curriculum?
5. What effects do you think engineering programs would have as you transitioned into college?
6. What factors went into deciding where you went to university and your college major?
7. If there were application-based engineering programs offered at SAS would you have taken them and why?
8. With the possible implementation of these programs in the upcoming redesign of the high school do you have any suggestions for what could be included?

Appendix C

Participant A Transcript and Codification

Theme Codification	Transcript
	The Researcher 0:00 Just starting with, when did you first become aware, like, interested in engineering or like the field of engineering?
First Exposure	Participant A 0:47 The first time I became aware was honestly, when Mr. Millar, he stopped me in the hallway. After school one day, I'd taken robotics as like just one of the like, electives at SAS. But he stopped me in the hallway, and he was like, Hey, you should join Robotics Club. And that was pretty much the start of it.
	The Researcher 1:06 So you didn't have any like, like it like you hadn't really done anything. Like prior to that. It was just; besides the robotics courses you've taken previously, it was just all it took?
First Exposure	Participant A 1:18 That was honestly mostly like, I'm always like, building stuff with my hands. And like, just like construction in general. But I wouldn't consider that like, I mean, at the time, I didn't even realize like *that* was engineering. I just like building forts in the woods as a child, but my first like real experience to like anything, like technological experience was actually Mr. Millar's robotics class.
	The Researcher 1:42 So what were some ways that like, your family had an effect on your interest in engineering? Did they support you?
Parental Influence	Participant A 1:51 They supported me, I definitely. I wouldn't say they had like, any sway really, like, they'd support me and pretty much whatever I ended up doing. But the only advice they gave me was just don't become a lawyer. So they're; because both lawyers, but every other

	field was pretty open. And once I started going into STEM, they supported me through like, donating to the robotics program a little bit, but just like, letting me go on the trips and stuff to compete in the tournament just like gifts, they're engineering related they'd probably swayed towards. The Researcher 2:33 Okay. And I guess you kind of maybe already answered this. But prior to entering High School, was there any curricular or extracurricular, like STEM activities that you participated in? Participant A 2:46 There's not no. The Researcher 2:49 And then, sorry, I'm moving on to the second section. So are you aware that currently at SAS there's no current engineering program or curriculum? Participant A 2:59 Yeah. The Researcher 3:07 Yeah. So yeah, that's kind of what I wanted to focus my project on because we have the two robotics classes, but those are kind of very self led. And yeah, there's no, like, structure. And it's kind of just like work time. So I guess, moving on to kind of that, what effects do you think that having engineering programs in high school would have on you as like, before, as you transitioned into college? How do you think they would have helped you? Participant A 3:32
Benefits	I think they would have helped me a great deal. So I'd say the most useful thing I got out of the robotics class besides like an interest in engineering, and just like the love for robotics, was they had a CAD session using like Autodesk Inventor, where they brought in some outside people from Autodesk and had them just go through the CAD software. And the second I got into college, it was like,

	Alright, here's Inventor, here's how you use it, and just having a little bit of pre knowledge. So that was very beneficial. But then other things such as, like, learning more about the engineering world, like what regulations are such as OSHA or what having to think sorry. Pretty much just anything related to the engineering world would have helped. The Researcher 4:27 Yeah, okay. Yeah. Ironically, the CAD part of the courses gone. Participant A 4:34 Really? The Researcher 4:34 Yeah, I guess. Yeah. Participant A 4:37 So you guys are SolidWorks anything or just The Researcher 4:39 Nothing? Nothing. Yeah. So I said okay, so what factors went into deciding where you went for university and your college major?
Outside Influence Change of Interest	Participant A 4:52 So I had to go in Virginia because I was in state tuition is a lot cheaper but In terms of the choice of major, I decided want to do engineering after just doing robotics for four years, pretty much. It just seems like the next logical step. And I know I talked to Mr. Millar Miss white about that a decent bit with them. In terms of why I chose; I'm currently a senior at Virginia Tech mechanical engineer. Yeah. So I chose Virginia Tech, because it's like one of the number one engineering programs in the country and it is continuously ranked like high in almost every engineering field. The Researcher 5:32 I guess you got pretty lucky and I'm getting that for in state. Participant A 5:37

	Yeah, that was nice. The Researcher 5:41 Okay, so if there were any, like application based engineering programs offered at SAS, would you have taken them and why?
Benefits	Participant A 5:50 I would 100% taken them, just because I think they'd be a lot more interesting than some of the other classes. They're taking there. And they would have been especially towards, like my junior and senior year, it would have been a lot more useful once I knew like I really want to do engineering.
	The Researcher 6:08 Okay. And then, I guess, with the, with the possible implementation of these programs, and the upcoming redesign of the High School, which if you don't know that, that's something that's been announced. And they're playing to redesign a lot of like, the layout and structure of a lot of courses and where, like, where they are. So do you have any suggestions for what could be included? Like in these programs? That will definitely prepare you for college?
Benefits Suggestions	Participant A 6:37 I would say a CAD just class or not class, but like section of a class. Anything with computer aided design. I know we already have computer science and computer science club. That was honestly very beneficial to and I actually got some credit that eliminated some of my college courses for that. Well you got to keep physics, but maybe more like Applied Physics and stuff in the actual like engineering program. Yeah, like honestly what TAS does,
	The Researcher 7:11 yeah,
	Participant A 7:12 I've every time I visited there, I was so jealous of --- we used to visit there for Vex. Do you know?

The Researcher 7:19
I'm in? I'm currently the mechanical lead for the FRC team. But yeah, I know. All that.

Participant A 7:27
Is it? Is it split up now? So you guys have different teams for each?

The Researcher 7:31
So yeah, the, I guess is probably changed a bit. But yeah, currently there is the we have the three robotics, I guess competitions we have a Vex mate and FRC and those; FRC is kind of separate from vex and Mate. And guys Vex nad mate tend to have a lot of overlap in terms of like the people on them, because their first semester and second semester where FRC is like kind of all year Yeah. So, yeah, that Yeah, so there's, yeah, there's Yeah, there's, yeah, there's definitely a lot more people interested in robotics at SAS. And, yeah, I guess it's kind of bit harder this year, because COVID. But yeah, we're still making robots. So that's good.

Participant A 8:13
That's good to hear that I remember. I was there four years ago. So that was before you guys had like the new shop and everything like that was it would go vex and mate kind together. But then the second it was switchover. Once the Vex competition was done, it was everyone knows on Vex, now you're on FRC go work on FRC. And there is no like dedicated FRC thing. So that's good to hear.

The Researcher 8:38
Oh, yeah. Yeah, yeah, yes, a lot of stuff is definitely come a lot more separated as a lot more people joined. Because a lot of people especially in VEX and mate will also work year round just on like preparing and teaching for the next year. And the second semester. So yeah, it's really got a lot better. And

Participant A 8:58
Thats really good to hear

The Researcher 8:59

yeah, and with the high school, I guess redesign, they've planned an expansion of both the robotics and robotics lab and then the robotics shop, as well as the expansion of the high school makerspace to allow it to encompass. Like, I guess more like it, allow it to like, a couple of like classrooms, I guess. And I think, talking with faculty at SAS, that's where a possible like engineering program could be implemented as a kind of that section. And so yeah, that's really interesting.

Participant A 9:38
Yeah.

The Researcher 9:38
It's funny you said to TAS, because, yeah, I yeah, definitely. I definitely thought that too. There I am for the, I guess other part of my study, I'm interviewing like a bunch of alumni from TAS who went through all the ludicrous amount of engineering programs they have there to see what effects it had.

Participant A 10:00
I had some friends on some of the TAS teams from when I was in like VEX and FRC, because it was they did the same thing kind of where they'd have one switchover from VEX to FRC. And we had all I remember is just talking with kids named Jonathan. And he's super cool guy. But every single time we just described their program you're like, so what's it like at SAS is like, Oh, you know, we have like this after school program and build most of the robot then. And he's like, Wow, I've had like, dedicated class and didn't get to touch a robot until this. This time, once I had enough knowledge, I was like

The Researcher 10:41
Yeah. Do you think that like through all those interactions, and like, I guess, trips and visits that you had to TAS and with the TAS, like team members? Is there any, like successful aspects of their, like specific successful aspects of their programs that you noticed, that could be like implemented?

Participant A 11:03
they kept pretty small team. I'm not sure how big the team sizes are now. But they had like, teams then sub teams on those teams like so for. I think it was for Vex, there was like four people or five people on a team at a time, which was way smaller than what we used to have back in my day. But uh, I guess just kind of like, just in depth coaching and like bringing in industry experts, like, you know, from time to time, Mr. Millar bring in, we had a Pratt and Whitney engineer, they'd come in and talk with us, and I was always super beneficial. But I mean, there's a lot of industry experts that are out there that would love to just like communicate about like, even the design process and stuff like that. I know, they go through, or they used to go through like, all the design process and the steps that would need to be taken before they even went into building the robot. And ours was kind of just like, hey, look, the parts are here. Let's build the robot.

Benefits

Limitations

The Researcher 12:07
Yeah, I think, yeah, that would definitely be beneficial. I think that's all I really have. Is there. If you have anything else that you wanted to add?

Participant A 12:21
Like, I'm good, that's good. So how long are you a junior, are you?

The Researcher 12:25
I'm a senior. Yeah, sorry. Yeah.

Participant A 12:28
So where are you going to college?

The Researcher 12:30
I'm going to Iowa State because I also have in state there for electrical Computer Engineering. Yeah.

Participant A 12:40

You guys. I know you guys. Were you part of the FRC team that won the I think it was last year the I forget which award it was I get updates from time to time.

The Researcher 12:51
2019 I guess my sophomore year it was we won the engineering inspiration award at the Sydney regional which allowed us to go to qualified to go to worlds in Detroit.

Participant A 13:05
How was worlds?

The Researcher 13:08
It was like, is probably the most fun I've had in like high school. Like that was like it was just so fun. But we like got last, like out of everybody.

Participant A 13:18
Every single team?

The Researcher 13:21
Or they had like they had I think that they had like four divisions. And we all last in our division. Because we like destroyed another teams robot accidentally. They like their robot like, do they have like a defense bot Which you don't know. Yeah, FRC is like they don't have anything actually. It's just like a drive base. And so they like rammed our bot and it got stuck in our bot. And so we try to back up to like, release ourselves and we ended up flipping theirs over, and it likedlike, destroyed their electronics.

Participant A 13:55
So that sounds like their problem. Right?

The Researcher 13:58
we got a penalised for it. And so yeah, so we got last in our division. And from the people we talked to there, our division was regarded as the worst division.

Participant A 14:10
Yeah you definitely weren't on the Einstein stage.

The Researcher 14:13
Yeah. Yeah,

Participant A 14:14
that's pretty cool.

The Researcher 14:15
Yeah, I would say it was 100% worth it

Participant A 14:19
for my senior year, so that was 2016-2017. We did the VEX competition. We had like one team place like dead last and then another team like 17th. And we had one in like eighth. I think my team was on like seventh. And we paired up with a TAS team and got the build award and tournament championship one. I don't know if you guys saw like the window of like, trophies because you sound like

The Researcher 14:44
those are if Yeah, if you got that if you guys got those trophies, they're 100% still there

Participant A 14:50
That was probably one of the most fun high school experiences.

The Researcher 14:55
Yeah, The Yeah, the competitions are definitely fun. Regardless of the outcome, I remember, we went to Worlds we went to like, we went to Home Depot like, five times, at least. While we were there, just because we were just kind of amazed at all the tools you can get for so cheap.

Participant A 15:16
Thats the fun thing now is I'm sitting here. And so we have senior design at Virginia Tech, just like they give you a company, and the

company has a project for you. They split the seniors up into teams for mechanical engineers, and they have to build a whatever the company pretty much asked for. It's literally like free labor for these giant corporations, but they give us class credit for it. And like so my team's got like five grand for, like working on stuff. As we're making a thing that just like removes yarn from these cardboard tubes, or like this fiber making company.

The Researcher 15:54
That's free credit. Yeah, sounds fun.

Participant A 15:56
But I remember just like I started looking at like the prices for things because we have five grand. And just like this is like one of the wheels we have to deal with. Yeah, it was like 30 bucks for a wheel

The Researcher 16:09
Wow. Yeah.

Participant A 16:11
Everything's so expensive in the engineering world.

The Researcher 16:13
Yeah, that's that. That's the probably our biggest struggle that we faced as at least in FRC because in Vex and mate a lot of the parts of more standardized but for FRC, whenever we have to order like, just like, just like the smallest parts, like a few drill bits or like some like specific hardware, we need, the shipping as always, like, upwards of like $80 just for the smallest thing.

Participant A 16:35
Do you guys ever go down to the hdb's to I forget what it's called. There's a little store down there. We used to send all like the kids. we can pick up this part for us. Yeah,

The Researcher 16:47
there's Oh, yeah, we always there's always a few kids that are runners between the hardware store and the lab.

Participant A 16:47
You guys I know. all nighters a long nights?

The Researcher 17:01
Well, yeah, we've had some long nights, actually, last year, in preparation for the season last year. Our bot was not assembled yet. And so because of like COVID we weren't allowed to travel. But TAS had agreed to like, set aside a section of their because they Oh, yeah, they announced that they're they just created a new TAS FRC original. And so last year, but and so TAS agreed to, like set aside a few members of their team to run our bot for us at that competition, because we weren't allowed to be there. And so because of that the deadline got pushed up, like significantly. And so we had to assemble our robot in like, a day or two. And so we stayed up. And we stayed up. And then like me, and like four other people actually did an all nighter with Mr. Millar. And we just stayed we're just in the lab all night and went to school the next day.

Participant A 17:58
Did he get you guys KFC?

The Researcher 18:05
Yeah, we got we Oh, yeah, we ordered food is pretty great. But then the next morning, the competition got canceled. Yeah, but the bot looks really nice. It's just been in our lab.

Participant A 18:19
I just Remember, we used to have some like really long nights where Mr. Millar would be like, you'd be like 8pm as Mr. Millar would just be like, screw it. I'm ordering KFC now. He's like, all right, and we'll sit down at I don't know if you guys still have like the old really dense wooden desk, with like a million holes in the top.

The Researcher 18:34
Oh, yeah.

Participant A 18:34

They're the back of the room. And we'd all sit down around the table. There's like just parts laying up all over the place. We would all sit there dead silent. Just eating KFC

The Researcher 18:45
definitely is pretty nice.

Participant A 18:48
are you going to go into; excited for anything in particular in college?

The Researcher 18:55
I'm not sure I've always enjoyed like, electronics and like, I guess computer stuff. So I'm, I'm excited to learn more about that. I yeah, and I went on a college tour before all the COVID stuff happened there. And I the facilities looked like really, really nice, especially compared to SAS when they don't really have any sort of, like, like, extensive like, shop or like, yeah, just really, really anything for engineering and then

Participant A 19:28
It getting a lot better than what it was, um, it used to just be a here's the drill press. Here's the hand tools and here's the chop saw. And we'll use the chop software things we're definitely we're not supposed to.

The Researcher 19:39
Yeah, yeah, that's probably definitely still the case. Yeah, we do have a lot. A few. A few more toys we just last year we got a CNC machine, which is like really nice. Especially for FRC when we got all the custom parts that's, that's really nice to have.

Participant A 19:57
surely you guys are using inventor a lot more Now you guys go to the CAD.

The Researcher 20:03

Yeah, yeah, we use a we use because we use fusion 360, which is another Autodesk product. And I guess we're kind of like I would prefer to use SolidWorks. Because FRC even get or FIRST even gave us like 35 licenses for SolidWorks to use for our team. But because so many people at the school don't have like PCs, they only have macs. We have to stick with fusion, which is kind of unfortunate. But

Participant A 20:30
yeah, that's a shame.

The Researcher 20:31
Yeah. And there's only I think there's like one or two people on our team that actually know how to use the CNC machine. So that's something

Participant A 20:40
well, I guess that's good. Because if you have like a few people that are really good at that versus like, and then you know who you have to go to for parts. Some people want like, I know, and we got the 3d printers, there's like, who wants to print something there would be one kid that knew how to make everything.

The Researcher 20:56
Yeah, and then this year, we got a like, a, like a lathe mill kind of combo thing. Like for like, like metal parts. And that's, we haven't really used it much yet. But yeah, that's also really nice. So we're definitely getting more tools and stuff like that. We're just running out of places to put them.

Suggestion

Participant A 21:19
Hopefully, hopefully, you get a lot more tools but I know it's not for you. Because you'll be graduated. Yeah.

The Researcher 21:24
In the tour all the shops and stuff at Iowa State seemed a bit more extensive than SAS anyway, so I'm definitely looking forward to that.

Participant A 21:42
I just went to one of the shops of Virginia Tech, the one reason for our senior design last time and there's just yeah, it's got like a mill a lathe a bender, two or three different like drill presses and like, band saws and stuff. And then it's got like its own section just for welding, which I'm excited about. Yeah.

The Researcher 22:06
Yeah, sounds pretty fun.

Participant A 22:10
All right. Any more questions for me? I don't know what time it is. As a class or some are it's,

The Researcher 22:15
we get today off for Chinese New Year so and it's like 10:30 in the morning. So its fine

Participant A 22:22
you should go and enjoy your day. Yeah.

The Researcher 22:27
Yeah. Thanks for participating in coming on for the interview

Participant A 22:31
Let me know if you have any more questions or anything or just shoot me an email,

The Researcher 22:34
okay, yeah, will do. Okay.

Participant A 22:36
Good luck. Thank you.

Appendix D

Participant B Transcript and Codification

Theme Codification	Transcript
	The Researcher 0:22 Okay, so I just have a few questions here just kind of led to my study. So when did you first become aware or like interested in engineering?
First Exposure Change in Interest	Participant B 0:34 I mean, I think it kind of had a sense of it when I was a kid. You know, I guess Legos in Minecraft is like the two classic ones. Right? But I guess not until I actually came to SAS and joined robotics teams. Did I really like get into it? You know? Yeah, definitely joining the Mate team and FRC teams, and working I guess after school every day was what really solidified my desire to do engineering.
	The Researcher 1:05 Okay, so I guess how old and like, I guess what grade were you in? When you first Oh, yeah.
First Exposure	Participant B 1:13 So I can just say yes, in my junior year or something goes like 16 or 17. ish. Yeah. Okay.
	The Researcher 1:19 And then. So what were some ways that your family had an effect on your interest in engineering?
Parental Influence	Participant B 1:27 Oh, I mean, they've just, they've generally been quite supportive of whatever I wanted to do.
First Exposure Parental Influence	Participant B 1:32 You know, find me Legos as a kid. definitely helped for sure. But I think, you know, they weren't really pushing me one way or another. Neither of my parents are engineers. And neither of them really had

	any direction for me to go to that they really supported over another so yeah, supportive parents always a good thing. The Researcher 1:54 Okay. So, prior to entering High School, were there any curricular or extracurricular STEM activities that you participated in? Participant B 2:05 Sorry, can you repeat? The Researcher 2:07 prior to entering high school? Were there any curricular or extracurricular STEM activities that you participated in?
First Exposure Change in Interest	Participant B 2:15 Oh, yeah, I guess back in middle school like seventh eighth grade. I guess there was kind of a Lego Mindstorms club that I sort of did like, once or twice a week. It was more for fun than for like, I want to do engineering, but I guess that was something I did that probably did contribute. A little bit. Yeah. The Researcher 2:35 Okay. Was it? Was it FLL? Or no, Participant B 2:39 no, no, it was just like, the teacher literally bought a couple Lego Mindstorms things and was like, here, kids have some fun and make some cool stuff. The Researcher 2:48 Okay. So are you aware that currently at a SAS there's no engineering program or curriculum? Participant B 2:58 I mean, I guess it depends how you define that, The Researcher 3:00 right? Yeah,

Participant B 3:01
there's math. Pretty sure there's still math. Yeah, I mean, tell me more about what kind of things you'd like to see, I

The Researcher 3:10
guess. So basically, I'm, I guess, forming my project around. I kind of like application based engineering curriculum. So at SAS we have, like the very high level like math and science courses. But currently, there's no courses at SAS, where you actually take all the skills you learn in those classes and apply them to, like real life engineering problems. And I moved to SAS my sophomore year, and when I, at the beginning, my sophomore year, and at my old school, they had like programs like these. And when I moved to SAS, I noticed like, Oh, they have all these, like, really nice facilities. And everything was like way nicer. But it was just something I felt was lacking. And especially with the amount of students that go into engineering from SAS, I felt like it was something that I could, like, possibly like, like, look into. So yeah, so my, I guess my project is seeing like the effects through interviewing SAS alumni who have gotten into engineering, and then also interviewing alumni from Taipei American school who have participated in engineering programs throughout high school that they have there. And then also going to engineering.

Participant B 4:23
And you came from TAS, right?

The Researcher 4:25
No, I have been at SAS the whole time.

Participant B 4:29
So where were you before? So? Yes, not so. Oh, yeah,

The Researcher 4:32
sorry. I was I guess that was unclear. I came from a school was in the US. Okay, sure. Sure. Sure. Okay.

Participant B 4:40

	Cool.
	Participant B 4:41
Limitations	Yeah, that's true. We don't really have a lot of, I guess, specifically engineering programs. I mean, I guess unless maybe count robotics, intro to robotics, advanced robotics, but really, that's just Millar sitting around and giving us stuff to do. But yeah, for sure. I think
Change in Interest	Most of the value I got from SAS facilities was them being able to let me have free rein with whatever I wanted to do. And then that's contributed more to my, I guess, engineering sense of engineering and design intuition, then maybe a course might have provided because I guess even in university, I'm at UBC right now, I mean, we don't have a shi**y engineering program by any means. It's pretty, it's probably one of the best in Canada. But even the, the modules that they have you take that are for engineering design are not really that, like, great, I would say, in teaching you like design principles and things like that, what is really good for, from at least what I've experienced is when they sort of teach you the higher level stuff, like the math and the science and the physics, and then when you have your own physical, like, I guess, experience with designing stuff, you can link that together by yourself. And for me, that makes a really, really powerful connection that helps me you know, I guess, advise my design intuition.
Benefits	
	The Researcher 6:14
	Okay. So, do you think if there? Do you think that there would be any effects? If you would have taken like, a program like this in high school as you transition into college?
	Participant B 6:28
Limitations	Yeah, I think I think, okay, for sure, SAS could use with a little bit more focus on like, application style classes. But end of the day, I think it's access to facilities and to material and to time in the shop. And time in. I think the, the robotics competitions are a great example. Just like, you don't have to, but if you really want to, you can go in and you can really do your thing. And you can get a lot of experience, probably by messing up a lot of parts. Yeah, yeah. So
Benefits	

	something like that, I think is quite, it's quite valuable to learning. Engineering Design, for sure.
	The Researcher 7:10 Okay, so what factors went into deciding where you went to university and your college major?
	Participant B 7:19 I think I kind of at by the time I was applying for college, because I, well, I'm, I'm actually Singaporean. So I had to do national service for two years. So I sort of applied a year into my national service at some time to think about what I wanted to do engineering was pretty much top of the list. What kind of engineering wasn't super clear to me, mechanical and mechatronics was kind of up there for me. So I sort of knew that North America was where I wanted to be, because I sort of had a great childhood, great most of my childhood in North America. And I thought the culture there fit me very well. So I did apply to a couple schools in North America, Canada and the US and ultimately settled on UBC for one reason or another, I guess. But the I mean, quality of the engineering program clearly was one factor, whether I got in, you know, another factor. And I also heard that UBC had very, very, very well funded design teams, engineering design teams. So that was something I was very attracted to. And so that was what ultimately had led me to chose choose UBC, because, you know, design teams, student design teams, STS were a great experience for me, and I sort of wanted to continue that at a higher level. So definitely, that was it.
Change in Interest Limitations Outside Influence Wanting More Benefits	
	The Researcher 8:44 Okay. Do you think participating in national service had any impact on like, like, any of your like, passion in engineering are like how you chose your college?
Outside Influence	Participant B 8:58 Yes, National Service really highlighted to me that if I wasn't doing something I really enjoyed. I should probably not do it. Yes. Okay.
	The Researcher 9:11

	So if there were application based engineering programs offered at SAS, would you have taken them and why?
	Participant B 9:20
Wanting More Limitations Benefits	I would have taken them mostly because, you know, I did the one semester intro robotics one semester, advanced robotics, like, you know, some people do and then that was junior year, and then senior year, I was like, Well, I guess I'll just do that again. So something else would have definitely been nice, just even just to sort of expand horizons. And I mean, like, if if you had like a real machinist, or a real you know, someone with an engineering background, teach those, I think they could be really valuable. More so than just having an actual, like, curriculum, the curriculum could be like, pretty loose, loose and you know, whatever, but having the experience of the person to sort of bounce on your ideas and have them be shot. Super, super valuable.
	The Researcher 10:01
	Yeah, one of the things that I've noticed throughout my research is that a lot of the schools that implement these programs instead of implementing the program, and then getting a teacher and I guess, teaching the teacher how to teach engineering, they bring in an actual engineer and teach them how to teach. And, like, I guess that seems to be like the main, like, thing they do. Yeah, that seems like yeah, it'd be very beneficial,
	Participant B 10:26
	Have you found that to be more effective than the opposite way around.
	The Researcher 10:30
	Or this isn't my own research. It's just it was, it was like a study somebody else had conducted on how the programs are implemented. And, yeah, that did seem to be more beneficial.
Benefits	Participant B 10:42
	Yeah, that definitely sounds right.

	The Researcher 10:44 Okay, and so, if you don't know, in the next few years, there is a upcoming redesign of the high school. And so this will, this will, this include, like a relocation and expansion of both the robotics lab and the robotic shop. And then I don't know if it was there, when you were there, but the high school makerspace will also get a, like a large expansion that will include sections for the sections to possibly put like classes in kind of in that area. And so with the possible implementation of these programs, and in the upcoming redesign of the high school, do you have any suggestions for what can be included in them? Participant B 11:28 I mean, I don't really know what the details of the expansion are. So are the shop and robotics gonna be moving into the makerspace kind of area? The Researcher 11:38 They're still going to be kind of separate, but it's still very, very preliminary. But what they've discussed so far is that there could be a possible like course space in the, like, makerspace wing. And so that's where that, like, they were looking to possibly implement these programs. Participant B 11:59 Yeah, I mean, like more, more resources, and more facilities for engineering and for design, in general, are great. revamping rooms is a nice thing to do, I guess, especially those rooms aren't really purpose built for engineering work. Like one, I think, well, I don't really know how it's changed. But one major gripe that a lot of engineers like robotics students had with the makerspace, and a lot of other students had, who wanted to use it for engineering work was that like, it was really, really, like pretty, its really beautiful. Their tables were so nice you could eat a steak dinner off of them, they were like maple tables. And I know, because I worked for the guy who made the tables, the furniture guy who designed them. So like, if you just if you sort of focus on practicality and functionality, as opposed to, you know, something to show off to people who visit the
Limitations	
Suggestion	

Limitations	school, I think that could be really valuable for the kids who really want to do something in there. I mean, I will give them credit, they bought a lot of stuff, a lot of 3d printers, laser cutters, things like that Arduinos You know, a lot of electrical stuff as well soldering irons. So that's great. Just like sort of, if the focus is building a space that, you know, will 100% pretty much be messy, a lot of the time, and will not be very beautiful, but it will see a lot of action and a lot of use. I think that's probably the direction to go as opposed to you know, a set piece for SAS The Researcher 13:36 Yeah, I definitely think that too. And I think that if it is used as like a kind of like show off piece that the people that actually want to use like the facility for its intended purpose can easily recognize and tell the difference.
Limitations	Participant B 13:50 Yeah, definitely. Definitely like a trained eye can tell no work is being done there or definitely work is being done there. The Researcher 13:56 Yeah. Yeah, definitely. So I guess that's really all I have. If you have any other like questions about SAS or what's happened. Yeah, feel free. Ah, yeah. Participant B 14:09 Have we won any World Championships recently FRC, Mate? The Researcher 14:14 FRC in 2019. We made it to the Detroit championships. And we didn't win but just qualifying from the city regional is... Participant B 14:29 that's awesome. The Researcher 14:29 Yeah. So yeah, the trip was really fun. I don't I don't think Mate has but and I guess with this year, and COVID a lot of the competitions

are still kind of at a standstill. But yeah, yeah. But everybody all the teams are so like making robots for them. And their each of their respective organizations has a lot of online challenges that teams can participate in, but there's no physical challenge or competition. So yeah, but yeah, we're still I guess building robots.

Participant B 15:01
Yeah, I mean, it sucks that all the competitions are like online because how does that even happen? I guess yeah.

The Researcher 15:06
Yeah.

Participant B 15:07
Well, how was the catalyst program? Do you guys still have that? Yeah,

The Researcher 15:12
we do. I personally, I've never taken it because this project is actually for the Quest program.

Participant B 15:21
Oh, you're in quest? Oh, yes. Good. Okay. How is that? That's that's another? Yeah.

The Researcher 15:25
Yeah. It's, it's, it's really fun. Yeah, I would say it was. It's definitely changed a lot since it was first implemented. And I definitely think that it was probably one of the better decisions I've made in high school. I definitely learned a lot better through like the, like, project based learning. And yeah, it's, yeah,

Participant B 15:44
that's, that's awesome. I think my year was the first year to do Quest and we joked up on them a little too hard.

The Researcher 15:51

Definitely has changed a lot. There's, there's a lot more opportunity for it because he used to be not like that much like, stem oriented. But yeah, I think it It definitely allows for much more free rein and what you want to pursue.

Participant B 16:14
That's awesome. That's awesome. Yeah.

Participant B 16:15
So have you been into the makerspace? recently?

The Researcher 16:19
Uh, yeah, it's and yeah, I can almost guarantee that not much has changed.

Participant B 16:25
Yeah, no, I could totally believe that. Yeah, the corner. There's like a pile of wires and metal sitting on a stand. I don't know if you've seen it. Mm hmm. It's supposed to be an exoskeleton. Oh, yeah. Not Yeah. Yeah. That's mine.

The Researcher 16:37
Oh, really?

The Researcher 16:40
Yeah. Yeah.

Participant B 16:42
Thank God. Okay, great. Cool. I wonder when Steigerwald is gonna throw that out. But that is that is mine. Yeah.

The Researcher 16:49
Yeah. All the makerspace. People like Miss Simone, and Dr. Steigerwald all there are quite proud of that. Oh, yeah

Participant B 17:02

Wanting More

Bet they show it off. That's like, awesome. Well, yeah. Here's a tip for you. If you go to steigerwald. And ask them for $5,000. They'll probably give it to you. You probably,

The Researcher 17:12
Actually. Yeah, we have. Me and a few friends. I've made a lot of funding requests. And proposals for the high school. This year we got we were actually really surprised that this happened. But we got approved to get to Markforged carbon fiber 3d printers for the robotics lab,

Participant B 17:32
Millar told me about that. I was I was pretty shocked. Yeah, thier not super cheap.

The Researcher 17:36
In total, it was like around like 30 grand.

Participant B 17:40
Jesus Christ. All right.

The Researcher 17:42
But anyway, we were so surprised to get approved. But yeah, we just drafted up. We drafted up a proposal and pitched it to Jason Cone, who was like, the innovation person for central administration. Okay, yeah. And we read through it and told him I was like, 30 grand, and he didn't even blink, so.

Wanting More

Participant B 18:02
And this school makes too much money. You got to make some of your tuition back. You gotta just take it from.

The Researcher 18:19
Yeah. Yes, that's the plan. That's awesome.

Participant B 18:14
Great. Well, looks like robotics robotic program. And stem in general is in good hands. So that's nice to hear.

The Researcher 18:18
Yeah, it's definitely getting a lot better.

Participant B 18:23
All right. You have anything else for me before I head out, or

The Researcher 18:25
Yeah, that's it. Yeah. Thank you for coming on for I guess this interview taking the time out of your day. Yeah,

Participant B 18:32
Sure. Thanks for having me. I hope I wish you the best in your Quest life, I guess. Yeah.

The Researcher 18:39
Yeah. Okay. All right. Have a good evening, then.

Participant B 18:43
See you later. Bye.

Appendix E

Participant C Transcript and Codification

Theme Codification	Transcript
	The Researcher 0:01 Okay, so then I guess I'll have a little bit of like a precursor to my study. So I'm going to be doing like interviews between SAS, alumni that have gone into engineering like yourself. And then the same thing with alumni from Taipei American school who have participated in engineering programs, but they have to gauge their effects. And then hopefully, like, use that to get them implemented at SAS. Okay. So I have a few quick questions. So firstly, when did you first become aware or like interested in engineering?
First Exposure Change in Interest	Participant C 0:43 Probably the first time I kind of became interested in it would be in junior year of high school. Probably the first real time, and then, you know, kind of changed my engineering interests. But that would definitely be the first like, maybe I'll go apply for engineering in college.
	The Researcher 1:03 Like, what was the thing that kind of like, like, I guess, sparked your interest?
First Exposure	Participant C 1:12 Yeah. So I think at that point, it was so I started playing around with... So first of all, physics classes. So the AP physics classes, you know, my teacher at the time was he majored in engineering, and we had some conversations around that. And, you know, it was it was easily my favorite course at the time. And then also was kind of getting involved with like, playing around with like Raspberry Pi's, and starting to get interested in some, some coding.
Wanting More	Participant C 1:38

	And then, you know, the year after that, it got, like, started worked with my brother and Mr. Millar, and worked to start the robotics team.
First Exposure	Participant C 1:47 And so that was like, really, when it started. And then before that was like, yeah, this is something I might be interested in.
	The Researcher 2:00 Yeah, I guess. Secondly, well, did it was there any ways that like, your family had an impact on your interest in engineering?
Parental Influence	Participant C 2:11 Um, I think so. My parents were in finance. And they both kind of encouraged me not to go into finance. So and then, you know, I had a, I had a twin brother, who is the same year as me, in high school, in the same year, the and everything. And he definitely got more interested more quickly than I did in especially computer science. So like, you know, when he applied to college, he applied specifically for computer science, and he was pretty, you know, writing apps and selling them in high school. And so I think that definitely, that definitely gave me more exposure to it. So that was definitely helpful. And I kind of started the path is like biomedical and electrical engineering. So a little bit separate than that. And probably by sophomore year of college had pretty much converged on computer science and computer engineering, as well.
Outside Influence	
	The Researcher 3:09 Okay. So, prior to entering High School, were there any curricular or extracurricular STEM activities that you participated in?
First Exposure	
	Participant C 3:27 Prior to high school?Not really. Yeah, I think there was like some extracurricular math stuff, but very little. Yeah. Okay.
	The Researcher 3:39 Are you aware that currently at SAS, there's no engineering program and core curriculum?

Wanting More

Potential Bias

Benefits

Outside Influence

Limitations

Participant C 3:46
in the in the core curriculum? Yeah. Yeah. I think I think there was like an electrical engineering and mechatronics. course when I was there, but that was about it. Yeah, I'm aware of that. And it was pretty limiting.

The Researcher 3:58
That, that course isn't even there anymore.

Participant C 4:00
Right. And it wasn't, it wasn't any good. It was like, learn how to solder a circuit. It was, you know, it wasn't it wasn't a very interesting course. So. But yeah, no, that's absolutely. I'm aware of that. And, and I'm glad that glad that you're working to change that. Because it is definitely something that I think would be beneficial to a lot of people.

The Researcher 4:23
I guess this is kind of a hard question, or because it's hard to answer question, but what effects Do you think having or participating in... do you think engineering programs would have as you transitioned into college if you would have taken them if they existed in high school?

Participant C 4:40
Yeah. Um, so I think for me, it probably would have given me a better idea of what it actually was. You know, like, I kind of was like, Oh, I liked my physics class, like, and my, my teacher in that physics course was an engineer. He recommended it. So I guess, you know, I guess we'll try that out. But didn't really have any idea of like, like, I went in as a biomedical engineer and didn't really have any idea what that meant. And then switched to electrical engineering not really knowing what that meant, either.

Participant C 5:10
And so, you know, I think like probably the biggest thing, like even even if not, you know, obviously, it wouldn't necessarily be a

Benefits Limitations	college level course. But just providing people with the ability to kind of see, you know, this is what engineering actually is. And this is, you know, like, how you can just kind of go and build stuff, you know, how you can actually apply some of the physics and chemistry and kind of making more people aware that it's like, an actual career path. Because without it being present in high school, there's not it's not as obvious that that's like, something you can go do. The Researcher 5:51 Yeah, I would say that the actual, like, applications of engineering are very misunderstood. Participant C 6:03 Yeah, and, you know, I think a lot of people kind of assume it's like, you're going to be doing, like what you do in your math class, or your physics class. And, you know, it's, it's nothing like that at all. Like, you apply some of that knowledge, but, you know, it's much more around just like actual, like, critical thinking and solving problems. And then, and, like, kind of creatively solving those problems than just memorizing, or, you know, learning specific algorithms or, or, you know, like, physics theorems and stuff like that. The Researcher 6:38 So, what factors went into deciding where you would go to university and your college major that you chose? Participant C 6:48 Yeah, so, so I went to, I went to Duke. And I kind of decided to go there. Participant C 6:55 Because I didn't really like I thought engineering was interesting, and was probably what I was going to want to do. But I was also very interested in like, international relations and political science, and,
Limitations	
Change in Interest	

Outside Influence	Participant C 7:06 you know, the computer science school, there wasn't part of the engineering school. And so it was like, you know, so basically, I wanted to, like I went there, because it was kind of a good school for everything. Participant C 7:18 Like it wasn't. And also, the other one was, like, my brother went to Carnegie Mellon, where you end up like, basically reapply, if you want to switch schools and switch majors. Participant C 7:28 And so I specifically went to Duke because it was like, you could, you know, you could transfer out of engineering, you transfer back into engineering, you can take classes in the non engineering side, you could get concentrations, double major with non engineering, and kind of just be more flexible, and how you actually,you know, would would choose what classes to take, what majors to get, what minors to get. Participant C 7:51 And all that. Participant C 7:53 And yeah, like, the, you know, that all that no matter what classes you took, and what department that they would be with, you know, strong professors and in schools in general.
Limitations	Participant C 8:08 And then in terms of the major, like, I applied for biomedical engineering, kind of just because that was the highest ranked engineering major at Duke. And it was like, you know, if I get if I get into that, and decide, I don't like it, like, it probably pretty easy to just switch to whatever else. Participant C 8:29 And I switched after one semester.

	Participant C 8:32 So that was, you know, so it was like, choosing what major was kind of easy, and then choosing what school was basically, like, I didn't really, you know, like, I thought there was a chance I might transfer out of engineering figured out I didn't like it. So I basically the idea was like, it's much easier to transfer out of engineering.
	Participant C 8:53 And I found that much more likely as to what I wanted to do.
	The Researcher 8:59 definitely.
	The Researcher 9:01 So if there were application based engineering programs offered at SAS, would you have taken them on why?
	Participant C 9:10 Yeah, I mean, absolutely.
Wanting More	
	Participant C 9:13 I was super, I wanted more application based stuff. Pretty much as soon as I started taking science courses at SAS, which was like freshman year.
Wanting More	
	Participant C 9:23 And then, you know, and it kind of turned into, like, you know, that was like, part of the reason that my brother and I started the robotics team senior year, it was like, there were really not like, you know, I took like, the electrical engineering course and the mechatronics courses, but, you know, I didn't really think either of them were super good. And they didn't really relate the other courses to application based stuff, and they didn't, you know, they weren't, they weren't very well structured.
Wanting More	
	Participant C 9:50
Wanting More	

And so, you know, basically like, yeah, we went and talked to a few teachers and like, we're like, okay, like, how can we actually make something that's, you know, more more application based.

Benefits

Participant C 10:02
Kind of like actually building, you know, something that we want to and like find some friends who want to do that.

Wanting More

Participant C 10:08
But yeah, no, I had there been an actual curriculum for that. That would have been amazing.

Participant C 10:14
You know, and I think a lot of a lot of my friends would have taken courses like that as well.

The Researcher 10:21
yeah. And I have my, I guess my final question with the possible implementation of these programs, and the upcoming redesign of the High School, which we don't know, they're kind of, they're doing that over like, the next few years redesigning, like the core layout, and like, where a lot of classes are located. Do you have any suggestions for what can be included in these programs?

Participant C 10:44
Yeah, so what's the redesign of the high school?

The Researcher 10:48
Yeah, they're really kind of just completely redoing, basically, like the entire High School. So from what I know, I'm pretty sure that the robotics lab and shop are getting expanded. And then the high school makerspace I don't know if that was there when you were attended. But no, it's, it's pretty small. But it's, they're looking to expand it. And then also add, like, possible room for like courses to be taught in that area. And so that's where they're kind of looking to possibly implement these programs. So yeah, if you have any suggestions for what could be included in them?

	Participant C 11:29 Yeah, actually, so where's the robotics lab? I don't think that was there when I would attend it, either.
	Participant C 11:37 Is it in the same as like, the same areas, like the shop,
	The Researcher 11:42 I'm not exactly too sure. Because a long time ago, but I'm pretty sure it is just kind of an expansion of the shop area.
Suggestions	The Researcher 11:55 From what I know, the entire robotics lab used to be the shop. So the room is the exact same size, but I got split into half and the shop is one side. And then there's like, just like a lab to kind of build stuff and like, teach on the other side.
Benefits Benefits	Participant C 12:20 Yep. No. Okay. Interesting. Yeah, um, you know, I think one of the, like, one of the simplest ones at Duke it was a great course that I do for engineering, which was basically like, you know, they, I stuck on Arduino based, like you spend a semester building robots with various sensors that have to basically navigate an obstacle course, right? So it's like it involves, you know, learning how the sensors work, how they actually behave, how they do both coding, in terms of actually getting that stuff set up, it involves, like, you know, soldering, and building and materials engineering to actually get these little robots set up. And it wasn't, like overly difficult.
Personal Bias	Participant C 12:55 And you know, that, and kind of, like I was saying before, like, it adds in a lot of like, creative problem solving, that actually happens in engineering.
Benefits	Participant C 13:05 And, you know, it's not kind of pigeonholed to just like computer science, or electrical engineering, or for whatever along there.

	Participant C 13:16 Like, in general, I think I would probably, I mean, I'm a little biased, because I love robotics, but I, I generally think robotics is is a very easy and accessible way to, to get people, you know, actually building things. And kind of doing engineering in that way.
Suggestions	Participant C 13:35 Because it's like relatively simple concepts of electrical, mechanical and computer science.
Benefits	Participant C 13:45 You know, in, and then and then obviously, like going more in depth into how those things actually work, like, and there's some other like, potentially cool projects, like, think any electrical engineering class, we like, built a radio out of a kit, but like doing that more from scratch would potentially be interesting, like you discussed, like, waves and e&m and how that relates to visit to like, the physics courses that you're taking. While at the same time, you know, you're building and designing these these circuits that actually make it work.
	Participant C 14:20 Yeah, you know, it's a little hard to say what people would actually be interested in.
	Participant C 14:27 But I would tend to go kind of towards the robotics problem solving projects.
	The Researcher 14:37 Yeah, SAS, definitely has a lot of very high level math and science courses, but then there's nothing really in place for or at least curricularly in place for actually applying all the concepts you learned in those classes.
Limitations	Participant C 14:51 Yeah, no, that's I mean, absolutely.

Participant C 14:55
And there there's really nothing that links them back to like, I remember in like AP Physics, we did like a Water Bottle boat competition, but like that was pretty much the extent of, you know, application in corporate giving classes, which like that's, you know, it was fun, but it wasn't really applied.

Participant C 15:17
And, you know, I don't know if there's like any computer science, I guess there was AP Computer Science That's, that's still the only avenue for that. I imagine.

The Researcher 15:25
There I think there is a there is a like an intro course, like a semester long intro course.

Participant C 15:33
Oh nice.

Participant C 15:35
Yeah, you know, I like, because I know computer science is like, not technically engineering, depending on what school you go to. But it is just easy in that, like, you can get people interested in it, and they don't need anything but a laptop to actually do it. Yeah. Like, I know, that's kind of what what roped me in was, you know, you learn these concepts, just go play around with them on your own without a lab or anything else.

The Researcher 16:00
The barrier to entry is just like basically nothing.

Benefits

Participant C 16:04
Right? Exactly. And like, even with like robotics, like, because they have so many, like ready made kits for for that. And like, you know, pre designed curricula than that, you know, the barrier for entry for

	those is pretty small to you know, people like a Raspberry Pi as well. $30.
Benefits	Participant C 16:23 Right. So, you know, and like, basically providing somebody with those and saying, you know, go build this thing. Participant C 16:31 You know, I think it definitely gives people kind of a, an outfit to actually learn how to how to kind of creatively build those things from from mostly scratch. Mm hmm. The Researcher 16:45 Yeah, definitely. So I guess that's all I have. If you have, like, any other questions or comments, feel free. Participant C 16:52 yeah. Participant C 16:54 Has I mean have there? So are you to say yes, right now? Yes. I'm a senior. Participant C 17:02 What have you been like in terms of application? Is there been any outlets that you've done? The Researcher 17:07 So, I so we have so we have the FRC team for robotics. And then there's actually there's there's now three robotics competitions, extra curricular. There's FRC and then which is like, yeah, like, probably larger robots. And then there's the Vex team. And then there is a mate team, which is like underwater. And so yeah, those Yeah, those are, I guess, really useful for kind of like that application based stuff. And then me and a friend founded like an engineering and design club, where people can come in with like their own, like projects they want to build, and they kind of have like, a community of people that can kind of help them do that. And so there's been

	like, some pretty cool projects that have kind of spawned from that. I guess, but But yeah, I guess it's all extracurricular, which kind of was unfortunate.
Suggestions	Participant C 18:02 Yeah, I didn't realize there were three robotics competitions as as does now. Yeah, yeah. It's kind of got Yeah, segmented. But yeah, there's still not really any curricular aspect Participant C 18:19 Yeah. No, I think it'd be cool if there was one, like, you know, they took one of those robotics competitions and made a class that, you know, would have two or two or three teams that competed in it, you know, like, it probably would take longer than that. I guess the classes are a semester. But you know, like, that seems like a pretty easy like, there's already an established Avenue into those and gives people a chance to compete in something. Participant C 18:41 I don't know. Participant C 18:45 So, but yeah, no, that is, I'm glad that you're pushing for this. Because it would have been nice to have when I was there as well.
Limitations	The Researcher 18:53 Yeah, it was also something I moved to SAS, my sophomore year. And there was at my old high school that I was at, for a year in the US. They had like a very extensive, like, engineering curriculum that I took freshman year and then I moved to SAS and SAS had like, way more facilities and way more classes and way more people. And that was like, the only thing that was kind of lacking that it was Participant C 19:20 Yeah, so yeah, that's, uh, yeah, that's, that's kind of interesting. And that's something I've heard about Singapore in general as well. Like, I know Yeah, obviously. SAS is kind of a American School Island

there, but they're just really not that many like creative application based classes and even in like the public schools in Singapore.

Participant C 19:40
yeah, no, that's, that's good. I'm glad you're doing that. I assume you're, you know, off to college in a semester. But, yeah, hopefully, like what's the what's the plan to kind of go further with this?

The Researcher 19:53
I mean, I have a so currently for my project. I am writing like a are doing all this kind of research on it and looking at a possible curriculums that could be implemented and then doing these interviews and then writing like a whole thesis paper at the end of the year on like the subject. So and then I hope to like have like a presentation plan to like propose. And so I like the like, SAS administration, but then I also have, like a lot of friends that are underclassmen that could that are also very willing to, like push for the program. So yeah,

Wanting More

Participant C 20:40
yeah, I imagine this is pretty popular. Yeah.

Participant C 20:42
Cool. Yeah, I don't have anything else. But you know, hope it works out. And it'd be great if it did. Yeah. You know, and obviously, let me know if there's any, any other questions or anything else I can do to help with this? But

The Researcher 20:55
yeah, thank you so much for taking the time.

Participant C 20:56
Yeah, of course.

The Researcher 20:59
All right. I think that's about it.

Participant C 21:04
Sounds good. See ya.

The Researcher 21:06
Have a good day.

Appendix F

Mattew Rodgers Interview Questionnaire

1. When did you first become aware/interested in engineering?
2. Prior to high school, were there any engineering or STEM activities that you participated in?
3. What were some of the ways that your family had an effect on your interest in engineering?
4. As you graduated from SAS from the original Kings Road campus in 1995 before the campus was relocated and renovated in 1997, what influences, if any, throughout high school led you to pursue and graduate with a degree in engineering.
    a. Between the curriculum at the time, teachers present at the school, and the campus and facilities, which had the biggest impact on your choice to pursue engineering.
5. Do you think the international location of SAS influenced STEM opportunities available to you in high school?
6. Now working at SAS today on the current campus, have you made any observations about how SAS approaches education in engineering differently from when you attended the Kings Road campus?
7. As you are involved with the proposed upcoming redesign of the high school, how do your experiences at both campuses impact your decisions made when ideating the redesign of high school opportunities in engineering?