Role of Motorsports Club In Engineering Education

Chepuri Sai Abhinav, Kowdodi Siva Prasad
Department of Mechanical Engineering, Hyderabad Institute of Technology and Management, Hyderabad, Telangana
saiabhinav2106@gmail.com, kowdodi.siva@gmail.com

***Abstract*— Mechanical engineering concepts such as Heat Transfer and FEM are better understood by visualizing and getting hands-on experience on the problem where many of the students fail. One such process that helps the students visualize, understand, and feel the concepts is participating in student-level design and development challenges. For example, FMAE conducts various motorsport events like the design and development of Quad Bike, Baja Buggy, Formula Student, etc. These competitions create a platform for the students to form a team, design and develop vehicles, and compete against other teams nationally and internationally. It also increases the student's ability to work in a team, takes responsibility for a mission-driven project, and increase leadership and managerial skills. During the process, the students enhance their skills of in-depth understanding, visualization, and knowledge of various engineering concepts.**

***Keywords*— FEM (Finite Element Method); Visualization; Quad Bike; Test Bench; Heat Transfer; Competition Based Learning.**

***JEET Category*—Research, Practice**

I. INTRODUCTION

A healthy competition plays a vital role in a student's life, in his academics, and career. Competition motivates the students and pushes them to work harder to get the best possible results. It makes the student concentrate better and feels responsible for a work or a project, which will help in his professional competitive career. Participating in a competition along with their team gives the student a great experience of working in a team, maintaining harmony with the teammates, working under pressure, and seeing the other competitors' work. This process and activity give the student immense knowledge, experience, and fun-oriented learning.

There are various student-centered competitions like Design challenges, Hackathons, Design and Manufacturing Challenges, Student Level Motorsport events, etc. Motorsports in recent times have become a hot topic in the hearts of young engineers because it involves speed, engineering, the most advanced racing systems, high performance, and intense competition. This led to the rise of student-level motorsport events, where a team of students gets to design and develop a fully running vehicle and compete with other teams nationally and internationally. A globally well-known clubs that conduct student-level motorsport events are SAE (Society of Automotive Engineers) International, SAE India, FMAE (Fraternity of Mechanical and Automotive Engineers) India, and ISNEE (Indian Society of New Era Engineers) India. In addition, they conduct many design and development challenges for motorsport vehicles like Formula Student, Quad Bike, Baja Buggy, Moto-Student, Aeration, etc.

The overall judgment criteria are divided into 2 phases, the static and the dynamic events. The static event consists of Design Evaluation, Sales Presentation, Cost Presentation, and CAE Presentation. Static events cover all the design aspects of vehicles and the use of proof of concept which went into making the vehicle. The static event involves interactions and presentations with the judges. Chassis calculations, drivetrain calculations, spring and suspension calculations, brake and steering calculations, and FEA reports are submitted to the judges for evaluation. During the static event, Technical inspection is carried out on the vehicle to ensure that the vehicle falls under the rules and parameters mentioned in the rulebook. During the dynamic events, the vehicle is tested in harsh track conditions to evaluate its strength and manufacturing quality of the vehicle. The dynamic tests like the Acceleration test, Brake test, Maneuverability test, Suspension test, Traction test, Dirtx, Fuel economy, and Endurance test are performed on the vehicle for every team.

Students develop various strategies and performance testing rigs to keep up with the competitors and the competition. A testing rig is an equipment that mimics the real-time loads on the vehicle but in a completely controlled condition. This is used to test the manufacturing quality of the vehicle parts before the event to ensure no damages or casualties during the event. There are various types of test rigs that the students develop for maximum performance, a few of them are engine test bench, braking system test bench, suspension system test bench, etc. During the competition, the graph of a student's knowledge, capability, and confidence have risen exponentially, thus helping them perform better in academics.

II. LITERATURE SURVEY

Summarized here is the literature survey on competition-based learning collected from various research papers and journals. CBL is an active curriculum that is used among many schools and colleges to increase the efficiency and academic performance of students. There are cases for this explained in

depth by many professors and students from different regions of the globe.

Project-based learning (PBL) is frequently employed in engineering courses, according to V. Kosse and D. De Pellegrin from the School of Engineering Systems and the Queensland University of Technology in Brisbane, Australia. The more relevant and in-depth the students' learning, the closer the project is to real-life. The Formula Society of Automotive Engineering (FSAE) is an excellent example of a team-based project focused on real-world difficulties, in which each student team develops and constructs a small race car for competitive evaluation. Since 2004, Queensland University of Technology (QUT) has participated in FSAE Australia. Based on the project's success, QUT has gone so far as to add a motor-racing specialization (second major) to its mechanical engineering degree. The benefits of teaching motor-racing engineering through real-world projects are discussed in this study, along with a discussion of the problems encountered and how they were overcome. Student response was gathered using QUT's online learning experience survey (LEX) as well as a tailored paper-based survey to confirm the authors' views on the instructional methodologies employed [1].

According to a Sino-foreign higher education institution in China, FSEC and other competitions associated with the Problem Based Learning paradigm aim to enhance students' knowledge and talents. The research looked into the perspectives and opinions of individuals engaged, with an emphasis on the benefits to the teaching and learning process. For this process study, the qualitative paradigm was used since it focuses on the human side, such as ideas, thoughts, feelings, and personal opinions concerning the FSEC. Data was gathered through interviews with students and staff, process observations of activities, and a review of related activity documentation and literature. Through thematic analysis, five important themes highlighting the benefits of FSEC for students' learning and experience were identified. The Formula Student initiative fosters an environment in which students are highly motivated to seek information through active learning and are proactively involved with their classmates and relevant stakeholders, resulting in a rewarding educational experience. The findings will help future endeavors plan for competition participation and ensure students' learning is also realized as part of their university living experience [2].

According to D Chindamo from the University Degli Studi di Brescia in Italy, student competitions can play a significant role in education since they encourage student and teacher interest and involvement. In the field of engineering, one of the most difficult competitions in Europe is the Moto student event, which the University of Brescia (UniBS) entered for the first time in 2016. It is a classic application of Kolb's theory of experiential learning, in which engineering theory and application collide in an intensive, 'hands-on' cooperation experience, resulting in a highly successful learning process that also includes so-called soft skills. The purpose of this paper is to provide a quick overview of competitions such as the Formula SAE and to share the authors' experience with a similar event, the Moto student contest [3].

According to Sukiman et al., competition-based Learning (CBL) is one of the ILOs incorporated in a few learning models as described by Issa et al (2014). Competition Based Learning entails a group of students working on an open-ended assignment with issues comparable to those encountered in the job. However, upon completion of the course's assigned task, performance is evaluated by other groups. This motivation is used to eradicate the mindset of "completing it just to get it over with" and to push students to consider an unpassable overall assignment. In addition, after the prescribed task is performed, a reward system is introduced. CBL can help students improve their soft skills, as well as their problem-solving and critical thinking abilities. It can be closely integrated with other learning methods, such as CBL (collaborative-based learning), PBL (problem-based learning and project-based learning), and game-based learning [4]. This learning technique provides students with the opportunity to educate themselves to compete in their future professional careers. Likewise, they can improve their learning activities and outcomes since the collaborative-based learning model enable students to share knowledge with other students by maximizing student participation.

III. METHODOLOGIES

Competition-driven motivation has a significant impact on the students, and it drives the individual to gain knowledge and work efficiently. Many motorsport clubs in the universities and colleges are student-coined clubs where students are responsible for any event and activity happening in the club. The activities vary from conducting workshops or webinars to hands-on training in 3D designing software or vehicle fabrication. There are various steps that the club heads follow among these activities before the competition. Participating and making a stand in the competition requires a great team of designers, fabricators, managers, and a captain. The best team builds the best vehicle and gets the best performance.

To find the best team from the university, initially, a word is spread through all the other clubs to intimate the students about the motorsports club and its activities. Upon responses from the students, interviews and tests are conducted to shortlist the responses. The shortlisted students are categorized into various wings in the team as per their interests and expertise. Design, Manufacturing, Testing, QA&QC, and Business and Marketing are the five wings that put their expertise and knowledge to build the best performance vehicle.

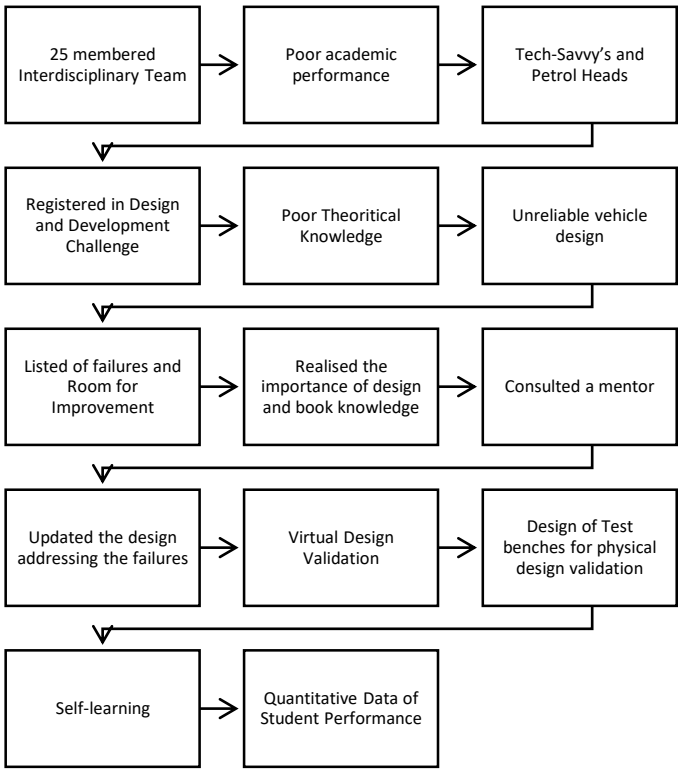
Fig. 1. First Team Meeting for FMAE Quad Bike Design Challenge at EDC HITAM

Students from all the wings are trained with the basics of 3D modeling software initially and then transferred to other wings. The Design wing is trained with 3D Modelling Software, Design Calculations, FEM, CFD, Topology Study, Design Optimization, and Report Making, which will help in the generation of CAE reports, and Proof of Concept reports. During the process, the students get in-depth knowledge and better understand various engineering concepts like Strength of Materials, FEM, CFD, etc. The knowledge they gain during the process helps them perform better in their academics. The Manufacturing wing handles the fabrication work required to build the vehicle. This involves reading and understanding the blueprint, cutting, welding, grinding, bending, polishing, CNC machining, FRP, etc. During the process, the students understand the difficulties in manufacturing, thus coming up with innovative fixtures which ease the process. They also get intense knowledge of machines and CNC programming. QA&QC wing plays an essential role in developing the vehicle. They ensure that the vehicle is designed and developed under specific rules mentioned in the rule book and ensure safe and best-manufacturing quality. The Business and Marketing wing is responsible for generating B-plan reports, finding sponsors, and generating funds.

The Testing wing is the most critical wing in the entire team. They test the vehicle in the worst conditions to ensure that they stand strong during the competition. It is difficult to predict the forces and loads directed to the components during dynamic events. Hence, it is harder to set boundary conditions during design and analysis. Although the components are analyzed through FEA and dynamic simulation during the design process, this doesn't conclude the maximum safety of the component. To ensure maximum safety, performance, and reliability, the engineers developed test benches that replicate the track dynamic conditions with real-time loads under completely controlled conditions. During the testing process, sensors and gauges are attached to the components to collect the data on forces, stresses, and displacements. The data collected by the sensors are used for topology study and design optimizations for future models of the vehicle in the upcoming years.

Students develop innovative test bench concepts and fixtures such as suspension system test bench, braking system test bench, engine test bench, etc. Students increase their innovative and problem-solving skills during the process, which will help the individual in his academics and career. Furthermore, participating in these competitions increases the student's confidence and the ability to handle the immense pressure. The significant advantage of this activity is that students from different engineering domains join the motorsports club and form an interdisciplinary team. The team works and develops the vehicle by sharing and combining the knowledge of all the engineering domains making the team multi-domain experts.

IV. RESULTS & DISCUSSION



A 25 membered interdisciplinary team of 12 mechanical engineers, five electrical engineers, three electronics and communications engineers, and two computer science engineers came together to form a team to participate in design and development challenges. The students who joined the team were those who found it hard to understand the theoretical concept taught in the class. They used to find it challenging to catch up with the classroom teaching where the rest of their classmates performed well. During this period, the student tends to lose interest in academics, leading him to bunk the classes, eventually damaging his academic performance during the exams. This was that one point that brought the team together. To their surprise, almost all the students who enrolled in the team were tech-savvy and interested in automobiles and racing. The team formed a motorsports club, hoping that they would design and develop a vehicle and participate in a design challenge one day.

In 2018, the team enrolled in the Quad Bike design challenge conducted by FMAE India. The students lacked the theoretical knowledge needed to design a reliable vehicle as they were irregular to the classes and had no prior exposure to vehicle designs, due to which an unreliable vehicle was achieved. This became a massive problem for the team when they participated for the first time and couldn't finish in the podium places. The students learned that theoretical knowledge is equally important to win in the competition and was motivated after witnessing the competitor's vehicles and ideology.

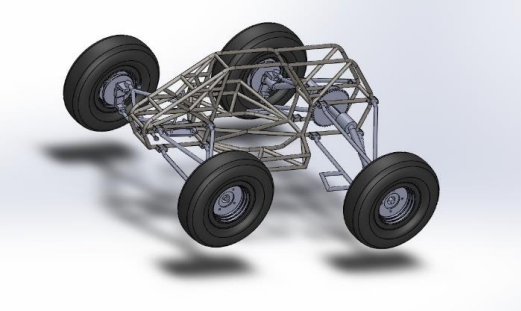


Fig. 2. Chassis Assembly of Quad Bike Created on CAD

The team wanted to revert harder and stronger. To make this possible, they started to understand what went wrong the first time and if there was any room for improvement. The team's experience was reported, and the list of failures, drawbacks, and challenges they faced was collected and quantified. This time, the team emphasized vehicle design, design calculations, and theory knowledge. A professor with 20 years of industrial experience mentored the team to improve their problem-solving and understanding skills during the process. The mentor related the team's current condition with a jar filled with big rocks, and there is always room for small rocks, sand, and water. Every student has a jar filled with different kinds of rocks as they have different likes and interests. To win the competition, every student from the team should have the same big rocks in the jar, i.e., the priorities. Every student's priority must be the competition and the academics, and there is always room for other activities.

This is where the students were headed towards the learning zone from their comfort zone. With fresh motivation and fire, the student started the updated version of the design by addressing the failures and drawbacks, and challenges that the team faced during the first competition. More efforts were put into virtual design validation and physical design validation by analyzing every design and component made by the students to fail-proof the concept. Virtual design validation was done through FEM analysis on Solidworks software. Physical design validation was done by manufacturing test benches for components. Test benches are the equipment that replicates live track loads to components but in controlled surroundings. The test benches were designed and manufactured with the help of the mentor. To understand the results and reactions, various engineering concepts such as Heat transfer, Thermodynamics and FEM were required. The team took the mentor's help to self-study through technical videos, journals, research papers, textbooks, and software. This made students understand the results and reactions and were able to optimize the design for better results.

Performing well in motorsport events requires expertize in mechanical engineering, electrical and electronic engineering, electronics and communications engineering and computer science engineering. During the designing process, the mechanical engineers learn about the strength of materials, stresses and strain, safety factors, heat transfer, thermodynamics, and design of machine members and many other important concepts thus helping the mechanical engineering students to perform well during the academic examinations. Similarly, students from all the branches participating in the motorsports events gets to work on their core subjects to gain of knowledge and thus performing well in the academics.

Fig. 3. Team Meet with Mentor

To evaluate the performance of students, data were collected before and after the competition. A survey was conducted among the students and mentors which quantifies the data consisting of student behaviour, academic performance, character, commitment, coordination, and motivation. The following are the survey questions and quantification of the results obtained.

Q1. Do you currently have fewer than six backlogs?

Students were initially asked if they had more than six backlogs, with a maximum of six backlogs set. By imagining the circumstances of the final semester's students, the upper limit was established. Without putting the students under pressure, it is simple to clear six backlogs during the last semester. Having more than six backlogs may include significant core subjects like strength of materials, machine design, heat transfer, etc. for mechanical engineers. At the time of the event, a student may pay a hefty price for lacking adequate knowledge in these subjects. During the design and manufacturing process of quad bike, the students increased their practical knowledge by designing and manufacturing the quad bike by consulting books, seniors, and faculty. The process made more than 72% of the students clear any outstanding backlogs of core subjects, therefore, reducing their backlogs to less than 6.

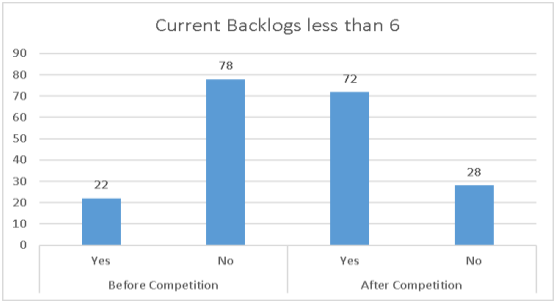


Fig. 4. Percentage of student's with less than backlogs (before and after the competition)

Q2. How would you describe your personality among these possibilities? (Extrovert and Introvert)

Strong speaking and listening abilities have a significant impact on a student's career. It is crucial that students be outgoing and confident when expressing their opinions in public. It was found that most students initially developed a habit of remaining introverted in their familiar surroundings. As a result, they lacked the self-confidence to speak up for themselves and found it challenging to be heard by others. The competition consists of static events where the student must present before the judges and persuade them that our work is an original work, such as B-Plan Presentation, CAE Presentation, Cost Report Presentation, etc. Performing well in the static competitions helped the student to gain confidence and to take a stand and express his thoughts and ideas. A graph (Figure – 5) was plotted according to the survey conducted before and after the competition which shows 80% of the students have changed into extroverts.

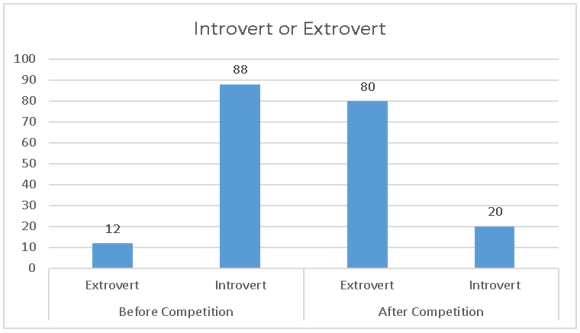


Fig. 5. Percentage of introvert and extroverted students (Before and after the competition)

Q3. Do you possess the technical knowledge of engineering concepts required to build a vehicle? (Yes, No)

A strong technical knowledge gives the team a significant advantage over the other teams in the competition. Because the subjects taught in the classroom are insufficient to build a vehicle, students must expend additional effort and time to consult textbooks, speak with alumni, seniors, industrialists, manufacturers, and others in order to construct a competitive vehicle. To understand their inputs, you must have strong comprehension skills and knowledge of what is being taught in the classroom. According to the survey conducted before and after the competition, 86 percent of the students were technically sound enough to build a vehicle on their own.

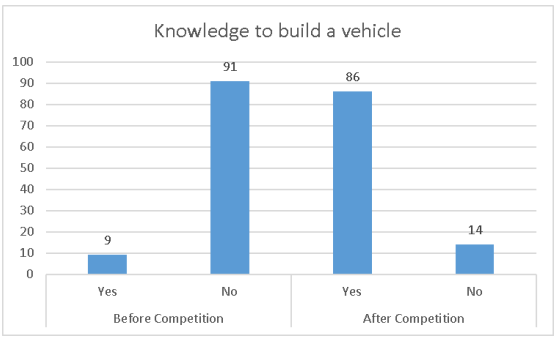


Fig. 6. Percentage of student's who has the knowledge to build a vehicle (before and after the competition)

Q4. Can you grasp engineering concepts through visualization?

Visualization can help students and professionals understand complex engineering concepts. Visualization aids in making a concept more understandable and easier to grasp. Students must visualize complex concepts such as vehicle dynamics and material strength in order to better implement them in the vehicles they design. The visualization also aids students in their regular academic classes, allowing them to perform better in exams. According to a survey conducted before and after the competition, 65 percent of students said their visualization and understanding skills had improved, allowing them to perform well in academics. The graph (Figure – 7) was plotted based on the responses of students.

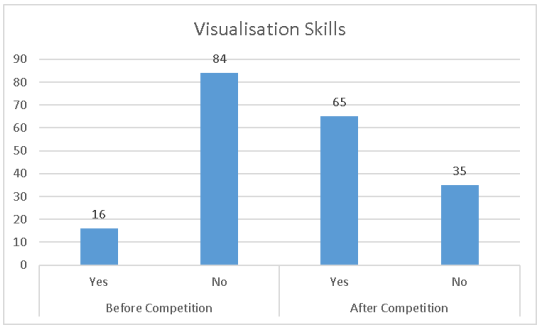


Fig. 7. Percentage of student's visualization skills (before and after the competition)

Q5. Do you feel confident representing our institution at national and international events? (AVG)

Confidence is an important factor in achieving success. Students must be self-assured and skilled in order to represent their institution at national and international events. They should be able to work well in groups and be proficient in presenting, public speaking, debating, and critical thinking. Participating in competitions prepares the student for public speaking, debating, and other activities that will benefit the student's professional career. According to a pre- and post-competition survey, 68 percent of the students improved their communication, public speaking, and debating skills. The graph (Figure – 8) was plotted based on the responses of students.

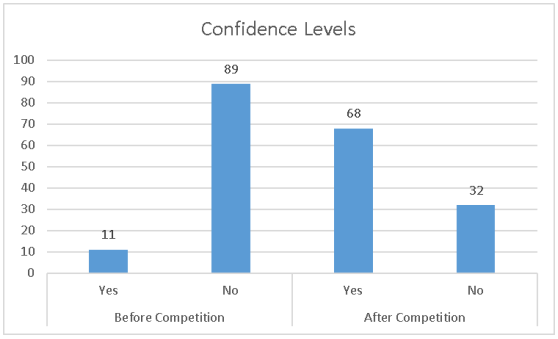


Fig. 8. Percentage of student's confidence levels (before and after the competition)

Q6. Do you consider yourself to be a Multi-Domain Expert?

To build a competitive vehicle, designers and developers must have multi-domain expertise in mechanical, electrical, electronics, communications, and coding. It is critical that

students understand multi-domain concepts in order to justify the proof of concepts required to present to the jury. Expertise in multiple domains is important not only for the competition but also for the student's professional career. According to a survey conducted before and after the competition, 68 percent of the students improved their knowledge of mechanical, electrical, electronics, and coding. The graph (Figure – 9) was plotted based on the responses of students.

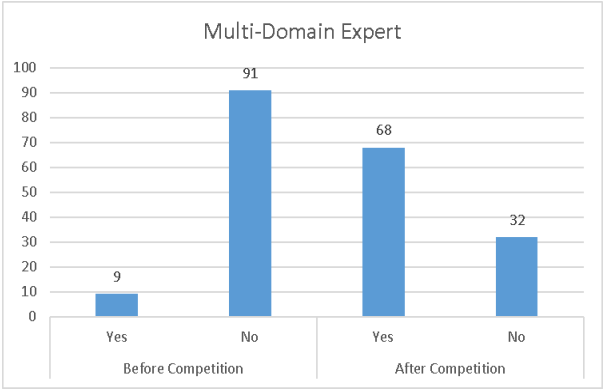


Fig. 9. Percentage of student's multi-domain expertise (before and after the competition)

Q7. Do you have basic knowledge in 3D design and modelling?

Every mechanical engineering student who wishes to pursue a career in the core mechanical field must be capable of 3D designing and modelling. 3D design and modelling assist students in transforming an idea or concept into a visual prototype. Today, 3D modelling has become a means of communication between several creators because it allows them to convert paper concepts to digital 3D figures that replicate the actual physical model. Understanding 3D modelling opens the door to many other fields such as digital rendering, additive manufacturing, finite element analysis, and so on. According to a pre- and post-competition survey, 86 percent of the students had learned how to create a 3D model using various software. The graph (Figure – 10) was plotted based on the responses of students.

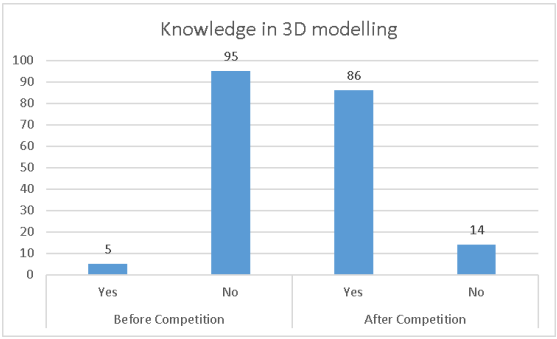


Fig. 10. Percentage of student's knowledge in 3D modelling (before and after the competition)

Q8. Do you have any hands-on manufacturing experience, such as welding, cutting, or grinding?

Manufacturing is a broad topic, so engineering students must have a solid understanding of the various types of manufacturing processes. Engineering students must be familiar with manufacturing processes. It helps them understand the different kinds of manufacturing processes and gives them an idea of the numerous career opportunities available in this field. It also assists students in determining which manufacturing process is efficient and cost-effective, as well as developing a futuristic design that aids the manufacturing process. According to a survey conducted before and after the competition, 70% of the students understood the fundamentals of the manufacturing process. The graph (Figure – 11) was plotted based on the responses.

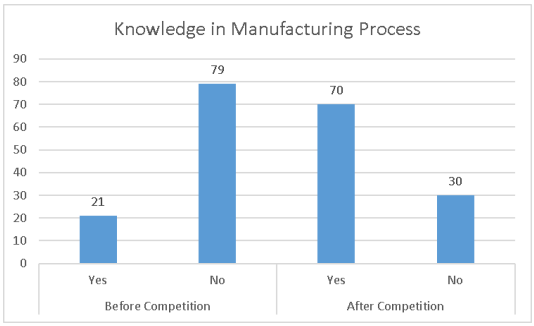


Fig. 11. Percentage of student's knowledge in manufacturing process (before and after the competition)

Q9. Do you have basic knowledge in FEM and Motion Analysis?

For engineering students, Finite Element Analysis is a powerful tool. It assists them in comprehending structural design, analysis, and motion analysis. Furthermore, it can be used to predict the product's strength and safety factor. It also enables engineers to simulate real-world conditions before beginning construction on the project. Knowledge and expertise in FEM and design provide students with an understanding of how the industry works and allow them to explore various career options. According to a survey conducted prior to and following the competition, 60% of the students have begun to practice FEM and Motion Analysis. The graph (Figure – 12) was plotted based on the responses of students.

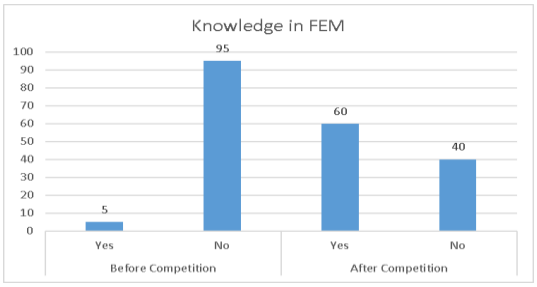


Fig. 12. Percentage of student's knowledge in FEM (before and after the competition)

Q10. Have you decided what would be your future goal? (Higher Studies, Job, Start-up, Not yet decided)

Choosing the right career option or a future goal is vital for the students who are pursuing engineering. The field of engineering is one that is in increasing demand. One of the most sought-after careers in the future is engineering, with a high likelihood of earning a competitive salary. The fierce

competition for jobs shouldn't discourage engineering students; instead, they should concentrate on honing their skill sets to set themselves unique in the competition. For engineering students who want to launch their careers overseas, higher education can also be a fantastic choice. Along with expanding your horizons, studying abroad will also help you become more accustomed to new environments and cultures, which will be extremely beneficial for your future career. A survey was conducted before and after the competition about the future goals of the students where over 92 % of the students have decided on their future goals. . The graph (Figure – 13) was plotted based on the responses of students.

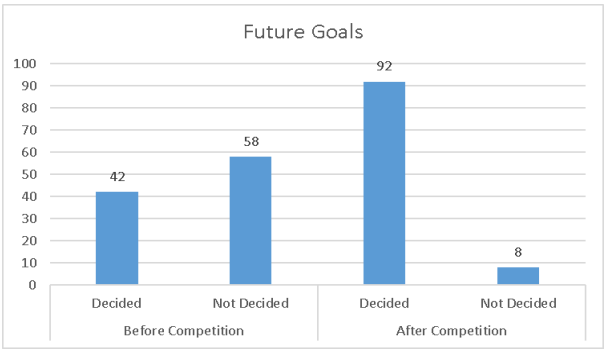


Fig. 13. Percentage of students who have decided their future goals (before and after the competition)

After analyzing the data, it was evident that,

- The student's academic performance has increased exponentially and was able to clear the backlogs if there were any.
- The students were able to catch up with the classroom activities which they used to find hard earlier.
- This activity had a good impact on introverted students by increasing confidence in them and helping them to speak out in many.
- It was also observed that students were more committed than ever before and a few of them have gone to start their start-ups and got registered under Start-up India Scheme.
- The students were motivated and were also able to motivate other students and also trained the upcoming batches to keep the legacy of the team going.
- Not all students had a remarkable impact by following this process, most of the students have turned their lives around to have a successful career and few of them are still on the verge of achieving it.

The graph (Figure – 14) was plotted based on the responses of students before and after the competition.

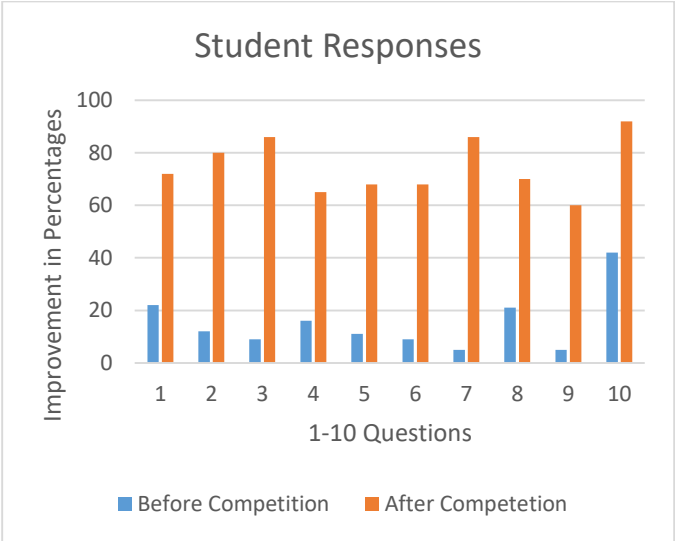


Fig. 14. – Graph representing improvement of student's performance in percentages from Questions 1-10 (before and after the competition)

V. CONCLUSION

Motorsports Club in engineering education has had a significant impact on students ever since it was introduced. It was evident through the data that the students who participated in the competition have gained immense knowledge of various engineering concepts, thus performing well in academics. Participating in the competition has increased the confidence and problem-solving skills of the students. The student's exposure and the experience from the competition will be an added advantage to his resume and will differentiate him from other graduates. This also makes the student industry ready to have a successful run in its competitive professional career.

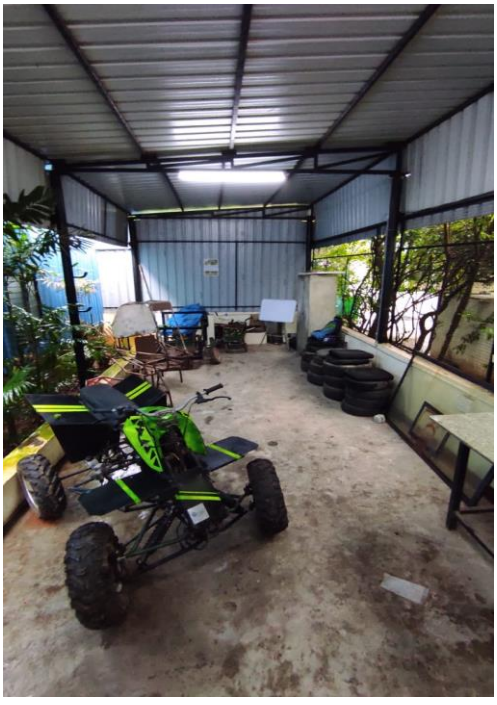


Fig. 15. Quad Bike Designed and Manufactured by the team

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