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SCAMPER Based Assessment Framework to Evaluate Final Year Engineering Projects in Higher Education Institutions

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Abstract— With rapid technological advancements of the 21st century, there is a greater onus on the higher education institutions (HEIs) to innovate teaching methodologies. Especially, engineering education which is at the forefront of latest developments, needs to provide a stimulating and feedback-oriented learning environment to the students. The current paper presents a SCAMPER technique-based assessment framework embedded with Bloom's Taxonomy that can be used for assessing the technical feasibility, identification, and resolution of challenges for final year engineering projects. A case study is conducted utilizing the proposed framework to evaluate projects of final year Mechanical Engineering undergraduate students. Results highlighted that among the control group, 67% of students followed the traditional "modify" solution approach to a given problem whereas in the experimental group, the solution approaches were more diverse with only 35% of students choosing the "modify" approach. In terms of overall assessment scores, 70% of the experimental group scored in the upper quartile from 7 to 10 whereas for the control group, only 30% of students scored between 7 to 8 with 8 being the highest score. Based on these results, we can assert that the proposed framework enables students to a) think critically and be open to exploring different approaches to solve a problem b) justify the chosen solution approach and c) clearly explain the potential challenges and their feasible solutions. Hence, this research addresses the need to design robust frameworks that will a) guide students to think critically and to focus on novel idea generation b) facilitate instructors to thoroughly evaluate projects and to provide students with timely and comprehensive feedback. We believe that this framework is flexible enough that can be adapted to successfully evaluate student projects from diverse disciplines in higher education institutions globally.

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1. Introduction

There is a renewed interest among academics and practitioners about how to educate learners and future workers so that they are better equipped to tackle the complex challenges of 21st century (Helker et al., 2024; WPU, 2019). One of the prominent outcomes of this thought process has been the introduction of Project Based Learning (PBL) in engineering fields. An engineer's ability to address complex societal problems has taken center-stage in today's rapidly changing world (Shaik et al. 2022). It is incumbent upon educational institutions to provide the necessary pedagogy to future engineers so that they can obtain required skills and competencies to be successful (Rao, 2013; Babu et al., 2024). PBL has been proven to help students to not only solidify their understanding and comprehension of technical concepts but also to improve their inter-personal and time-management skills (Brateris, 2022; Markula & Aksela, 2022). It encourages students to learn by doing contrary to the Problem Based Learning which relies heavily on students attending lectures, taking notes and passing the exams (Hubbard, 2019). Researchers have further stressed that an educational endeavor should enable students to excel in cognitive, affective and psychomotor skills domains as emphasized in Bloom's taxonomy (figure 1). Hence, it is imperative that HEIs continue to innovate since translating students' academic progress into uniform time or process measures may not be the ideal approach anymore (Levine & Pelt 2021; Murthi & Bassett, 2022).

The current paper attempts to present a novel assessment framework that enhances traditional assessment methodology by integrating it with SCAMPER technique and the cognitive learning domain of Bloom's Taxonomy. We will present a detailed description on the cognitive aspects of learning, followed by the discussion on SCAMPER and highlighting its ability to enable creative learning, idea generation, and self-reflection in students. Building on these concepts, we will introduce the assessment rubrics used in the evaluation. Then, a case study that was carried out utilizing the proposed framework to evaluate the FYPs of mechanical engineering students at a HEI in India will be discussed. Finally, results and discussions are provided followed by outlining limitations and future research directions.

A. Capstone/ Final Year Project (FYP) in Engineering Programs

The concept of FYP began in the early 1900s when HEIs started taking note of the need to instill practical knowledge and reinforce learning in students via hands-on projects (Kinzie, 2013; Suryawanshi et al., 2021). FYPs embody Design Based Engineering Learning (DBEL) that require students to design practical, research-based solutions which ultimately promote deeper learning (Kolodner, 2002; Tempelman & Pilot, 2011; Wei et al., 2023). Typically, in engineering programs, the FYP is a continuous effort spanning over either 1 or 2 semesters and carries a significant weight (El-Kady, 2014; Ryder 2004). For example, at the current case study site, students work on FYP across 2 semesters which require 15 hours of lab work per student per week. In general, each FYP should address a problem faced by the society and provide a viable solution which can be sellable even if it is not an entirely novel solution. With respect to students' learning outcomes, each individual student should have acquired basic engineering knowledge, ability to solve given problems, commitment to professional ethics, project management skills, and sufficient hands-on experience with the modern tools (Brooks et al., 2004; Collier, 2000; Julien et al. 2012; Upson-Saia, 2013). But it is the opposite that is most commonly observed in FYPs which just end up being non-creative exercises predominantly due to ambiguous and unreliable assessment methods (Naqvi et al., 2019). Based on prior experience guiding FYPs, we have observed that one or more of the following continue to occur without intermittent evaluation.

1. Outsource the entire project to the local market.

2. Duplicate major portion of an already existing solution without critical evaluation.

3. Ambiguous definitions of outcomes or success criteria making it challenging for students and evaluators to understand the expected performance metrics.

4. Inconsistent tracking of project progress

5. Ignoring or deviating from established methodologies.

6. Failure to consider interdisciplinary aspects of the project.

7. Lack of emphasis on ethical considerations.

8. Insufficient reflections on the learning experiences of the project.

Traditional assessment tools such as end-of-course surveys, alumni surveys, instructor evaluation reports, assignments etc. (4) are insufficient to weed out inefficient approaches and hence students aren't motivated to invest in enhancing their technical capabilities. They further fall into the traditional project management assessment process evaluating different phases of a project without focusing on evaluating technical capabilities of the students.

2. Literature Review

Critical thinking and independent ability to approach new design problems are essential skills to become a successful professional. Especially in the field of engineering, students who lack the ability to learn independently and renew design skills continually can becoming professionally obsolete since the evolution of technologies and design landscape is so rapid. FYPs or capstone projects have been a cornerstone of engineering education since they present students with an opportunity for self-evaluation and to identify areas of improvement. They also carry substantial weight in the overall grade for an individual and hence are a vital component in the journey of degree attainment. A study of related literature shows that self- or peer-report surveys along with project deliverables are some of the most common tools used for project assessment (Garcia On et al, 2011; Ohland et al. 2004; Adams et al., 1999; Podsakoff et al., 2003; Wei et al., 2023; Rio & Rodriquez, 2022; Vivar-Quintana et al., 2014; Nolte et al., 2021). But these instruments have limited utility for formative purposes since they often lack features that can help differentiate levels of competencies. Also, a 'one size fits all approach' to learning and assessment design may not be effective for all students. A good assessment should be designed in such a way that a) it is responsive to the diverse needs of the student cohorts based on their learning styles, b) it must clearly lay the interrelationships between the learning activities and assessment tasks c) motivate and engage students to learn and reinforce learning (Biggs, 2003; Stewart, 2005).

It is critical that both the educators and the educational institutions are equipped with the necessary tools and frameworks. They can then help students to attain the required skills and characteristics to thrive at workplaces and to become productive members of the society. But there has been lack of a comprehensive framework that addresses the need to thoroughly evaluate FYPs. Hence, the current paper attempts to integrate the cognitive learning domain of Bloom's Taxonomy with the SCAMPER idea generation and evaluation technique and the traditional assessment tool thus presenting a three-pronged approach to evaluate engineering projects. Researchers have laid down a detailed foundational hierarchy of learning at different levels for cognitive, affective, and psychomotor domains as shown in figure 1(Bloom, 1956; Dave, 1970; Simpson, 1972; Brindha 2020). Since the current study is focused on assessing the critical thinking, understanding of technical feasibility and potential challenges in addressing engineering problems, we will limit our integration with the cognitive domain of Bloom's Taxonomy.

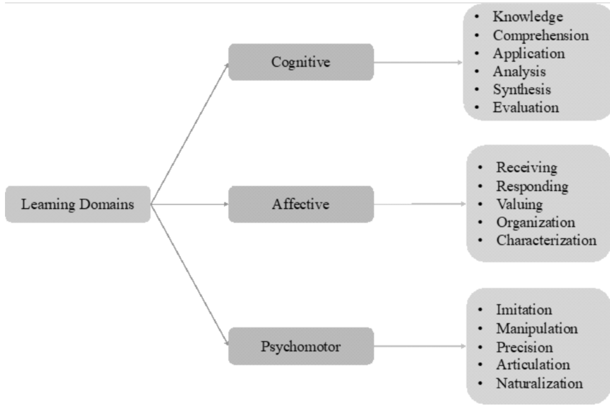

Fig. 1 : The 3-Domains of Learning in Bloom's Taxonomy

Earlier acquaintance with the subject matter would need to be built upon to develop a complex level of understanding of any subject (Bloom, 1956). This process could begin with a simple recall of facts (knowledge) and then gradually navigate through different hierarchical processes until we reach the stage of evaluation. Since this process follows an investigative path starting from the simple recollection of facts and asking incremental questions until the desired result is achieved, it is often referred to as knowledge-by-thinking ability. The cognitive domain of Bloom's taxonomy specifically deals with this ability of students (Naqvi et al., 2019). Table I outlines the different learning aspects in the cognitive domain.

Table I : Levels of Cognitive Domain. (Krathwohl Et Al., 1964; Ruhl, 1956; Armstrong, 2010)

Level	Definition
C1	Knowledge: Ability to remember and recall specific facts.
C2	Comprehension: Ability to understand and interpret the meanings to make sense out of information, summarize and define specific characteristics of information.
C3	Application: Ability to apply the previously gained knowledge in a new but similar situation.
C4	Analysis: Ability to break down the information into smaller components and to be able to identify and explore relationships.
C5	Synthesis: Ability to put together elements or parts to form a whole or to create something new. Also referred to as originality or creativity.
C6	Evaluation: Ability to judge, assess or critically evaluate available information, material, and methods

SCAMPER technique is one such widely used tool that can help to facilitate comprehensive learning in students and aid in thorough individualized evaluation of their progress. As outlined in figure 2, SCAMPER represents the following sequence of categories and actions: (S) Substitute, (C) Combine, (A) Adapt, (M) Modify/Magnify/Minimize, (P) Put to other uses, (E) Eliminate, and (R) Reverse/Rearrange. For each operator category, a set of questions suggest reflection and an action such as add, modify, etc. An attempt to answer these questions provides the necessary stimulus that redirects analogical search to solve a problem (Serrat, 2017; Lockton, 2012). To better understand this, let us consider an example scenario where a designer is tasked with improving the grip of shoes to make them safer for icy conditions. As a first step, the designer might choose to replace the sole following the Substitute (S) approach of SCAMPER framework. After this, the designer proceeds to a series of investigative questions such as 1) What exactly can be substituted (outer sole, mid sole or both?) 2) Are there other better materials available? 3) Can the dimensions of the sole be changed? Brainstorming on these questions can generate ideas that could lead to replacing the sole either entirely or partially with a different material and dimensions. The main strength of the design heuristics embodied by the SCAMPER's operator categories comes from the fact that similarity relationships may exist with analogies that are retrieved through the operators (Daly et al., 2012). Researchers have argued that every new design problem could in some way or another be related to the other already solved problems (Polya, 2014). It has been further discussed that with this correlation, designers can study the results, methods used for the problems that are already solved and learn from them to solve the existing problem at hand. These arguments apply to both mathematical problems and general problem solving. SCAMPER embodies this approach to problem solving where a practitioner can attempt to find a solution by utilizing a heuristic that builds on previous results (Moreno et al., 2014).

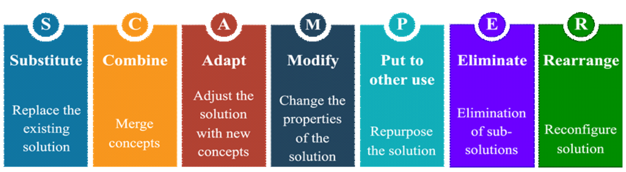

Fig. 2 : Anatomy Of Scamper

A number of studies in the product-related domain show that SCAMPER based approach to problem solving has resulted in numerous novel results as well (Boonpracha, 2023; Altiparmak, 2021; Tharwa, 2019; Hussain & Carignan, 2016; Zhang, 2022; Lindquist, 2023). This highlights the effectiveness and ability of SCAMPER to increase creativity. It has also been noted that these SCAMPER enabled solutions possess a higher utility when compared to the solutions generated by more traditional methods such as TRIZ (Chulvi et al., 2013). Further, teams using SCAMPER based strategies were found to demonstrate dedicated efforts to reframe a given problem and to further develop the generated ideas (Lopez-Mesa et al., 2011; Isaksen, 2023). Hence, SCAMPER method was chosen for the current study owing to its capabilities to help with enabling creative and innovative approaches to problem-solving and simultaneously assess the performance of students.

3. Research Design

The current framework based on SCAMPER and Bloom's Taxonomy is specifically designed to evaluate the technical feasibility, identification and resolution of technical challenges for engineering projects. This approach pays equal attention to the students' as well as supervisor's role which has been traditionally lacking in other approaches. Tables II and III demonstrate the mapping between rubrics questions following SCAMPER approach with the standard cognitive domain of Bloom's Taxonomy. We apply this framework to two cohorts of mechanical engineering students and demonstrate that such a SCAMPER oriented assessment framework can positively transform the current FYP practices and enable students achieve their learning outcomes. First assessment for students should be carried out in the preliminary stages of FYP to get a sense of what their current plan for solution is and their idea about which approach might work well for them to address the problem. As shown in Table II, working on either substitute, reuse, and rearrange approaches addresses the cognitive learning level C2 that focuses on the student's ability to understand and interpret the meanings to make sense out of information, summarize and define specific characteristics of information. While working on the "Adapt" approach, students can enhance their ability to apply the previously gained knowledge in a new but similar situation in line with C3 level of cognitive domain. The approaches of "Combine" and "Eliminate" focus on the ability to break down the information into smaller components and to be able to identify and explore relationships (C4). Whereas, the "Modify" approach enables to judge, assess or critically evaluate available information, material and methods.

Table II :
Review I - Mapping Between Scamper Rubrics And Cognitive Domain

Category	Rubrics	Cognitive Learning Level
Substitute	What makes you think that the problem requires a substitute solution?	Comprehension
Combine	Does it compromise in anyway by combining the concepts?	Analysis
Adapt	Why only that concept is chosen for adapting?	Application
Modify	Is modification of concept/feature required?	Evaluation
Put to other use	Have you explored all the possibilities for the reuse?	Comprehension
Eliminate	Is that the least preferred concept/feature in the existing solution?	Analysis
Rearrange	What are the hurdles in the current solution?	Comprehension

The initial assessment must be conducted during the scope and feasibility analysis phase which will help both the students and supervisors evaluate whether the planned approach is feasible or not and to take any corrective actions as needed. Later, a second assessment is required towards the end of the FYP to evaluate their level of adherence to the initial approach, potential changes, overall knowledge and awareness about the process implemented. Table III outlines the corresponding mappings between SCAMPER rubrics and the learning domains of Bloom's Taxonomy for the 2nd review. This assessment focuses on the progress from Review I and tries to determine students' understanding of the technical feasibility of their approaches. The detailed assessment forms for each of these reviews are presented in the methodology section.

Table III :
Review II - Mapping Between Scamper Rubrics And Cognitive Domain

Category	Rubrics	Cognitive Learning Level
Substitute	Does the proposed solution address the need for substitution?	Application
Combine	Effect of merging of concepts on the project outcomes?	Analysis
Adapt	Did the adopted concept survive the intended purpose?	Analysis
Modify	Does the modification address the problem?	Analysis
Put to other use	Is the solution viable for the proposed reuse?	Synthesis
Eliminate	With the proposed elimination does the solution still fit the acceptance?	Evaluation
Rearrange	Did the reconfiguration of solution help in removal of hurdles?	Synthesis

A. Methodology

The conventional method of evaluation, which primarily relies on presenting the work before a panel of reviewers and assessing the traditional project management dimensions, lacks in thoroughly assessing the technical acumen of students. Moreover, students often struggle to identify their shortcomings without proper assessments provided by the instructor. To address these issues, our framework inspired by the SCAMPER tool aims to guide students and assist reviewers in better assessing the technical approaches of students to the design solutions. To demonstrate the effectiveness of this robust framework, the current research carried out an investigative case study evaluating the FYP of mechanical engineering students.

1) Data Collection

A sample of 275 (n) final year mechanical engineering undergraduate students from a HEI in Southern India were considered for this study. These students who were working on their FYPs were divided into 2 groups – control (137) and experimental (138). The experimental group was informed about the assessment rubric at the beginning of the FYP and were provided the necessary guidelines to achieve the expected learning outcomes. The control group followed the traditional approach to FYP completion and evaluation and were not exposed to the SCAMPER assessment rubric. Figure 3 outlines the phases involved in the proposed methodology which integrates SCAMPER based assessment to specifically evaluate the technical dimensions of FYPS. This provides an additional layer over the traditional assessment methods with rely on general project management phases focus on initiation, planning, design, execution, and communication. With the integration of SCAMPER at 2 stages, both the students and supervisors would get a) timely

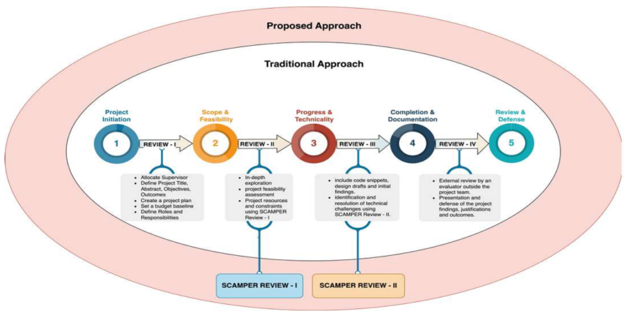

Fig. 3 : Scamper Assessment Embedded Review Phases

feedback on student progress b) identify areas of improvement c) gauge technical feasibility and ability to address potential challenges.

Before initiating the work on FYPs, students were given all the guidelines for the project, the expected outcomes and the criteria for an acceptable solution. Students were free to choose a project idea of their liking but were encouraged to think creatively and choose to address a problem prevalent in the society. Once the students were instructed on necessary details, the following steps were carried out in each of the above phases.

2) Project Evaluation Framework: 18-Week Duration

a) 1st Phase - Initiation (Weeks 1-2):

Tasks

- Allocation and Finalization of Project Supervisors.
- Selection of Project Title.
- Submission of Project Abstract, Objectives, and Expected Outcomes.

Evaluation Criteria

- Appropriateness of the chosen supervisor.
- Clarity and relevance of the project title.
- Quality of the project abstract, outlining clear objectives and expected outcomes.

During this phase, the assessment rubric was shared with the experimental group.

b) 2nd Phase - Scope and Feasibility (Weeks 3-5):

Tasks

- In-depth exploration and definition of the project scope.
- Assessment of project feasibility, considering resources and constraints.

Evaluation Criteria

- Clarity and specificity of the defined project scope.
- Thoroughness of the feasibility analysis.
- Identification and mitigation of potential risks.

After a gap of about 3 weeks since the inception of the project, 1st review based on SCAMPER rubrics is carried out. Table IV outlines the rubrics with a questionnaire used to evaluate the students' progress and approach towards the project at this point. Main focus is on the technical scope, feasibility, thoroughness of the plan to evaluate whether student is able to demonstrate a comprehensive understanding of project viability and innovation opportunities.

c) 3rd Phase - Progress and Technical Challenges (Weeks 6-10):

Tasks

- Regular progress updates, including code snippets, design drafts, or initial findings.
- Identification and resolution of technical challenges.
- Evaluation Criteria
- Consistent and documented progress updates.
- Effective resolution of encountered technical challenges.
- Adherence to proposed timelines.

During this phase, the second SCAMPER based review is carried out using the assessment form outlined in Table V. Main focus is on determining whether student is able to identify and address the technical challenges adequately and justify the approaches taken.

d) 4th Phase - Timely Completion and Documentation (Weeks 11-15):

Tasks

- Timely completion of the project's main components.
- Comprehensive documentation of the project, including code, design, and results.

- Completion of fabrication prototype, simulation, analysis, etc.
- Evaluation Criteria
- Adherence to the project timeline.
- Quality and completeness of project documentation.
- Successful completion of prototype, simulation, or analysis.

e) 5th Phase - External Review and Defense (Weeks 16-18):

Tasks

- External review by an evaluator outside the project team.
- Presentation and defense of the project findings, justifications, and outcomes.
- Evaluation Criteria
- Quality of the external review.
- Clarity and effectiveness of the student's defense.
- Integration of feedback from the external review

Table IV :
Scamper Review – I

Category	Rubrics	Substandard (0-4)	Marginal (5-6)	Worthy (7-9)	Excellent (10)
Substitute	Why does the problem require a substitute solution?	Unable to identify the need	Understands the basics but hasn't fully explored the need	Has clarity on the need	In addition to identifying the need, presented the market survey.
Combine	Does it compromise in any way by combining the concepts?	Adverse effects of combining the concepts have not been explored.	Mentioned the effects of combining the concepts, but not confident in justifying.	Understands the effect of combining the concepts.	Thoroughly understands the effects of combining the concepts and their limitations.
Adapt	Why only that concept is chosen for adapting?	Lacks clarity on adapting a chosen concept.	Has clarity on a chosen concept but has not fully explored fully other available concepts	Has acquired clarity on most of the available concepts.	Done an extensive survey to justify the chosen concept.
Modify	Is modification of concept/feature required?	Absence of familiarity on the modifications needed	Has some knowledge on the modifications but not aware of its consequences	Gained good awareness on modification of concepts and its consequences	Has thorough understanding of modifications along with its impact.
Put to other use	Have you explored all the possibilities for the reuse?	Did not sufficiently explore the possibilities.	Somewhat explored the possibilities but faces difficulty in justifying them.	Has explored most of the possibilities for reuse with justification.	In addition to exploring all possibilities, understands the pros and cons of each.
Eliminate	Is that the least preferred concept/feature in the existing solution?	Almost no knowledge on the preferred features of the existing solution.	Marginally familiar with the preferences of the existing solution.	Analysed in-detail on the preferences of the existing solution	Able to present evidence for the preferences.
Rearrange	What are the hurdles in the current solution?	Fails to address the hurdles in the existing solution.	Addresses most of the hurdles but has vaguely justified.	Fully addressed the hurdles with justifiable solutions.	Has sound understanding on the hurdles and how to overcome them.

This framework provides a structured approach to project evaluation, ensuring a thorough assessment of each project's quality and guiding students in identifying and addressing the shortfalls.

Table V :
Scamper Review – II

Name	Rubrics	Substandard (0-4)	Marginal (5-6)	Worthy (7-9)	Excellent (10)
Substitute	Does the proposed solution address the need for substitution?	Seems to have no understanding on the impact of the substitution.	Has sound understanding on the proposed solution for substitution and its impact	Has clarity on proposed substitution but lacks assessment on the need.	Fully aware of the proposed substitution with assessment.
Combine	Effect of merging of concepts on the project outcomes?	Lacks background knowledge on the concepts merged	Has limited knowledge on the concepts	Has a good knowledge on the concepts merged and their intended outcomes	Has performed thorough assessment on the merged concepts and their long-term impact.
Adapt	Did the adopted concept survived the intended purpose?	Seems to have substandard understanding on the concept adopted	Has marginal understanding on the concept adopted.	Has made worthy observations on the concepts adopted along with their intended purpose.	Able to foresee the survival of the concept for the intended purpose.
Modify	Does the modification address the problem?	Unable to corelate the concept modified.	Able to do modification of the problem but not the best possible way.	Could find the potential solution for the problem.	Able to provide the modification for the problem in the best possible way
Put to other use	Is the solution viable for the proposed reuse?	Fails to show the viability of the proposed reuse.	Has shown marginal viability of the proposed reuse	Demonstrated worthiness for reuse of the concept.	Concept demonstrates viability of the proposed reuse with the assessment of its impact
Eliminate	With the proposed elimination does the solution still fit the acceptance?	Unable to present the impact of proposed eliminated concept	Presented the importance of eliminated concept but has vague understanding.	Has sound understanding on the eliminated concept but failed to comply	Presented with evidence the acceptance of solution
Rearrange	Did the reconfiguration of solution helped in removal of hurdles?	Did not assess the impact of reconfiguration.	Has marginally addressed the hurdles	Has addressed majority of the hurdles but no confidence on the possible acceptance of reconfiguration	Has confidence and evidence to claim the acceptance of the reconfiguration

4. Results And Discussions

As part of this case study, a total of 275 students working on 91 FYPs in total were evaluated. To have a comprehensive understanding of the effects of SCAMPER based assessment framework on the technical approaches to design problems, each student was evaluated via the 2-stage review framework. Scores on the SCAMPER assessment forms for both the experimental and control groups were collected by the evaluators and external examiners. Even though students were working on FYP as part of a group, we focused on evaluating each student individually to assess their understanding of technical feasibility of the chosen approach, identifying and devising solutions for potential challenges. From figure 4, we can observe that the SCAMPER Review I assessment scores for control group students was in a narrow range from 5 to 8 and a majority of those students (around 70%) scored between 5 to 7. These are the students who understand the requirements and may have some clarity on the need for the chosen approach but have not yet fully explored to understand all the components and challenges. On the other hand, only about 30% of the students have good clarity on the need for proposed approach and were able to back their understanding and need for the approach via a thorough market survey.

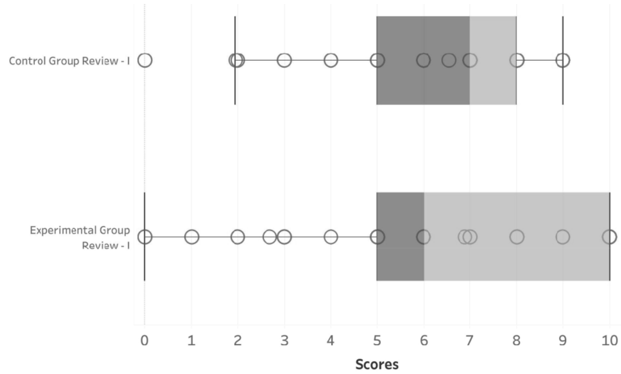

Fig. 4 : Review I - Score Distributions

With respect to the students from experimental group, the assessment scores had a wider range from 5 to 10. It is worth noting that 70% of the students scored in the upper quartile from 7 to 10. These students were able to clearly explain the need for a particular solution approach and have comprehensively researched its components and challenges. About 30 % of the students struggled a bit about explaining the need for the chosen solution approach even they have understood the requirements. This demonstrates that students with prior knowledge of SCAMPER based assessment framework were motivated to better research the need for the chosen approach and clearly understand its technical feasibility. The performance of both the groups drops in SCAMPER Review II as shown in figure 5. The range of scores for control group fell from 5 (min) – 8 (max) to 3 (min) – 6 (max). Whereas for the experimental group, the range of

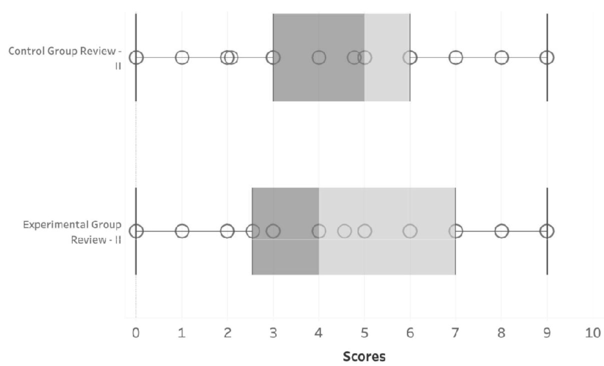

Fig. 5 : Review II - Score Distributions

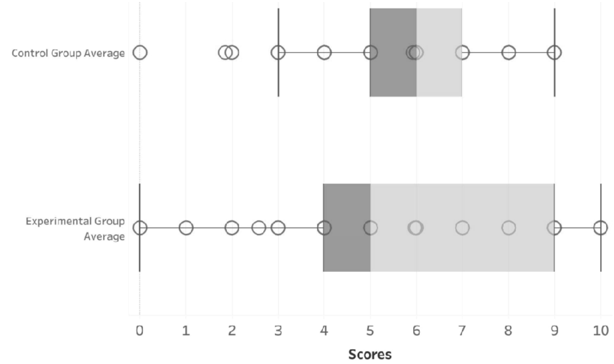

Fig. 6 : Average - Score Distributions

scores decreased from 5 (min) – 10 (max) to 2.5 (min) – 7 (max). In general, for every student, the score attained in Review II were at least 30% lower than the score obtained in Review II.

Review II extensively focuses on evaluating the students' in-depth understanding of the challenges, ability to choose and successfully implement potential solutions to address the challenges. The comparatively lower scores in Review II indicate that students may not have prioritized identifying all of the potential challenges and then brainstorming on possible solutions. Also, figure 6 indicates that the average scores for control group was from 5 (min) to 7(max) whereas for the experimental group, the average ranged from 4(min) to 9 (max). These observations highlight potential challenges encountered by students in maintaining the same level of proficiency over consecutive assessments. Such comprehensive evaluations of students distinctly point out the strengths and weaknesses of each group member, helping them to identify the areas for improvement and motivating to focus on those areas in future assignments. Furthermore, the evaluators and supervisors noted that the thorough assessment forms compelled them to ask questions addressing different aspects of a technical project which they would have skipped otherwise. Thus, the current framework could be instrumental in not only guiding students to carry out their research project, but also to assist the examiners in effectively evaluating each group member from multiple aspects. Hence, this framework cements the importance of supervisor's role in enabling comprehensive learning and skills' development of students. The entire multi-pronged process also forces the project supervisor to properly write and submit the project proposal and instruct the students at the very beginning to prepare themselves for the SCAMPER-based evaluation.

Along, with individual evaluations, the current study also focused on identifying the distribution of different solution approaches by the 2 study groups. Figures 7 show that among the control group projects (45), almost 67% of the groups followed the 'Modify' approach and the adoption of remaining approaches is minimal. Whereas among the experimental group projects (46), there is a fair adoption of other solution approaches too even though 'Modify' was still the most common choice at 35% overall. But almost 50% less groups selected the 'Modify' option when compared to the control group. This shows that students without the awareness of SCAMPER technique, lacked motivation to investigate diverse solution approaches.

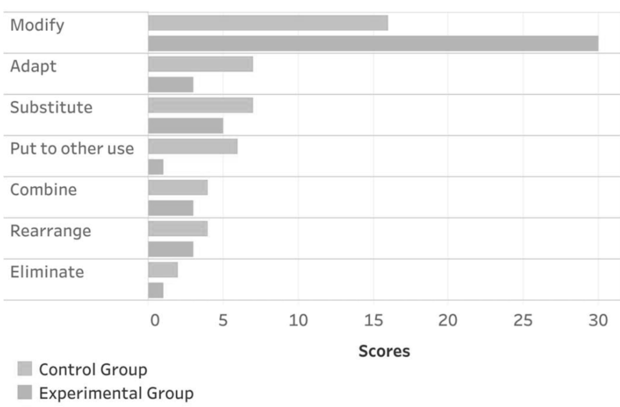

Fig. 7 : Distribution of Project Solution Approaches by Control Group And Experimental Group

SCAMPER method can be considered as an idea generation enabler, because it proposes seven "operators" that suggest possible actions that can be carried out with a given design problem to solve it. This encourages the students to consider different factors and methods simultaneously which further enhances creativity. The increased diversification of solution approaches by the students with SCAMPER awareness is further demonstrated in Figure 8. Following SCAMPER technique, students are presented formal triggering questions that enable the ability to engage a problem in a different way, and generate variants or improvements for suggested or existing solutions. Most importantly, this will aid the students to diverge from the typical solutions that are characteristic of design problems. Some students may spend a large quantity of time creating repeated, or idea variants from different categories. A different group can have a tendency to develop small variations to previously generated ideas when alternative categories of ideas are not apparent. Regardless, SCAMPER based assessment framework can help to create improvements and more refined versions of the ideas with additional exploration of alternative categories of ideas. As Michalko, 2006 pointed out, SCAMPER has the potential to increase the odds of discovering a novel idea by generating alternatives of that novel idea. Based on the results, we can assert that following the SCAMPER technique as a guiding framework to problem-solving combined with the assessment rubric, a) instructors were better able to identify and categorize different approaches to the design problems b) students were able to think critically and diversify their problem-solving approaches with timely feedback.

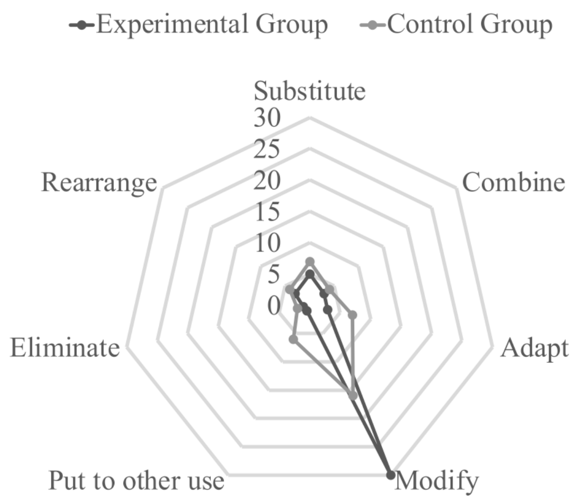

Fig. 8 : Project Solution Approaches

Conclusions, Limitations And Future Research

The central focus of engineering education is to develop interdisciplinary-minded and highly talented practitioners with an innovative disposition and problem-solving ability to address the dynamic challenges of 21st century. Hence there is an ever increasing need to develop robust tools and frameworks that can help in cultivating competence in innovative thinking. Therefore, we strived to present a comprehensive assessment framework with a specific focus on evaluating technical capability of students in FYPs. It further emphasizes equal participation from both the students and their supervisors which has been particularly lacking in the engineering projects' assessment space. To ease this process for both the parties, we have formulated 2 separate assessment forms which lead to clear conclusions about whether the students managed to attain the required FYP learning outcomes.

Though we have attempted to generalize the framework to make it applicable to any field, there are limitations with this study. Implementing the correct rubrics necessitates a deep understanding of the domain, which may pose challenges for institutions lacking the requisite expertise or resources to effectively apply the framework. This reliance on domain knowledge could hinder widespread adoption and effectiveness in diverse contexts. Nevertheless, we aim to continue this research by incorporating Outcome Based Education concepts. We would further revise the framework so that it is able to identify unique learning approaches and gauge the level of attainment of expected learning outcomes by students. More specifically, we plan to focus on addressing the following research questions:

- Does the use of the framework produce actionable information that can aid in instructional decisions?
- Does the framework offer flexibility of integration with the expected learning outcomes?
- Does the use of framework assist in identifying the students' levels of attainments of the expected learning outcomes?
- Has the use of the framework helped advance student learning and students' perceptions of learning?
- Do the instructors and students see value in the framework and are they able to use it effectively?

Based on our preliminary results highlighting the positive effects of SCAMPER based assessment framework, we stress the importance of implementing this framework for FYPs in every discipline of undergraduate engineering program. We believe that this work is flexible enough to be adopted by any engineering program in institutions across the world to evaluate their FYPs thus giving this work a significant importance.

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