Alumni Outreach and Education of New Members for the Society of Automotive Engineers

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ABSTRACT

The purpose of this IQP is to attract and introduce new members to the Formula Society of Automotive Engineers (FSAE) Collegiate Design Competition, along with introducing these new members to general engineering concepts which will be used during the FSAE competition and throughout their time at WPI. The other purpose of this IQP is to reconnect with WPI Alumni who had previously completed the FSAE MQP. By contacting alumni, we were able to recreate the history of the club and have created a community of active alumni to assist the team in the design and build process as well as job acquisition for team members.

ACKNOWLEDGEMENTS

We would like to thank our IQP advisor David Planchard who supported our ambitions and provided guidance and assistance throughout the project. We would also like to thank all the alumni who provided us with valuable information and were generous enough to take time out of their days so that we could interview them. As well as this, we would like to thank the WPI Archives, WPI Formula Society of Automotive Engineers, and the WPI American Society for Mechanical Engineers for contributing to our IQP.

EXECUTIVE SUMMARY

The purpose of this Interdisciplinary Qualifying Project (IQP) was to accomplish developing an alumni network and continuation upon the development of instructional material for the new member seminars.

The alumni network is meant to reconnect with the alumni from past years of the WPI FSAE team to develop a network, to grow sponsorships, host design reviews of the race car, and create a place for graduating students to gain information relating to their job search. The necessity for developing an alumni program has become more apparent as unnecessary mistakes have been made regarding the design of the car, and could have been avoided if the alumni program existed.

To fulfill this portion of the project we consolidated over 130 names of people who participated in the WPI FSAE team from 1986, the start of the team, until 2001. Furthermore, a LinkedIn Group was created for all alumni that were found to create a singular place where the majority of Alumni could be contacted all at once. There is also a reference spreadsheet that contains all the info that was able to be consolidated on all members whose names we found to allow direct contact with alumni should it be necessary.

The second purpose of this IQP will be to continue on the development of instructional material for the Worcester Polytechnic Institute (WPI) chapter of the Society of Automotive Engineers (SAE), developed by the 2018-2019 IQP to improve new member involvement and retention. These seminars will assist the new WPI SAE team members to gracefully join the older members in skillfully designing and fabricating a Formula SAE car over the academic year. The instructional material presented consisted of powerpoint presentations coupled with a hands-on activity for students to participate in. The goal is to increase interest in subject matters related

to engineering. Furthermore, the project team modified previously made presentations, condensing one hour's worth of information into a 15-minute presentation of basic and introductory knowledge followed by a hands-on activity to further solidify the content.

SEMINARS

Seminar I, Intro to WPI FSAE

An overview of the collegiate competition Formula SAE. The seminar will discuss WPI's FSAE schedule as well as options for IQPs, MQPs, and ISPs related to FSAE. In addition to this, the impact of FSAE on getting internships and the many resources available at WPI were discussed. The hands-on activity that followed this was an egg drop experiment where students designed safety mechanisms for their eggs within the bounds of a 3D printed FSAE race car frame.

Seminar II, Solidworks

Members were taught step-by-step how to design basic parts in SolidWorks with instruction from a member on how to create a mug. Homework help was also offered to anyone taking ES1310 at the time. Following the design of the mug, new members were introduced to some introductory design projects that they could do to benefit the team.

Seminar III, Tailoring Resumes to Engineering

Members attended a presentation that covered many important parts of resume creation such as formatting, things to include and not include, and were shown a collection of example resumes to provide real-world examples of the topics previously covered in the presentation.

Following the presentation, students were welcome to work on their resumes and ask for help on their resume as well as job and internship searching in general.

Seminar IV, Machining

Students were rotated between three different stations throughout this session. This seminar was partnered with WPI American Society of Mechanical Engineers(ASME).

Presentation: Students were introduced to basic additive and subtractive manufacturing processes as well as the precision manufacturing techniques commonly used with CNC mills and Lathes.

Mill: Students viewed a demonstration of how a mill is operated, and can be used to make precision parts, and were encouraged to ask questions pertaining to their uses, and operation.

Lathe: Students viewed a demonstration of how a lathe is operated and can be used to make precision parts, and were encouraged to ask questions pertaining to their uses and operation.

Results

Overall, due to our Seminars, we have managed to increase our member retention, with us introducing between 10-15 new active members to our team, more than double the number of new members retained from last year to this year. Furthermore, the knowledge of many of these members seems to be in line with the knowledge of the prospective new members last year, meaning that delivering the content from our seminars was retained.

The result of the alumni network is that we now have access to many engineers who are aware of the rules and regulations of FSAE, and who can help us to design and build a better racecar and team. Contact information for more than 30 alumni were found, and 21 of them were

interviewed about their experiences when they were on the team, and how their time on the team affected their career. We also have access to many people who may be able to sponsor the team in the future providing a larger operating budget for access to superior parts and manufacturing processes that we cannot currently afford.

In summary, this IQP accomplished all of the goals set. The member retention and knowledge of the WPI FSAE team's new members were increased through the use of educational presentations and hands-on activities. As well, an extensive alumni network was created that can provide insight to students designing and building the car, as well as creating a network for finding jobs and internships with various companies within numerous fields of engineering.

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Executive Summary	Editor	Author	Editor
Preface	Author	Editor	Editor
Introduction	Editor	Editor	Author
Background	Author	Editor	Author
Methodology	Editor	Author	Editor
Findings	Editor	Editor	Author
Conclusion	Editor	Author	Editor
Recommendations	Author	Editor	Editor
Appendices	Editor	Editor	Author

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

Formula SAE (FSAE) is a collegiate level design competition that challenges students to design a Formula style vehicle for potential sale to weekend autocross enthusiasts. Every aspect of the theoretical production is evaluated, from the business model and cost of production to the design and performance of the vehicle.

The WPI FSAE team was founded in 1985 and has grown tremendously in the past few years specifically. Looking at the team's history it has disbanded and reemerged many times due to the intensity of the program as well as the knowledge and time commitment that developing a race car requires.

The WPI FSAE team is split into two groups of students. One group is the annual Major Qualifying Project (MQP) who is responsible for the design and adherement to a strict set of rules for the FSAE competition. The second group consists of the rest of the undergraduate students who assist the MQP team to manufacture and assemble the vehicle. In addition, a professor oversees and evaluates the design of the vehicle's systems while providing critical hands on experience to the SAE club members and MQP team. Throughout the year, SAE club members are also welcome to design and build their own subsystems as additions to the car, either alongside or in addition to the MQP requirements. Previous projects from club members have included a custom Formula 1 style steering wheel and a full fiberglass body. Club members have also completed independent efforts to redesign and upgrade previous FSAE cars.

WPI's SAE club has consistently had a positive impact on WPI undergraduate students. This impact ranges from providing hands-on engineering experience to attracting recruiters to visit WPI from prominent companies including Ford Motor Company, Uber, and SpaceX. Some students have even been offered full-time positions as a result of their Formula SAE

involvements. FSAE consistently receives interest from prospective students, usually in the range of 60-70 students based on previous officer headcounts at initial interest meetings that occur at the beginning of each year. For instance this year, according to officers of FSAE there were 68 students in attendance. SAE is an important component to the WPI community and it serves a critical role in engaging students in engineering design.

INTRODUCTION

The Worcester Polytechnic Institute's Chapter of the Society of Automotive Engineers finds difficulty in the retention of new members. This problem is mainly caused by the lack of advertising and the absence of a regular and consistent instructional program to entice new members to the Formula SAE Design Competition. This is a repeating problem that the club has attempted to fix for many years, however with last years Interqualifying Project we began to see some success. While that success was unable to translate into a vast retention of new members, the program put on by the previous IQP organized interested members and engaged them. This year we seek to follow the example from last year through organization and engagement, as well as incorporating organization into the core of the club. For example, while last years IQP focused on lengthy information sessions on the weekends, we plan to incorporate the information session with the weekly chapter meetings. We will also be modifying the presentations to fit within a shorter period while conveying the key specifics of each subject. We also are going to broaden the topics and not focus specifically on cars as we gauge the group of students attending the seminars, ideally bringing in different disciplines from mechanical engineering students. The information sessions will also be in collaboration with similar clubs or associations to present our club to a wider range of students thus improving our chances of retaining more students.

The WPI FSAE team also lacks the resources that many other FSAE teams obtain through alumni networks. Such benefits come in the form of Alumni providing information, design feedback or monetary value to the club. The lack of an alumni network is likely due to the WPI FSAE team’s lack of continuous history. Further, relationships with alumni are dependent on the students that were part of the club at the same time as they were, hence, the club has since lost contact with almost all previous alumni before 2014. We aim to bring alumni back into

contact with the club through means of communication such as FaceBook, email, and LinkedIn. Alumni will also be able to follow the design and build process, along with driving and competition results through the WPI SAE Facebook Page and the new website that was built as a part of this project.

Overall, our IQP has two main goals. The first is to improve the number of members that participate in the WPI Chapter of the Society of Automotive Engineers through more active advertising, information sessions which align with chapter meetings, and engagement of new members. The second goal is to connect the rich and diverse history of the WPI FSAE Organization in a manner to benefit the development of new cars. We hope that our IQP will be successful in its goals and bring necessary change to the club for its continued growth and survival.

BACKGROUND

Problem

Member Retention

Attracting and retaining new members to the WPI FSAE team is an integral problem which has a direct impact on the future and the success of the cars built by the club. Many students of WPI are interested in SAE but believe that the club is only for a select few students. This belief stems not only from the club not properly being advertised to the WPI student body but also that the majority of our members are currently Mechanical Engineering Majors. This makes the club hard to find and join as well as adding to an appearance that it is only for Mechanical Engineering Majors. While this is not the case, it is a problem which prevents students already attending WPI from joining the FSAE team. However, not only is there a problem attracting students already attending WPI, but the club also suffers from attracting incoming freshmen to the club.

To dive deeper into this issue, we found that freshmen are used to a high school atmosphere where you have few options for clubs and sports, however sports are given a much bigger emphasis than highschool. Given these circumstances it was a lot less time commitment and a student was almost guaranteed to work with their close friends. Lastly, compared to high school the workload was significantly less than at WPI. Compounding on the fact that FSAE is generally a smaller group who spends late nights in the shop and weekends going racing, kids don’t want to commit time to it. It also seems freshman are hesitant to be willing to jump into something that makes them uncomfortable. This creates a barrier to almost every new student who comes into the team.

Furthermore, most incoming members, do not have the skills associated with automotive engineering, and to many, it is the first time they will work on or design parts for cars. Unfortunately, we lack a system where experienced members of the FSAE team teach and guide freshmen members on many of the basic automotive tasks. Some of these tasks may include the use of SolidWorks, the proper use of tools, and basic vehicle dynamics. Many students want a step-by-step guide and without the proper resources such as one-on-one mentors and courses in designing race cars, it is very challenging.

Without engaging the new members, the club will inevitably disappear. Many of the prospective members remain interested in joining the club but feel as though they lack the knowledge to participate or that they are the "wrong major" to participate in the club, causing them to become more involved in other clubs which aren't as technical and specific. For example, the 2018-2019 school year began by attracting 46 new members, unfortunately, at the end of the school year, only four freshmen members remained. Ideally, our goal is to retain 10 new members in the 2019-2020 year.

Alumni Relations

The WPI FSAE team faces problems with the retention of knowledge from year to year. Learning how to design and build a fully functional race car in four years is extremely difficult. Not only does the team require a diverse and active group of new members, but also a strong backing of sponsors and experienced mentors. Many highly competitive formula teams use their professional connections, prominently alumni, to gain access to machinery, knowledge, and funds to aid in building their FSAE car. Alumni connections can also help to alleviate extreme costs as building an FSAE car costs at least 20,000 dollars in addition to travel assistance and

competition registration fees. However, the biggest gain from having a strong alumni presence is the guidance they can provide from their own experiences to improve the designs from year to year. Passing down information and knowledge in four years is difficult especially when teams lose funding or members.

By reaching out to alumni, we should be able to develop these relationships and strengthen this aspect of the team. However, finding the alumni was one of our biggest challenges during the IQP. Previously before MQP & IQP reports were digitized they were given to the advisors or the team, however after 20 years, many have been destroyed or lost meaning that finding the names of team alumni posed a challenge. The second challenge was finding how far back the team went, and compiling all of the information we gathered. Fortunately for us, LinkedIn and Facebook allowed us to locate people's contact information after finding names through what MQP & IQP reports we uncovered. This part of the project was still very reliant on alumni being willing to interview with us and still be active on their Facebook and LinkedIn accounts.

To record this information we also overcame the challenge of starting a website for the team, which has not happened since 2009. The new website presents the team in a professional and forward looking way, while also containing a complete team history for alumni and sponsors to visit. We overcame no one currently on the team knowing how to build a website by coordinating with friends who do know website design in order to produce the website we were looking for.

Past Work and Research

There were two previous IQPs which addressed the structure of the club and the education of new members. The first SAE IQP was completed in 2015 and was focused on the

organization of the club and how other SAE teams would organize their team. The next IQP was completed in 2018 and focused on the education and incorporation of new members.

The IQP completed in 2015 was driven by the need to reduce the knowledge and participation gap between the MQP and the rest of the club through the means of reorganizing the structure. In order to gather information, other local FSAE teams were interviewed about their organization, some of those teams including Massachusetts Institute of Technology and Rensselaer Polytechnic Institute. Information was also gathered from the student body of WPI pertaining to club activities, what would make a club attractive to join and reasons why students have left a club. As a result the IQP determined that the key to influencing members to be more active in the club was to implement a structure dependent on leaders of subsections and implement a type of mentor program. Unfortunately the mentor program has not lasted, however there is still a semblance to a leader system within the club with senior members directing the other members on projects and work.

The 2018 IQP, with an already strong club, faced the challenge of boosting the new member attendance. To accomplish this goal, they decided to run automotive related programs on the weekend to enhance the knowledge base of new members. This would reduce the steep learning curve of the club and allow new members to take on more projects within the club. In addition to the theoretical learning, the seminars were also accompanied with a hands on activity to engage and demonstrate the automotive principals. Such seminars often lasted 2-3 hours and covered topics such as engine development, aerodynamics, vehicle dynamics and electrical systems. Each seminar also collected information on the level of difficulty, attendance, and desired topics to be covered. At the conclusion, the IQP group had mild success attracting new members, with 4 new members gained throughout the year. It was a 50% increase from the past

year, yet once again the initial gathered interest did not translate into overall new member retention as only 8.7% percent of the initial interest was converted into active new members. Therefore the problem of new member retention continues to be a problem.

This IQP group condensed each seminar and presented at the weekly general body meeting. In addition to this, the amount of presented information was limited to 30 minutes in order to maintain the engagement of the audience. In turn this would appeal more to interested students who don't want to spend 2-3 hours on the weekend to attend another lecture. In addition, by running the information seminars with the SAE general body meetings, not only are interested students informed on the work going on, but are also adapted to the weekly SAE general body meetings.

Solution

As active members and leaders of WPI's chapter of SAE who are passionate about the success of the team, we propose this 2019-2020 Interactive Qualifying Project to face the challenge of member recruitment and retention while providing new members with the knowledge they need to excel as a member of FSAE. These changes will make FSAE more exciting and fulfilling for incoming members.

Furthermore, we intend to build upon the 2018-2019 IQP which created a curriculum surrounding the main aspects of automotive engineering and design to provide members with the skills necessary to have success in whatever area of engineering they are excited about. Based on their feedback about their IQP and our goals, our project will include a more general and condensed version of these seminars at 6 of our weekly GBM meetings throughout A and B term. We plan to advertise these seminars through various means to increase the attendance of people wishing to learn about various engineering topics, with our successive seminars moving

further towards FSAE specific themes. The response form for each seminar is improved as well to give a better representation of attendees feedback and to allow continuous improvements of these seminars and the FSAE Chapter throughout this IQP. Our seminars will also be presented to related clubs such as ASME to recruit members who may also have an interest in FSAE. Finally, we want to spread what WPI FSAE is to get our name recognition throughout the school through table sitting and presenting to new clubs, hoping to develop partnerships with them and their members. This improved solution will increase new member retention and involvement by continuing the cycle of growth while also providing students with an opportunity to delve into areas of engineering they would otherwise not be involved in.

The solution to our proposed problem with alumni and team history is to find alumni from 1985-2000 and interview them about their time on the team and to record what their experience was like. This will then provide current and future students with an active alumni network for all members of WPI FSAE to help acquire internships and jobs as well as for the team to learn from previous years mistakes to further improve the car and the team's placement at competitions. These solutions will enrich students' education by making them more well rounded and providing a fun and intellectual atmosphere where they can work with other aspiring engineers. We will also be working towards involving previous FSAE Alums through a Linkedin group, and a website to bolster communication. In our proposal, we stated we would like to make a facebook group however this changed after comparing the number of alumni who were on linkedin compared to facebook. The IQP group believes these solutions will allow us to accomplish our goals.

OBJECTIVES AND EVALUATION METRICS

This IQP will evaluate its success based on completely our primary objectives. The objectives are split into two categories: the alumni network development and new member development.

In regards to developing the alumni network, there are three objectives. First, to get in contact with as many alumni as we can reach out, ideally at least 30 from when the team started up to 2016. As we reach out and start interviews, each interview will have written documentation about their years on the teams for records and to help put together the website. The second goal is to develop a team history for new members and current members to understand the evolution of the team this is through part of the website with each team year and the information that goes along with it. Finally, we want to successfully start to develop the relationship between the current team and the alumni by holding in person interviews if possible and collecting interest on doing a design review days.

The new member development program has new and expanded metrics for the target of the program based on the 2018-2019 FSAE IQP. First, we want to expose students to automotive engineering and the WPI FSAE team to gain recognition as a club. Another objective is to present and educate students gradually by slowly introducing more automotive focused topics during General Body Meetings and to obtain a higher retention rate than from last year's seminars. Identical to last year we also want to give our incoming students both academic knowledge that is useful for the team, as well as hands-on experience that so many freshmen lack. This experience will help students to decide their direction in life. Using last year's IQP numbers and the changes to the new member program our goal for the number of new members we retained for this year is 10. In this goal we would also like to expand the number of new

members besides in the other grades besides for freshman. Finally, we would like to collect survey data on how we can make the seminars and impact freshman further to not only help the club but more importantly, WPI.

METHODOLOGY

Our IQP team made two main goals. The first was to create an alumni network while also developing a record of the team's history. The second was to continue on the development of the new member seminars while increasing levels of awareness and engagement of students on the FSAE team.

To accomplish the development of an alumni network we planned to use LinkedIn, Facebook, and other forms of social media as well as copies of previous MQP papers to get in contact with alumni. Finding those from recent years was decided against, as it would benefit the team more to contact older, more experienced engineers who were at one point on the team. As well as this, finding older members provided a greater challenge than members who are still in contact with the team today. In order to create the alumni network and gain knowledge about the team when these alumni were on it, we arranged to conduct interviews.

We managed to contact many alumni through LinkedIn, however other social media platforms did not work as well as we had hoped. Using sources such as social media proved much more feasible than paper records as it took hours to sift through large amounts of MQP and IQP reports with a minimal payoff in regards to names related to FSAE. Of the social media platforms we tried, LinkedIn was the most practical as it contained the most important information for our purpose. We could identify the alumni's name, age, year of graduation from WPI, and any affiliation with FSAE or other alumni. From these attributes of a person's profile, we could identify if they were the alumnus we were looking for. LinkedIn also provided a way to directly message people who we identified, assuming their profile did not already provide an email or another form of contact information. We were able to form a large network solely from this method of contacting alumni. However, through interviews of alumni, we continued to

uncover more names, even coming across a website the team had at one point published that had more than 80 names contained within. Contacting alumni whose names we acquired from interviews of other alumni allowed us to expand our alumni network further.

Despite our success in contacting alumni through LinkedIn, we did have some difficulties. Many of the people whose names we uncovered we could not find on LinkedIn. Realistically, it would not be possible to get in contact with every single alumnus, so it was decided that those who were on LinkedIn would be the main alumni we would target. As well as this, the assumption that many of the alumni did not have a large online presence was made based on previous efforts, so we did not find a use in searching other social media websites the further into our research we became. In summary, we used LinkedIn as it was the most efficient option, and allowed us to contact enough alumni to gain an idea of how the team evolved following its inception.

Through our numerous interviews with previous alumni, we hoped to gain knowledge on what led to the success of the team in the past. We also hoped that by keeping in contact with these alumni, we could bounce ideas off of them to better refine our design changes from year to year and prevent repeated mistakes. The team now has access to files which document the mishaps of teams from year to year, and the suggestions that the members of those teams have for our current team to prevent both the mistakes they made as well as to decrease the risk of further difficulties. The information gained will allow design teams to maintain realistic yet challenging design goals for each consecutive year, while also providing insight into design opportunities that the team may want to attempt in the future.

While forming the alumni network, this IQP was also working on increasing new member retention and the basic engineering knowledge of all new members. We used a similar

technique to the previous 2018-2019 FSAE IQP, however, we made minor changes through their recommendations as well as where we saw this IQP providing the most benefit to students. Our seminars were presented on Monday nights along with the General Body Meeting for the FSAE team. We shorted our seminars compared to last year's IQP from three hours to about an hour in order to increase member turnout and to keep to information that can be of direct use to new members this year. Further, we changed the subject of many of the seminars to be built around basic engineering skills and information rather than FSAE specific topics. This choice was meant to help all students that wished to attend even if they did not continue to be involved in the team. As well as this, we hoped that this would show to students of all majors that they can be involved in FSAE, which would further increase our member retention. Secondly, we advertised the club by contacting different clubs such as the American Society of Mechanical Engineers (ASME), the Society of Women Engineers (SWE), Motorsports, and Greek life to reach beyond the border of simply focusing on race cars to attract additional new members. Finally, we suggested that all students stop by the shop at all times of the day to get to know current members and to get further involved. In the following sections, we will be discussing each of these methodologies further.

FINDINGS

Following the model of the 2018-2019 IQP with the SAE team, after each seminar the participants were asked to complete a standardized survey. This survey not only demonstrated the effectiveness of each seminar but also allowed for the presentation quality to be reviewed. Hence, not only what topics would new members enjoy learning about and their interest in participating in SAE but also the overall quality and difficulty of each of the seminars. The results of the standardized survey would allow for comparisons between this IQP and the 2018-2019 IQP to further enhance knowledge of what interests new members. The survey can be viewed in Appendix A. The first four questions, as shown below, asked participants to rate a certain category on a scale from 1-5.

1. How would you rate the quality of the presentation
    a. Scale from 1-5, where 1 is “Awful” and 5 is “Exceptional”
2. How would you rate the complexity of the material covered for your current skill/knowledge level?
    a. Scale from 1-5, where 1 is “Very Easy” and 5 is “Too Complex”
3. How would you rate the quality of the Hand-On activity?
    a. Scale from 1-5, where 1 is “Awful” and 5 is “Exceptional”
4. How would you rate the difficulty of the Hands-On activity?
    a. Scale from 1-5, where 1 is “Very Easy” and 5 is “Too Complex”

Table 1: Numerical Question Averages

	Seminar I	Seminar II	Seminar III	Seminar IV	Average
Question 1	2.56	4.3	4	4.14	3.75
Question 2	3.78	3	3.4	3	3.295
Question 3	3.78	4.46	2.8	3.79	3.7075
Question 4	2.73	2.62	3	2.64	2.76

Figures 1-4 below show the trend line of each of the question averages. The line on the figures below signify how the ratings generally changed with each seminar. These figures also show the individual seminar averages.

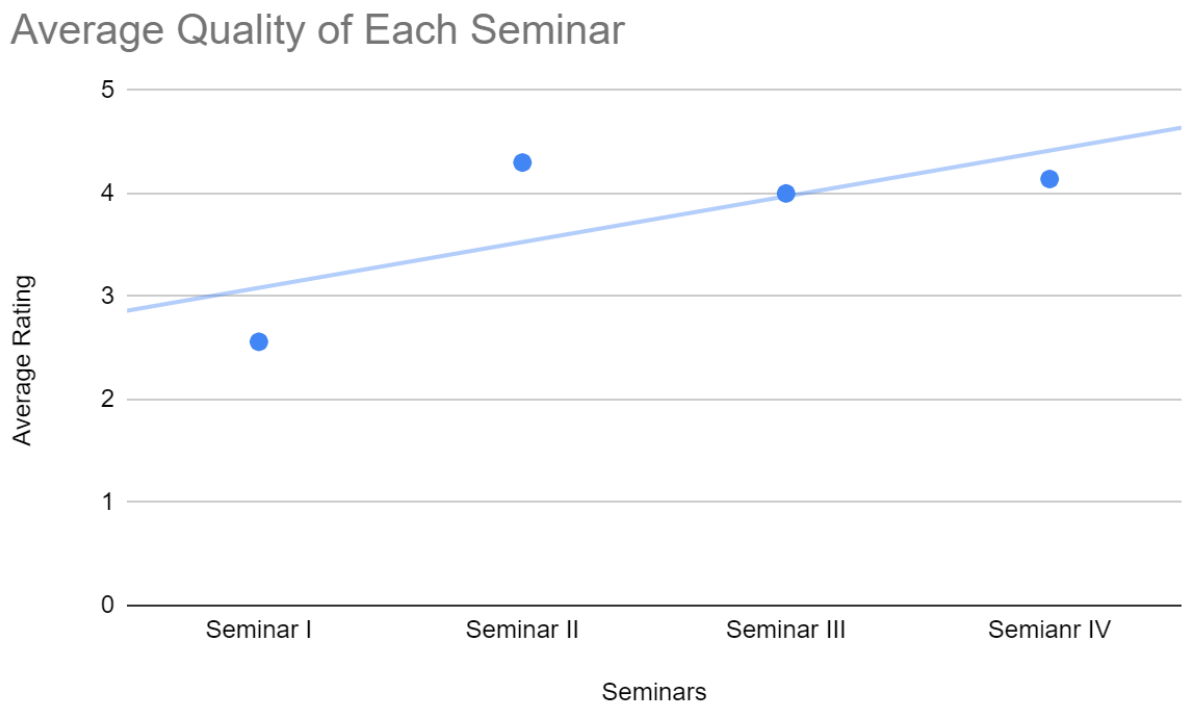


Figure 1: Presentation Quality

In figure 1, it is clear that the seminar 1 is an outlier with a lower quality compared to the rest of the seminars. Hence the trend line may not be entirely accurate. Seminar 1 may have a lower rating compared to the rest of the seminars because not only is it the first seminar but as shown in table 2, the information presented is also the most technically complex. In addition seminar 1 had the largest attendance, which made organization and movement of groups more difficult. However the overall trend of the quality of the seminars improved which is pertinent for instilling information to the students who attended the seminars.

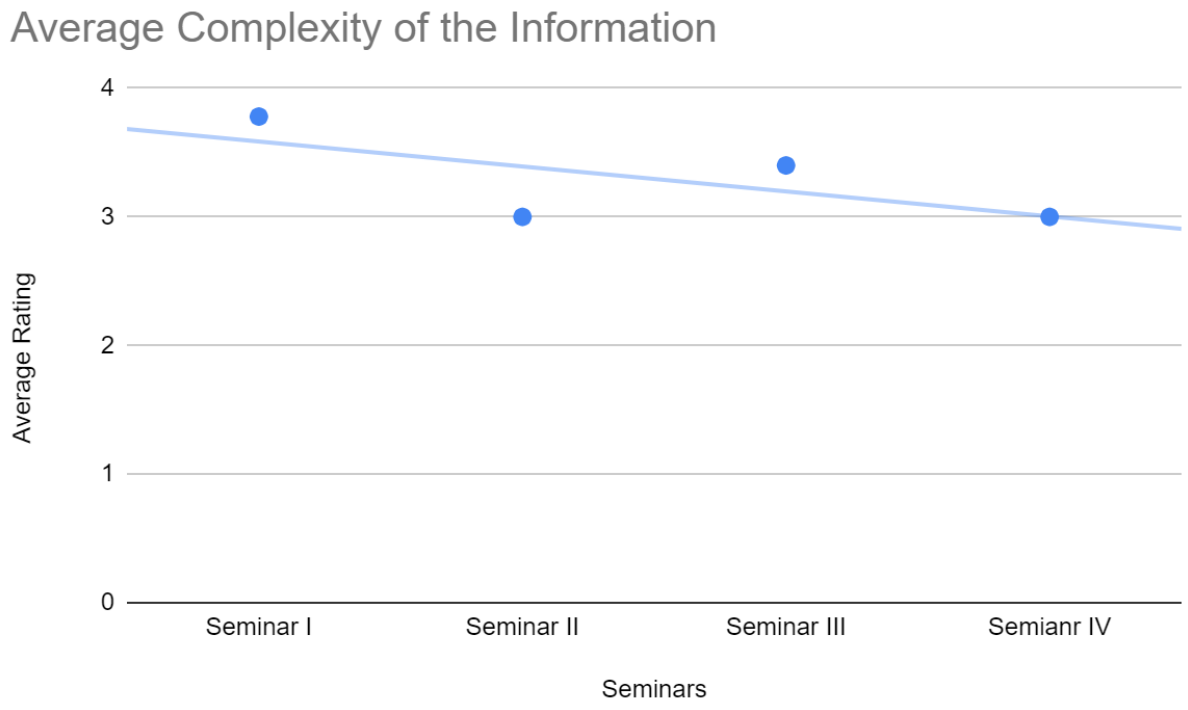


Figure 2: Average Complexity of Information

Figure 2 shows that the average complexity of the information generally decreased with each seminar. However, the seminars generally had an above average complexity with a range of difference of 0.78. This means that typically complexity of the seminar stayed at about the same level which we believe to be ideal for attending students. This means students will know how

complex the information will be before attending the seminar. A slightly complex level also keeps students engaged and thinking without creating confusion.

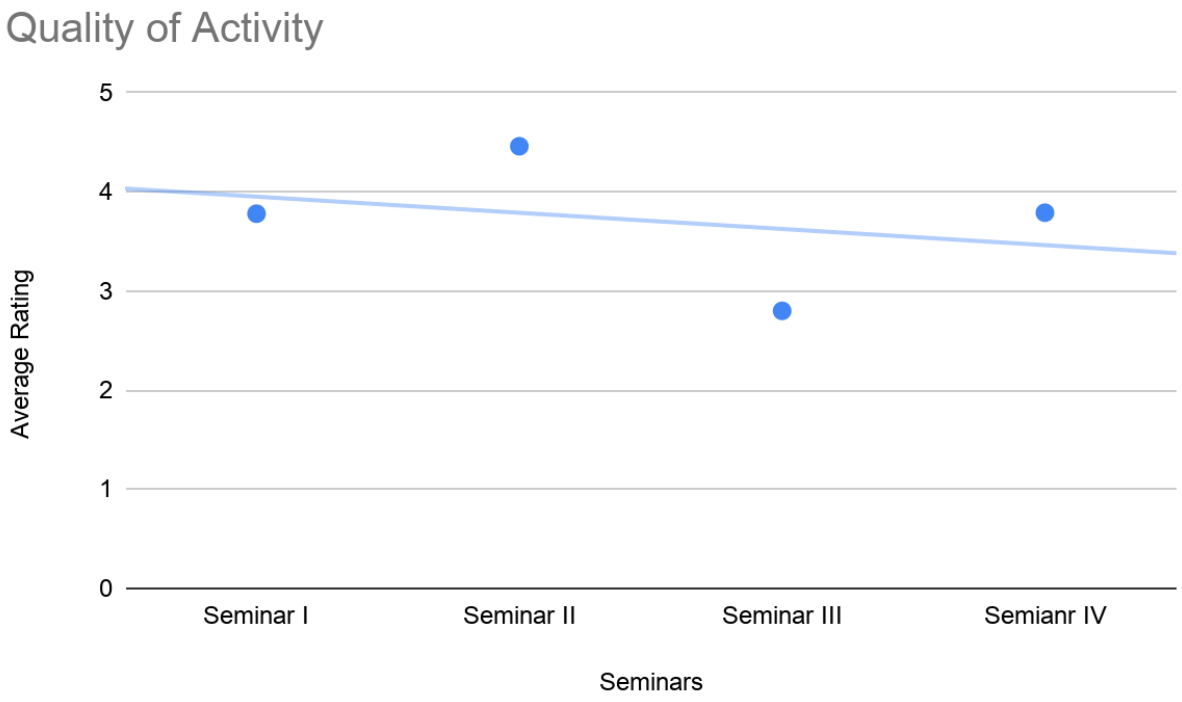


Figure 3: Average Quality of Activity

The average quality of the activities were generally of a high level with the exception of seminar 3. Yet, all of the seminars were around an average rating (3) or well above. This demonstrates that the activities were fun, engaging and were an accurate representation of the material learned throughout the seminar. However as seminar 3 was slightly below average, if the seminar was to be put on again, the activity should be changed to be more engaging and generally increase the level of quality.

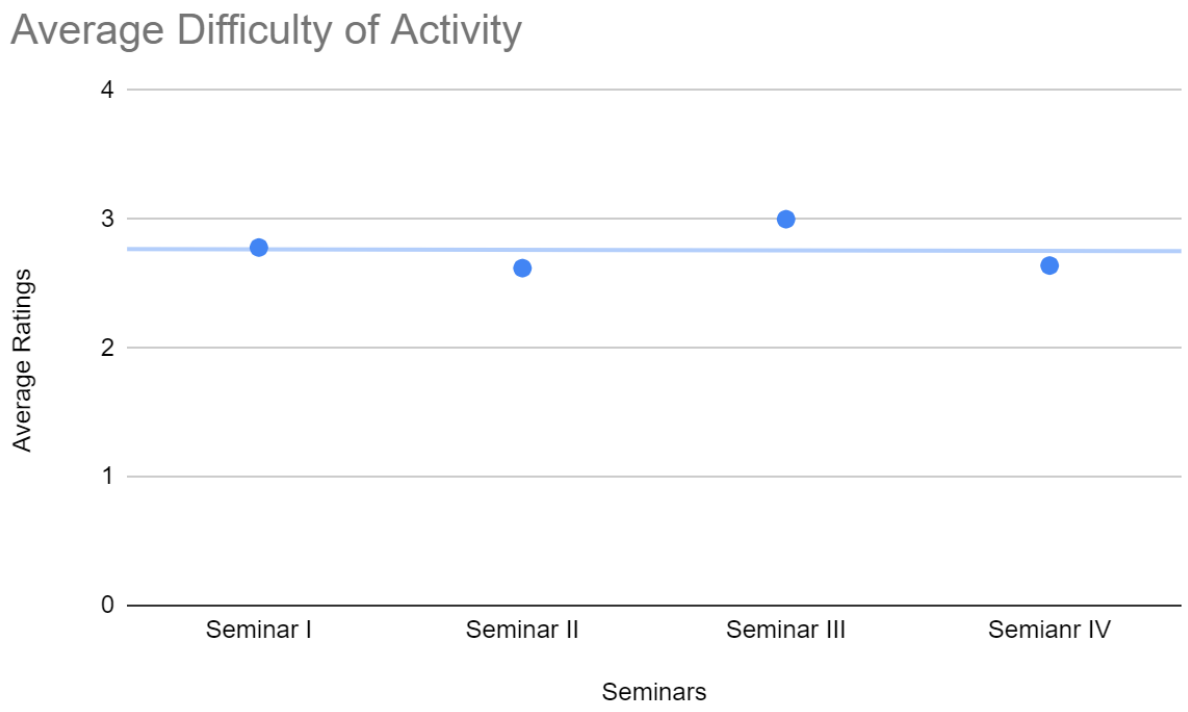


Figure 4: Average Difficulty of Activity

The average difficulty remained level throughout all of the seminars and was slightly below average. While the consistency in difficulty is ideal for students deciding whether to attend the seminar, the average difficulty could be increased slightly to further engage students. In addition, a slight increase of difficulty could also increase the average quality rating of the seminars. However, a difficulty close to an average rating (3) or slightly above is ideal as it may provoke thought of the students while still allowing everyone to participate in the activity.

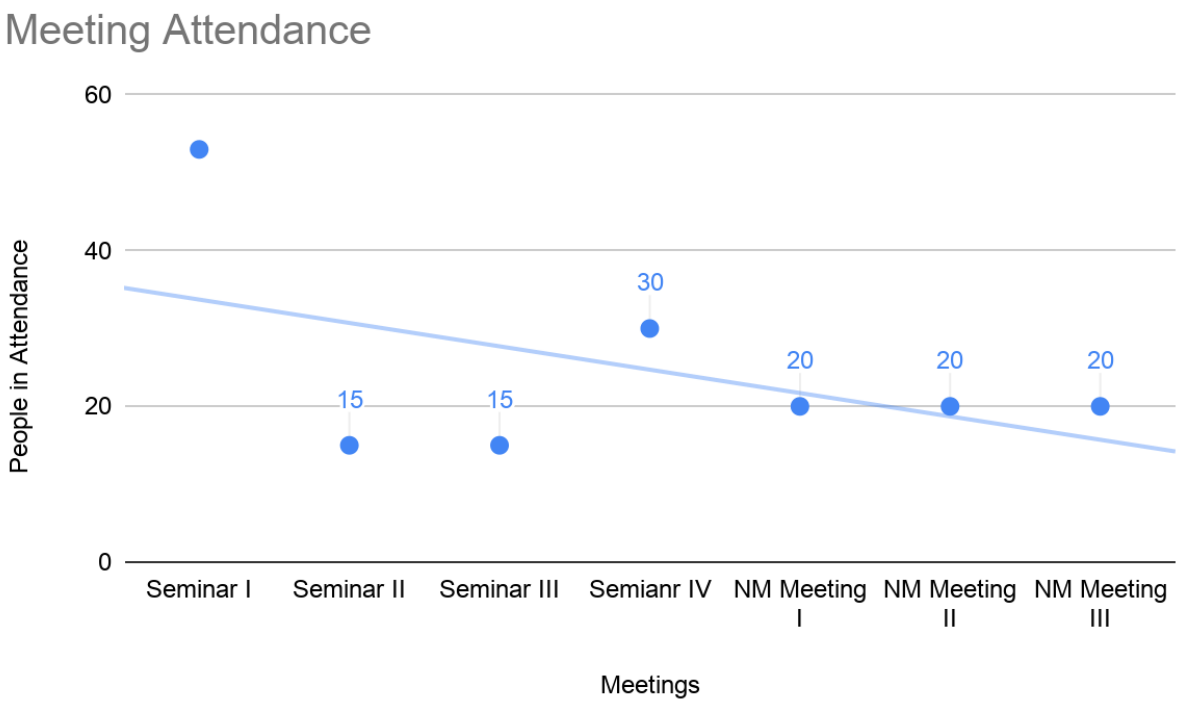


Figure 5: Attendance of Each Meeting

As well as numerical questions, the survey also included three questions on what the attendants of the seminars liked about the presentation, what topics they would like to learn more about and any other feedback the attendants had to offer. The full survey can be viewed in Appendix A. The responses were then analyzed as to how to further improve the quality of each seminar and tailor the information to the audience.

Seminar attendance also increased in comparison to the previous IQP with an average of 24.7 people in attendance at each meeting, including the new member meetings. This is an increase of 5.2 people per meeting in comparison to the 2018 SAE IQP. However, as shown in Figure 5 above, the trend was decreasing attendance after the first seminar. In addition, the second and third seminars equalled our meeting with the lowest attendance, with each seminar having only 15 people attend. We believe that this is due to the nature of these seminars being

more career focused rather than an information focused. Seminar two covered how to use SOLIDWORKS and seminar three presented how to build a resume for engineering. Possibly by focusing on more automotive topics in the future could improve attendance. However by Partnering with the Society of Manufacturing Engineers in the fourth seminar and presenting a popular subject, the seminar was the second most populated meeting behind the first seminar. The partnership also generated interest in SAE from students who had previously not know about SAE. Toward the end of A term, new member meetings were held to inform members on how best to continue participation within the club after the seminars ended. These proved to be popular with 20 people attending each meeting. This proves that while conversion to active participation within the club is still low, students are interested in making that conversion.

Figure 6: New Members Visiting the Shop

New members visiting the shop was also recorded in order to see how the seminars affected attendance in the shop. Throughout the beginning of A term, 12 new members entered the shop on average for 40 minutes, as shown in Figure 5 above. Unfortunately many new members only visited the shop once or twice throughout the term. Yet, despite new members visiting the shop only once or twice the average amount of time spent in the shop is 29 minutes.

CONCLUSION

The goal of the IQP was to aid the WPI FSAE team in increasing new member retention and to form an alumni network. In past years, low member retention has proven to be a difficult problem to alleviate, however, this year we have managed to keep a record number of students involved on the team at this point in the year. The success of this project is coupled with increased member involvement from the educational seminars, and an increase in members visiting the shop on a weekly basis. As well as this, we succeeded in contacting numerous alumni, and in creating an alumni network of more than 20 active alumni from before the year 2000. Despite our original goal of interviewing 30 alumni, we agreed that the number of alumni we now have is sufficient to fulfill our intentions with the alumni network. Overall, our project succeeded both in increasing new member retention, involvement, and education, while also creating a basis for the future alumni network of the team.

Recommendations

The 2019-2020 IQP recommends that for a future IQP that they improve and continue a few key aspects of the project. First, interviewing alumni and continuing to connect with them has benefitted the team in more ways than one. However, this IQP was only able to connect with a few of the many alumni within the Formula SAE network. Specifically this IQP focuses on 1985-2000 alumni whereas we still have alumni from 2000-2019 alumni who have never been contacted. These alumni are resources for the team, they can provide knowledge, potential sponsorship, and potential job providers. If the alumni portion were to be continued another suggestion is to get as many in person interviews as possible or if that is not possible then try to do a skype session. Through our interviews we have found that in person interviews are much more engaging and the alumni have a better response than to a phone interview. The in person

interviews are the best because the alumni become excited to be involved again and it helps to spark some of their memories.

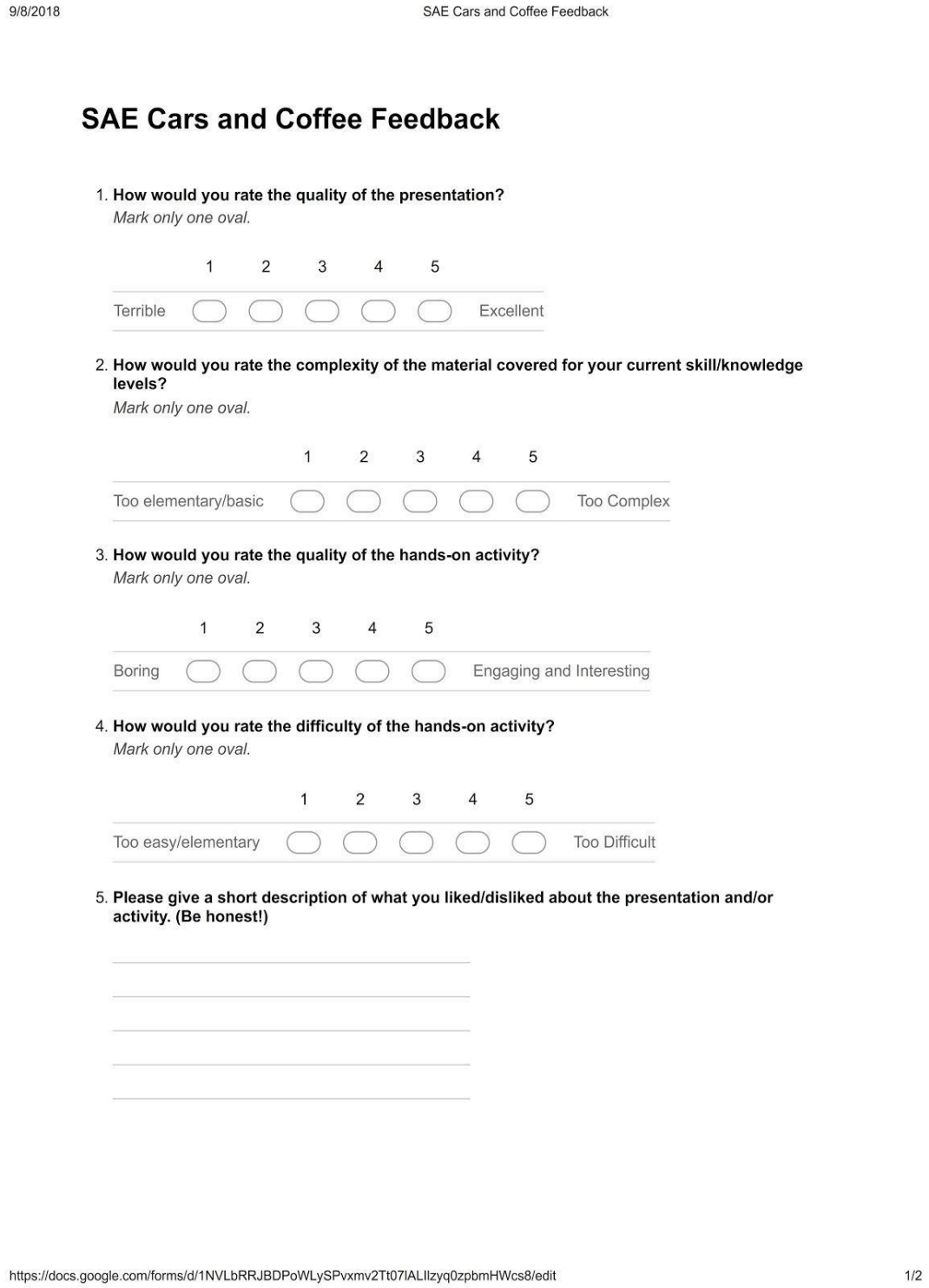
The second half of the recommendation for the alumni portion of the project is for the IQP group to be in charge of holding a design review day. This portion of the project may vary dependending on the term due to the stage of the design. The benefit of having a design review day is that it would bring fresh perspectives on the design, and could bring up potential questions that design judges would ask. The other benefit is that seniors would have a chance to ask alumni about their day to day jobs and find companies that would be good places to apply. We believe these two recommendations would improve the alumni portion of the project.

For running new student seminars, based on our engagement and feedback, we might recommend changing doing seminars for doing one large project. The students were much more engaged with the hands-on days where they did not feel it was similar to a class. Hands-on days also allowed the new members to become friends with the current members, therefore creating an initial bond between the two groups which has been one of the biggest problems in the past. These recommendations should help the next IQP improve based on what we have learned.

REFERENCES

Abadjiev, Michael, et al. *Project Proposal for IQP*. 2018, *Project Proposal for IQP*.

Appendix A: Feedback Survey



9/8/2018 SAE Cars and Coffee Feedback

SAE Cars and Coffee Feedback

1. **How would you rate the quality of the presentation?**
   Mark only one oval.

	1	2	3	4	5	
Terrible	◯	◯	◯	◯	◯	Excellent

2. **How would you rate the complexity of the material covered for your current skill/knowledge levels?**
   Mark only one oval.

	1	2	3	4	5	
Too elementary/basic	◯	◯	◯	◯	◯	Too Complex

3. **How would you rate the quality of the hands-on activity?**
   Mark only one oval.

	1	2	3	4	5	
Boring	◯	◯	◯	◯	◯	Engaging and Interesting

4. **How would you rate the difficulty of the hands-on activity?**
   Mark only one oval.

	1	2	3	4	5	
Too easy/elementary	◯	◯	◯	◯	◯	Too Difficult

5. **Please give a short description of what you liked/disliked about the presentation and/or activity. (Be honest!)**

https://docs.google.com/forms/d/1NVLbRRJBDPoWLySPvxmv2Tt07lALIlzyq0zpbmHWcs8/edit 1/2

Figure 7: Feedback Survey

Figure 8: Feedback Survey Cont.

Appendix B: Feedback Survey Numerical Results

Table 2: Feedback Survey Numerical Results

	Seminar I	Seminar II	Seminar III	Seminar IV	Average
Question 1	2.56	4.3	4	4.14	3.75
Question 2	3.78	3	3.4	3	3.295
Question 3	3.78	4.46	2.8	3.79	3.7075
Question 4	2.73	2.62	3	2.64	2.76

Appendix C: Feedback Survey With Written Results

Table 3: Seminar I Feedback

Please give a short description of what you liked/disliked about the presentation and/or activity. (Be honest!)	**Topics you would like to learn more about?**	**Any other feedback?**
It was really interesting, gave a lot of useful info, and reinforced my interest in joining.	Everything, I want in.	I want to drive and also build the car.
Crowded	Carbon fiber	Yes
Liked seeing the shops and cars. Cool to know all the resources available	How car parts all work together	Jess had good energy level
I wouldve liked more time to see the car and shop, I didn't really see what the activity was supposed to do for us.	What parts are made vs bought and the work that goes into making them	
Being able to talk with the new members gave me a good understanding of their skill level and amount of interest in the club	None that aren't already being covered in future seminars	

Table 4: Seminar II Feedback

Please give a short description of what you liked/disliked about the presentation and/or activity. (Be honest!)	**Topics you would like to learn more about?**	**Any other feedback?**
I liked that it was meant for people with		

basically no experience.		
Little to fast at the beginning		
All.	*CAD within solidworks (and why it sucks)*	
I liked learning to use the basic functions of solidworks	*Rendering/ turning parts into assemblies*	
It was fun, but a bit slow and simplistic at times for me.	*Suspension*	
It is great, a little bit fast.		
I learned the basics of solid works. You guys responded to my questions and helped me out when I tripped up.	*Functionality of automobile parts.*	
I was just really slow with solid works. I thought the presentation was good, I am just bad with windows 10	*Working on cars- oil changes, wrenching on cars, etc*	
I feel like there were a lot of features given that felt more like "follow the leader" than actually knowing what it does (which is understandable because trying to cover solid works in an hour is pretty impossible)	*Everything*	*No*
The presentation allowed the presenter to flow through and cover a multitude of features. I wish the project was a little	*Analysis*	*I love you guys :)*

more complex and that the drawing was completed in the most efficient manner(revolve a thin wall around an axis instead of shelling out the cup stuff like that)		
The description mentioned being able to progress Solidworks knowledge or introduce others into solidworks... but we only covered basic tools.	*Cam, assemblies.*	
I learned the basics of solid works. You guys responded to my questions and helped me out when I tripped up.	*Functionality of automobile parts.*	

Table 5: Seminar III Feedback

Please give a short description of what you liked/disliked about the presentation and/or activity. (Be honest!)	**Topics you would like to learn more about?**	**Any other feedback?**
A lot of words in not a lot of time, a bit overwhelming.	*Suspension*	
Real Resumes	*Wheel Bearings*	
Straight to the point = good		

Table 6: Seminar IV Feedback

Please give a short description of what you liked/disliked about the presentation and/or activity. (Be	**Topics you would like to learn more about?**	**Any other feedback?**

honest!)		
Hard to see some of the tools		
Mills	*Mills*	
Short and sweet	*Short and sweet*	
I liked the videos	*What parts were designed in order to complete this? Steps this team took to complete the car*	*Nope*
Very engaging presentation with images and videos	*A more in-depth look on what projects these machines have made*	
Seeing how machines are controlled was cool		
	How day to day use of the Higgins lab works.	
We just watched, but I'm not really sure how to get people to do hands on stuff in such a short amount of time	*Wrenching on cars, oil changes, etc*	
I liked learning about the different types of manufacturing and their pros/cons.	*I would like to learn more about the different areas, career wise, you can go*	

And seeing the tools actually run	*into as MechE.*	
Demonstrations	*All the resources on campus*	

Appendix D: How to Use our Materials

In order to continue this IQP, information, statistics and general plans are needed to further improve each of the seminars and engage new members. To begin our IQP uses a google folder to organize all documents into their appropriate positions. Our folder, which is titled “IQP 2019-20”, is very organized. For example, within the seminars folder, are folders of each seminar containing the appropriate information to present that seminar again. Such information includes the presentation slides, background research and time schedule with activity and needed materials to complete the activity.

The other highly useful resource is the 2018 google folder which contains all of their information on how to present seminars. While this previous IQP did not search for previous SAE Alumni, they presented more seminars which went into more detail and lasted longer than the 2019 seminars.

Overall with access to both of the google folders from the 2019 and 2018 IQP, a wide collection of information on Seminars and Alumni relations are available. In addition, the information allows for flexibility in presenting seminars and data on the success of both short and long seminars. Hence, another IQP can determine what changes they believe will make the greatest impact in the retention of new members. On the other hand, a following IQP will also have a standard questionnaire for interviewing alumni and proven methods to find and contact alumni.

Appendix E: Seminar Summaries

Seminar I: Introduction to SAE

The first seminar was aimed at introducing new members to the society of automotive engineers and the competitions they host. We also cover the basic rules of the Formula SAE competition and why we participate in this competition over other competitions such as Baja and the Clean Snowmobile Competition. To begin all of the offices and MQP introduced themselves to reduce the awkwardness and allow familiarity between new members. Next we begin the presentation introducing members to the different segments of the Formula SAE competition, such as dynamic and static event. We also included video of our car driving at competition and how we placed in respect to the total amount of entrants. Major rules and how to get involved with the club were covered. At the halfway point of the seminar we split the audience into two groups, one which attended a shop tour and the other participated in an activity. After 15 minutes the two groups switched.

Table 7: Seminar I Structure

Content	**Duration**	**Time Start**	**Time End**
Informal Discussion and Arrival	10 Minutes	4:50 pm	5:00 pm
Introductions	5 Minutes	5:00 pm	5:05 pm
Presentation	20 Minutes	5:05 pm	5:25 pm
Break Into Groups	5 Minutes	5:25 pm	5:30 pm
Group 1 Activity/Group 2 Tour	15 Minutes	5:30 pm	5:45 pm
Group 1 Tour/Group 2 Activity	15 Minutes	5:45 pm	6:00 pm

Immediately before beginning the presentation, we held an informal discussion and showed on board video of the 2018 car at competition. By doing so, new members were able to make connections and begin to familiarize themselves with members of the team. Hence, making new members more

comfortable and encouraging members to attend the seminars and visit the shop. This time also allowed new members to arrive without missing information. Immediately following the discussion, introductions of the officer board, MQP and IQP members occurred to further familiarize new members with members currently on the FSAE team. In addition, we used this time to explain how any major could actively participate within the FSAE team. The discussion and introduction time was designed to allow members to arrive without missing any of the presented information.

After the discussion and introduction, we began our presentation. First, we described who SAE as an organization is, why the WPI SAE Collegiate Chapter participates in FSAE and what events are hosted at the competition. The distinction between dynamic events, such as autocross, skidpad, and endurance, and static events, such as business, design review and tilt. Next, the basic rules of the FSAE competition were covered. These include devices such as the frame, either carbon of space frame, aerodynamic devices such as wings and the front impact attenuator. All of which are crucial in making sure that the car is rules compliant and will be able to pass technical inspection. How to obtain class credit with FSAE was the next topic. We highlighted that while there is an MQP team each year, there can also be an IQP and ISP's occuring at the same time. We helped demonstrate this fact by showing how many members have received class credit for working with the FSAE team. To conclude the presentation, demonstrated how beneficial SAE is for obtaining jobs and internships. In this case we used personal stories and examples of where previous alumni have worked and where current students have held an internship.

Table 8: Seminar I Activity Materials

Item	**Quantity Per Group**	**Total Quantity**	**Estimated Cost**
3D Printed Frame	1	10	$28
Popsicle Sticks	2	20	$2
Cotton Ball	10	100	$3
Tape	0	1	$2

Scissors	0	3	$0
Small Zip Lock Bag	1	10	$3
Straws	3	30	$2
Plastic Silverware	3	30	$0
Egg	1	10	$2

Everyone in attendance was split into two groups, the first group remained in the room and participated in building a frame to protect and egg, while the other team took a tour of the Formula SAE shop. After 15 minutes, these teams swapped so that group 1 tours the shop and group 2 participates in the egg drop.

The egg drop activity consisted of splitting up the new members into teams of five. Each team was given one 3D printed model space frame of our car an egg and a zip lock bag to begin. The goal was to package the egg within the frame and modify the frame so that the egg could survive a crash. Participants were allowed access to plastic silverware, straws, cotton balls, popsicle sticks and tape to create the safest vehicle possible. The rules were completely open to encourage groups to attempt different methods of protecting the egg. Each team had 10 minutes to construct the safest frame before testing began. The first, and the easier, test had each team slide their frame down 3 ft tall board into a wall. The then surviving eggs would participate in sliding the frames down the stairs into the wall. Most frames protected the eggs during the first test, but the stairs proved to be more difficult as only 2 teams had surviving eggs after that test. At the conclusion of the testing, teams were asked why they believed their eggs broke and how they would prevent it from happening if doing the same activity again.

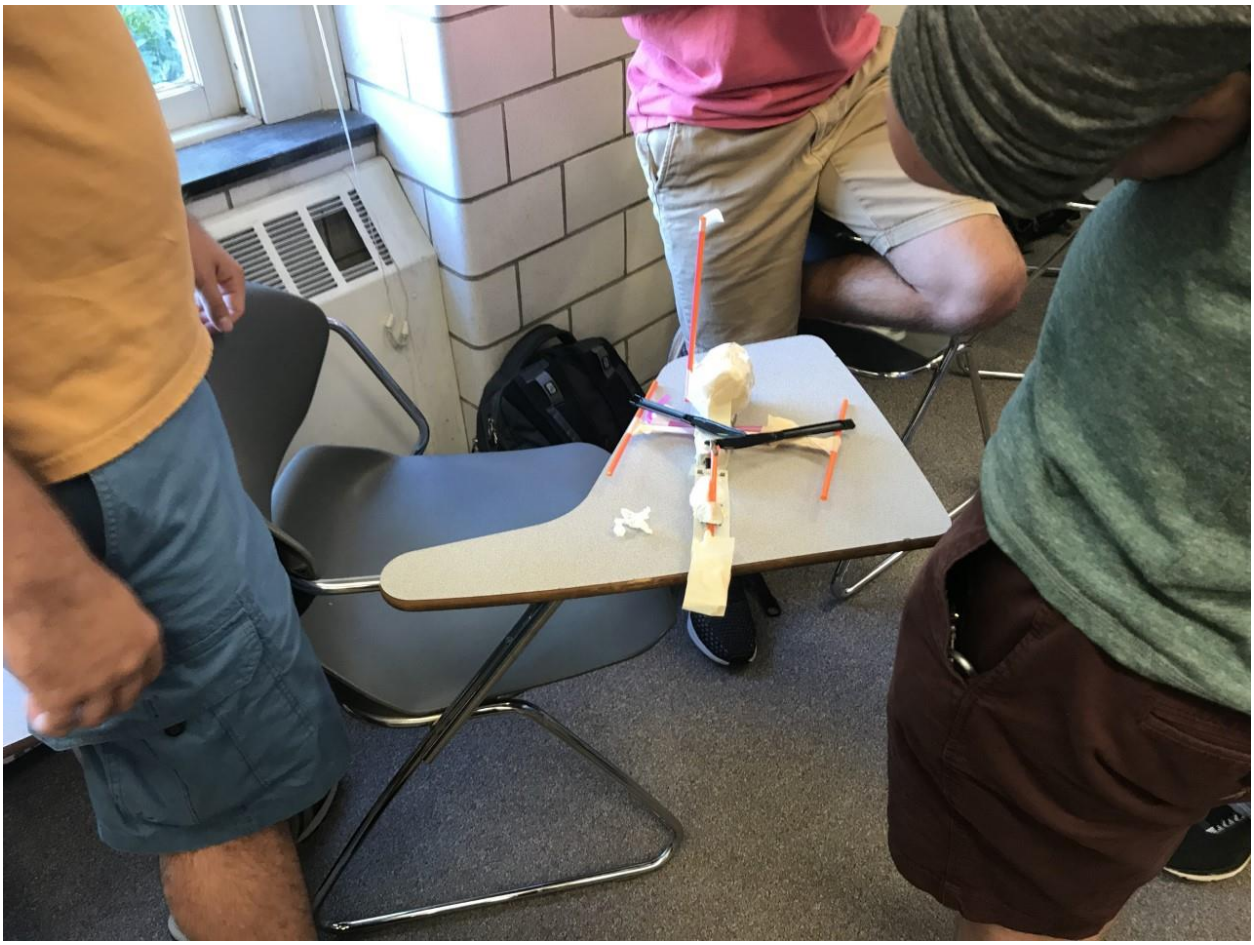


Figure 9: Egg Drop Frame Building

The portion of the activity was the shop tour. By taking new members to the shop we hoped to familiarize them with the setting and encourage new members to come to the shop independently of the seminars or hands-on days. The tour covered our location in HL005 in Higgins and our space in the MQP lab also located in Higgins. Basic information on where the WPI FSAE team does work such as design work, building the car, carbon fiber manufacturing and general fixing of a car occurs. In addition, information about the 2019 car “Margarita” and the 2015 car “Little Guy” were given and how they respectively finished in the FSAE Michigan Competition. At the end of the tour, there was a small amount of time to answer any questions from the new members.

Seminar II: SOLIDWORKS

The purpose of this seminar was to introduce new members to computer aided design, and more specifically on using SOLIDWORKS. Since all of the design work completed by the MQP uses SOLIDWORK, it is especially important for new members to become familiar with SOLIDWORKS. A survey prior to this seminar was sent to new members to gauge their ability with SOLIDWORKS, using this information the tutorial was crafted to abilities of the members. The seminar began with an informal discussion to allow people to arrive, and showed people how to find SOLIDWORKS on the school computers. After that, we presented new members with various projects they could work on after the SOLIDWORKS tutorial. Next was the activity and tutorial which had students design a mug using various tools and concepts. Afterwards and introduction to rendering and materials allowed new members to customize their mugs.

Table 9: Seminar II Structure

Content	**Duration**	**Time Start**	**Time End**
Informal Discussion and Arrival	15 Minutes	4:50 pm	5:05 pm
Presentation	5 Minutes	5:05 pm	5:10 pm
SOLIDWORKS Tutorial	50 Minutes	5:10 pm	6:00 pm

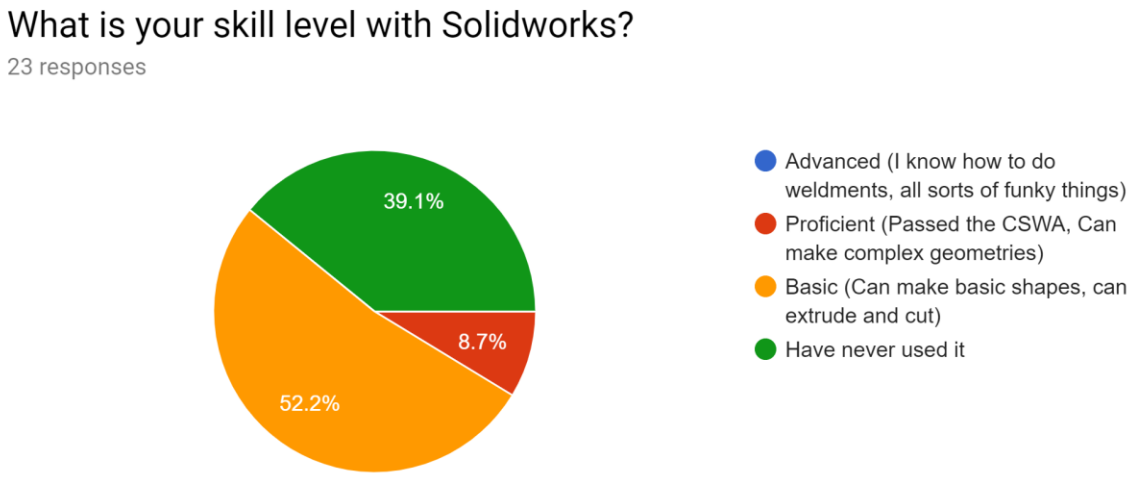


Figure 10: New Member Competency with SOLIDWORKS

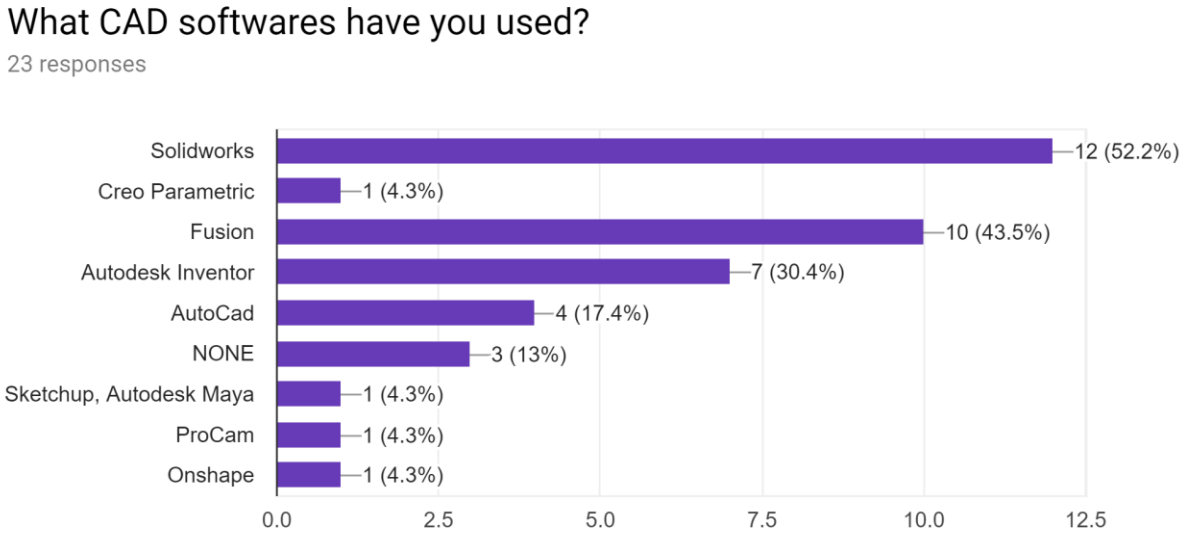


Figure 11: Previously Used CAD Applications by New Members

Prior to the second seminar, a survey asking new members to rate themselves with SOLIDWORKS and what CAD applications they had used previously to help determine the level of difficulty the tutorial should cover. As shown above, 52.2% of participants said they had a basic

understanding of SOLIDWORKS while the nest largest group at 39.1% said they have never used the application before. 8.7% of responses said they have already passed the CSWA exam and no one believed they had advanced knowledge of SOLIDWORKS. The next question ask what CAD applications participants previously used. SOLIDWORKS was the most popular with 52.2% of participants having previously used the application. This data corresponds to the previous question of what percentage of people had basic knowledge of SOLIDWORKS. Because of this information, the tutorial was designed to show participants different ways to create shapes and even introduce them to new tools.

Figure 12: SOLIDWORKS Mug Tutorial

The SOLIDWORKS tutorial featured the creation of mug, which covered basic topics such as planes lines and extrusion and more advanced topics such as splines, dimensioning, swept and swept bases. The mug for a more advanced user may take 15 minutes to complete, yet by describing each of the tools, how they work made the tutorial last 50 minutes. To begin the basic shape of the mug without the handle was sketched using a combination of straight lines and splines. Dimensions were added and using the revolved base command created the basic shape of the mug. Next the handle was undertaken using a

swept base method. In order to complete this, we created a plane on the surface of the mug and sketched the basic shape or profile of the handle. Afterwards, the path was created using a spline line and dimensions were included. The Swept Boss/Base tool was then used to create the shape of the handle. To finish the model the Fillet tool was used to smooth out the edges and the shell tool was used to allow the mug to be used properly. A demonstration of how to change the material and the appearance of the mug was shown to the participants, as well as how to render the mug. Throughout the tutorial knowledgeable members from FSAE were walking around to help participants if they may have encountered a problem or had questions.

Seminar III: Tailoring Resumes to Engineering

The third seminar covered was designed to help new members with their resumes for the upcoming WPI career fair. This seminar was presented three days before the career fair and many students do not know how to create a resume for engineering companies. Therefore this seminar was designed to help students obtain internships over the summer and talk to recruiters at the career fair. The seminar began with a quick presentation about how to create a resume with example resume. To end the seminar, we reviewed resumes and answered questions of the members in attendance.

Table 10: Seminar III Structure

Content	**Duration**	**Time Start**	**Time End**
Informal Discussion and Arrival	15 Minutes	4:50 pm	5:05 pm
Presentation	25 Minutes	5:05 pm	5:30 pm
Resume Review and Questions	30 Minutes	5:30 pm	6:00 pm

This seminar was divided in half with the first half dedicated to how to write a resume and approach people at the career fair. The second half was dedicated to any questions and a resume review. Note that before the seminar, new members were encouraged to create and bring their resume to the seminar. The presentation began with what information to include with a resume and the order of the information. Next, we highlighted some of the information companies do not want to see on resumes. In addition, the presentation placed emphasis on checking resumes for errors as that is an easy way for companies to disclude or discount an applicant. To conclude the presentation, we showed example resumes and what was good about them or what they could change to make it better. Furthermore, how one could present themselves with each of the resumes.

Once the presentation was concluded any questions from the attendants were answered and explained. For example some questions included was information about the career fair, how to dress, when to arrive and how to sign up to the career fair. Afterwards, the resumes of students were reviewed or advised as they were created. At the same time informal discussion about internships and jobs occured between senior members of SAE and attendants of the seminar. This seminar also allowed member to arrive late or leave early dependent on their schedule.

Seminar IV: Manufacturing

The final seminar partnered with the Society of Manufacturing Engineers (SME) to instill manufacturing education upon everyone in attendance. Because of the partnership, this seminar had slightly more people compared to the other seminars. To combat the number of people 3 groups were created to make sure everyone could participate in the activities and experience the

presentation. The two activities for this seminar was a HAAS Mill demonstration and Lathe Demonstration which were led by members of the FSAE team that had experience with manufacturing. After completing this seminar, attendants should be adept in additive manufacturing, subtractive manufacturing and how to use the tools and machines here at WPI.

Table 11: Seminar IV Structure

Content	**Duration**	**Time Start**	**Time End**
Informal Discussion and Arrival	15 Minutes	4:50 pm	5:05 pm
Future Programs and Break into Groups	5 Minutes	5:05 pm	5:10 pm
First Rotation	15 Minutes	5:10 pm	5:25 pm
Second Rotation	15 Minutes	5:25 pm	5:40 pm
Third Rotation	15 Minutes	5:40 pm	5:55 pm
Informal Discussion and FSAE Promotion	5 Minutes	5:55 pm	6:00 pm

The presentation began by explaining all the facilities at WPI which are available for students to use, this includes both additive and subtractive manufacturing. Next, safety while using these facilities were stressed, along with the basic users quiz which allowed students to use the machines in Washburn and the Higgins Machine Shop. Basic safety equipment were covered, including safety glasses, closed toed shoes, gloves, face shields and ear protection. An explanation of each piece of safety equipment, how to use them and when it is appropriate to use or not to use the provided safety equipment. For example, when using a rotary tool, gloves should not be worn as if they get caught in the tool, they make drag one's hand into the tool. Basic examples of what to and what not to wear in the machine shops was also included. Next, the various types of additive manufacturing was covered, this includes additive manufacturing for metals, plastics and resins. The different types of machines, such as stereolithography and

selective laser sintering, were explained as to how they work and what applications these machines could be applicable for. Positives and negatives for each type of machine were also given, with an emphasis that each machine was created for a specific purpose.

The second portion of the presentation covered traditional subtractive manufacturing processes. What each machine was and what application they were designed for was explained as well as where each of these machines can be found on the WPI campus. For example laser cutting was covered as an extremely precision machines which can cut metal and wood by using a high powered laser. An emphasis on mills and lathes with computer numeric control (CNC) was presented as these machines combined with CNC can produce very high precision parts. The features of mills and lathes was explained and to demonstrate a CNC mill in process, a video of upright manufacturing was played. During this time, the piece being machined was explained as to the significance of the car and other examples of parts designed and manufactured in house were explained.

The activity consisted of a demonstration on a manual mill and lathe. The idea was to demonstrate the skill processes of manufacturing as well as give a live example. While participants did not use the machines themselves, as time prevented anything but a quick example. However, how to begin using the machine, how to set it up to one's specifications, and how to use the machine properly was covered. After which the demonstrator, proceeded to manufacture a small and simple part which the attendants could hold in their hands after the demonstration.

To conclude the seminar, the team explained what FSAE is and how it applies to almost every major. Furthermore, how manufacturing was always needed and a great way to get involved with FSAE is to help with manufacturing. Also, that the team offered an MQP each

year to senior members within the club which focused on the design and creation of a race car. Any questions about the team were answered, and a quick tour of the shop was given to a few interested attendants.

Hands on Day I: Fix “Little Guy”

At the start of the 2019-2020 school year, the 2015 FSAE car known as “Little Guy” was in disrepair and needed work so that members could drive the vehicle. The Hands-On day was designed around what needed to be accomplished in order or Little Guy to start. The vehicle required a change of exhaust and a new mount for the radiator, as well as a coolant. When the attendants arrived, they were split into two groups, each headed by an active member of the FSAE team. The first team was in charge of replacing the exhaust while the other team worked on created a bracket to hold the radiator to the side of the vehicle.

Table 12: Hands-On Day I Structure

Content	**Duration**	**Time Start**	**Time End**
Informal Discussion and Arrival	15 Minutes	1:50 pm	2:05 pm
Identify What Work Needs to be done	5 Minutes	2:05 pm	2:10 pm
Split Into Groups	5 Minutes	2:10 pm	2:15 pm
Working Time	2 hours	2:15 pm	4:15 pm
Adding Coolant	5 Minutes	4:15 pm	4:20 pm
Starting the Vehicle	10 Minutes	4:20 pm	4:30 pm

The first group decided to take on replacing the radiator, while a simple task at first glance, due to Little Guy being older and exposed to the elements, many of the bolts on the exhaust were rusted or otherwise fragile. In addition, other considerations needed to be

considered, such as the replacement exhaust, supports for the exhaust, and the exhaust gasket. While accomplishing this task, attendants were required to create their own plan, and find their own tools. However throughout the process they were advised or offered recommendations by active FSAE members when the group was stuck or were using an approach that could either damage the vehicle, the tool or themselves. Despite the setbacks, the attendants were able to completely replace the exhaust and add a read support to prevent excessive vibrations in the exhaust while driving.

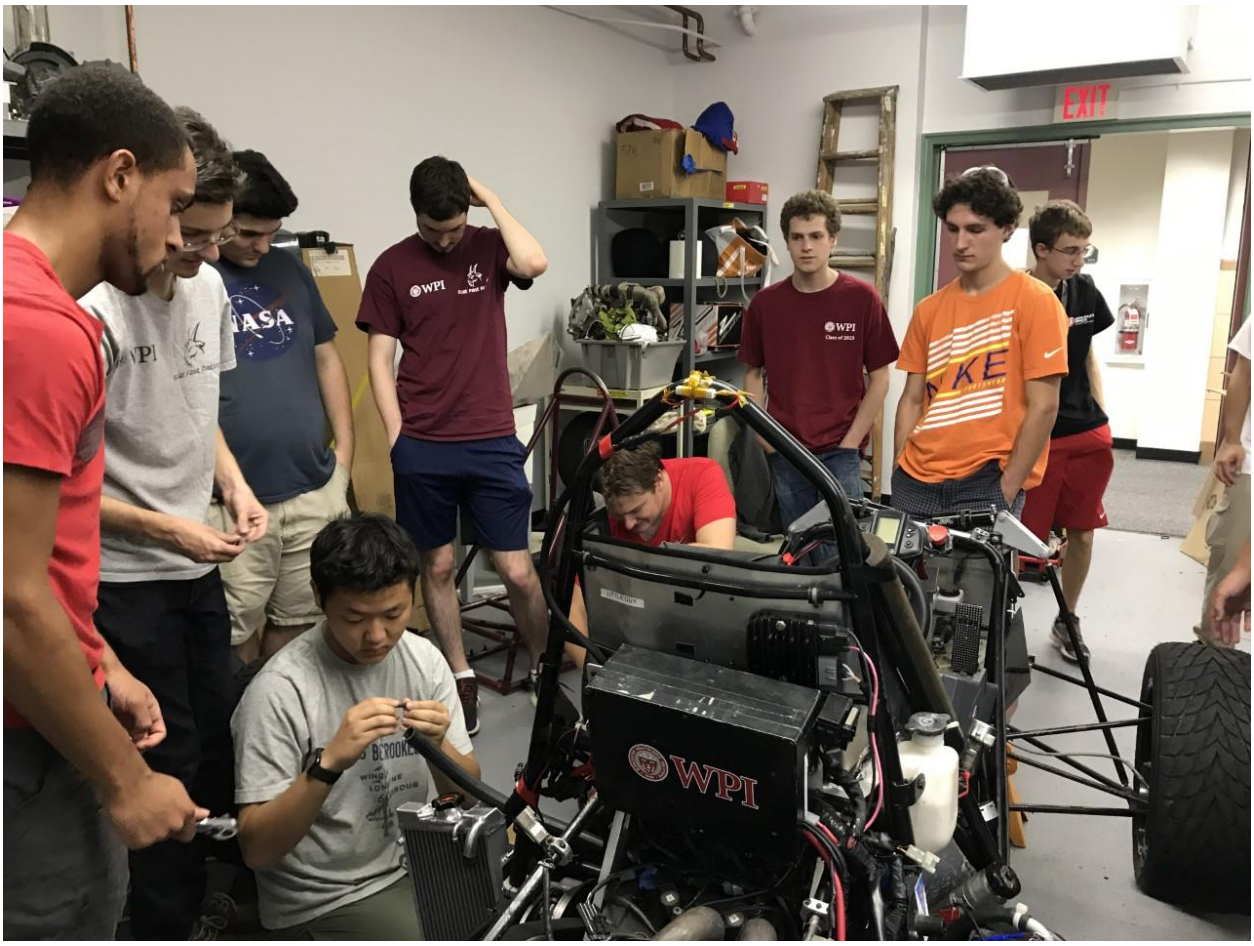


Figure 13: Group 2 Mounting their Radiator Bracket

The second group was in charge of building a mounting bracket to hold the radiator, the bracket must not be able to deflect and be able to withstand direct forces from the front. To

accomplish this task, the group analysed the old mounting bracket and why it failed. With the knowledge of how the old bracket failed and that the new bracket would be located in roughly the same location. Attendants used metal from the shop and the machine shop to create a bracket that would bolt into the same place as the old bracket but would also have rear bracing from a strut that connects to the frame of the vehicle. This group encountered a couple of setbacks such as inaccurate measuring and inexperience with machining yet were able to make a bracket which held the radiator sufficiently.

The final part of the Hands-On day was to add coolant and to start the vehicle to remove any air bubbles within the coolant system. The process was fairly simple, attendants attached the coolant hoses to the radiator, ensuring each was on tight with a hose clamp. Then, water was introduced the system and filled to the “cold fill” line on the coolant reservoir. To complete the day, the vehicle was moved outside and started to “bleed” the coolant system. This also acted as a reward to all the participants in this activity, as they were responsible for the vehicle being able to start.

Hands on Day II: Aerodynamics

The aerodynamics Hands-On day served to teach the basic principles of aerodynamic devices and the importance of aerodynamics on vehicles. The Hands-On day began with a short presentation on aerodynamics before attendants were given a model frame and asked to create a downforce generating body. Afterward, attendants measured how much downforce their body generated in a homemade wind tunnel.

Table 13: Hands-On Day II Structure

Content	**Duration**	**Time Start**	**Time End**
Informal Discussion and Arrival	15 Minutes	1:50 pm	2:05 pm
Aerodynamics Presentation	25 Minutes	2:05 pm	2:30 pm
Construction of Aerodynamic Bodies	30 Minutes	2:30 pm	3:00 pm
Testing	20 Minutes	3:00 pm	3:20 pm
Informal Discussion and Questions	10 Minutes	3:20 pm	3:30 pm

The Hands-On day began with a presentation about aerodynamics, to start how aerodynamics can affect a vehicle and some of the basic vocabulary associated with aerodynamics devices. Then, the basics of drag, downforce and how the shape and size of a vehicle greatly influences those characteristics. For example, a large aerodynamic vehicle can have more drag than a small less aerodynamic vehicle because of a small overall area on the front of the vehicle. Next, airfoils were explained how they can create either lift of downforce based on the shape and where is create a low pressure area. Furthermore, how the creation of both lift and downforce follows Bernoulli's principle, which explains the speed of air as it interacts with an airfoil. To conclude the presentation, various aerodynamics devices found on formula style vehicles, such as front wings, rear wings and diffusers, were explained how they generated downforces or interacted with the air.

Table 14: Hands-On Day II Activity Materials

Item	**Quantity Per Group**	**Total Quantity**	**Estimated Cost**
3D Printed Frame	1	10	$28
Popsicle Sticks	3	30	$2
Tape	0	1	$2

Scissors	0	3	$0
Straws	3	30	$2
Cardboard	3 Pieces 10” x 10”	30	$0
Scale	0	1	$0
Fan	0	1	$0

Figure 14: Teams Testing Aerodynamic Devices

The activity commenced with attendants finding teams of 2-3 people, each group were given three pieces of 10” x 10” cardboard and a model frame. All of the teams took different approaches to creating downforce, some teams decided to use a more traditional front and rear

wing, while others attempted to take less conventional methods. While constructing their aerodynamics devices, teams were allowed to test their designs in order to test ideas and further develop an understanding of what shapes can create downforce. Members of the SAE team walked around throughout the construction period to answer any questions that might arise from the participants. After construction, each team tested their aerodynamic package in respect to how much downforce it would create, teams ranged from creating -2 g of downforce, or 2 g of lift, to a team which created 70 g of downforce. In general, teams found that the larger airfoil shape they could create typically created the most downforce, and the team with the most amount of downforce created a singular large airfoil which covered the entire frame. These findings correspond with real life, as while aerodynamic devices are heavily restricted, diffusers/undertrays which create the most downforce on vehicles, are modeled to most closely resemble a large airfoil under the vehicle.