New Member Expansion and Alumni Outreach for the Society of Automotive Engineers

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ABSTRACT

The purpose of this IQP is to attain and attract new members of a variety of backgrounds for the Formula Society of Automotive Engineers (FSAE) Collegiate Design Competition, while demonstrating the importance of diverse skill sets from different majors as the transition to Formula Electric begins. The other purpose of this IQP is to connect with alumni who had previously been involved with the FSAE MQP. As a result, critical information about past teams successes and failures were gathered that will be vital to the prevention of recurring failures within the FSAE team. After speaking with them, we found a community of recent FSAE alumni that can be useful for design review and career opportunities for graduating students.

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

The purpose of this Interdisciplinary Qualifying Project (IQP) was to further develop an alumni network and continue forming educational material for new member seminars.

The expansion of the alumni network is intended to gather important data about previous competitive MQPs at WPI and to provide the current team with history about how the team has grown to its current state. Connection with alumni from the past twenty years is aimed to provide relevant design input, external resources, and career opportunities for students participating in FSAE at WPI. Recent years of the MQP have demonstrated that the lack of knowledge about the teams historical successes and failures can be detrimental to the overall success of the project, and can be the difference of weeks of worth of work fixing problems that have been known to occur previously. Because of the previously stated, maintaining connection with alumni is important to avoid recurring problems.

To complete this focus of the project, a list of 80 alumni was compiled from the student authors of Formula SAE project reports from the year 2000 to present. These reports were found on the WPI Gordon Library web archives. The contact information and details about their experience on the WPI FSAE team were recorded and accessible through google drive when further contact is necessary. We have intentions of organizing design review and activities on campus with alumni once it is acceptable to meet in-person.

The second purpose of this IQP is to expand the technical material to present at new-member seminars for the WPI chapter of the Formula Society of Automotive Engineers first developed by the 2018-2019 IQP and continued by the 2019-2020 IQP to increase new-member retention. This year's IQP will provide additional technical information to these seminars with the intent to increase the number of members from other areas of study. Historically, Mechanical Engineering is the majority of member's major in the WPI FSAE team. With a transition to

Formula Electric during the 2020-2021 academic year, it will be increasingly necessary to have a wide range of knowledge within the team from majors including but not limited to; Electrical Engineering, Robotics Engineering, and Computer Science. In addition to mechanical-oriented presentations, we have created technical seminars that focus on components of the formula race car outside of Mechanical Engineering.

SEMINARS

Seminar I, Intro to Aerodynamics

A virtual introduction to how aerodynamics function in respect to a Formula SAE race car. Basic physics principles were presented in context to general aerodynamics using an example of an airplane wing. These concepts were connected in context to drag, lift, cornering speed, and other effects aerodynamics have on a race car. A specific example was explained of how cornering speed can be calculated on a formula SAE car without downforce added, and compared to the addition of downforce.

Seminar II, Intro to Internal Combustion Engines, why we are transitioning to Electric

A virtual introduction to the components and processes that allow an internal combustion engine to function, and how to optimize these processes for performance applications. A concise history of the development of the internal combustion engine was presented. Comparison between 2-stroke and 4-stroke engines was made, showing how each process operates. Concepts of carbureted and fuel injected engines, and the effects of engine timing were discussed. In addition, this seminar stressed the importance of the similarities between the concepts of fuel efficiency in commuter vehicles, and maximizing power for competitive applications. How competitive efficiency is achieved through air-flow improvements was also shown and attendees

were provided with modern examples from well-known brands in the automotive industry. General engine regulations from the 2020 FSAE competition rule book were explained, and encouraged that further investigation into the current rule book be taken by attendees. Lastly, the WPI FSAE team's transition to an electric-powered car was explained.

Seminar III, Electric Systems in 2020 WPI FSAE Racecar

A detailed overview of the electric systems used in the first FSAE Electric race car built at WPI. A brief history of the FSAE electric competition was presented following a list of the major components of the WPI car's electrical system which was divided into two sections; powertrain and low voltage systems. Detailed technical explanations of each system such as the vehicle control unit, driver interface, safety systems, and data acquisition were completed using visual flowcharts and diagrams to help with clarity.

Seminar IV, Suspension and Handling

An in-person introduction to how vehicle suspension systems operate, and how they are designed to achieve the greatest performance. Beginning with a simple definition of suspension and why suspension is used on automobiles in the first place, presenting these concise concepts gave attendees a background to base our further material on. We presented factors that can influence handling, and handling conditions next. We explained that several factors from tire compound to weight distribution on the vehicle can cause poor handling symptoms such as oversteer, understeer, bump steer, or instability. After explaining what these poor-handling conditions look like during operation, we provided an overview of the geometry behind suspension systems, and how we can design suspension systems with specific characteristics like

caster, camber, toe, and roll center to achieve desired handling. Lastly, we provided an introduction to suspension design software that was utilized in the 2019-2020 WPI FSAE MQP.

Results

The result of creating an alumni network for WPI FSAE from the year 2000 to present is a group of experienced and knowledgeable people who are willing to contribute towards the team's success. Furthermore, their knowledge is relevant to the modern FSAE race car, as the competition has remained similar within the last 20 years. From the 80 alumni names retrieved from the Gordon Library project database, contact information for more than 15 people was found and contacted. Social-media messaging platforms were the primary source of contact because their WPI email addresses are not commonly utilized post-graduation. 9 alumni responded to our messages and were interviewed about their experience while on the FSAE team, and how their involvement with WPI's FSAE team has impacted their professional career. Many alumni that were interviewed offered use of facilities, or equipment, and all offered their opinions and experience for future MQPs to improve their designs and team experience.

Expanding the educational new-member seminars brought the interest of several different fields of study, beginning a necessary diversification of skills to the WPI FSAE team. Four technical seminars were executed; three were held virtually through Zoom while the last one on suspension and handling was in-person. 40 new members were added to the FSAE team this year, 20 of which attended at least one of the new-member seminars. Of those 20 new members, two are working on an undergraduate degree in robotics engineering, one is studying electrical engineering, and several other students plan to minor in either robotics engineering or computer science. In addition to retaining these members, three new members joined the WPI FSAE officer board, as secretary, treasurer, and competition coordinator. The new-member seminars

were responsible for an increase in new members by approximately 50 percent, and an increase of major-diversity by 25 percent. Since new members cannot be evaluated for interaction by using sign-in sheets in the shop, the data collected on new member growth is based on attendance of the new-member seminars, and other FSAE meetings, and participation in virtual communication with the FSAE team through Slack.

This IQP succeeded in meeting the goals set for each focus of this project. A relevant alumni network was created to document the team's historical successes and failures, and provide experienced resources to current members at WPI. Through the expansion of new-member seminars, the WPI FSAE team experienced an increase in membership and the beginning of widening the skills and knowledge by involving students with fields of study like computer science, electrical engineering, and robotics engineering.

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

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

SAE International, previously known as The Society of Automotive Engineers (SAE) is a global organization based in the US that develops engineering standards for many industries. Since 1980, SAE International has organized an annual design competition for college-level students known as Formula SAE (FSAE). Evaluation of each team's car is based on characteristics that make the design attractive for vehicle-enthusiasts such as manufacturing analysis, fuel economy, and autocross.

The participation in FSAE at WPI began in 1986 and has fluctuated in team-size over time. After several instances where the group disbanded, the WPI FSAE team has now been growing significantly for the past five years. Most recently, a transition to FSAE Electric is responsible for a large increase in student participation. The FSAE team at WPI has two groups of students that make up its body of members. A Major Qualifying Project (MQP) forms annually and is responsible for the design and completion of the car to the standards set by SAE International. The remainder of the undergraduate students that are involved with the team support the MQP to the extent of their technical ability and often contribute to the project by designing and building support equipment like a tool box on wheels that can be utilized while at competition.

Involvement with the WPI FSAE team has benefits for students that will outlast their time at school. Hands-on engineering design experience that is critically analyzed by professionals is almost a unique attribute to the FSAE competition that will better prepare students for their professional careers. The level of seriousness and commitment that students at WPI devote to the FSAE team attracts companies like Roush-Yates, Space-X, and Ford Motor Company to visit the school’s campus to recruit for employment opportunities.

To maintain a growing team size, students new to WPI are recruited and encouraged to participate in the team's many activities throughout the fall. According to previous officers, each year between 60-70 students express interest in the WPI FSAE team by attending initial interest meetings held at the beginning of each year. This year, about 65 people attended our initial interest meeting. The FSAE team is critical to providing WPI students with exposure to relevant engineering experience.

INTRODUCTION

The majority of students participating in the WPI chapter of the Formula Society of Automotive Engineers study mechanical engineering. Historically, the knowledge and skills needed to be successful while competing in the FSAE design competition have been primarily mechanical, making the population of the WPI FSAE team appropriate. Beginning this year, WPI students completed a transition from the use of an internal-combustion engine in the FSAE competition to a completely electric powertrain for FSAE Electric. The introduction of the electric powertrain has created a need for team members that are fluent in data management, electrical circuits, and many other topics that extend beyond what an average mechanical engineering student learns in their curriculum. This IQP aims to improve the recurring struggle within the WPI FSAE team of new-member retention while expanding outreach to students studying electrical engineering, robotics engineering, and computer science by organizing new-member seminars that highlight relevant sections of this year's FSAE Electric race car.

The WPI FSAE team also lacks documentation from previous MQP's to provide current teams with information about previous successes and failures. Last year's IQP began an alumni database focused on members that attended WPI between 1986-2001. While recording the team's history is important, our goal is to provide WPI FSAE members with important information that translates to their current race car build. Gathering information from past team members from the year 2000 to present will provide relevant information to benefit the team, because the competition has been more similar over the past 15-20 years. Alumni will be interviewed over the phone with their answers recorded into a database accessible to the entire team.

This IQP has two goals we plan to accomplish. The first is to expand the presence of students studying majors other than mechanical engineering to provide the necessary knowledge

for success in the recently transitioned FSAE Electric team. The second goal is to connect with alumni from the year 2000 to present in order to further complete our historical records and allow opportunity for recent alumni to be involved in the current MQP's design and building process. By recording their experience on the WPI FSAE team, we aim to prevent recurring mistakes and further excel our build timeline and technological development each year.

BACKGROUND

Problem

Member Retention

The Formula SAE team at WPI has had a chronic problem with retaining new members each year. Many students at WPI are interested in participating in the project but are under the assumption that the FSAE team is exclusive or can only be joined if selected. These misconceptions are formed by uninformed students and allowed to continue because of the team's lack of outreach or advertisement. The result is less new members who are Sophomores, Juniors, and Seniors because their information about FSAE is from the general student population at WPI. While a larger number of our new members are incoming freshmen, the volume of new member retention, new or existing students, is still a problem that the WPI FSAE team faces.

Many FSAE alumni say that the barrier that is preventing our new-member retention from growing is the difference between clubs in high school to those in college. In high school, clubs are generally very structured, and meet often. For example, a local robotics club may meet twice per week on Tuesdays and Thursdays from 6-8 PM, where each evening members will learn about certain components and apply their knowledge to their project. Extending beyond WPI, many college clubs are less structured, and open to fulfill the needs of each member; in other words, a participant will only get as much value or knowledge out of a club as the amount of effort they devote to it. This is especially true with the WPI FSAE team. A shop atmosphere creates a space where there are constantly activities and projects being worked on in the FSAE shop every day throughout the week. This adjustment can be discouraging for new members

because becoming acquainted with current members of the team usually comes before projects are presented for them to contribute to.

Attracting new members is essential to the continuation of the team. By organizing a combination of virtual and in-person new-member seminars, we hope to involve more students by making these introductory technical discussions accessible and scheduled at convenient times during the week.

Major Diversity

At the end of the last academic year the WPI FSAE team made the decision to transition their efforts to competing in the FSAE Electric competition. By replacing the internal combustion engine and and supporting hardware with electrically powered components, the team's success in creating a reliable system that will be compliant with SAE International rules is reliant on the amount of knowledge and skill we can involve in this project. Unlike previous years of competition, mechanical engineering is no longer the dominating force behind the potential of each year's MQP; although there is still the necessity for mechanical engineering to design and build the car surrounding these electrical systems. This leaves the existing WPI FSAE team with a large skills and knowledge gap, because the team is almost exclusively populated with mechanical engineering students.

This IQP plans to produce introductory seminars that focus on specific areas of the first WPI FSAE Electric race car that is being designed this year. These seminars will highlight the importance of involving majors such as electrical engineering, robotics, and computer science and also provide opportunity to connect with existing MQP members in those fields of study to get a jump start on becoming involved with projects on the team. Outside of the MQP

recruitment process, we hope to recruit at least five new members to the team that will expand our skills set and level of expertise in these non-mechanical areas.

Data Retention

Retaining information from alumni prior to graduation is a problem the WPI FSAE team has struggled with for several years. Every year in which the team completes an MQP, a new set of challenges and successes occur. The great level of difficulty that is inherent with designing a competitive race car means that challenges and setbacks will happen. In recent years, it has been observed that many challenges are not unique to that specific team and that often previous WPI FSAE teams have encountered the same issues; whether it be technical or relational. Outside of the annual MQP report, the team lacks a system to collect data from each year's project in an organized manner.

The high cost of building a FSAE race car, especially with FSAE Electric on the forefront, means that support from alumni to provide their experience with the process and potential opportunities to utilize space or equipment could save the team both time and money. Involving alumni will provide constant unorganized data retention, as WPI students interact with alumni and learn about previous experiences of the team. This method of data retention can be as effective as standardizing a method to record information from MQP members, so long as alumni connection is maintained. A combination of strong alumni relationships and persistent data retention from graduating team members will create an available background of knowledge for incoming team members to hit the ground running. We hope these resources will prevent recurring mistakes and allow the team to evolve faster, and become more competitive with the current financial support and team size.

By connecting with alumni from the past 20 years we plan to develop a full history of the team and make the historical successes and failures of each year accessible to current WPI FSAE members. We also hope to establish positive relations with the alumni contacted with plans to hold design reviews, and events that allow alumni to visit the team or participate in testing.

Past Work and Research

Three Interactive Qualifying Projects have been completed through involvement with the WPI FSAE team in the past. The first IQP took place during the 2015-2016 academic year and focused on organization of the current team and creating a structure for organization for future SAE teams at WPI. The second IQP occurred during the 2018-2019 academic year and worked on developing the first new-member seminars to get more new-members involved and interested in the topics related to FSAE. The most recent IQP took place during the 2019-2020 academic year and began developing an alumni network while continuing to organize new-member seminars.

The 2015-2016 IQP was created because of a separation between the participation of the MQP and the rest of the WPI FSAE team. While almost everyone who participated in the FSAE team was an MQP member, the number of undergraduate students who were joining the team out of personal interest was increasing. Because of the many responsibilities of the MQP to make progress throughout the school year, the remaining team members had little opportunity to contribute or learn about the car. It was obvious that changes needed to be made to the structure of the team to further incorporate team members outside of the MQP in the construction of the race car. Other FSAE teams in the surrounding area like Rensselaer Polytechnic Institute and Massachusetts Institute of Technology were contacted to gather information about how their teams are operated and organized. Through this outreach to other schools, and surveying WPI students about what would make participating in the FSAE team more attractive, this IQP determined that a mentor program that would embrace teaching new members technical concepts would be necessary to increase involvement of non-MQP members. They also began to assign leaders to subsections of the project to help structure the mentor program. Unfortunately, the

mentor program did not continue, but has impacted the team's mentality to still involve new members with projects for the MQP.

The IQP that took place during the 2018-2019 academic year expanded the previous group's ideas to further involve new members on the team by developing educational seminars to give students an introduction to the WPI FSAE team and several topics associated with the race car. The team had grown significantly since the first IQP in 2015, so new-member retention was focused on more so than involvement of current members. Over the weekend this IQP would hold these seminars in order to attract potential members to the club and give anyone who attended background knowledge of certain areas of the car to better prepare them for future projects within the team. Each seminar was between two and three hours long, and combined theoretical teaching with hands-on activities to engage students as much as possible. The result of the 2018-2019 IQP was 4 new members on the team, which was only 8.7% of the initial interest from the beginning of the year. However, this was a 50% increase from the previous year in new members.

The 2019-2020 IQP focused on improving new-member retention from the previous year. The largest change in approach from the 2018-2019 IQP was how they scheduled the new-member seminars. Instead of longer two or three-hour seminars during the weekend, this IQP shortened the amount of lecture material to a maximum of 30 minutes and planned their sessions during the week. The shorter duration was intended to maintain the interest of new members, despite being in classes all week already. Planning their sessions during the week was meant to increase attendance because students often would prefer to spend their weekends at their leisure instead of being in a classroom. Their efforts resulted in 10 new members of the team during the 2019-2020 academic year.

Another focus of the 2019-2020 IQP was developing an alumni network for the WPI FSAE team. This provided insight into how the team has evolved over time, and their experiences from 1986-2001. Connection with these alumni began to provide useful background information for current teams to use while in their MQP to maximize their chances for success, and prevent any avoidable mistakes. Having a positive relationship with alumni also provided opportunity for resources and testing facilities for the team to use for future projects.

Solution

As a passionate member of the WPI FSAE team, I propose this 2020-2021 Interactive Qualifying Project will continue to work on improving new-member retention by organizing accessible meetings to give students the information and opportunities they need to become successful participants and contributors to the WPI FSAE team. With the transition to FSAE Electric beginning this year, I propose that this IQP also recruits members from other majors relevant to the project. By involving a larger variety of students the team will benefit from a larger outreach within the school, the potential support from other departments, and an increased team size.

Listening to the recommendations of the previous year's IQP, I intend to build upon their progress of beginning alumni outreach and the recording of historical data about the team's experiences to aid in the future Major Qualifying Projects completed within the WPI FSAE team. While the last group focused on contacting alumni from 1986, when the WPI FSAE team was founded, to 2000, former team members will be contacted this year from the year 2000 to present to further complete the team's history and experiences. Once these alumni are contacted, interviews will be scheduled and conducted over the phone to gather their experience while a part

of WPI FSAE, and to offer further contact when future events are organized for the team. These connections will become accessible to the WPI FSAE team as resources for technical advice while designing the car, potential internship or job opportunities, and to learn from previous team's mistakes. By further embracing alumni connections the team has the potential for greater success both during the design process and at competition.

A solution to the proposed problem of member retention will be to create a combination of virtual and in-person new-member seminars in an attempt to maximize convenience and engagement with students. The recommendation by the 2019-2020 IQP to replace seminars with an introductory project to attract new members has been made impractical by the introduction of the corona virus into society. Without being able to meet in-person regularly, I decided to create a series of concise but informational seminars to be held virtually. These will allow new members to begin participating in FSAE events at a low commitment level, that will still provide important educational value. Towards the end of this project coordination with WPI's staff is expected to hold at least one in-person seminar.

The solution to a shortage of major diversity on the team will be creating seminars that highlight areas of the first WPI FSAE Electric race car where knowledge in electrical engineering, computer science, and robotics engineering is essential to an operational system. By providing new members with current examples where knowledge they learn in the classroom can be applied, my goal is to have interest from these different majors increase. Current MQP members that are involved in the design of these components will present at these new-member seminars to provide accurate information about the current MQP progress, and provide new members an initial contact to someone in their major, or area of interest, to get involved with projects on the WPI FSAE team.

OBJECTIVES AND EVALUATION METRICS

This project will be evaluated by its success of its two objectives which were developed from the teams identified problems: new member development, major diversity, and data retention.

Data retention will ultimately be accomplished by current MQP members documenting their experiences into accessible locations for future teams to reference. Before this can happen, a location for this data, and the historical successes and failures must be documented from years prior. This IQP plans to contact as many alumni between the years 2000 to 2020 as possible and interview at least 10 of those people. Interviews will be conducted over the phone because of coronavirus restrictions, and increased accessibility to alumni who have moved longer distances away from Massachusetts. Written records of these interviews will be completed with their answers to each question, contact information, and information about their years attending WPI and specific fields of study. Completing these interviews will help the WPI FSAE team learn about its history and prevent recurring mistakes, to excel the progress of future MQPs and increase our competitiveness on the national stage.

New member development will be evaluated based on a goal to increase new members on the team by 25 percent this year, based on the 10-15 new members we gained from the 2019-2020 IQP. This year's new member development has evolved to include the focus on increasing member diversity as much as possible. This will provide a necessary expansion of knowledge and skills within the team to become prepared to participate in the WPI FSAE Electric MQP in the years ahead. While these evaluation metrics differ from previous years, the goal of this focus remains the same. Organizing new-member seminars that provide students with introductory concepts and topics to get themselves interested in the team and wanting to become more

involved. With the addition of offering sessions virtually I hope that more students have the opportunity to attend because they can log into the seminar from home. After each seminar, feedback surveys will be distributed to each attendee to evaluate the seminar in hopes to improve them for future years and provide the most engaging events as possible to help grow the WPI FSAE team.

METHODOLOGY

New member seminars looked different than previous years, as the coronavirus brought strict social restrictions to colleges across the world. At the time that seminars took place students could attend organized meetings on campus with approval of the school. The largest challenge to holding seminars in person was how WPI separated students on campus and remotely due to the risk of students who work remotely potentially bringing the coronavirus onto campus with them. Taking classes remotely, I decided that the opportunity to draw a comparison between seminars held in person and virtually through Zoom would provide valuable insight as to the benefits that each method of conducting meetings has. This IQP held three new member seminars virtually, one seminar in-person, and a hands-on day working on our older FSAE car used primarily for exhibition days and autocross events.

All new member seminars that were planned for this year were promoted through the WPI FSAE email alias, which was updated after this year's initial interest meeting which added over 30 students to our regular contact list that expressed interest in participating on the team. An alternate mode of communication that the team utilizes for less formal contact, a messaging application called Slack, was also used to promote the new member seminars.

Virtual Seminars were held on Thursday afternoons, times varied with the availability of students. Once the details were decided, an email including the date, time, and Zoom meeting invitation was sent to the WPI FSAE email alias. Although this was after students submitted an initial interest form sent out earlier that week, my hope was that anyone who found time last minute could attend the seminar if they were interested as they were available for everyone to attend. The Seminars were planned to be between 30 minutes to an hour in duration, and they averaged 50 minutes after questions were answered. Zoom has a function within its application to

record the meeting, so each seminar conducted virtually has an MP4 video file associated with it that can be referenced by members at any time. This will enable students to learn about the topics covered during future academic years, even if an IQP isn't organizing seminars for that year.

While the new member seminars were being developed, connection with alumni from the year 2000 to 2020 began. Initially, MQP reports that were found in the WPI Gordon Library archive were used to compile a list of 60 alumni who contributed to the WPI FSAE team within that time span. My initial plans to utilize the email address associated with WPI for each alumnus quickly proved to be ineffective as I learned these email addresses are deactivated soon after graduation. Unlike the 2019-2020 IQP, I had success using the social media platform Facebook Messenger to contact alumni during this project. Because the group of alumni that I was targeting is of a lower age group, I suspect this translated into a greater online presence which resulted in more success using Facebook as my primary source of contact. After interviewing several alumni, it also became apparent that the people I interviewed offered connections to other former students associated with FSAE. Alumni providing additional contact information for people they suggest I should interview also brought success.

Although there was success in finding members through social media, this project did have difficulties finding the contact information for many names found from past MQP reports and getting responses from those who were contacted. Although it is unrealistic to expect every alumnus to be successfully contacted, it was found that a higher percentage of people responded to contact through Facebook messenger than email or phone numbers associated with their name. This motivated the decision to use this method of contact as a primary source, if information had not been provided by alumni who had already been interviewed.

By interviewing alumni, I hoped to create positive relationships with past students that have valuable insight into the work that current MQPs are working on in WPI FSAE. Not only

will experience be provided but resources to equipment or space is possible when relationships with alumni are formed. It is important to remember the past to strive towards a better future, and in the case of WPI FSAE being informed of the successes and failures of previous teams will influence design choices, team dynamics, and the overall success of the team for years to come.

FINDINGS

In a similar manner to previous IQPs that were focusing on WPI FSAE new member development, a feedback survey was distributed to students who attended each seminar to provide their experience and suggestions. These surveys enable this project to track trends in attendance, overall quality in the presentations of material, the difficulty of material covered, and suggestions for future seminars. Comparisons to previous years where new member seminars were organized can also be made. The survey results can be viewed in Appendix A. The first two questions in each survey asked attendees to rate each category on a scale from one to five, as shown below.

1. How would you rate the quality of this presentation?
    a. Scale from 1-5, where 1 was “terrible” and 5 was “excellent”.

2. How complex was the material covered for your current knowledge level?
    a. Scale from 1-5, where 1 was “easy” and 5 was “complicated”.

Table 1 Numerical-Scale Question Averages

	Seminar I	Seminar II	Seminar III	Seminar IV	Average
Question 1	4.125	—	—	4.000	4.063
Question 2	2.500	—	—	2.667	2.584

The largest drawback to conducting new member seminars virtually was the low number of students who responded to the feedback survey distributed, despite there being many participants during the session. Although The first seminar had successful feedback participation, the second and third were non-existent. The fourth seminar was conducted in-person and the feedback survey was distributed to members while the seminar was still in session. This created more motivation for students to complete the feedback survey because its completion was prompted at a specific time.

Figures 1 and 2 below show the trend of presentation quality, and difficulty of the material covered during each seminar. Along with the overall trends, each seminar's average is shown.

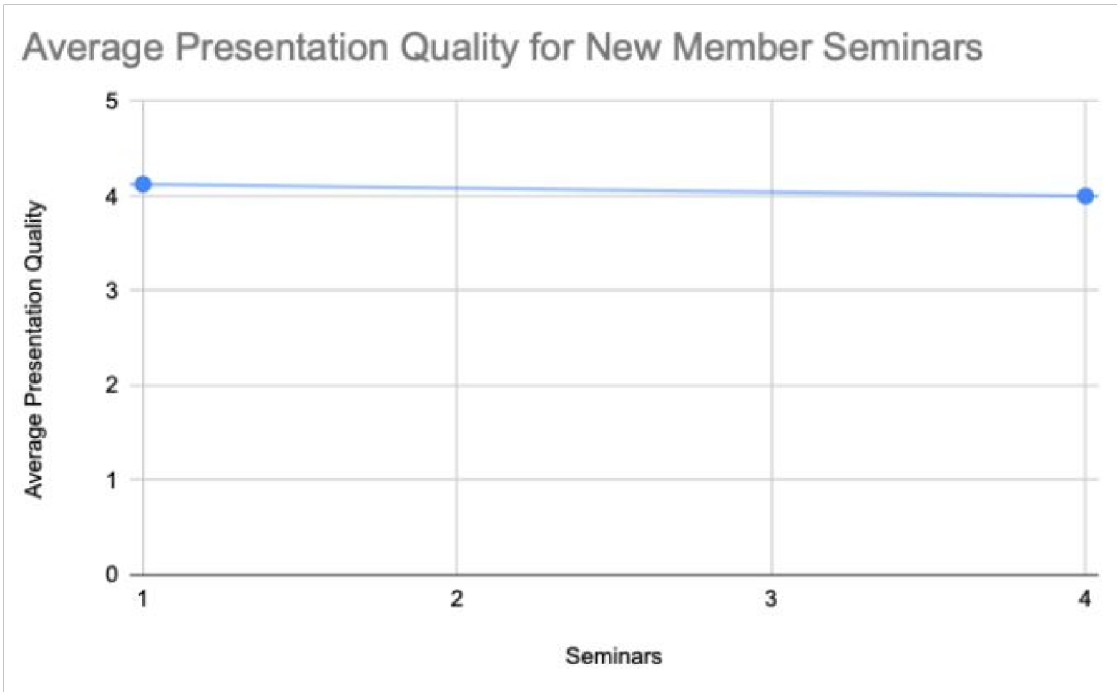

Figure 1: Average Presentation Quality

When examining figure 1, it is clear that the first seminar which was conducted virtually and the fourth seminar done in person were rated with similar levels of presentation quality. A reason for the fourth seminar being rated less was its longer duration, which lasted about 2 hours compared to the first seminar that had a duration of 35 minutes. Another reason for the average quality of presentation to be rated lower by students is the increased complexity of information discussed at the fourth seminar as shown in the results for Question 2 in Table 1. Overall, presentation quality was higher than the previous year's seminars which shows that the improvements suggested by students have translated into more effective seminars.

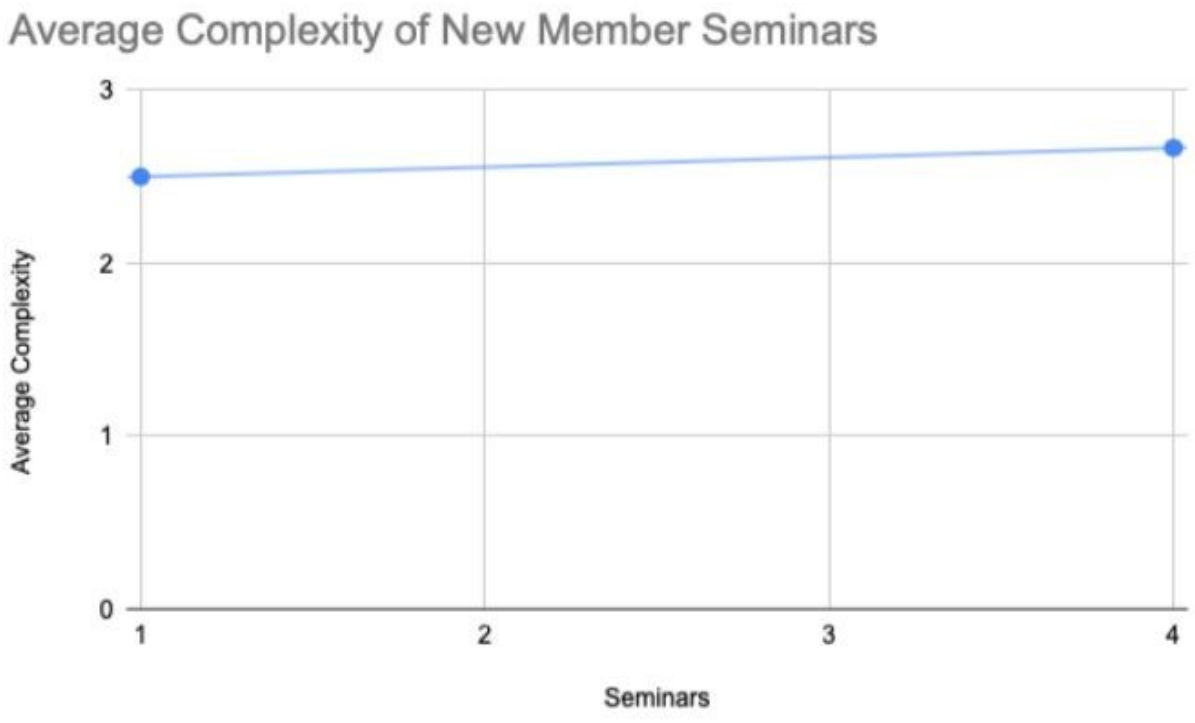

Figure 2: Average Complexity of Information

The trend that figure 2 shows is the average complexity of information increasing over the course of the seminars. The first seminar focused on aerodynamics and was the first seminar I had organized for the FSAE team. Because this seminar was held virtually, the content presented was aimed towards teaching basic concepts while maximizing the engagement of attendees. I had concerns that presenting material that was too complex through this virtual platform would decrease popularity of the seminars, and therefore lower attendance. When comparing the virtual seminar's content complexity to the fourth seminar, which was conducted in person, an increase can be observed. The range of difference between these two different means of presentation is 0.167, or an increase in average complexity of information by 6.2 percent. This slight increase can be described as a result of the detailed demonstration of suspension modelling software, Optimum Kinematics, during the in-person seminar on suspension and handling.

In addition to the two numerically rated questions, the feedback survey distributed included three short answer questions asked to describe the attendee's experience at the seminar, and their thoughts on how to improve them. A complete version of the feedback survey distributed to students can be found in Appendix A.

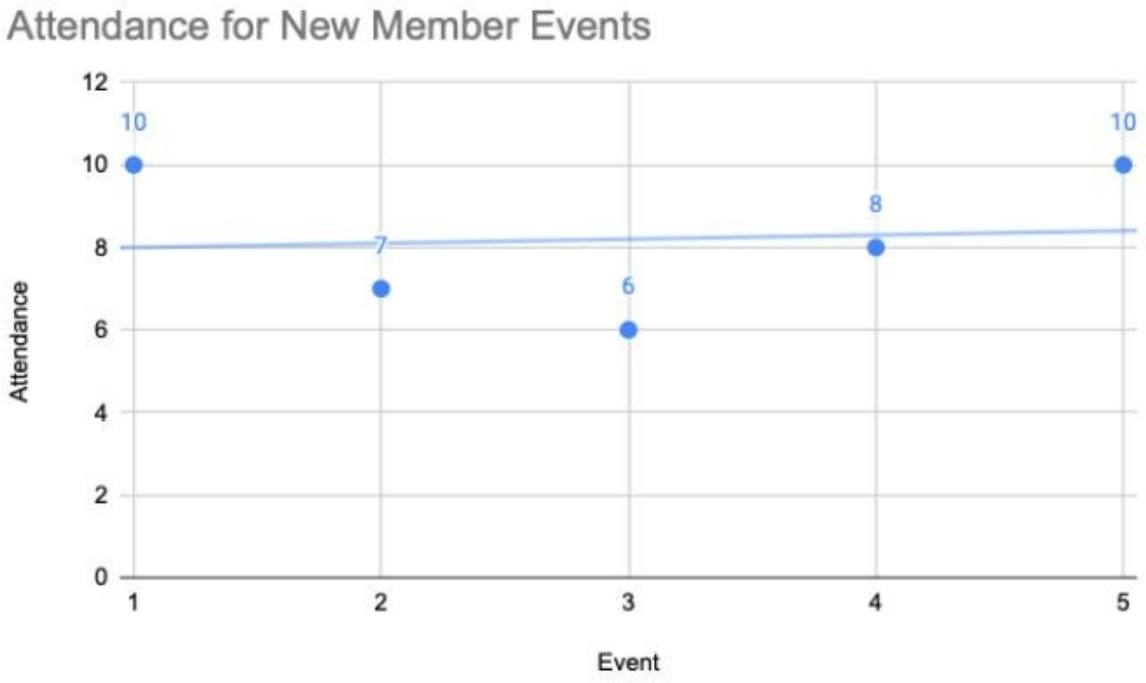

Figure 3: Attendance of Each Event

Figure 3 shows a decrease in attendance for virtual seminars over time. By the third virtual seminar, attendance had decreased by 40 percent. This is consistent with previous years, as students typically get busier as the term progresses. With the introduction of an in-person seminar attendance almost returned to its initial amount at the beginning of the term. This was expected because of the social restrictions at the time; as having an in person event is very uncommon. Ten people attended the fifth event which was a hands-on day working on the older FSAE car that the team uses for driving practice and autocross events. This outcome was also predicted because students had the opportunity to work on a car and learn about the WPI FSAE team first hand.

The overall attendance numbers this year were significantly lower than seminars organized by the 2019-2020 IQP. I attribute this to the current coronavirus restrictions, despite

my efforts to make the virtual seminars more convenient for students to attend than in-person sessions. In contradiction to my assumptions at the beginning of this project, virtual seminars lost attendance over time, while the in-person events produced a larger turnout. Because the majority of classes at WPI have been taught virtually this year, a cause for the decreased virtual-seminar attendance is that students are tired of being on their computers after a full day of online classes and assignments. The same reasoning is why the two in-person events that were organized for this project had higher attendance, students looked forward to the change in scenery and the opportunity to get outside of their typical online environment.

Another observation was made about comparing virtual and in person events was the percentage of students who signed up for the seminars that actually attended them. Based on the initial sign-up surveys that were distributed earlier in the week that the seminars were being conducted, a surplus of students planned to attend compared to the actual numbers that logged into the Zoom meeting. For our first virtual seminar on aerodynamics 19 students completed the signup survey that included the data, time, and Zoom information for the seminar. Of those 19, only 10 students actually attended the meeting. When comparing these same trends for both the in person seminar on suspension and handling and the hands on day, every student who signed up for the event was accounted for during the seminars. The conclusion I have made regarding these results is that despite the virtual seminars being more convenient for students to attend, they are also less of a commitment. This translates into students being more likely to sign up for the event, without being sure that their schedule can allow for their attendance.

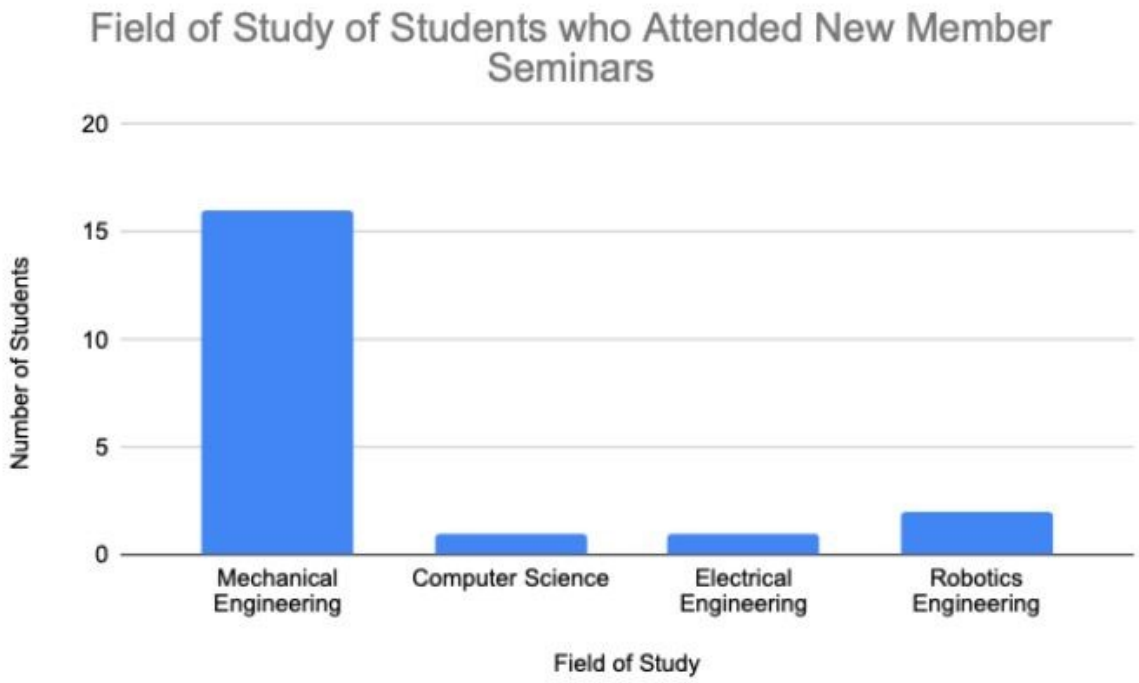

Figure 4: Field of Study for Students who Attended New Member Seminars

Figure 4 shows that the majority of new members who are involved with the WPI FSAE team this year remain mechanical engineering students. Despite this vast majority, four students are studying majors outside of mechanical engineering out of the twenty students who attended a new member seminar this year. Compared to last year's two current members who were not studying mechanical engineering, this is a 60 percent increase in major diversity.

Although the overall attendance of the new member seminars was less than the previous year, the students who attended have all become active participants in communication within the team through Slack, and

CONCLUSION

The goal of this IQP was to continue improving new member development while adding new members who bring experience and knowledge in other fields of study and to build an alumni network for the years 2000-2020 to establish historical successes and failures of the WPI FSAE team. This year brought a new set of challenges for the team as the transition to FSAE Electric begins in addition to the history of difficulties with new member retention. We have successfully increased our new member retention for this year from the 10-15 student range provided by the 2019-2020 IQP to 20 new members that participated in the new member seminars. This is a minimum of 25 percent increase in new members and three of these new members also joined the officer board as secretary, treasurer, and competition coordinator. This IQP also successfully interviewed 10 alumni between the years 2000-2020 to fulfill the teams history and gather critical information about the team's historical successes and failures, as the beginning of a more complete and accessible data retention system for current team members to reference. Overall, This project has succeeded in further developing new member engagement and education while retaining a wider range of technical backgrounds within these new members, while creating connections with alumni who have graduated within the past 20 years.

Recommendations

The 2020-2021 IQP recommends for a future IQP to continue development of new member seminars that highlight more specific sections of the FSAE Electric race car. As the existing team becomes more familiar with these systems, specific seminars covering topics like data acquisition and battery design should be created to give new members an opportunity to see the complexity of the project and hopefully attract more students from electrical engineering, computer science, and robotics engineering. Mechanical engineering students should continue to be recruited through new member seminars also, but the importance of variance in knowledge and technical background will only become increasingly important as years progress. As the coronavirus has created many limitations for the 2020-2021 IQP, I recommend trying to schedule as many in person seminars as possible to get students engaged and excited about FSAE at WPI. As in person events can become more common, project-based seminars should be considered to involve new members in introductory design projects. This year, new members would greatly benefit from regular meetings to discuss projects to design and build components for older FSAE cars, but without regular in person contact these projects are difficult to see through.

The second part of my recommendation for a future IQP is to further standardize the team's data retention system. Now that information has been gathered from alumni dating back to the clubs beginnings in 1986, attention needs to be focused towards making sure members of the team who graduate record the successes and failures they have experienced while building the car in a location accessible to the entire team. This will ensure that information will not be lost with graduating students, and the team can track its progress more accurately.

REFERENCES

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

Babcock, Jessica, et al. *Alumni Outreach and Education of New Members for the Society of Automotive Engineers*. 2019, *Final Report for IQP* .

Appendix A: Feedback Survey

FSAE Aerodynamics Seminar Feedback

How would you rate the quality of the presentation?

	1	2	3	4	5	
Terrible	○	○	○	○	○	Excellent

How complex was the material covered for your current knowledge level?

	1	2	3	4	5	
Easy	○	○	○	○	○	Complicated

What did you like or dislike about the presentation?

Your answer

What topics would you like to learn more about?

Your answer

Additional Comments?

Your answer

Submit

Appendix B: Feedback Survey for Numerically Rated Results

	Seminar I	Seminar II	Seminar III	Seminar IV	Average
Question 1	4.125	—	—	4.000	4.063
Question 2	2.500	—	—	2.667	2.584

Appendix C: Feedback Survey With Written Results

Table 2: Seminar I Feedback

What did you like or dislike about the presentation?	**What topics would you like to learn more about?**	**Additional Comments?**
I liked the visual aids	*Everything else, basically*	*Good, informative, and detailed presentation with events in the future to get the audience more involved.*
Would have liked more in-depth lecture on designing aero	*suspension geometry and adjustments to improve handling*	
Was very cool	*A bit more of the inner workings of what goes on; like some screenshot or demo of fluid dynamics analysis or some sldprt demos. More of what the team has actually specifically done in the past to get a feel for what the actual steps to making this car are.*	
I liked how the presentation taught us how to calculate lift and drag.	*Stages of development (and what goes into each stage) of the drivetrain of either the electric vehicle or the internal combustion-powered vehicle.*	

I liked how the "guest speaker" was involved, however, I feel (for		
a presentation) the host should have had more involvement in the presentation.		

Table 3: Seminar IV Feedback

What did you like or dislike about the presentation?	**What topics would you like to learn more about?**	**Additional Comments?**
The demonstration of optimumkinematics and dynamics	*Chassis*	*I love all of the opportunities to get involved. I will certainly try to stay involved. Thank you.*
I really enjoyed both of the videos. The slideshow was well organized. Seeing the computer software was very interesting.	*A seminar on the drivetrain and relevant information on the gearing of the cars. I would love to learn more about gear ratios and stuff.*	*Can't wait for the next one!*
I liked how the first part of the first part of the presentation discussed the concepts of different steering/suspension components, and their impacts on the handling properties of the car. However, although interesting at first, the second part of the presentation (when some finer details about Optimum Kinematics and Optimum Dynamics) felt too detailed while glossing over some critical concepts and terminology. Although I generally understood these from prior experiences, to have a better presentation they should have been discussed in further detail while omitting a lot of the unnecessary information about how to use Optimum Kinematics and Optimum Dynamics.	*I would like to learn more about the impact of each type of general suspension setup and their direct impacts on a vehicle's properties.*	

Appendix D: How to Use our Materials

Access to the materials provided by this IQP is essential to the success of the future IQP that will be continuing this project. In the SAE Google Drive, the location for this year's project information is labelled "IQP 2020-21". Here an organized list of each component that contributed to this IQP is listed including alumni interviews, seminars, timeline and goals, and the final report. For example, the seminars folder contains the sign up form, a research document, the presentation, and feedback survey for each respective seminar. Other useful resources within the SAE Google Drive are the folders containing the compiled information for each previous IQP that occurred in 2018-2019 and 2019-2020.

Overall, by utilizing the resources located within the Google Drive for the SAE team, instructions on how to present new member seminars, and past topics and research can be referred to to determine the future information that will be most useful for new members during that given year based on the current evolution of the team. Also, all records and data for the alumni database are stored within the SAE Google Drive. These interviews will be necessary to develop an accessible system for accessing historical successes and failures and to make the team's history available. The contact information provided along with these interviews will also be useful for future inclusion of alumni on the team.

Appendix E: Seminar Summaries

Seminar I: Aerodynamics

The first new member seminar provided an introduction to aerodynamics. This was intended to be done in person, but the protocols for access to classrooms and approval for gatherings on campus meant the only events that could be held in person were the last two of the project. Despite not being able to have students complete the hands on wind tunnel activity as performed during last years seminars, the virtual seminar was successful and engaging for members from all backgrounds. An aerodynamics major from the existing WPI FSAE team was invited to be a guest speaker at this seminar to provide accurate definitions and concepts for the attendees.

This seminar began by providing a description about what aerodynamics is in a general sense and related to vehicle performance. During the same slide the concepts of lift and drag were introduced and later given context using an example of an airplane wing. Introductory theory like Bernoulli's principle was explained in an attempt to express the relationship between air velocity and pressure. After some introductory topics were discussed, racing-specific examples were provided including a brief calculation of how the addition of downforce can increase cornering speed.

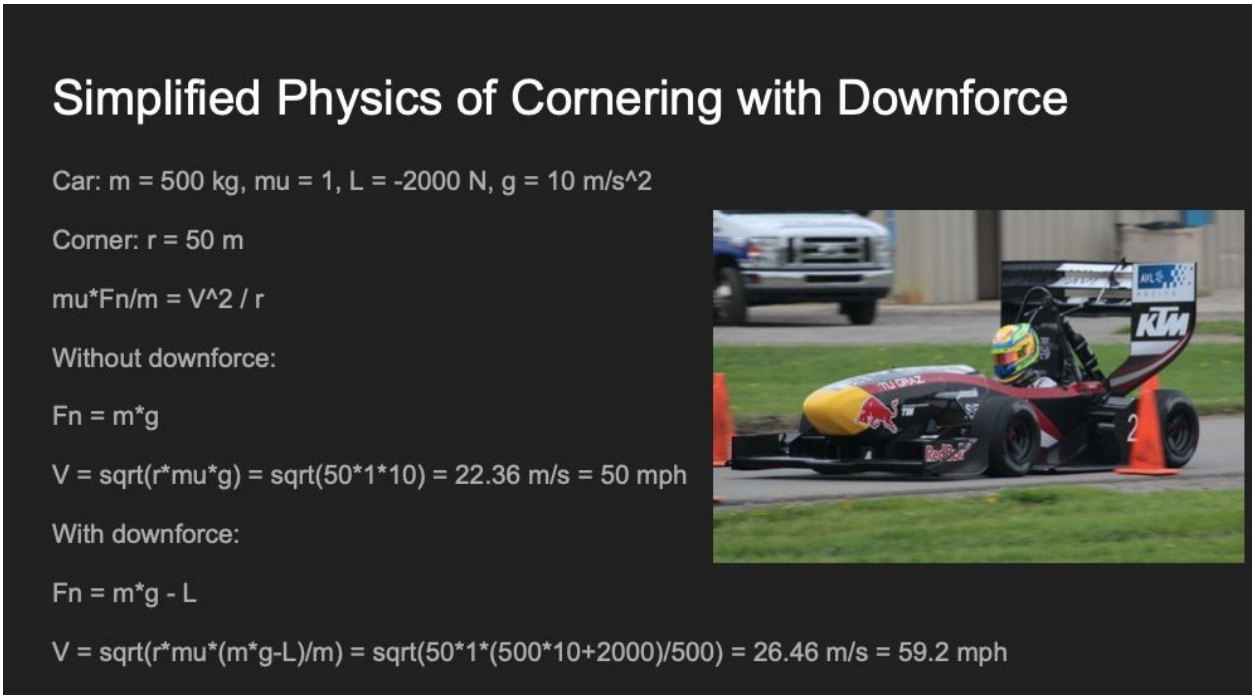

Figure 5 : Aerodynamics Seminar Cornering Speed Calculation

The methods that are used to alter aerodynamic effects in racing applications were then described in detail. Explaining the purpose and applications of a front wing, undertray and diffuser, rear wing, and canards on a race car of any type. Examples cited use of these devices varied from Top Fuel drag racing to super modified oval racing. The specific applications of these methods of altering aerodynamic properties of a vehicle were discussed in terms of FSAE, and the aerodynamics used on previous WPI FSAE cars.

The virtual application that enabled this seminar to be conducted remotely, Zoom, has a function to allow the meeting to be recorded. This seminar was video recorded in entirety and archived in the SAE Google Drive so that future team members can reference the video as an introduction to aerodynamics, especially if seminars aren't being organized at the time the information is needed.

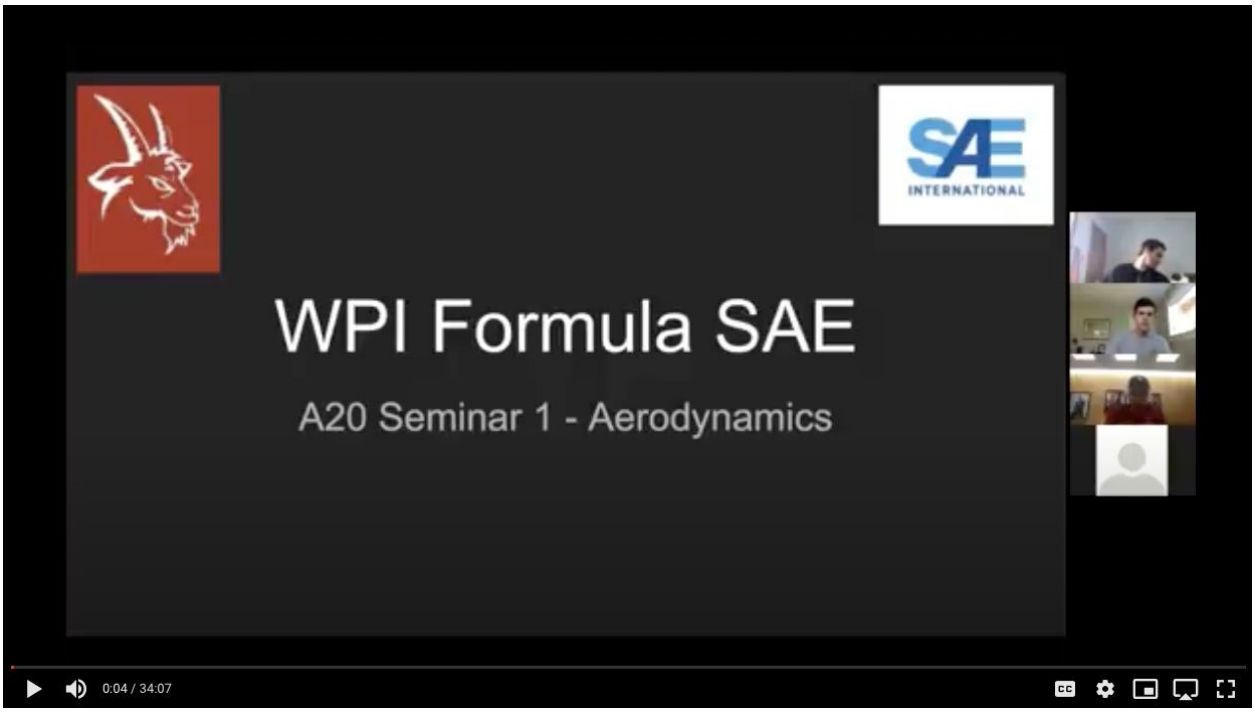

Figure 6: Screenshot of Video Recording for Aerodynamics Seminar

Seminar II: Introduction to Internal Combustion Engines, and Why We're Going Electric

The second virtual new member seminar discussed the different components that are part of the internal combustion engine system. Although the WPI FSAE team is transitioning away from using internal combustion engines the mechanical and thermodynamic systems associated with an engine and its developments through history provides background knowledge to members for working on older FSAE cars that are used for driving practice and autocross events and provide an understanding for why the team is making this major transition to FSAE Electric.

Beginning with what defines an internal combustion engine and how they process a combination of air and fuel, many detailed visual aids were incorporated to help portray the

complexity of moving components that need to operate in order for a modern automotive engine to function correctly. A brief history was presented of the creation of the 4-cycle internal combustion engine and how it was integrated into the automotive industry through the late 19th century. A comparison between two- and four-cycle engines was made, and insight was provided about why four-cycle engines were dominant in the automotive industry.

I continued the seminar by introducing the idea of efficiency, and how greater efficiency can be achieved to increase fuel economy in automobile engines. I then presented a brief video on YouTube to demonstrate how engines are becoming more efficient in modern society. The difference between fuel injection systems and carburetors was then explained, and I showed attendees the developments that have been made to fuel injection systems such as electronic throttle body control opposed to the manual operation that early systems used. My goal for this seminar was to produce a presentation that would be introductory enough for members who had no prior knowledge of engines to follow along, but still teach somewhat knowledgeable students about more specific topics like direct fuel injection systems, and how fuel injection dates back to much earlier than many people are aware of.

The main take away that I wanted students to learn from this seminar was how efficiency should be examined when wanting to build a performance engine for competition, not only for wanting the best fuel mileage for someone's daily driver. The more efficiently an engine can process air and fuel, the more power it has potential to create. By making connections to different areas where efficiency can be improved within an internal combustion engine and explaining how competitive racing programs modify their components to maximize power I hoped to draw a distinction between performance and production vehicles while respecting the similar concepts of having an efficient engine.

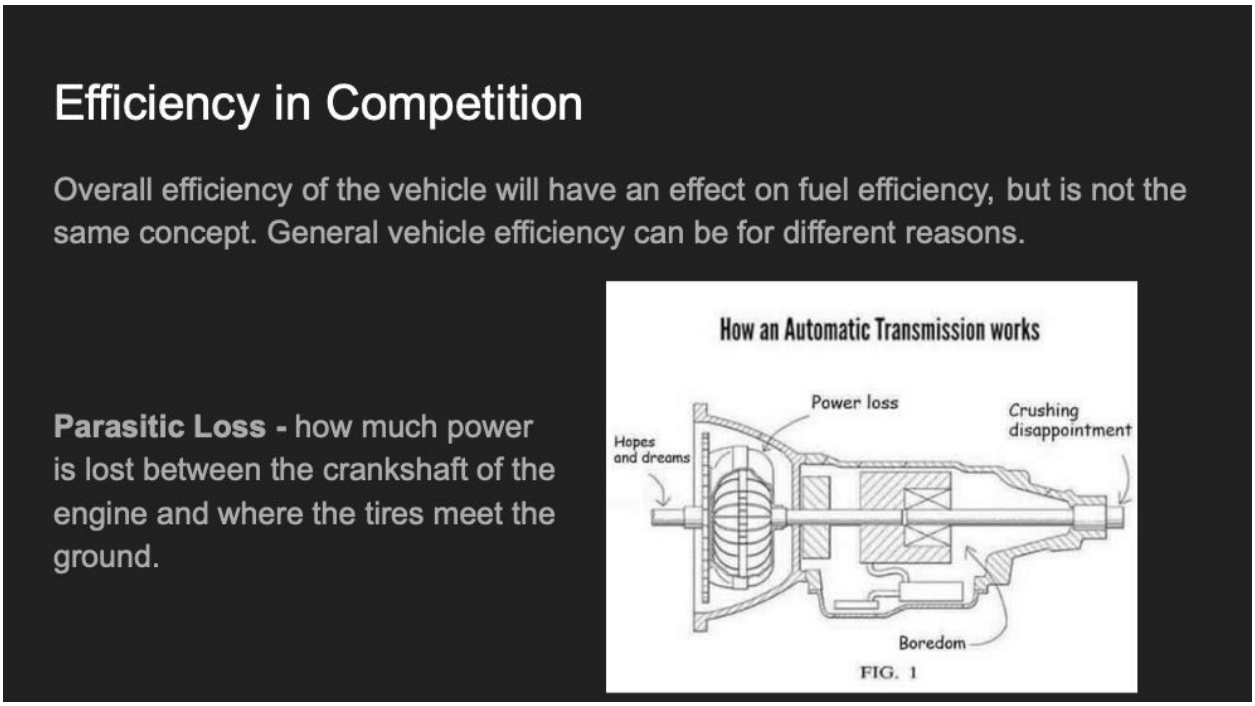

Figure 7: Factors that Influence Efficiency for Internal Combustion Engine Seminar

Figure 7 shows how the distinction was made between having an efficient engine and maximizing fuel efficiency. Fuel efficiency can be influenced by many factors within the vehicle that are not directly related to how an internal combustion engine operates, for example, parasitic loss through an automatic transmission.

The 2020 FSAE rule book was recommended to be at least looked over by the attendees, while specific engine requirements were explained. Details on how previous MQP teams at WPI were able to increase the performance of their single cylinder 450cc engine through engine tuning and alterations to the compression ratio and valve train were explained, relating the concepts discussed earlier in the seminar to the WPI FSAE team.

Lastly, the introduction of electric cars into society and a short history of how they have developed was presented. The increasing market for electric vehicles in society, and how the WPI FSAE team believes that this transition to FSAE Electric will better prepare students for

careers in the automotive industry by providing exposure to cutting-edge developments in technology and relevant systems to electric vehicles.

Seminar III: Electric Systems

This virtual seminar featured a current FSAE Electric MQP member who presented his knowledge about the electrical systems involved in the first ever WPI FSAE Electric race car. This event was the primary effort to attract students who major in electrical engineering, computer science, and robotics engineering to the team by highlighting areas of the car that require expertise in these fields of study.

To begin the seminar, I provided background information of the FSAE Electric competition in order to give new members insight into the number of teams who typically compete, and the differences between the internal combustion engine competition. The guest speaker provided a detailed list of components that are utilized in the design of the WPI FSAE Electric car to make it operational including the powertrain system that is comprised of a motor, inverter, and accumulator, and the low voltage system that houses vehicle control, the driver interface, safety systems, and data acquisition. Using a series of flowcharts and visual aids, each of these subsystems were explained giving specific design and operational requirements that the 2020-2021 MQP is having to work with currently.

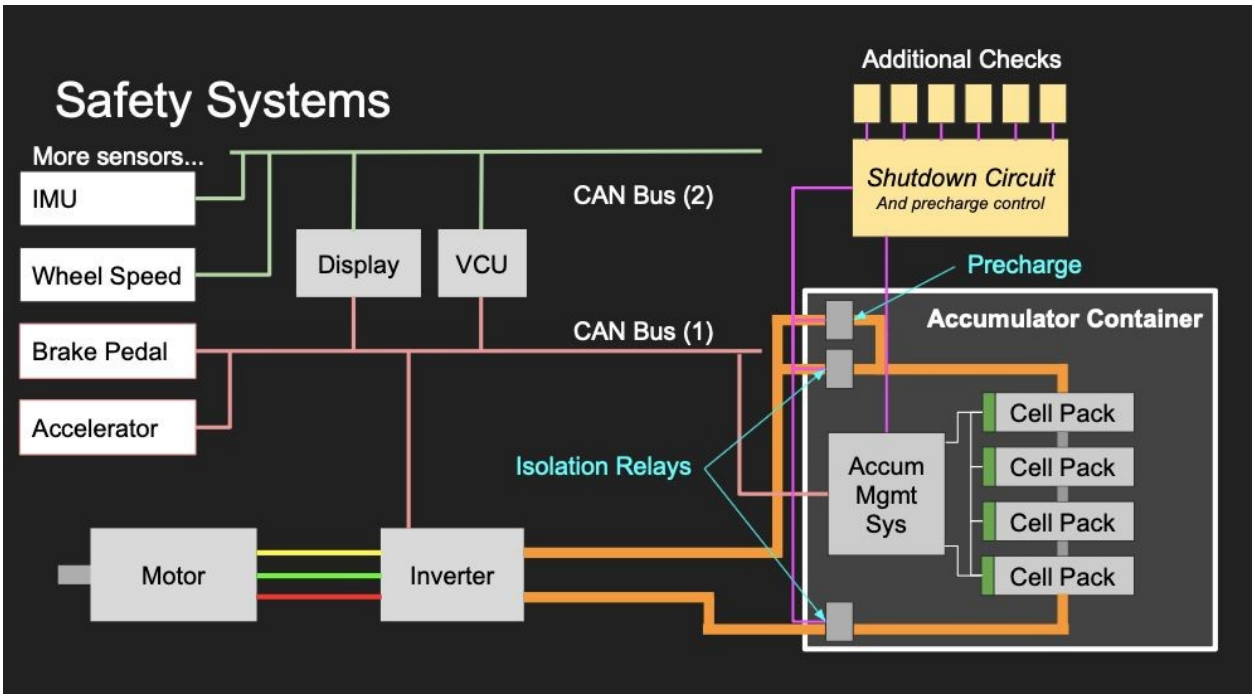

Figure 8: Safety Systems Diagram for WPI FSAE Electric Race Car

Seminar IV: Suspension and Handling

This seminar focused on the concepts related to vehicle suspension and handling, specifically those that pertain to racing applications. This was the only new member seminar that was able to be completed in person. Although a hands on day was organized in person the following week, it was not considered a technical seminar. A current graduate student at WPI who was on the 2019-2020 FSAE MQP gave new members a demonstration of the suspension modelling software, Optimum Kinematics, during the second half of this seminar.

Figure 9: Optimum Kinematics Demo for In-Person Suspension and Handling Seminar

To begin this seminar, I wanted students to know what the general definition of suspension was to deepen their understanding for the topics discussed later in the session. According to the Oxford English Dictionary, suspension is “the temporary prevention of something from continuing or being in force or effect.” In a competitive application where suspension is applied to a vehicle, suspension is a means to control the tires of a car on the track. I sketched a simple visual to show the new members how the use of suspension systems on vehicles can increase contact with the ground.

Figure 10: Suspension Effect Visual for Suspension and Handling Seminar

Next, I presented a variety of common factors that can influence a vehicle's handling including tire size, compound, and tread pattern, the location of weight, and the vehicle's drivetrain (whether its front wheel drive, rear wheel drive, or all wheel drive). I proceeded to explain the driving symptoms that can occur if any of the previously mentioned factors are improperly adjusted or worn out such as oversteer, understeer, bump steer, and instability. These were the four main topics of discussion that immediately followed. I described what each symptom is, and common causes for them. For example, instability can be caused by a lack of traction or improper toe adjustment. It is when the direction of the vehicle has to constantly be corrected.

The influence that suspension geometry has on handling characteristics was stressed, as it will be a major component of the MQP project for the mechanical systems subteam. I gave introductory explanations about shock and spring adjustment with regards to damping and spring

rates, caster, camber, toe, ackerman, roll center, and scrub radius. Because of the complexity of each of these suspension adjustments, I played multiple short videos on Youtube that gave concise descriptions of these concepts with supporting animations and videos to help students visualize how these factors influence a vehicle's behavior while driving.