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Enhancing the Outcome of Mechanical Engineering Design Course with the SCAMPER Methodology Framework

SCAMPER Metodoloji Çerçevesi ile Makine Mühendisliği Tasarım Dersinin Çıktısının Geliştirilmesi

Onat Halis TOTUK

ABSTRACT

Methodology frameworks in engineering education are structured approaches or models used to design, implement, and evaluate educational practices in engineering disciplines. These frameworks provide a systematic way to organize and optimize the teaching and learning process, ensuring that engineering students receive a comprehensive and effective education. SCAMPER is a creative thinking technique used to generate new ideas and approaches for problem-solving or project development. Each letter in SCAMPER stands for a different prompt to enhance the process targeted. These prompts stand for the substitute, combine, adapt, modify, put to another use, eliminate, and reverse. Evolving SCAMPER as a methodology framework for Mechanical Engineering education involves adapting its principles and prompts to cater specifically to the needs and challenges of engineering students. This study presents the use of SCAMPER methodology as an educational framework for mechanical engineering and application to the Mechanical Engineering Design course given for senior year students with proposed examples based on experiences collected from previous classes thought.

Keywords: Methodology framework, Design education, SCAMPER, Mechanical engineering design, Educational innovation

ÖZ

Mühendislik eğitiminde metodoloji çerçeveleri, mühendislik disiplinlerinde eğitim uygulamalarını tasarlamak, uygulamak ve değerlendirmek için kullanılan yapılandırılmış yaklaşımlar veya modellerdir. Bu çerçeveler, öğretim ve öğrenme sürecini düzenlemek ve optimize etmek için sistemli bir yol sağlar, bu sayede mühendislik öğrencilerinin kapsamlı ve etkili bir eğitim almasını sağlanır. SCAMPER, problem çözme veya proje geliştirme için yeni fikirler ve yaklaşımlar üretmek için kullanılan yaratıcı düşünme tekniğidir. SCAMPER' daki her harf, hedeflenen süreci geliştirmek için farklı bir ipucunu temsil eder. Bu ipuçları sırasıyla yerine koyma, birleştirme, uyarlama, değiştirme, başka bir amaçla kullanma, eleme ve tersine çevirme anlamına gelir. SCAMPER'ı Makine Mühendisliği eğitimi için bir metodoloji çerçevesi olarak evrimleştirmek, prensiplerini ve ipuçlarını mühendislik öğrencilerinin ihtiyaçlarına ve zorluklarına özgü olarak adapte etmeyi içerir. Bu çalışma, SCAMPER metodolojisinin makine mühendisliği eğitimi için bir eğitim çerçevesi olarak kullanımını ve son sınıf öğrencilerine verilen Makine Mühendisliği Tasarımı dersine uygulanmasını, önceki derslerden elde edilen deneyimlere dayalı önerilen örneklerle sunmaktadır.

Anahtar Sözcükler: Metodoloji çerçeveleri, Tasarım eğitimi, SCAMPER, Makine mühendisliği tasarımı, Eğitimsel yenilik

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INTRODUCTION

Methodology frameworks within the realm of engineering education encompass meticulously structured approaches or models. Their purpose lies in shaping the blueprint for designing, executing, and appraising educational practices within the diverse spectrum of engineering disciplines. These frameworks stand as the cornerstone of a methodical infrastructure, offering a systematic pathway to arrange and enhance the dynamics of the teaching and learning journey. By doing so, they seamlessly facilitate the delivery of a comprehensive and impactful educational experience to aspiring engineers.

In the evolution of Engineering Education Research (EER) as a discipline, the collaboration between EER scholars and experts in learning theory, psychology, education research, and other social sciences becomes crucial to shaping learning theories rather than solely drawing from them, especially in integrating business-related skills into modern engineering education; thus, this paper outlines rigorous EER research and methodological traditions to foster interdisciplinary dialogue and future collaborative advancements (Reynolds & Dacre, 2021). This exploratory review paper utilizes a methodological taxonomy to analyze 142 articles from major engineering education journals published in 2018, highlighting diverse profiles across journals, identifying patterns and trends, offering insights for novice researchers, and addressing crucial questions about quality and rigor in the emerging field of Engineering Education Research (EER) (Liu, 2019). The systematic literature review (Reynolds & Dacre, 2021) organizes studies on engineering identity, categorizing them by four variables: definitions of engineering identity, factors impacting its development, interventions influencing it, and measurement methods, offering insights for future research and educational enhancements in the field by connecting various strands of literature and methods and aligning identity definitions and factors with interventions.

One of the methods used for learning is PLB (Project Based Learning). The paper by (Lacuesta et al., 2009) outlines an experience utilizing problem-based learning (PBL) methodology to cultivate positive learning attitudes and multifaceted skills in engineering students, leading to a significant shift from traditional teaching to an independent learning model, with positive assessments from both instructors and students, providing valuable insights for other authors seeking to implement active learning methodologies in engineering education. In another study, the integration of Education for Sustainable Development (ESD) principles within problem-based learning (PBL) in engineering education revealed challenges due to curriculum constraints and contextual balancing, yet highlighting the potential and limitations of sustainability integration, using empirical analysis of two engineering master programs at Aalborg University, Denmark (Guerra, 2017).

One of the studies explores how methodology discourses, particularly discussions on rigor and methodological diversity, have been integral in shaping and advancing the emerging field of engineering education research, contributing to the broader literature on science and technology studies by analyzing the role of these discourses in boundary work and their impact on the development of the field (Beddoes, 2014). An example of different methods, flipped learning is studied in a qualitative synthesis of quantitative and qualitative research of the approach in engineering education, aiming to provide practitioners with insights by critically assessing existing research, revealing that flipped learning gained traction among engineering educators after 2012 and highlighting the need for future research to establish the pedagogy of flipped learning through a comprehensive exploration of various aspects and grounded theoretical frameworks (Karabulut-Ilgu et al., 2018).

Addressing challenges like sustainability, the fourth industrial revolution, and employability, this article evaluates the need for new engineering programs that cultivate cross-disciplinary skills, contextual understanding, and the ability to navigate complexity, analyzing past and present institutional responses, including student-centered learning, theory-practice integration, digital learning, and professional competency definition, while also discussing emerging trends such as personalized curriculum models for lifelong learning (Hadgraft & Kolmos, 2020).

To sum up the importance of research on the subject in this exemplar study, the authors advocate for the implementation of systematic reviews in engineering education to facilitate access to the literature, encourage objective critique, identify research gaps, and suggest new directions for the field's advancement, drawing parallels with systematic reviews in other disciplines (Borrego et al., 2014).

When the studies of SCAMPER employed in engineering education is concerned, there are numerous works that can be listed. In response to evolving market demands, the engineering industry requires interdisciplinary skills and creative thinking; thus, modern engineering education should prioritize nurturing innovative thinking, problem-solving abilities, and transferable skills through creativity-focused courses and innovative teaching methods, as demonstrated in this study utilizing project-based learning and SCAMPER strategies to assess differences between high- and low-creativity learners in terms of cognition, motivation, and personality traits over two semesters (Wu & Wu, 2020). Another study explores the impact of utilizing the SCAMPER technique on third-year product design students' creative idea generation, revealing that the technique enhances creativity in tackling existing product problems, as evidenced by improved indicators of fluency, flexibility, originality, and elaboration in their generated ideas (Boonpracha, 2023).

Concentrating on the design aspect, the study by (Plichta et al., 2018) presents a case study utilizing the SCAMPER method for innovating abrasive tools used in machining challenging materials, demonstrating its effectiveness in modernizing designs, enhancing functions, and generating innovative solutions, while also providing a structured approach for creative activities supported by theoretical and experimental knowledge. Another qualitative study investigated the efficacy of the SCAMPER technique from the perspective of Vocational College students, revealing that while some students unconsciously used the technique, they were generally unaware of it; however, the findings underscore the technique's potential to significantly enhance creativity and thinking skills in learning, particularly in fields like fashion design (Kamis et al., 2020). A study (Chan, 2017) proposes an industrial design approach using the SCAMPER method to reshape the system for renting, thereby addressing cost concerns and making the system more accessible, reliable, and mobile for medical personnel in the dental implant market.

On the creative thinking side, the study (Sirbiladze, 2017) mentions the technique, renowned for its simplicity, is an effective creative thinking and problem-solving method in the design process, emphasizing that innovation is often rooted in modifying existing concepts; despite the availability of various methods like reversed brainstorming, Hurson's thinking model, and others, SCAMPER stands out as a straightforward and accessible approach to fostering creativity and breaking down barriers against innovation. Another research aims to assess basic and altered creativity levels in an architectural design studio course using the Torrance Creativity Thinking Test components (Fluency, flexibility, originality, and elaboration) and the SCAMPER technique, finding that creativity-based instruction enhances architectural design skills in terms of fluency, flexibility, originality, and elaboration, but raises concerns about the potential negative impact on students' originality and potential design imitation (Talebi et al., 2020).

Concentrated on a former curriculum, the study by (Wulandari & Ega Santoso, 2019) employs a combination of project-based learning and SCAMPER strategies to enhance fluid mechanics learning, revealing that this approach resulted in high levels of student attention, happiness, interest, and engagement as measured by questionnaire responses.

In this paper, a modified version of SCAMPER, called SCAMPER-ME, that is specifically designed for Mechanical Engineering education is propose. How SCAMPER-ME can be used as a methodology framework to guide students through the creative process of engineering design is explained. The pedagogical benefits of incorporating SCAMPER-ME into the curriculum and how it can enhance students' creativity, problem-solving skills, and engineering design abilities are also discussed. The application of SCAMPER-ME to various design projects and challenges in Mechanical Engineering courses is demonstrated. An example of how SCAMPER-ME can be used to improve a bicycle design project is also provided.

In the realm of engineering education, conceptual design plays a pivotal role in shaping the foundation for innovative and effective engineering solutions. Conceptual design involves the exploration and formulation of ideas at the initial stages of a project, setting the stage for the detailed design and implementation phases (Pugh, 1991; Ullman, 2010). The significance of robust conceptual design methodologies cannot be overstated, as they lay the groundwork for successful engineering outcomes.

The Engineering Design Research (EDR) community emphasizes the importance of methodological frameworks that guide students through the creative and critical thinking processes inherent in conceptual design (Cross, 2021; Otto & Wood, 2001). This study introduces the SCAMPER-ME methodology, an adapted version of the SCAMPER technique tailored for Mechanical Engineering education, as a methodological framework to enhance conceptual design in engineering courses. SCAMPER-ME aims to foster creativity, problem-solving skills, and engineering design abilities among students, aligning with the principles of effective conceptual design.

These references (Pugh, 1991; Ullman, 2010; Cross, 2021; Otto & Wood, 2001) provide insights into the theoretical foundations of conceptual design and underscore its importance in the engineering design process. By integrating SCAMPER-ME into Mechanical Engineering education, we aim to bridge the gap between conceptual design theories and practical application, providing students with a structured approach to explore their creativity and develop innovative engineering solutions.

The SCAMPER technique is versatile and can be applied in both top-down and bottom-up design approaches, depending on the context and the level at which the design process is initiated. It offers a creative thinking framework that can be flexibly adapted to different stages of the design process, making it a valuable tool for engineers and designers regardless of their chosen design methodology. Top-down design typically involves starting with a broad perspective or a high-level overview and then gradually breaking down the components into more detailed sub-systems or elements. In the context of the SCAMPER technique, the process often begins with a predefined problem or existing design. Conversely, a bottom-up design approach involves starting with detailed components and gradually assembling them into a complete system.

The comparison between the two approaches in terms of SCAMPER constituents are as follows:

Substitute: In a top-down approach, substitution may involve considering alternative components or materials at a higher level, examining how the overall system can be improved by substituting one major element with another. At a bottom-up level, substitution may involve considering alternative materials or components within a specific subsystem.

Combine: Combining, in a top-down context, could involve integrating entire subsystems or major components to create a more holistic and integrated solution. Combining, in a bottom-up context, might involve integrating smaller elements or features to enhance a particular aspect of the system.

Adapt: Adapting in a top-down manner might entail adjusting the overall design to better align with external factors or changing requirements. Adapting at a lower level could entail adjusting individual components to better suit the requirements or constraints of a specific context.

Modify: Modification at a higher level could refer to altering the overall structure or design approach to enhance performance or functionality. Modification in a bottom-up approach might involve tweaking individual components or processes to optimize their performance.

Put to Another Use: This may involve considering how the entire system or major components could be repurposed or applied in a different context. This may involve exploring how specific components or features could be repurposed within the context of a particular subsystem.

Eliminate: Eliminating at a top-down level might involve removing entire features or subsystems that are deemed unnecessary. Eliminating at a bottom-up level could involve removing unnecessary features or components from a specific subsystem.

Reverse: Reversing in a top-down perspective could mean looking at the overall design from a different viewpoint or considering how the system operates in reverse. Reversing in a bottom-up perspective might involve examining how individual components operate in reverse within a subsystem.

SCAMPER-ME METHOD

Creative thinking and problem-solving are integral to the design process, aiming to transform ideas into innovations and dismantle barriers to creativity. Among various methods for fostering creative thinking, the SCAMPER technique is recognized as a straightforward and effective approach, rooted in the notion that novelty often emerges from modifying existing concepts. Introduced by Bob Eberle, SCAMPER involves seven techniques: substitute, combine, adapt, modify, put to another use, eliminate, and reverse, each prompting specific questions during brainstorming to spark innovative ideas and solutions as seen in Fig.1. The technique doesn't follow a strictly sequential order, and participants are encouraged to think freely, even if responses seem illogical, ultimately facilitating diverse thinking approaches for creative outcomes.

The SCAMPER technique involves seven distinct strategies for creative thinking and problem-solving: Substitute, Combine, Adapt, Modify, Put to Another Use, Eliminate, and Reverse. Each strategy prompts specific questions to guide brainstorming sessions, encouraging exploration of different aspects of a product, service, or process, ultimately fostering innovation and creativity through multidimensional problem-solving.

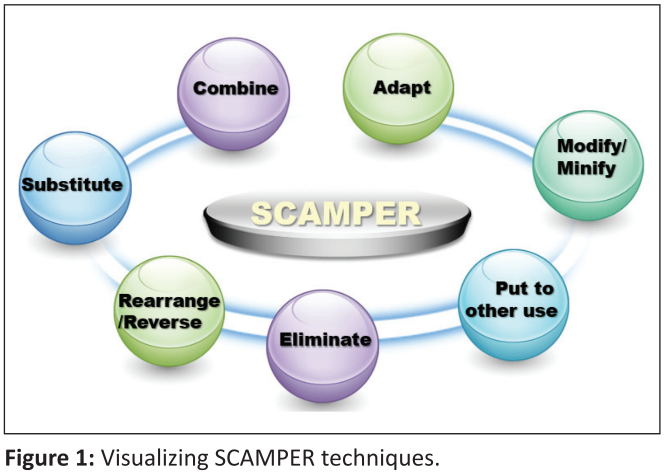

Figure 1: Visualizing SCAMPER techniques.

Forming an educational methodological framework for the Mechanical Engineering Department of a university involves tailoring the approach specifically to the needs of the discipline. In order to create that, certain values are to be considered. These could be listed as:

- Understanding the Department's Mission and Vision
- Identifying the Department's Learning Outcomes
- Conducting a Curriculum Review
- Establishing Educational Principles and Bases
- Identifying Pedagogical Strategies
- Integrating Industry-Relevant Content
- Technology Integration
- Promoting Experiential Learning
- Assessment and Evaluation
- Faculty Development and Training
- Promoting Student Engagement
- Establishing Advisory Boards
- Continuous Improvement
- Communication and Implementation
- Monitoring and Evaluating

When we think in terms of mechanical engineering education, one can employ SCAMPER as a methodology framework. It involves adapting principles and prompts to cater specifically to the needs and challenges of engineering students. As an exemplary situation, we created a new framework called "SCAMPER-ME" (SCAMPER for Mechanical Engineering). Here we modify and expand the SCAMPER methodology to suit Mechanical Engineering education. For the Solve (S): We emphasize the problem-solving aspect of engineering design. Encourage students to identify real-world engineering challenges and devise innovative solutions using the SCAMPER-ME prompts. For Conceptualize (C): We encourage students to conceptualize their designs from various angles, considering factors such as materials, manufacturing processes, and system integration. For Adapt (A): We adapt existing engineering concepts, principles, or technologies to address new challenges or optimize existing designs. Encourage students to explore how ideas from different engineering disciplines can be adapted for their projects. For Modify (M): We encourage students to modify existing mechanical designs, components, or processes to improve performance, efficiency, sustainability, or user experience. For Propose (P): Instead of just substituting or combining, this step focuses on generating new proposals for mechanical designs, systems, or machines. Students can come up with entirely new concepts and ideas that have not been previously explored. For Evaluate (E): We teach students to critically evaluate their proposed solutions using engineering principles, feasibility

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analysis, and potential impacts on society and the environment. For Refine (R): We emphasize the iterative nature of engineering design. Students should continually refine their designs based on feedback, testing, and analysis. For Model (ME): We incorporate modeling techniques and simulations to enable students to test and optimize their designs before physical prototyping virtually.

By incorporating these modifications and expanding the SCAMPER methodology for Mechanical Engineering education, students gain a comprehensive framework to enhance their creativity, problem-solving skills, and engineering design abilities. We apply the SCAMPER-ME framework in Mechanical Engineering education as follows:

- Select a Mechanical Engineering Project: Choose a project that aligns with the learning objectives and challenges students to think creatively and analytically.
- Introduce SCAMPER-ME: Explain the SCAMPER-ME framework and its eight steps to students, highlighting the importance of each stage in the engineering design process.
- Explore Existing Solutions: Encourage students to study existing engineering solutions and designs relevant to their projects.
- Apply SCAMPER-ME Prompts: Guide students through each SCAMPER-ME prompt to generate new ideas and modifications for their project.
- Develop Concepts: Have students create detailed engineering concepts based on their SCAMPER-ME ideation.
- Prototype and Test: Depending on the scope of the project, encourage students to build physical prototypes or use computer simulations to test and evaluate their designs.
- Iterate and Refine: Emphasize the iterative nature of engineering design, and have students refine their concepts based on feedback, testing, and analysis.
- Present and Discuss: Organize presentations where students can showcase their designs and explain the rationale behind their decisions.
- Reflect and Learn: Facilitate discussions on the learning outcomes and experiences gained through the SCAMPER-ME process.

By incorporating SCAMPER-ME into Mechanical Engineering education, students are equipped with a structured approach to explore their creativity, develop innovative engineering solutions, and cultivate essential skills required in their future engineering careers.

The top-down analysis of creating a framework for a Mechanical Engineering Design Course involves carefully structuring the course to promote effective learning and the development of essential design skills. The requirements of this framework include:

- Defining Learning Objectives
- Understand the Target Audience
- Establish Educational Principles and Bases
- Integrate Design Thinking
- Develop a Structured Design Process
- Incorporate Project-Based Learning
- Provide Hands-On Learning Opportunities
- Utilize Design Software and Tools
- Integrate Industry Collaboration
- Encourage Interdisciplinary Collaboration
- Promote Iterative Design
- Include Design Reviews and Critiques
- Assessment and Evaluation
- Facilitate Effective Communication Skills
- Continuous Improvement

With this wide variety of aspects, one needs to focus on the system as well as focus the audience's (students and faculty) needs. SCAMPER might be a good method to achieve this need. It is a method of creative thinking employed to foster fresh ideas and innovative approaches in tackling problems or advancing projects, where each letter represents a distinct prompt to aid in exploring various dimensions of relative endeavor.

Pedagogical Aspect

In a Mechanical Engineering design course, the pedagogical aspect of SCAMPER can be a valuable tool to foster creativity and critical thinking among students. By incorporating SCAMPER into the curriculum, educators can encourage students to explore various dimensions of problem-solving and design innovation. There are numerous advantages that can be listed below about incorporating this method to design education as well as the design solutions.

- **Promoting Creative Thinking:** SCAMPER prompts encourage students to think beyond conventional solutions and explore creative alternatives. It challenges them to generate innovative ideas by applying different strategies to their design projects.
- **Problem-Solving Approach:** SCAMPER provides a structured problem-solving approach that can help students tackle complex engineering design challenges. Each SCAMPER prompt guides students to examine different aspects of their designs and identify potential improvements or novel ideas.
- **Applying Course Concepts:** Integrating SCAMPER in the design course allows students to apply the theoretical concepts they have learned in practical situations. It bridges the gap between theory and real-world engineering design problems.

- **Enhancing Design Iterations:** SCAMPER encourages students to revisit their designs multiple times, experimenting with each prompt. This iterative process can lead to refinements, which is crucial in engineering design to achieve optimal solutions.
- **Team Collaboration:** SCAMPER can be used as a collaborative exercise where students brainstorm and share ideas. This fosters teamwork, communication skills, and the ability to build upon each other's concepts.
- **Real-World Relevance:** SCAMPER is a technique commonly used in industry to spur innovation and product development. Introducing it in the design course exposes students to a practical approach used by professionals.
- **Flexibility and Versatility:** SCAMPER can be adapted to different design projects and challenges, making it suitable for a wide range of Mechanical Engineering applications.
- **Project Diversification:** By incorporating SCAMPER, students can explore a diverse range of ideas, leading to projects that vary in scope and application, further enriching the learning experience.
- **Critical Evaluation:** SCAMPER prompts require students to critically evaluate their designs and potential modifications. This evaluation process strengthens their ability to justify design decisions based on engineering principles.
- **Building Confidence:** As students engage in the SCAMPER methodology and come up with innovative ideas, it boosts their confidence in their problem-solving abilities and creative potential.

To implement SCAMPER pedagogically, instructors can integrate it into design exercises, group projects, or even as part of design reviews. They can also organize workshops or brainstorming sessions dedicated to applying SCAMPER to specific design challenges. The goal is to provide students with a structured yet creative approach to tackle engineering design problems, preparing them to become more innovative and adaptable engineers in the future.

APPLICATION of SCAMPER to DESIGN COURSE

Here's how we apply SCAMPER to a final year graduation project mechanical engineering design course.

For the ***Substitute:*** Students to consider replacing certain materials, components, or processes in the project with alternatives that could improve performance, reduce costs, or enhance sustainability. Substitute traditional manufacturing methods with additive manufacturing (3D printing) for specific components. Replace conventional materials with advanced composites to reduce weight while maintaining strength.

For the ***Combine:*** Students should think about combining different concepts, techniques, or technologies to create a more integrated or multifunctional solution. Combine IoT (Internet of Things) sensors with the mechanical system to enable real-time monitoring and data analysis. Integrate renewable energy sources into the mechanical design to create a hybrid system.

For the ***Adapt:*** Students should explore how similar ideas or solutions from other industries or projects could be adapted to improve the graduation design project. Adapt the principles of biomimicry to design a more efficient and sustainable mechanical system. Take inspiration from nature to improve the aerodynamics of a vehicle or the efficiency of a turbine.

For the ***Modify:*** Students should identify aspects of the project that could be modified or tweaked to enhance performance or address specific challenges. Modify the shape or design of a key component to reduce drag and improve overall efficiency. Adjust the control algorithms to optimize the performance of a robotic system.

For ***Put to another use:*** Students should consider how the project could be repurposed or utilized in different applications or industries. Explore the potential use of the mechanical system in the medical field or as an educational tool. Investigate how the project could be applied in the aerospace or defense industry.

For the ***Eliminate:*** Students should identify unnecessary elements or processes in the project that could be eliminated to simplify the design or reduce costs. Consider removing non-essential features from a product to make it more affordable for a broader market. Eliminate manual calibration processes by implementing automated calibration methods.

For the ***Reverse:*** Students should think about reversing certain aspects of the project to create a new perspective or unique functionality. Reverse the flow direction in a heat exchanger to improve efficiency in specific scenarios. Create a device that can transform mechanical energy into electrical energy but also experiment with its reverse function.

SCAMPER is a versatile technique, and not every prompt may be applicable to the specific project. Students used the prompts that align best with the goals and challenges to stimulate creative thinking and come up with innovative solutions for the mechanical engineering graduation project.

Application Example

To complete the benefit loop of applying SCAMPER into the mechanical engineering design course, one has to give an example. The example applied in Çankaya University Mechanical Engineering Department ME 407 Innovative Engineering Analysis, and Design and ME 408 Innovative Engineering Design and Implementation courses is given below for this purpose and Fig.2. shows this example.

In the project of Improving a Bicycle Design:

- ***Substitute:*** Replace the traditional chain mechanism with a direct-drive system to reduce maintenance and increase efficiency.
- ***Combine:*** Integrate regenerative braking technology to recover energy during braking and store it for future use.

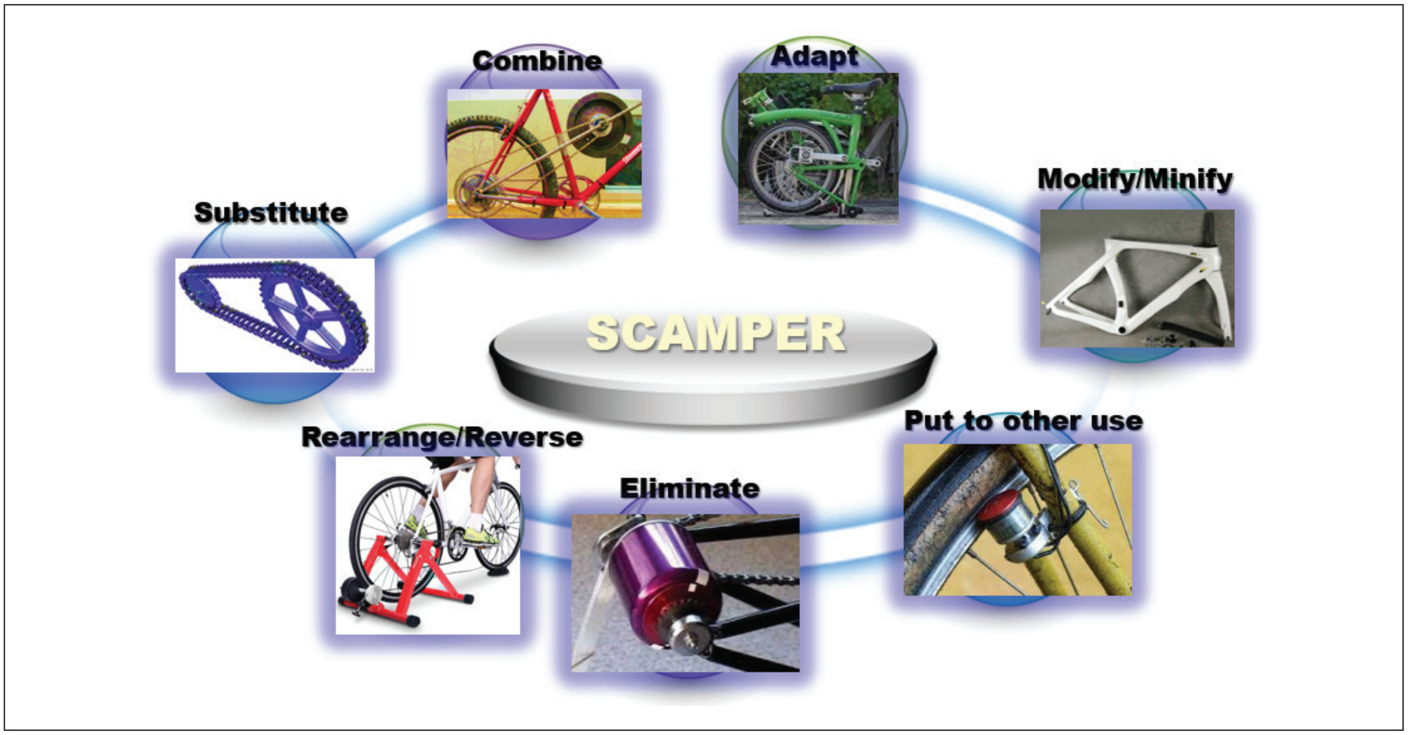

Figure 2: Application of SCAMPER to the bycycle project.

- ***Adapt:*** Adapt the foldable design of electric scooters to create a collapsible bicycle for easy storage and transportation.
- ***Modify:*** Modify the frame material from steel to carbon fiber to reduce weight without compromising strength.
- ***Put to another use:*** Explore the possibility of using the bicycle's kinetic energy to power small electronic devices, such as lights or phone chargers.
- ***Eliminate:*** Remove the need for manual gear shifting by implementing an automatic transmission system.
- ***Reverse:*** Create a bicycle that can transform into a stationary exercise bike for indoor workouts.

This example demonstrates how the SCAMPER methodology can lead to innovative and creative solutions in Mechanical Engineering design. The process encourages students to think critically and explore various angles to improve existing systems or develop new and sustainable solutions to real-world challenges.

CONCLUSION

The study discusses the importance of methodology frameworks in engineering education and how they can provide a systematic way to design, implement, and evaluate educational practices in engineering disciplines. It introduces SCAMPER, a creative thinking technique that can be used to generate new ideas and approaches for problem-solving or project development. It then proposes a modified version of SCAMPER, called SCAMPER-ME, that is tailored specifically for Mechanical Engineering design education. It explains how SCAMPER-ME can be applied to various design projects and challenges and how it can foster creativity, problem-solving skills, and engineering design abilities among students. It also outlines the pedagogical benefits of incorporating SCAMPER-ME into the curriculum and provides an example of how it can be used to improve a bicycle design. It concludes by highlighting the potential of SCAMPER-ME as a versatile and effective methodology framework for Mechanical Engineering education.

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