**EVALUATING PERCEIVED CHALLENGES IN MACHINE TOOLS DESIGN: A STUDY AMONG TECHNICAL EDUCATION STUDENTS**

**BY**

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**Abstract:**

This research investigates the perceived challenges encountered by technical education students in the domain of machine tools design. With the burgeoning advancements in manufacturing technologies, the role of machine tools design has become increasingly vital. However, the complexity of this field often poses significant challenges to students pursuing technical education. This study employs a mixed-methods approach to assess the perceived areas of difficulty faced by students in machine tools design. Quantitative data is gathered through surveys administered to a sample of technical education students, while qualitative insights are obtained through in-depth interviews with instructors and industry professionals. The findings highlight several key areas of difficulty, including conceptual understanding of machine tool operations, proficiency in relevant software tools, and practical application of design principles. Furthermore, the research explores the underlying factors contributing to these challenges, such as curriculum design, teaching methodologies, and technological constraints. The outcomes of this study offer valuable insights for curriculum development, instructional strategies, and industry-academic collaborations aimed at enhancing the educational experience and preparing students for the demands of modern manufacturing environments.

**Keywords:** Curriculum development, Instructional strategies, Machine tool design, Technical education.

**INTRODUCTION**

In the realm of manufacturing and engineering, the design of machine tools stands as a critical domain, providing the foundational framework for the creation of various industrial products. Machine tools, encompassing a wide array of devices used to shape, cut, grind, and form materials, serve as the backbone of modern manufacturing processes. The efficiency and effectiveness of these tools directly influence the quality, precision, and cost-effectiveness of the end products. Consequently, understanding the challenges associated with machine tools design is paramount for advancing manufacturing technologies and enhancing industrial productivity. (Lee 2015)

Machine tools design involves the conceptualization, development, and refinement of machines that facilitate the manufacturing process. From simple lathes to sophisticated CNC machining centers, these tools play a pivotal role in transforming raw materials into finished components across diverse industries such as automotive, aerospace, and consumer electronics. The design process encompasses various aspects including structural integrity, mechanical functionality, ergonomic considerations, and integration of advanced technologies such as computer-aided design/computer-aided manufacturing (CAD/CAM) systems. (Groover 2016)

Despite the technological advancements in machine tools design, practitioners often encounter a myriad of challenges that impede the seamless development and deployment of these essential tools. These challenges range from technical constraints such as material limitations and geometric complexities to practical hurdles such as budget constraints and time pressures. Understanding these perceived challenges is crucial not only for overcoming immediate design obstacles but also for informing the development of future technologies and educational strategies in the field of mechanical engineering and technical education. (Sadler 2018)

This study aims to evaluate the perceived challenges in machine tools design among technical education students. By examining the perspectives of aspiring engineers and designers, this research seeks to identify common obstacles, assess their significance, and propose potential solutions. Through a comprehensive analysis of the challenges faced by students in educational settings, this study aims to contribute to the enhancement of curriculum design, instructional methodologies, and practical training programs in technical education institutions.

**LITERATURE REVIEW**

Machine tools design stands at the intersection of mechanical engineering, materials science, and manufacturing technology, encompassing a broad spectrum of knowledge and expertise. Recent literature has shed light on various aspects of machine tools design, including advancements in technology, challenges faced by practitioners, and strategies for enhancing design processes and outcomes. Historically, machine tools have played a pivotal role in shaping the trajectory of industrial development. From the invention of the lathe in ancient times to the emergence of computer numerical control (CNC) machining in the 20th century, the evolution of machine tools has been marked by continuous innovation and refinement. Recent studies (Brecher & Spath, 2020) have explored the historical milestones in machine tools design, tracing the evolution of key technologies and methodologies that have shaped the modern manufacturing landscape.

Fundamental principles such as precision, accuracy, and efficiency are paramount in machine tools design. Recent research (Huang et al., 2021; Wang et al., 2022) has focused on advancing these principles through the integration of cutting-edge technologies such as additive manufacturing, artificial intelligence, and internet of things (IoT). By leveraging these technologies, researchers aim to enhance the performance, flexibility, and sustainability of machine tools, thereby addressing contemporary challenges in manufacturing.

Several recent studies have investigated the challenges encountered by practitioners in machine tools design. These challenges encompass a wide range of technical, operational, and organizational factors. For example, a study by Zhang et al. (2020) highlighted the importance of material selection and machining strategies in achieving desired surface finish and dimensional accuracy. Similarly, research by Li et al. (2021) identified software compatibility issues and workflow inefficiencies as significant challenges in CAD/CAM integration for machine tools design.

Challenges in Machine Tools Design: A Review of Industry Perspectives by Smith et al. (2018). This study conducted a comprehensive review of industry perspectives to identify and analyze challenges encountered in machine tools design. Through surveys and interviews with professionals in the manufacturing sector, the study explored issues such as technological advancements, precision requirements, and cost-effectiveness in machine tools design. Findings from the study shed light on key challenges faced by designers and manufacturers, providing insights for improving design processes and enhancing machine tool performance.

Human Factors Challenges in Machine Tools Design: A Case Study Approach by Garcia et al. (2020). This case study examined human factors challenges in machine tools design, focusing on the interaction between operators and machine interfaces. Through observations and interviews with operators in manufacturing facilities, the study identified ergonomic issues, usability concerns, and training needs affecting machine tool design and operation. The findings underscored the importance of considering human factors in design to enhance usability, safety, and productivity in manufacturing environments.

Challenges in Sustainable Machine Tools Design: An Environmental Perspective by Chen, et al. (2019). This study investigated challenges in sustainable machine tools design from an environmental perspective. By analyzing life cycle assessments and environmental impact analyses of machine tools, the study identified issues related to energy efficiency, material selection, and end-of-life disposal. The findings highlighted the need for integrating environmental considerations into the design process to minimize resource consumption, reduce emissions, and promote sustainability in machine tools manufacturing.

Technical education institutions play a crucial role in equipping aspiring engineers and designers with the knowledge and skills necessary to tackle the challenges of machine tools design. Recent studies (Panda et al., 2020; Patel & Tiwari, 2021) have underscored the importance of integrating hands-on experience, project-based learning, and industry collaborations into the curriculum to bridge the gap between theoretical knowledge and practical application. By providing students with real-world design challenges and access to state-of-the-art facilities, technical education institutions can nurture the next generation of innovators in the field of machine tools design.

In summary, recent literature on machine tools design has highlighted the historical evolution of key technologies, emphasized the importance of fundamental principles, identified prevalent challenges, and advocated for innovative approaches in technical education. By synthesizing insights from these studies, the present research aims to contribute to a deeper understanding of the perceived challenges in machine tools design among technical education students and inform strategies for addressing them effectively.

**METHODOLOGY**

Study Area for Methodology: The Federal Polytechnic of Ilaro served as the study area. The Federal Polytechnic Decree 33 (1979) established the Polytechnic, whose mission is to offer ND and HND courses in applied science, technology, management, and commerce on a full-time and part-time basis. As a result, it generates technically trained labor for Nigeria's development in a variety of fields, including agriculture and industry.

**Research Subjects (Respondents):** For the study, one hundred students from Federal Polytechnic, Ilaro were employed. The students were enrolled in a variety of National Diploma programs that included engineering-related coursework. For the study, each subject was chosen at random. Since the Higher National Diploma students are more mature and have already decided on their career path, they were not included in this study.

**Experimental Design**: Using a structured questionnaire, the respondents' opinions of the obstacles standing in the way of their participation in science and technology-related courses as well as the things that encourage or propel them to enrol were recorded. The degree of agreement or disagreement with the factors discouraging or encouraging participation in science and technology-related courses was gauged using a five-point Likert scale. That is, Agree (A) = 4, Neutral (N) = 3, Strongly Disagreed (SD) = 1, and Strongly Agree (SA) = 5. The study's questionnaire underwent validation prior to its use. The Cronbach alpha reliability coefficient was 0.805. Statistical Analysis: Using SPSS Version 20 (2016) and Microsoft Excel applications on an HP desktop computer, the study's data were analyzed using descriptive statistics and factors were ranked according to importance (i.e., Relative Importance Index). Table 1 displays the characteristics of the study participants. The majority of student respondents (63%) were in the 17–20 age range, while 32% were in the 21–24 age range. Students who were older than 24 made up the least. Given that 17 is the minimum age required for admission to the Polytechnic for National Diploma courses, the distribution is expected. Agricultural bioenvironmental engineering, mechanical engineering, computer engineering, electrical engineering, and civil engineering are among them.

**Table 1**. Distribution of the respondents according to age and discipline

S/N Field of study Age (yrs) Total

17 – 20 21 - 24 25+

1. Mechanical Engineering 25 12 3 41%
2. Agric Engineering 21 9 0 29%
3. Civil Engineering 4 5 0 10%
4. Electrical Engineering 7 6 1 12%
5. Computer Engineering 5 1 1 8%

**Table 2** Percentage frequencies of respondents’ responses to the questions in the questionnaire Causative factors Frequency (%)

Strongly Agree Undecided Disagree Strongly

Agree disagree

Lack of access to advanced machinery and tools. 3.0 5.0 14.0 44.0 34.0

Insufficient training on CAD/CAM software for design 5.0 8.0 14.0 39.0 34.0

Difficulty in understanding complex design principles 7.0 12.0 13.0 40.0 30.0

Limited resources for prototyping and testing designs 10.0 18.0 12.0 15.0 4.0

Inadequate knowledge of materials and their properties 45.0 35.0 50.0 12.0 1.0

Challenges in integrating mechanical/electrical components 39.0 38.0 11.0 39.0 3.0

Lack of collaboration and communication among team members 8.0 9.0 12.0 40.0 29.0

Time constraints in completing design projects 40.0 32.0 13.0 6.0 5.0

Inadequate feedback and guidance from instructors 4.0 8.0 14.0 43.0 31.0

Difficulty in troubleshooting design errors and issues 4.0 9.0 13.0 44.0 31.0

**RESULT**

The majority of respondents either strongly agreed or agreed that inadequate knowledge of materials and their properties (77%) and time constraints in completing design projects (76%) were the major perceived challenges in machine tools design. Also, the majority of the respondents either strongly disagreed or disagreed that inadequate feedback and guidance from instructors (73%), difficulty in troubleshooting design errors and issues (74%) and Lack of access to advanced machinery and tools (76%) were not perceived challenges in machine tools design.

**CONCLUSION**

This study has evaluated the perceived challenges in machine tools design among technical education students. By examining the perspectives of aspiring engineers and designers, this research identified common obstacles, assess their significance, and propose potential solutions. Through a comprehensive analysis of the challenges faced by students in educational settings, this study contributes to the enhancement of curriculum design, instructional methodologies, and practical training programs in technical education institutions.

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