Application of Solidworks Simulation to Improve Mechanical Design Skills of Mechanical Engineering Students in the National Institute of Construction Technology and Management, Edo State, Nigeria

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Abstract

Solid Works, a comprehensive 3D CAD design solution, equips the product design team with all the necessary tools for mechanical designs, verifications, motion simulations, data management, and communication. This paper delves into Solidworks as a pedagogical simulation software, a practical tool that can significantly enhance the mechanical design skills of mechanical engineering students at the National Institute of Construction Technology and Management, Edo State, Nigeria. The study was structured as an educational design experiment, utilizing Solidworks to teach design concepts. Two equivalent groups were formed; one was the experimental group, and the other was the control group. Both groups were given the same project, with the first group using SW-P and the second group using the traditional method. The results showed that Solidworks is an efficient method for enhancing mechanical design skills. Students using Solidworks demonstrated a deeper understanding of the design concepts, surpassing those using the traditional method.

Keywords: Solidworks, mechanical design, skills, mechanical engineering

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Introduction

Mechanical engineering design is the heart of innovation that emphasizes creating, improving, and optimizing machines, components, and systems. Notably, mechanical engineering design entails identifying and solving engineering problems. Although engineering design can take many forms, it is all based on processes. The mechanical design consists of conceptualizing, modeling, and improving mechanical systems. Mechanical engineers are essential in realizing complex concepts, including the design of state-of-the-art automobiles, space probes, and even basic gear mechanisms. Mechanical engineering design is a dynamic field that requires a blend of technical expertise, creativity, and problem-solving abilities. Engineering design courses provide a platform for educators to prepare students with skills and experience in design concepts (Perez et al., 2021)

Insinuations suggest that a growing number of graduates from the mechanical engineering field were not developing the necessary skills needed in the engineering ecosystem. For instance, (Kuppuswamy & Mhakure, 2020; and Yavuzcan and Gür 2020) noted that most engineering education institutions produce great scientists knowledgeable in engineering science, mathematics, analytical techniques, and research but lack the needed skills in engineering designs. Similarly, Cohen and Katz (2015) stated that the mechanical engineering curriculum of many institutions does not include courses that teach students essential professional knowledge needed to become a design engineer. Students who graduate from engineering programs should be prepared to meet the demands of the industry because most engineering jobs involve both designing and practicing.

The use of a wide range of diverse meanings, spaces, processes, and instructional techniques to gain a global perspective on creating the student learning experience is becoming more and more common in research on digital learning (Philippe et al., 2020). Because of recent advancements in computer technology, the fields of science and engineering have become very dynamic. These advancements have produced numerous computer programs to tackle classic and new problems. These applications help design, develop, and control complex systems using the computer's enhanced computational capabilities. Most subjects taught in science education have been covered by computer-based visual simulation learning (Jensen et al., 2002; Chen et al., 2011). A review of these research findings revealed that learning performance can be enhanced if a visualized learning environment promotes learner interactions and allows manipulation (Jensen et al., 2002).

Solid Works is a complete 3D CAD design solution, providing the product design team with all the mechanical designs, verifications, motion simulations, data management, and

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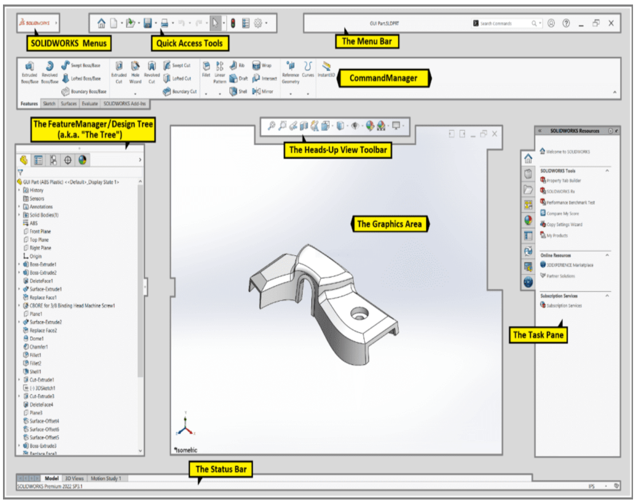
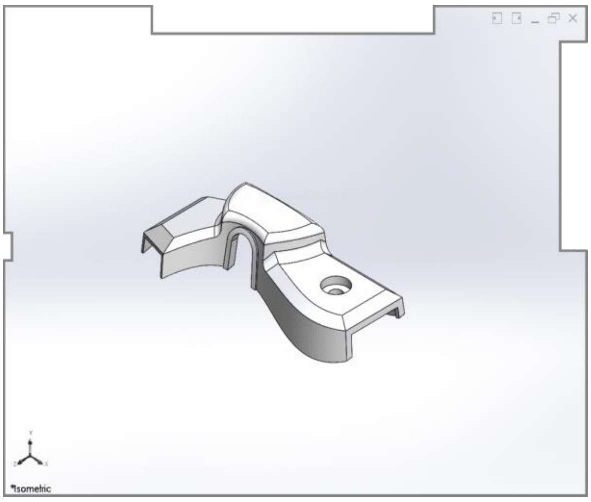
communication tools that they need (Netshimbupfe et al., 2020) The Solidworks software is a mechanical design automation application that lets designers quickly sketch ideas, experiment with features and dimensions, and produce models and detailed drawings. Solidworks adopts parametric modeling techniques and integrates part modeling, assembly modeling, and automatic generation of 2D engineering drawings and other functions. Numerous studies have emphasized the importance of software in engineering designs (Cekus et al., 2019; Eslami, 2017; Fialkova et al., 2023; Gajdoš & Tomek, 2022; Miclosina et al., 2021; Mitin & Sul'din, 2022; Saleh Al-Hammadi et al., 2022; Widiyanti et al., 2016; Yang et al., 2021; Zhetenbayev et al., 2023). They play a pivotal role in engineering designs, revolutionizing how engineers conceptualize, analyze, and create efficient, reliable, and innovative designs, accelerating progress in various engineering fields.



The Solidworks User Interface



Graphics Area

The traditional instructional model recommends bringing a physical model made of wood or plastic to the classroom to develop students' spatial imagination. This is done to familiarize students with solid models. Studies point to severe problems with the incorporation of physical models. In this instance, a larger model is necessary for students to comprehend clearly. However, carrying big models is inconvenient. Furthermore, it was not possible to alter the models at will. As such, the traditional models could not meet the demands of mechanical design education. Using SolidWorks' handy modeling function, students can create a corresponding 3D model and edit it at leisure, providing an intuitive understanding of part design.

Mechanical design and drafting courses are essential courses for engineering majors. The emphasis of mechanical design and drawing courses is different for different majors. However, the primary purpose is to cultivate spatial imagination ability, guide students' robust modeling and 3D construction, and cultivate engineering and technical personnel for enterprises with modern design philosophy and creative thinking ability. The simulation context empowers strong practical quality, aims to develop students' ability to think, analyze, and raise engineering questions, and improves their capacity in design processes.

Generally, mechanical engineering students in the National Institute of Construction Technology and Management, Edo State, Nigeria, are scheduled to take mechanical design and drawing courses in their early years. These courses serve as a connecting link between the preceding and the following in cultivating students' professional ability. The teaching quality is directly concerned with the grasp of subsequent professional knowledge and even influences students' curriculum design and diploma projects. Moreover, mechanical design and drafting courses are firmly applied in future careers.

Strong spatial analysis and imaginative skills are required of engineering students. However, engineering design processes are challenging due to the student's insufficient learning infrastructure, space imagination, and mechanical part exposure. Traditional machine design learning requires students to transfer between 2D pictures and 3D objects, which is precisely why these courses are challenging. It would be highly beneficial if a bridge could be built to integrate the design and manufacturing processes seamlessly. Solidworks modeling creates a visual link and eliminates the need to convert 2D figures into 3D objects. Furthermore, it allows engineers to design components and assemblies in 3D accurately. As a result, it can potentially increase students' comprehension of figures and pique their interest.

Objective of the study

SolidWorks software is a powerful 3D CAD (computer-aided design) program engineers use for design. It helps create models, drawings, and simulations quickly and easily. Thus, this study aims to explore the impact of Solidworks simulation software on mechanical engineering students' design skills.

Method

A quasi-experimental design was adopted. The participants comprised mechanical engineering students from the National Institute of Construction Technology and Management, Edo state, Nigeria. The samples (*n = 47*) were randomly drawn from the Mechanical Engineering Department. The experimental processes were conducted in the laboratory, and skills in mechanical design were determined with a structured questionnaire. The students were assigned to groups (A and B). while the A group was labeled the experimental group, the B group was considered the control group. The students participated in a pre-experiment survey by completing a questionnaire. Students' mechanical engineering design skills were evaluated in a preliminary test.

In the experiment, the experimental group was guided to use SolidWorks to create virtual components and assemblies in digital forms. Students grouped into small design teams could design and visualize their design options for evaluation. While creating virtual components, students could use the feature creation sequence to simulate the design process to visualize how to assemble the designed components. Students could assemble virtual components by the mating relations among components and understand how the components would be assembled for proper operation. On the other hand, group B represents the control condition, and mechanical design was taught using the traditional method. The post-test study was conducted similarly to the pre-test, except the questions were reshuffled. The data from the pre-test and post-test were subjected to data analysis.

Result

Table 1 shows the mean and standard deviation scores for the group.

		Pre-test		Post-test		
Group	N	Mean	Standard Deviation	Mean	Standard Deviation	Mean Gain
Experimental	24	43.17	10.54	50.19	13.68	7.02
Control	23	42.29	11.29	44.39	13.38	2.01
MD		0.88		5.08		

Table 1 shows that the mean in the pre-test study for experimental conditions is 43.17 while the mean in the pre-test for control conditions is 42.29, giving the pre-test mean difference of 0.88. The finding indicates no significant difference in the participants' mean scores on mechanical design skills. On the other hand, the post-test study reveals a mean of 50.19 for the experimental conditions and 44.39 for the control condition, with a mean difference of 5.08. The gain score for the two conditions was 7.02 and 2.01, respectively. Thus, the result shows that the experimental conditions improved mechanical design knowledge due to their exposure to the Solidworks software.

Table 2 shows a t-test comparison.

Source of variation	N	Mean	SD	df	*t*	Sig
Experimental	24	50.19	13.68			
Control	23	44.39	13.38	185	7.328	000

A t-test analysis was performed on the data to determine whether the Solidworks simulation software would increase students' mechanical design skills. The analysis established a significant difference between the experimental and control conditions on mechanical design skills *MD* = 5.08, t (185) = 7.328, p = .000. Thus, the result suggests that the Solidworks software might be used to improve student's mechanical design skills.

Discussion

This study examined the impact of simulation software on mechanical design skills among mechanical engineering students at the National Institute of Construction Technology and Management, Edo state, Nigeria. The result showed a significant difference between the students taught mechanical design processes using Solidworks simulation software and those prepared with conventional methods. For the pre-test and the post-test study conducted, the mean and standard deviation scores showed that exposing the students to Solidworks simulation software significantly influenced their mechanical design skills in the post-test study (*M* = 50.19, *SD* = 13.68) compared to the control group (*M* = 44.39, *SD* = 13.38). The probable explanation for this outcome is that SolidWorks helps to develop a visual representation of the concept in a 3D view. It displays the model in a particular orientation and scale. The drawing view can be annotated with dimensions, geometric tolerances, notes, and other annotations to represent the model with clarity. Thus, users can create parts and assemblies with precise relationships between components and analyze designs' static, kinematic, and dynamic behavior or evaluate the fatigue, thus providing the best-in-class responses.

Conclusion

Solidworks potentially facilitates 3-D modeling, dynamically displaying the cutting process and generating virtual assembly and assembly exploded views. For mechanical engineering design, some instances demonstrate how SolidWorks can dynamically present complex issues encountered in mechanical design and drafting while establishing a fundamental volume model. These issues include an exploded view, plane intersections with the primary volume model, and assembly. The finding supports the significance of Solidworks on the curriculum, students' aptitude for design and spatial imagination, their motivation to learn, and their capacity to recognize drawings. Utilizing Solidworks in the classroom has been demonstrated to substantially reduce the challenge of teaching and learning, boost student motivation, and contribute to successful teaching outcomes. The finding suggests regularly educating teachers in this area and integrating SolidWorks resources into the classroom.

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