Outcome-Based Education (OBE) for the Integration of Mechanical and Electrical Engineering Teaching Method

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Abstract

Outcome-Based Education (OBE) is growing in importance for teaching mechanical and electrical engineering together. This paper explores the background, significance, methods, application, findings, and conclusions of using OBE in this combined field. The research background focuses on society's concerns about education quality and skill development, as well as the evolution of educational theories. OBE's main goal for integrating mechanical and electrical engineering education is to develop highly skilled professionals. Its importance lies in increasing employability, promoting interdisciplinary thinking, improving educational quality, aligning education with industry needs, fostering innovation and competition, and encouraging lifelong learning. Implementing OBE can enhance teaching quality, boost skills and knowledge, improve problem-solving abilities, increase employability, and strengthen teamwork and communication. It also makes the curriculum more relevant to industry, builds stronger partnerships, enhances reputation, supplies qualified professionals, and boosts innovation, competitiveness, and sustainable development.

Introduction

Outcome-Based Education (OBE) is a teaching method that focuses on what students need to learn and understand by setting clear goals. In Mechanical and Electrical Engineering, OBE involves defining these learning objectives and planning lessons accordingly. Instead of teaching mechanical and electrical engineering separately, the curriculum could start with a problem that requires understanding from both areas. This encourages students to learn the skills needed from both fields to find solutions. For example, courses might cover how mechanical components function and how electronics control them accurately. This might involve projects where students create a robotic arm that combines mechanical movement with electronic controls. At the beginning of an OBE course, students know what they are expected to learn by the end. These outcomes might include designing systems that integrate mechanical and electrical skills, solving complex problems involving both fields, and understanding how mechanical and electrical components work together. Based on students' performance, teaching methods can adapt to ensure everyone develops the necessary skills for combining mechanical and electrical engineering (Sumathi, Savithramma, & Ashwini, 2024; Spady, 1998; Steele, 1992).

The Outcome-Based Education (OBE) method focuses on ongoing improvement. It helps teachers and students continuously enhance their efforts. Teachers assess how well students achieve learning goals, which allows them to find ways to improve teaching methods. The OBE approach offers a clear and focused educational path, equipping students with essential skills and knowledge for success in this interdisciplinary field (Guggari, Okoye, & Abraham, 2023; Xu, Ge, & He, 2024).

The study aims to highlight what the modern industrial world demands. In fields like robotics, automotive engineering, and automation, mechanical and electrical systems must work together efficiently. For instance, in robotics, the structure of a robotic arm allows it to move, while electrical systems help control its precise movements. These systems are dependent on one another. However, traditional teaching often separates these areas of study, which means students aren't fully prepared for jobs that require skills in both. Outcome-Based Education (OBE) for integration seeks to fill this gap, producing graduates equipped to meet the demands of industries that need a blend of mechanical and electrical expertise. As technology rapidly progresses in areas like mechatronics and smart manufacturing, it’s crucial for engineers to grasp both areas. Engineers working on smart factories, for example, must integrate mechanical machinery with cutting-edge electrical control and communication systems to achieve automation and high efficiency. This study also emphasizes focusing on students’ potential achievements.

Background and Importance

Mechanical and electrical engineering have both advanced rapidly and become more complex in recent years. Traditional teaching methods often focus on delivering knowledge and skills separately, without showing how they connect to real-world industry needs. This results in a gap between classroom learning and workplace requirements. The integration of mechanical and electrical engineering presents challenges due to their differences. Mechanical engineering focuses on mechanics, materials, and manufacturing, while electrical engineering deals with electronics, circuits, and control systems. To bridge this gap and prepare students for the demands of modern engineering, a new approach is essential. OBE emerges as a solution to these challenges. OBE shifts the focus to what students need to learn and achieve by the end of their program. Specifically, in the integration of mechanical and electrical engineering, OBE defines the skills students should acquire. OBE is crucial for integrating mechanical and electrical engineering education for several reasons. First, it enhances students' employability. By aligning educational outcomes with industry needs, students gain practical skills and problem-solving abilities that make them ready for real jobs. Employers appreciate this readiness, and students can adapt quickly to the workplace. Second, OBE fosters a more active learning environment. Students are not just passive recipients of information; they become active participants in their learning journey. They understand the goals and can take charge of their learning process to achieve these goals. For example, if students need to develop a fault diagnosis system for mechanical-electrical equipment, they are encouraged to explore techniques, work with peers, and find resources on their own to reach their targets. Third, OBE improves the quality and relevance of the curriculum. It involves ongoing evaluation and enhancement of teaching content and methods. Educators continuously assess whether the current curriculum meets the desired outcomes and make necessary adjustments (Spady, 1994; Spady & Marshall, 1991; Vickery, 1988).

Key Principles

In recent years, when teaching mechanical and electrical engineering together, it's really important to set clear learning goals. These should cover technical knowledge and skills but also include abilities like teamwork, clear communication, and critical thinking. For example, one goal could be to create a control system for a machine using electrical sensors and actuators. Students should also be able to explain the design process and what it means in simple terms (Abdullah & Primus, 2020).

Student-Centered Approach

Outcome-Based Education (OBE) focuses on the individual student in the learning process. It customizes teaching approaches, materials, and assessments to fit each student's specific needs and abilities. In a mechanical and electrical engineering course, this method involves giving different levels of help and challenges, depending on what students already know and how they learn (Acharya, 2003; Han, Mason, Cook, Rutar Shuman & Turns, 2020).

Continuous Assessment and Feedback

Checking progress regularly is really important in Outcome-Based Education (OBE). This helps students understand how they are doing and if they are meeting their goals. There are different ways to assess progress, such as through quizzes, projects, presentations, and practical exams. In projects that involve both mechanical and electrical engineering, it's helpful to do assessments at various points during the design and building stages. This makes sure students are on the right path and helps them improve by providing useful guidance (Wong, Kwek, & Tan, 2020).

Curriculum Alignment

The curriculum should be carefully planned to help students meet their goals. Each module and course should play a role in achieving the main learning objectives. For instance, classes like mechanical dynamics and electrical circuits should be synchronized, allowing students to combine their knowledge from both areas when tackling joint projects. This coordination ensures that learners effectively integrate what they've learned in practical situations (Tan, 2019).

Backward Design

Outcome-Based Education, or OBE, often uses a method called backward design. This means you start by deciding what you want students to learn or achieve in the end. Once you have those outcomes, you can plan the rest. You think about the teaching activities that will help students reach those goals, select the right learning materials, and decide how you will test their understanding. For example, imagine you want students to learn how to solve problems in complex mechanical-electrical systems. In that case, you'd focus their learning on practical exercises and real-world case studies. These methods help students gain the skills they need by giving them hands-on experience (Wiggins, Grant, & McTighe, 1998).

Emphasis on Lifelong Learning Skills

OBE, which stands for Outcome-Based Education, aims to equip students with more than just technical skills. It focuses on lifelong learning skills for their careers. This includes the ability to learn independently, solve problems, and stay current with technological changes. For mechanical and electrical engineering students, this might involve learning how to keep up with the latest industry standards and new technologies. The main ideas of OBE help teachers combine lessons from both fields effectively. This ensures that students gain the necessary skills and knowledge to excel in a multidisciplinary engineering environment (Williams, Johnson, Peters, & Cormack, 1999).

Methodology

Defining Learning Outcomes

Mechanical and electrical engineering integration blends ideas from both engineering fields. This means learning goals need to be clear so students get the knowledge and skills they need. One goal is to learn how to create systems that mix mechanical and electrical parts. For example, students should learn to build a robotic arm with mechanical parts for movement and electrical parts for control and sensing. It's also important for students to understand how mechanical and electrical components interact. They need to analyze how changing a mechanical design impacts electrical performance and vice versa. For instance, altering the gear ratio in a machine can change the motor's power needs. Students should become familiar with key software tools, like CAD for mechanical design and software for simulating electrical circuits. Communication and teamwork skills are also crucial. In real projects, mechanical and electrical engineers work closely together. For example, when creating an automated manufacturing line, both need to ensure mechanical conveyors and electrical control systems work together smoothly. Problem-solving is essential. Students should be able to tackle tough challenges, like improving the energy efficiency of a hybrid vehicle, by identifying problems and suggesting solutions. Clearly defined learning goals in this engineering field help students gain the skills they need for success (Adam, 2004).

Specific Skills and Knowledge

In mechanical and electrical engineering integration, several skills and knowledge areas are crucial for success. First, understanding electrical circuits is vital. This includes knowing how resistors, capacitors, and inductors work. Being able to design and analyze circuits is important, especially for power supply and signal processing. For instance, you might create a reliable power supply for a machine with changing power needs. Another key area is sensors and actuators. Sensors, such as those that measure position, force, and temperature, help monitor mechanical systems. Mechanical design skills are important, too. This involves understanding materials and construction to design strong structures that work with electrical parts. Imagine designing a gearbox that connects to an electric motor; choosing the right materials and gear sizes are a key. These skills and knowledge areas are fundamental for effective mechanical and electrical engineering integration, allowing for the creation of innovative and reliable systems (Acero, Velasquez, Apaza, Callata, & Lloclla, 2023).

Mechanical Design Skills

Knowing how to use CAD/CAM software is a key for designing mechanical parts and how they fit together. You need to understand how to choose materials for these parts by considering their strength, durability, and cost-effectiveness. It's crucial to have the skill to design mechanisms and transmissions that convert electrical energy into mechanical motion. Being proficient in 3D modeling with tools like SolidWorks or AutoCAD is important for creating intricate mechanical structures. A strong understanding of stress analysis and finite element methods is essential to ensure designs are strong and safe. Designing precise gears, bearings, and other mechanical components is necessary for efficient power transmission. Additionally, grasping how to manage heat within mechanical systems is critical to prevent them from overheating and ensure they run smoothly (Mott, Vavrek & Wang, 2018; Adegbite et al., 2023).

Electrical Engineering Skills

Ability to design and analyze different types of electrical circuits, including both digital and analog ones, Understanding the operation of electrical motors, drives and control systems. Skilled in creating power electronics circuits for motor control and converting power. Proficient in writing programs for microcontrollers and creating embedded systems for controlling electrical equipment and familiar with important electrical safety standards and regulations (Adegbite et al., 2023).

Integration and Interfacing Skills

It’s important to know how to smoothly connect mechanical and electrical systems. It needs to understand communication protocols and how different parts work together. It’s also crucial to understand sensors and actuators and how to link them with these systems. You should be able to design mounts and enclosures that fit electrical parts without disrupting how they work. Knowing about signal conditioning and filtering techniques is vital for accurate data transfer between these systems. Developing custom protocols can help different systems work together smoothly. Additionally, understanding electromagnetic compatibility (EMC) is important to stop electrical and mechanical parts from interfering with each other (Adegbite et al., 2023).

Problem-Solving and Troubleshooting Skills

The ability to finding and fixing issues in systems to combining mechanical and electrical parts and know how to detect and isolate faults with specific techniques. Experience in using of testing tools and equipment in solve problems. Find troubles step-by-step by checking various possible causes. Use devices like oscilloscopes, multi-meters, and logic analyzers to detect faults. Analyze error codes and system logs to accurately pinpoint issues.

Experience in implementing corrective measures and verify their effectiveness (Delvicario, Lauria, Mellodge,, & Yu,, 2018; Lin, Shahhosseini, & Badar, 2017).

Project Management Skills

I have the ability to manage projects that involve combining mechanical and electrical components. This means I can plan schedules, manage budgets, and allocate resources effectively. I am familiar with various project management methods and tools. I have good communication and teamwork skills, which help me, work well with diverse teams. My leadership skills are strong, allowing me to guide teams of mechanical and electrical engineers successfully. I can develop detailed project plans, complete with goals and timelines. I'm also skilled at identifying risks and finding solutions to potential issues in these projects. Plus, I can communicate effectively to keep stakeholders informed about project progress and to address any of their concerns (Panuwatwanich et al., 2011).

Industry Requirements and Expectations

Understanding both mechanical and electrical engineering is very important in many fields today. Professionals in this area have to meet certain standards. One major expectation is having a solid grasp of both mechanical and electrical basics. For mechanical engineering, industries expect a good understanding of mechanics, thermodynamics, and materials science. On the electrical side, engineers should know about circuits, electronics, and control systems. Take the automotive industry as an example: engineers working on hybrid vehicles need a clear understanding of how engines and transmissions work mechanically, as well as knowledge of the electrical parts like batteries and motor control systems. Teamwork across different fields is essential too. Mechanical and electrical engineers frequently collaborate with software engineers, manufacturing experts, and project managers. Effective communication, sharing ideas, and working towards common goals are vital. In aerospace projects, for instance, teams from mechanical, electrical, and software divisions must work closely to ensure an aircraft's flight control system operates successfully. Being familiar with industry standards and regulations is also important. This ensures integrated systems are safe and comply with legal conditions. In manufacturing, for instance, optimizing the mechanical and electrical parts of a production line to cut down on downtime and energy use can lead to big savings. High quality and reliability are essential. Systems should consistently perform well in their intended environments. Meeting all these expectations helps professionals contribute effectively and drive innovation in mechanical and electrical engineering fields (Han, Mason, Cook, Rutar Shuman & Turns, 2020).

Population and Sample

Population

The group we are focusing on includes anyone interested or involved in both mechanical and electrical engineering, along with related education and industries. This group covers educational institutions such as universities, high schools, administrative offices, and technical or vocational schools that teach mechanical or electrical engineering. These institutions have teachers, students, and staffs who are interested in the subjects taught, teaching methods, and the overall quality of education. The survey results most likely come from a smaller segment of this large group. The main aim is to grasp the thoughts, preferences, and needs of the entire population involved.

Sample

The sample in this study appears to consist of representatives from various Educational Institutions, Secondary School, technical and vocational institutes and administration offices related to mechanical and electrical engineering. Here are some details about the sample:

Types of Respondents

Educational Institutions: There are responses from universities such as Tianjin University of Technology and Education, as well as Federal Technical and Vocational training Institute, colleges and etc. Respondents from these institutions include faculty members and possibly administrators who have insights into the curriculum and educational programs related to mechanical and electrical engineering integration.

Respondent Characteristics

Gender: The majority of respondents are male, but there are also some female respondents, indicating an attempt to capture a diverse range of perspectives within the sample.

Age and Qualification: From the bar chart of the data given below most respondents are in the 30 - 40 age groups, which may suggest that this age cohort is more likely to be involved in decision-making processes regarding engineering education and industry requirements.

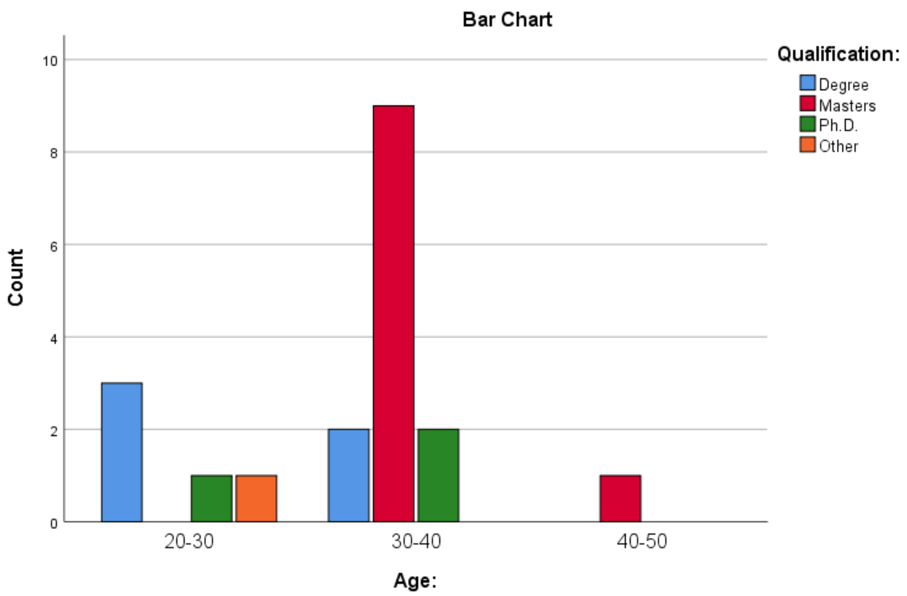

Figure 1. Age and Qualification of the Respondents

A significant number hold a master's degree, with some having a bachelor's degree and a few with a Ph.D. This indicates a relatively well-educated sample, which is likely to have a good understanding of the technical and educational aspects of mechanical and electrical engineering.

Years of Experience: Many respondents have more than 11 years of experience, which implies that they have substantial practical knowledge and insights into the field. However, there are also respondents with 1 - 5 years of experience, and a few with more than 16 years of experience, adding some diversity to the sample in terms of experience levels.

Table 1. Years of Experience

		Frequency	Percent
Valid	1-5	5	26.3
	11-15	12	63.2
	16-20	2	10.5
	Total	19	100.0

Overall, the sample seems to be a diverse group of individuals from different educational and industry backgrounds, which can provide a comprehensive view of the industry requirements and expectations for outcome-based education in the integration of mechanical and electrical engineering.

Data Collection Method

The data collection method for this survey on industry requirements and expectations for outcome-based education in the integration of mechanical and electrical engineering appears to be a questionnaire-based approach. Here are the details:

Questionnaire Design

Structured Questions: The questionnaire contains a series of structured questions covering various aspects of mechanical and electrical engineering integration. These questions are designed to gather information about the current state of integration in institutions and companies, the importance of integration for competitiveness, the desired outcomes of education programs, the importance of different technical and soft skills, and the evaluation of existing educational programs and potential areas for improvement.

Rating Scales: Many questions use rating scales to quantify responses. For example, questions about the frequency of using integrated mechanical and electrical engineering in teaching or products processes use a scale from "Always" to "Rarely". Questions about the importance of various factors use scales such as "Very important" to "Low" or "Critical" to "Not important". This allows for a standardized way of collecting and analyzing responses.

Distribution of the Questionnaire

The questionnaire was distributed online. Considering the current prevalence of online surveys and the ease of data collection and analysis, it's possible that an online platform was used.

Targeted Audience: The questionnaire was targeted at individuals who have a good understanding of mechanical and electrical engineering integration in their respective institutions or Schools. This includes faculty members, administrators in educational institutions, and engineers, managers, or technical experts in companies.

Response Collection and Recording

Response Recording: The responses were recorded in an Excel spreadsheet. Each row represents a respondent, and the columns contain the responses to each question. This format allows for easy data entry and subsequent analysis.

Data Integrity: To ensure data integrity, it's likely that some validation was done during the data entry process. For example, ensuring that responses to rating scale questions were within the defined range and those mandatory questions were answered.

Overall, the questionnaire-based data collection method used in this study provides a structured way to gather a large amount of information from a targeted audience. However, like any data collection method, it has its limitations, such as potential response biases (e.g., respondents may overstate or understate certain aspects).

Detailed Analysis of Survey

Utilization and Importance

Current Utilization

The data shows that the extent of utilization of integrated mechanical and electrical engineering in institutions varies. Around 47.6% of the respondents (9 out of 19) indicated "Often" or "Always," suggesting a relatively high frequency of utilization in some institutions. However, about 15.8% (3 out of 19) reported "Rarely" indicating that a significant portion of institutions have limited integration in their teaching or product processes. But, 36.8% of the institutions uses sometimes. For example, institutions like the Federal Technical and Vocational training Institute and Tianjin University of Technology and Education seem to have a higher level of utilization, while Wolkite Poly Technic College and Arsi Zone Administration Office have a lower level.

Importance to Competitiveness

The majority of respondents rated the importance of mechanical and electrical engineering integration to their institution's competitiveness as high or very high. About 78.9% (15 out of 19) rated it as "High" to "Critical."

This indicates that most institutions recognize the significance of integration in enhancing their competitive edge.

Table 2. Importance of Mechanical and Electrical Engineering Integration

		Frequency	Percent
Valid	Low	1	5.3
	Moderate	3	15.8
	High	7	36.8
	Very high	3	15.8
	Critical	5	26.3
	Total	19	100.0

Institutions such as the General Wingate polytechnic college and the Chinese Academy of Sciences emphasized the critical role of integration in competitiveness, highlighting the need for a strong integration strategy.

Importance of Outcome-Based Education Focusing on Industry Needs

Overall Importance: Almost all respondents (17 out of 19) considered it very or extremely important for educational programs in mechanical and electrical engineering integration to focus on specific outcomes related to industry needs. This shows a strong consensus on the relevance of aligning education with industry requirements.

Table 3. Importance of Outcomes in Education

		Frequency	Percent
Valid	Slightly important	1	5.3
	Moderately important	1	5.3
	Very important	15	78.9
	Extremely important	2	10.5
	Total	19	100.0

Specific Outcome Ratings: Technical Proficiency in Integration: Rated as very important by most respondents. Over 57.9% (11 out of 19) gave it a rating of 4 or 5, emphasizing the need for graduates to have strong skills in designing integrated systems.

Table 4. Technical Proficiency in Integration (E.G., Designing Integrated Systems)

		Frequency	Percent
Valid	Slightly important	1	5.3
	Neutral	2	10.5
	Moderately important	5	26.3
	Very important	11	57.9
	Total	19	100.0

Problem-solving Skills in Mechanical and Electrical Contexts: Also highly regarded, with around 47.4% (9 out of 19) rating it as very important. This indicates the importance of equipping graduates with the ability to handle complex problems in the field.

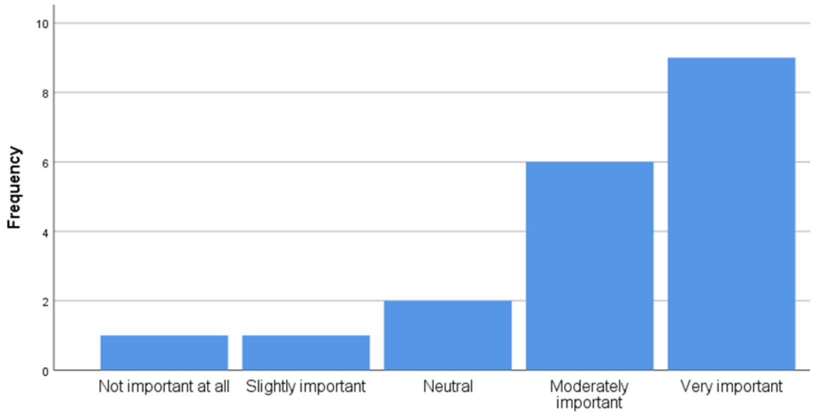

Figure 2. Problem-Solving Skills in Mechanical and Electrical Contexts

Ability to Work in Teams with Diverse Backgrounds: Considered very important by about 68.4% (13 out of 19) of the respondents, highlighting the collaborative nature of the mechanical and electrical engineering industry.

Table 5. Ability to Work in Teams with Diverse Backgrounds

		Frequency	Percent
Valid	Neutral	2	10.5
	Moderately important	4	21.1
	Very important	13	68.4
	Total	19	100.0

Understanding of Industry Standards and Regulations: Nearly 63.2% (12 out of 19) of the respondents rated it as very important, emphasizing the need for graduates to comply with industry norms.

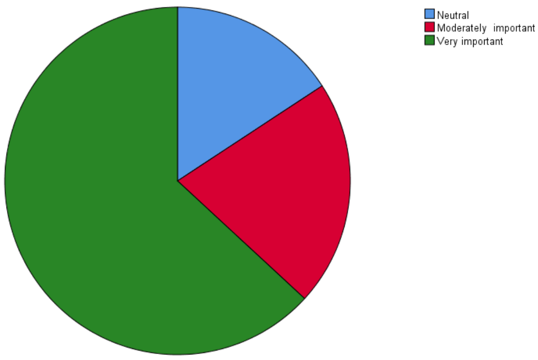

Figure 3. Understanding of Industry Standards and Regulations

Adaptability to New Technologies and Changes in the Field: Rated as very important by about 57.9% (11 out of

19) of the respondents, reflecting the dynamic nature of the industry.

Table 6. Adaptability to New Technologies and Changes in the Field

		Frequency	Percent
Valid	Slightly important	1	5.3
	Neutral	3	15.8
	Moderately important	4	21.1
	Very important	11	57.9
	Total	19	100.0

Project Management Skills for Integration Projects: Around 57.9% (11 out of 19) rated it as very important, indicating the importance of graduates being able to manage projects effectively.

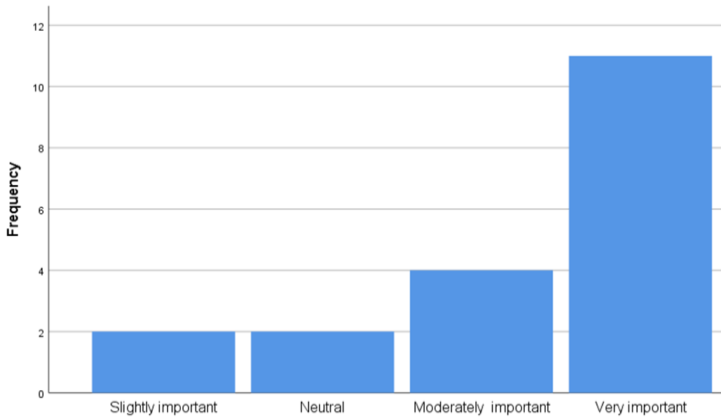

Figure 4. Project Management Skills for Integration Projects

Communication Skills (Written and Oral) in Presenting Technical Information: Rated as very important by about 87% (13 out of 15) of the respondents, emphasizing the need for clear communication in the field.

Table 7. Communication Skills (Written and Oral) In Presenting Technical Information

		Frequency	Percent
Valid	Neutral	2	10.5
	Moderately important	6	31.6
	Very important	11	57.9
	Total	19	100.0

Technical Skills and Knowledge Areas in Outcome-Based Education

Importance Ratings

The respondents were asked if they rate the importance of the following technical skills and knowledge areas that should be emphasized in an outcome-based education and their responses are summarized in the following table below. Knowledge of Mechanical Design Principles and Software: Rated as very important by about 57.9% (11 out of 19) of the respondents, highlighting its significance in the field.

Table 8. knowledge Of Mechanical Design Principles and Software (E.G., CAD)

		Frequency	Percent
Valid	Slightly important	2	10.5
	Neutral	3	15.8
	Moderately important	3	15.8
	Very important	11	57.9
	Total	19	100.0

Electrical Circuit Design and Analysis: Around 47.4% (9 out of 19) rated it as very important, indicating its importance but perhaps with a slightly lower emphasis compared to some other areas.

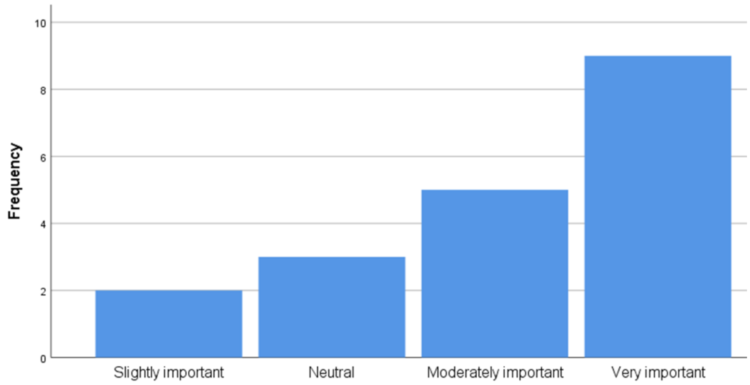

Figure 5. Electrical Circuit Design and Analysis

Programming for Control Systems: About 73.7% (14 out of 19) rated it as very important or moderately important, showing the growing importance of programming skills in modern mechanical and electrical engineering.

Table 9. Programming For Control Systems (E.G., PLC Programming)

		Frequency	Percent
Valid	Not important at all	1	5.3
	Slightly important	1	5.3
	Neutral	3	15.8
	Moderately important	6	31.6
	Very important	8	42.1
	Total	19	100.0

Mechatronics System Design and Integration: Rated as very important and moderately important by about 63.2% (12 out of 19) of the respondents, emphasizing its central role in the integration of mechanical and electrical components.

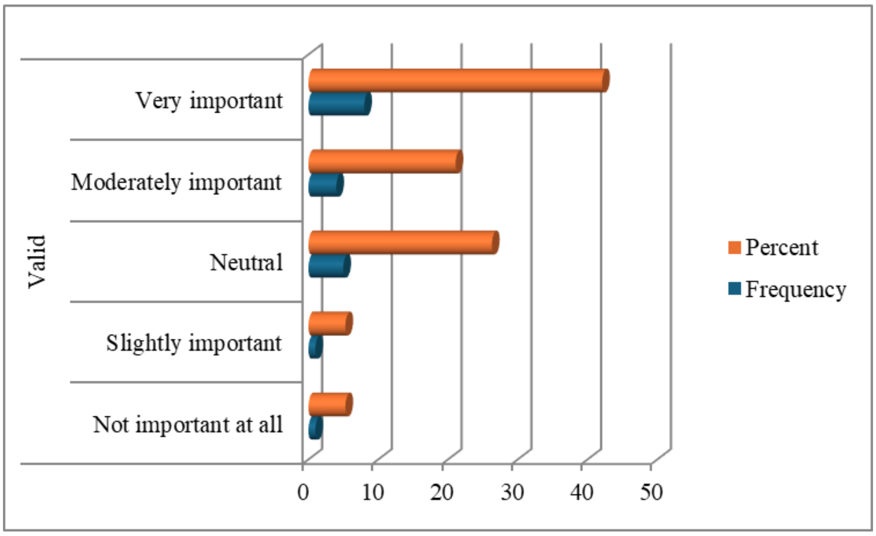

Figure 6. Mechatronics System Design and Integration

Sensor and Actuator Technologies: Around 68.4% (13 out of 19) rated it as moderately important and very important, highlighting its relevance in modern systems.

Table 10. Sensor and Actuator Technologies

		Frequency	Percent
Valid	Not important at all	1	5.3
	Slightly important	1	5.3
	Neutral	4	21.1
	Moderately important	6	31.6
	Very important	7	36.8
	Total	19	100.0

Understanding of Power Systems in Mechanical and Electrical Setups: About 73.7% (15 out of 19) rated it as moderately important and very important, indicating its importance in the overall functioning of integrated systems.

Table 11. Understanding of Power Systems in Mechanical and Electrical Setups

		Frequency	Percent
Valid	Not important at all	1	5.3
	Slightly important	1	5.3
	Neutral	3	15.8
	Moderately important	6	31.6
	Very important	8	42.1
	Total	19	100.0

Knowledge of Manufacturing Processes for Integrated Products: Rated as moderately important and very important by about 63.7% (14 out of 19) of the respondents, emphasizing the need for an understanding of the production aspect.

Table 12. Knowledge of Manufacturing Processes for Integrated Products

		Frequency	Percent
Valid	Slightly important	2	10.5
	Neutral	3	15.8
	Moderately important	5	26.3
	Very important	9	47.4
	Total	19	100.0

Simulation and Modeling of Mechanical and Electrical Systems: Around 68.4% (13 out of 19) rated it as moderately important and very important, showing its usefulness in design and analysis.

Table 13. Simulation and Modeling of Mechanical and Electrical Systems

		Frequency	Percent
Valid	Slightly important	3	15.8
	Neutral	3	15.8
	Moderately important	7	36.8
	Very important	6	31.6
	Total	19	100.0

Frequency of Skill Update Expectation

The majority of respondents expect employees to update or expand their technical skills in these areas More frequently and annually are equal (about 26.3%, 5 out of 19) each and every 1 - 2 years (about 31.6%, 6 out of 19). This indicates the need for continuous learning to keep up with technological advancements.

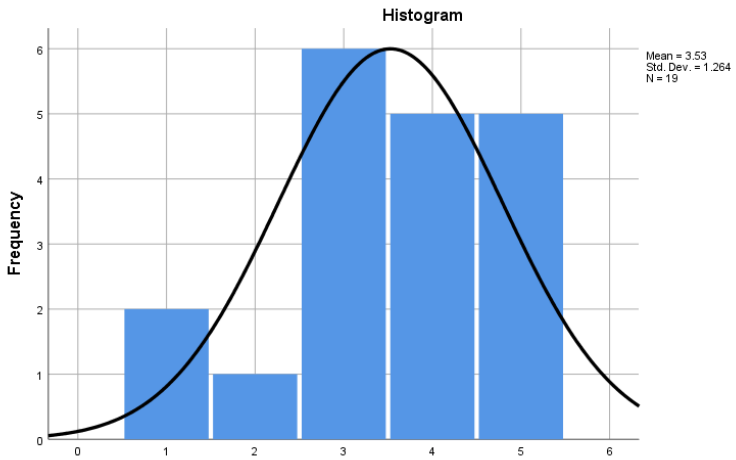

Figure 7. Expected Employees to Update or Expand their Technical Skills

Institutions like Tianjin University of Technology and Education and the Chinese Academy of Sciences emphasized the importance of frequent skill updates, while some others had slightly different expectations.

Soft Skills and Competencies

Importance Rankings

Communication Skills (Interpersonal and Technical Communication): Ranked as moderately important and very important by about 73.7% (14 out of 19) of the respondents, highlighting its crucial role in the workplace.

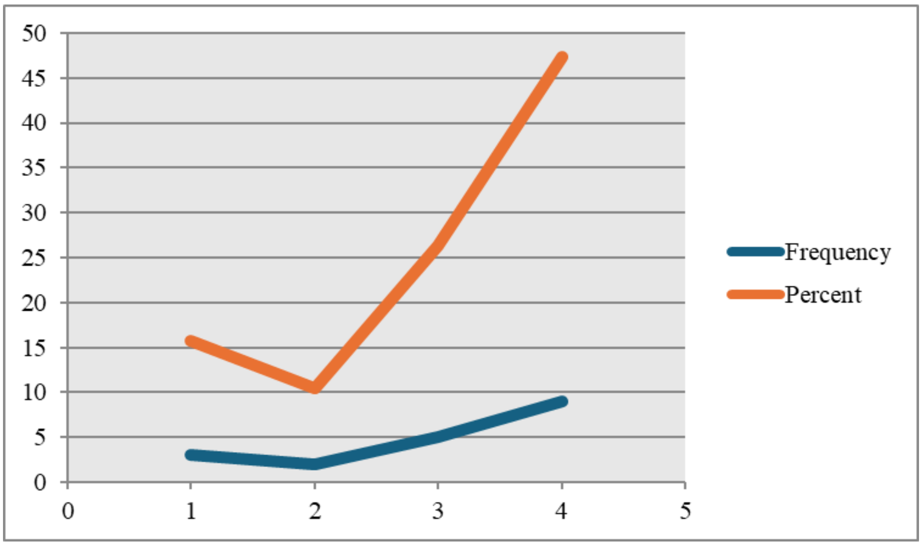

Figure 8. Communication Skills (Interpersonal and Technical Communication)

Teamwork and Collaboration Abilities: Considered moderately important and very important by around 73.7% (14 out of 19) of the respondents, emphasizing the collaborative nature of the industry.

Table 14: Teamwork And Collaboration Abilities

		Frequency	Percent
Valid	Not important at all	1	5.3
	Slightly important	2	10.5
	Neutral	2	10.5
	Moderately important	5	26.3
	Very important	9	47.4
	Total	19	100.0

Project Management and Organization Skills: Rated as moderately important and very important by about 68.5% (13 out of 19) of the respondents, indicating the need for effective project handling.

Creativity and Innovation in Problem-solving: Around 79% (15 out of 19) rated it as moderately important and very important, showing the value of creative solutions in the field.

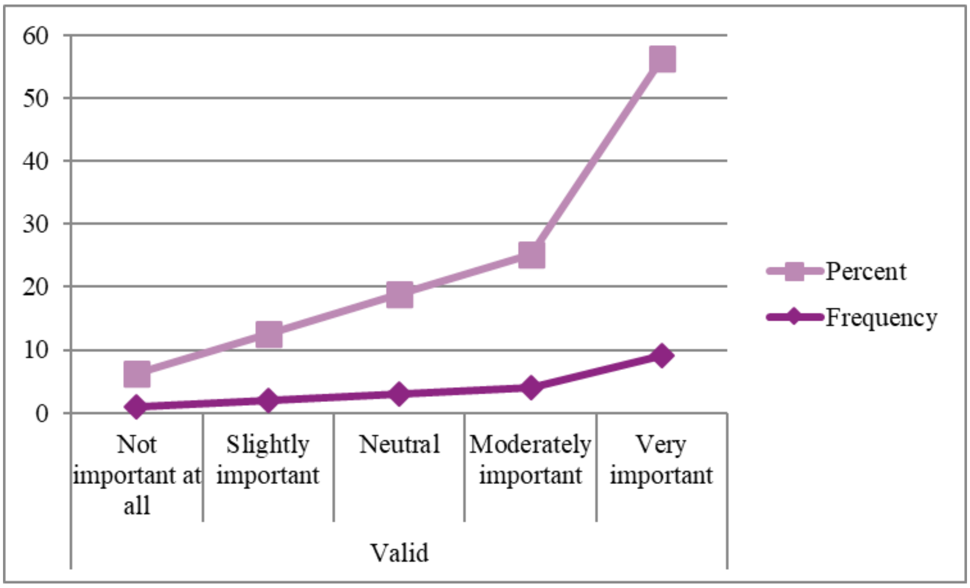

Figure 9. Project Management and Organization Skills

Table 15. Creativity and Innovation in Problem-Solving

		Frequency	Percent
Valid	Not important at all	1	5.3
	Slightly important	1	5.3
	Neutral	2	10.5
	Moderately important	6	31.6
	Very important	9	47.4
	Total	19	100.0

Adaptability and Flexibility in Work Environments: About 73.7% (14 out of 19) rated it as moderately important and very important, reflecting the need to adapt to changing work conditions.

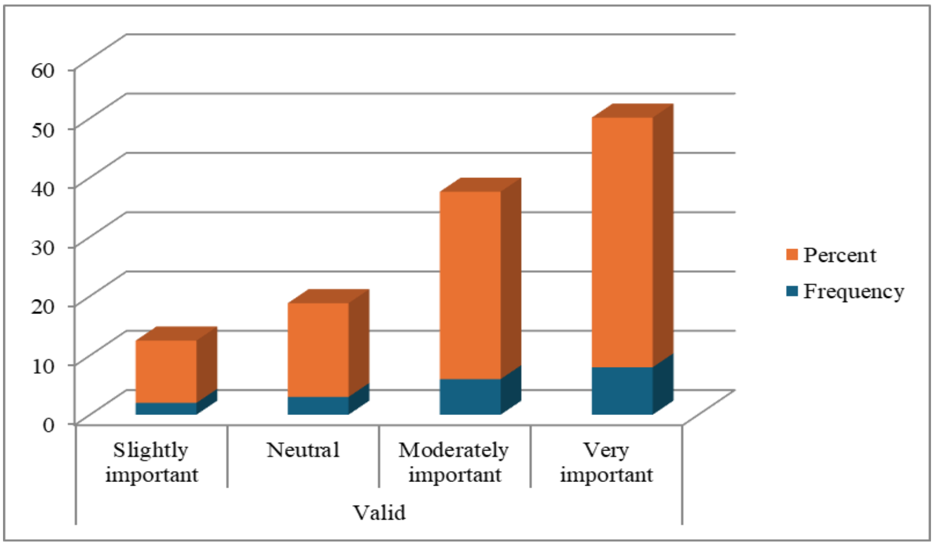

Figure 10. Adaptability and Flexibility in Work Environments

Time Management and Ability to Meet Deadlines: Rated as moderately important and very important by around 68.5% (13 out of 19) of the respondents, emphasizing the importance of timely completion of tasks.

Leadership Skills (Even at an Entry-level to Lead Small Tasks or Teams): About 63.1% (12 out of 19) rated it as moderately important and very important, indicating its growing importance in the industry.

Analytical and Critical Thinking Skills: Rated as moderately important and very important by around 73.7% (14 out of 19) of the respondents, highlighting the need for sound decision-making.

Table 16. Analytical and Critical Thinking Skills

		Frequency	Percent
Valid	Slightly important	3	15.8
	Neutral	2	10.5
	Moderately important	6	31.6
	Very important	8	42.1
	Total	19	100.0

Perception of Educational Institutions in Development of Soft Skills

Only about 21.1% (4 out of 19) of the respondents thought educational institutions were doing a good job of developing these soft skills in students. The majority (about 63.2%, 12 out of 19) had a more neutral or negative perception, suggesting that there is room for improvement in this area. Institutions like Tianjin University of Technology and Education were seen as doing a relatively better job, while others needed to enhance their efforts in soft skill development.

Alignment of Educational Programs with Industry Requirements

Perceived Alignment

The perception of the alignment of current educational programs with industry requirements varied. About 42.1% (8 out of 19) of the respondents rated it as "Moderately closely" or "Very closely," while 52.6% (10 out of 19) rated it as "Slightly closely" and "Not at all closely." This indicates a need for improvement in bridging the gap between education and industry. Some institutions, like the General Wingate polytechnic college and Tianjin University of Technology and Education, had a more positive perception, while others, like the Federal TVET Institute, felt there was a significant disconnect.

Areas Needing Improvement in Educational Programs

Curriculum Content Related to the Latest Industry Trends and Technologies: Rated as urgently needing improvement by about 68.4% (13 out of 19) of the respondents, highlighting the importance of keeping the curriculum up to date. Practical Training and Hands-on Projects: Also rated as urgently needing improvement by about 57.9% (11 out of 19) of the respondents, emphasizing the need for more practical experience in education. Industry Partnerships and Internships: Around 73.7% (14 out of 19) rated it as urgently needing improvement, indicating the value of strong industry connections. Teaching Methods that Encourage Real-world Problem-solving: Rated as urgently needing improvement by about 73.7% (14 out of 19) of the respondents, showing the need for more practical and problem-based learning. Exposure to Different Industry Applications and Case Studies: About 73.6% (16 out of 19) rated it as urgently needing improvement, emphasizing the importance of providing diverse industry exposure.

Future Trends and Their Impact

Likelihood of Future Trends

The likelihood of future trends such as increased use of artificial intelligence and machine learning in design and optimization, greater emphasis on sustainable and energy-efficient solutions, and expansion of the Internet of Things in integrated systems was rated as likely or very likely by the majority of respondents (about 63.2% for different trends). This indicates the expected growth and importance of these trends in the industry. Institutions like the Chinese Academy of Sciences and Tianjin University of Technology and Education were among those that recognized the high likelihood of these trends.

Impact on Skills and Knowledge Requirements

The respondents believed that these trends would require advanced technical skills in the new technologies rated as important and greater focus on interdisciplinary knowledge and skills, requirement for continuous learning and adaptability, enhanced importance of problem-solving and innovation skills and changes in the types of soft skills needed. This shows the need for educational institutions to adapt their programs to meet these evolving requirements.

Expectations from Educational Institutions

Incorporation of Emerging Technologies

About 73.7% (14 out of 19) of the respondents expected educational institutions to incorporate relevant emerging technologies into the curriculum. This reflects the importance of keeping the education up-to-date with the latest technological advancements. Institutions like the Chinese Academy of Sciences and Tianjin University of Technology and Education were expected to lead in this regard.

Fostering an Environment of Innovation

Around 78.9% (15 out of 19) of the respondents expected educational institutions to foster an environment of innovation and experimentation. This would help students' creativity and ability to adapt to new challenges. Universities with a strong research focus, such as the Chinese Academy of Sciences, were seen as having the potential to create such an environment.

Strengthening Interdisciplinary Teaching

About 84.2% (16 out of 19) of the respondents expected educational institutions to strengthen interdisciplinary teaching and learning. This is crucial for students to understand the integration of mechanical and electrical engineering and other related fields. Institutions like Tianjin University of Technology and Education, which offer a wide range of disciplines, were expected to enhance their interdisciplinary efforts.

Establishing Industry Partnerships

Around 89.5% (17 out of 19) of the respondents expected educational institutions to establish partnerships with industry for practical exposure and projects related to future trends. This would help students gain real-world experience and understand industry needs. Vocational training institutes like the Federal Technical and Vocational training Institute were expected to further expand their industry connections.

Suggestions for Improvement

Some of the common suggestions for improving the outcome-based education in mechanical and electrical engineering integration included strengthening practical training, updating curriculum content more frequently and enhancing industry collaboration. These suggestions can help educational institutions better meet the industry requirements and improve the quality of graduates. Institutions like the TVET Institute recommended process mutual curriculum design and increasing cooperative training to better prepare students for the industry.

Results of Descriptive Analysis on Survey

Frequency of Use: The usage of integrated mechanical and electrical engineering in institutions varies. Responses range from "Always" to "Rarely", with "Often" and "Sometimes" being common responses. Institutions with higher levels of technical focus or those in the field of technology education tend to use it more frequently. Importance for Competitiveness: The integration is generally regarded as very important or critical for the competitiveness of institutions. Ratings mostly fall in the "Very high" to "Critical" range, indicating that it is seen as a key factor in maintaining a competitive edge in the industry.

Importance of Industry - Relevant Outcomes in Education

Overall Importance: Respondents strongly emphasize the importance of educational programs focusing on specific outcomes related to industry needs. Ratings are predominantly "Very important" to "Extremely important ", highlighting the need for a close alignment between education and industry requirements.

Key Outcomes for Graduates:

Technical Proficiency: Skills such as technical proficiency in integration (e.g., designing integrated systems), problem - solving skills in mechanical and electrical contexts, and understanding of industry standards and regulations are rated as very important. This reflects the industry's expectation that graduates have a solid technical foundation.

Soft Skills: Soft skills like the ability to work in teams with diverse backgrounds, communication skills (written and oral), and adaptability to new technologies are also considered crucial. This shows that the industry values not only technical expertise but also interpersonal and adaptive abilities.

Technical skills and knowledge areas for emphasis

Important Areas: Knowledge of mechanical design principles and software (e.g., CAD), electrical circuit design and analysis, programming for control systems (e.g., PLC programming), mechatronics system design and integration, sensor and actuator technologies, etc., are considered important to be emphasized in outcome - based education.

Update Frequency: The expected frequency for employees to update or expand their technical skills in these areas is typically annual or every 1 - 2 years, indicating the need for continuous learning to keep up with technological advancements.

Soft Skills for Success

Key Soft Skills: Communication skills (interpersonal and technical communication), teamwork and collaboration abilities, project management and organization skills, creativity and innovation in problem - solving, adaptability and flexibility in work environments, etc., are ranked as important soft skills for success in mechanical and electrical engineering integration.

Current Development in Education: Opinions on whether educational institutions are doing a good job of developing these soft skills vary. Responses range from "Very good" to "Poor", suggesting that there is room for improvement in soft skill development within educational programs.

Alignment of Education Programs with Industry Requirements

Match with Industry Needs: People have various views on how well current educational programs in mechanical and electrical engineering fit industry needs. Some feel there's a strong match, while others see no alignment at all. Many agree there's room for improvement to bridge the education-industry gap.

Key Areas for Improvement: To better align education with industry requirements, several areas need attention. These include updating curriculum content with the latest industry trends and technologies, increasing practical training and hands-on projects, enhancing industry partnerships and offering more internships, using teaching methods that emphasize real-world problem-solving, and giving students more opportunities to learn from different industry applications and case studies.

Internship and Co - op Programs

Prevalence and Importance: Many schools and companies offer programs that allow students in mechanical and electrical engineering integration to gain work experience. These include internships and co-op programs. Such programs are considered crucial because they help identify and train future employees. They also build strong ties between the industry and educational institutions. Ratings for these programs are often very high due to their importance. Importance of Practical Experience: Practical experience through internships and projects is extremely important for students learning to become professionals in this area. Hands-on learning and exposure to real-world situations is a key to preparing students for careers in the industry. These experiences are vital for developing the necessary skills and knowledge needed to succeed.

Qualities and Skills of Interns/Recent Graduates

Essential Traits: For interns or newcomers in a job, several traits are crucial. Being able to solve real-world problems by applying theoretical knowledge is important. Having initiative and being self-motivated are also key. It's important to be willing and quick to learn new things. Professionalism and a strong work ethic matter a lot too. Additionally, understanding the company culture and being able to work well within the team are vital. These traits help in making the transition from school to work smooth and successful.

Collaboration between Institutions and Companies

Collaboration Status: Many institutions collaborate with companies in some way to enhance the quality of education in mechanical and electrical engineering integration. However, there are various challenges associated with these collaborations.

Challenges: Different goals and priorities between the company and the institution, difficulty in scheduling and coordinating activities, lack of communication and information sharing, resistance to change in the educational curriculum, limited resources (time, money, personnel) for collaboration, legal and administrative hurdles, and quality and commitment of students participating in the programs are all identified as challenges.

Future Trends in Integration

Expected Trends: Looking ahead, to see a rising in the usage of artificial intelligence (AI) and machine learning for designing and optimizing processes. We can also anticipate advancements in additive manufacturing, which will enable more personalized production of mechanical and electrical parts. Products and processes will feature more complex and integrated smart systems. Additionally, new materials with distinct mechanical and electrical properties are expected to emerge. These changes reflect the direction mechanical and electrical engineering are likely heading.

The Significance of Interdisciplinary Teamwork

Comprehensive Skill Development: By working together, students from mechanical and electrical engineering backgrounds can acquire a broader range of skills. For instance, mechanical engineers can learn about electrical control systems, and electrical engineers can gain insights into mechanical design and manufacturing when faced with challenges in integrating mechanical and electrical systems, a diverse team can offer unique ideas and approaches (Y. -L. Han, G. Mason, K. Cook, T. Rutar Shuman and J. Turns, 2020).

Challenges and Solutions

Outcome-Based Education (OBE) has become a popular teaching method, especially in mechanical and electrical engineering. However, for it to be successful and truly beneficial for students, certain challenges need to be managed effectively. When applying OBE to areas like Mechanical and Electrical Engineering (MEE), we encounter several issues. By addressing these strategically, educational institutions can implement OBE successfully, ensuring that students receive a comprehensive and practical education. Here are the challenges and potential solutions:

Different Educational Backgrounds of Students

Challenge: Students entering these interdisciplinary programs often come with varying levels of knowledge and skills. Some might excel in mechanical areas, while others are stronger in electrical topics.
Solution: Introduce assessments at the start and offer bridging courses to level the playing field. These initial courses should cover fundamental concepts shared by both mechanical and electrical fields, such as programming basics, circuit theory, and key mechanical principles.

Combining Mechanical and Electrical Knowledge

Challenge: Mechanical and Electrical Engineering are distinct areas with their own theories and methodologies.
Solution: Curriculum developers should collaborate to create courses that seamlessly integrate mechanical and electrical topics. Courses can be divided into modules focusing on specific interdisciplinary topics, with complexity increasing as students’ progress.

Balancing Theory and Practice

Challenge: A key goal of Outcome-Based Education (OBE) is to ensure that students can use their knowledge in real-world situations.

Solution: To ensure students gain practical experience, it's important to include labs, workshops, and design challenges in the curriculum. Collaborating with companies in the fields of robotics or automated systems gives students the chance to work on real-world projects, helping them to understand the practical challenges of interdisciplinary engineering (Hoidn, S., 2020).

Conclusion

Implementing Outcome-Based Education (OBE) for mechanical and electrical engineering can be challenging, but it's worth the effort. When schools address these challenges and find effective solutions, they prepare students well for the changing fields of mechanical and electrical engineering. OBE focuses on what students need to learn, making education more student-centered. This approach actively involves students in their learning journey and motivates them to reach clear learning goals. It improves their understanding and skills in mechanical and electrical engineering and teaches them how to use this knowledge in real-world situations. With OBE, educators improve their teaching methods by aligning lessons with specific learning goals. This leads to more focused, effective teaching, which benefits students. Developing appropriate assessment methods to accurately measure student learning can be difficult. Educators must also stay updated with the latest developments to effectively implement OBE.

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