STATICALCS: AN INTERACTIVE WEB-BASED LEARNING TOOL WITH INTEGRATED CALCULATORS FOR STATICS OF RIGID BODIES

An Undergraduate Thesis
presented to the
Civil Engineering Department
College of Engineering
Mindanao State University
General Santos City

In partial fulfillment
of the requirements for the degree
Bachelor of Science in Civil Engineering

IAN CARL P. COÑA
SOPHIA DAPHNE C. FAELNAR

Novemberr 2025

Contents

Title Page **i**

1 Introduction **1**

1.1 Background of the Study 1

1.2 Statement of the Problem 2

1.3 Scope and Limitations 3

1.4 Significance of the Study 5

1.5 Conceptual Framework 6

1.6 Definition of Terms 7

2 Review of Related Literature **14**

2.1 Statics of Rigid Bodies in Engineering Education 14

2.2 Conceptual Difficulties in Learning Statics 14

2.3 Procedural and Analytical Challenges 15

2.4 Mathematical Readiness in Statics 16

2.5 Math Anxiety and Its Impact on Engineering Students 17

2.6 Importance of Free Body Diagram Construction 17

2.7 Visualization and Spatial Ability in Engineering 18

2.8 Technology-Based Learning for Engineering Student 18

2.9 Web-Based Learning in Engineering Education 19

2.10 Related Systems and Existing Educational Tools 22

2.11 Summary of Literature 23

3 Methodology **25**

3.1 Research Method 25

3.2 Research Respondents 26

3.3 Research Locale 26

3.4 Research Procedure 27

3.4.1 Website Development Process 28

3.4.2 Website Navigation and Functional Flow 29

3.4.3 Website System Architecture 31

3.5 Statistical Tools 32

References **36**

Chapter 1
Introduction

1.1 Background of the Study

Engineering Mechanics is one of the fundamental components of engineering education, and *Statics of Rigid Bodies* serves as its essential foundation. The course develops the analytical skills needed to understand how forces and moments act on bodies at rest, making it a prerequisite for more advanced engineering subjects. In the Civil Engineering curriculum of Mindanao State University – General Santos (MSU–Gensan), *Statics of Rigid Bodies (ENS161)* is a core subject required for academic progression in the engineering program.

Despite its importance, many students find Statics difficult due to its mathematical requirements and abstract nature. Students often struggle with force systems, moments, and the construction of accurate *Free Body Diagrams (FBDs)*, which are necessary for solving *Statics of Rigid Bodies* problems. I. Salami and Perry found that learners commonly face conceptual and procedural difficulties in Statics, including challenges in visualizing forces and connecting equations to physical situations. These difficulties are further intensified by weak mathematical foundations, particularly in algebra and trigonometry, which are essential for problem-solving in Statics. Felix noted that incoming college students often exhibit declining mathematical readiness, affecting their ability to perform well in computation-heavy subjects.

Additionally, affective factors such as math anxiety contribute to students' performance challenges. Incierto et al. found that higher levels of math anxiety are associated with lower academic achievement, indicating that many students struggle not only with understanding concepts but also with the emotional stress associated with solving mathematical problems. Research also shows that appropriate tools, such as calculators and structured digital aids, can reduce computational errors and alleviate anxiety by allowing learners to focus on conceptual understanding (Segarra and Cabrera-Martínez).

Traditional lecture-based instruction, which relies heavily on verbal explanation and boardwork, often provides limited visualization and interactivity. Modern learners, particularly those belonging to Generation Z, respond more positively to technology-supported learning environments. Szymkowiak et al. emphasized that digital-native students benefit from online tools, multimedia resources, and interactive platforms that enhance engagement and comprehension.

Given these challenges, students benefit from supplementary learning tools that reinforce classroom instruction, enhance visualization, and support step-by-step problem solving. In response, the study developed *StatiCalcs*, a web-based interactive learning tool designed to help MSU–Gensan Civil Engineering students understand *Statics of Rigid Bodies*. The platform provides topic-aligned resources and integrated calculators that generate step-by-step solutions and visual representations, offering an accessible and technology-supported supplement to traditional instruction.

1.2 Statement of the Problem

This study aims to develop a web-based learning tool, *StatiCalcs*, specifically designed for the subject *Statics of Rigid Bodies*. After the development of the application, the study seeks to determine the level of perception of Civil Engineering students and instructors of MSU–General Santos regarding its usability, accessibility, and user satisfaction.

Specifically, this study aims to answer the following questions:

1. What is the level of perception of Civil Engineering students of MSU–General Santos regarding *StatiCalcs* in terms of:

   1.1 Usability

   1.2 Accessibility

   1.3 Satisfaction

2. What is the level of perception of Civil Engineering instructors of MSU–General Santos regarding *StatiCalcs* in terms of:

   2.1 Usability

   2.2 Accessibility

   2.3 Satisfaction

3. Is there a significant difference between the level of perception of students and instructors in terms of usability, accessibility, and satisfaction?

1.3 Scope and Limitations

This study focuses on the design, development, and evaluation of a web-based learning tool, StatiCalcs, intended to assist Civil Engineering students of Mindanao State University – General Santos in studying the subject *Statics of Rigid Bodies*. The website covers all major topics in Statics, including force systems, equilibrium, structures, centroids, moments of inertia, and friction. It integrates conceptual explanations and calculators to help users understand and solve problems interactively. The evaluation of the tool focuses on three aspects: usability, accessibility, and user satisfaction.

The respondents of the study are limited to Civil Engineering students, specifically second-year students currently enrolled in *Statics of Rigid Bodies* and senior students who have already taken the subject, as well as instructors teaching the same course in the College of Engineering of MSU-General Santos during the Academic Year 2025–2026. The data were collected through survey questionnaires administered after the respondents had explored and used the developed website

The study does not measure students' academic performance or actual improvement in examination results. It also excludes students and instructors from other engineering programs and subjects such as Dynamics and Mechanics of Materials. Moreover, the study focuses solely on perceptions regarding the usability and effectiveness of the developed tool and does not account for external factors such as internet connectivity, learning motivation, or prior knowledge of the respondents.

The scope of this project includes the development of a website using modern web technologies, focusing on both frontend and backend functionality. The backend of the website is built using Java, which handles the application logic and processes user interactions. The frontend interface is designed with Tailwind CSS, ensuring a responsive, modern, and visually consistent user experience. Version control and collaboration are managed through GitHub, while deployment and hosting are automated via Netlify. ChatGPT is utilized as a supplementary tool to assist in web design decisions, code arrangement, and debugging, providing guidance and improving workflow efficiency.

The limitations of the project include the reliance on specific technologies and platforms. The backend is limited to Java, which may restrict integration with other programming languages or frameworks without additional configuration. The frontend design is dependent on Tailwind CSS, and deviations from its utility-first approach may require additional custom CSS. While GitHub and Netlify streamline version control and deployment, they require internet connectivity and account setup, which could pose challenges in offline or restricted environments. ChatGPT serves only as a supportive tool and does not replace the developer's judgment or expertise. Additionally, the website's functionality and performance are constrained by the features provided by the chosen technologies and hosting platform, limiting scalability for highly complex or resource-intensive applications.

1.4 Significance of the Study

This study is conducted to develop a web-based learning tool, *StatiCalcs*, which aims to support the teaching and learning of *Statics of Rigid Bodies* among Civil Engineering students of Mindanao State University – General Santos. The results and outcomes of this research are expected to benefit the following:

Students. The developed website serves as a supplementary learning tool that allows students to practice problem-solving in *Statics of Rigid Bodies* through an interactive and user-friendly platform. As learners today are inclined toward technology-based education, *StatiCalcs* provides an accessible and engaging way to enhance understanding and reinforce classroom instruction.

Instructors. The tool can be integrated into teaching strategies to improve the delivery of complex statics concepts. It may also assist instructors in providing visual and computational demonstrations that complement lectures and classroom exercises.

School Administration. The study may provide the institution with an example of how digital learning tools can be developed and implemented to improve academic performance. It may also encourage future initiatives that promote technology-driven learning in other engineering courses.

Future Researchers. This study may serve as a reference for future studies that aim to develop similar educational tools or further improve *StatiCalcs* by adding new features, expanding its scope, or evaluating its long-term impact on student learning.

1.5 Conceptual Framework

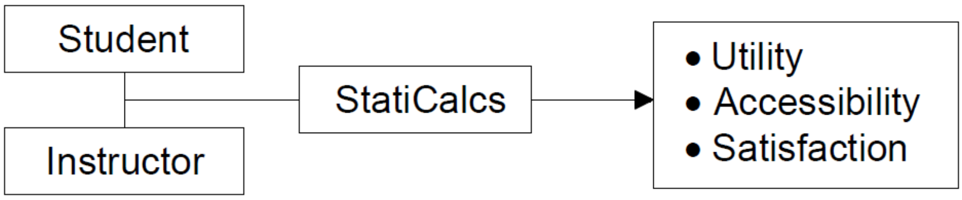

Figure 1.1: Conceptual Framework

This study is anchored in a conceptual framework that describes the relationship between users of the system and the web-based learning tool *StatiCalcs*, and how their interaction with the platform leads to the evaluation of three key system attributes: usability, accessibility, and satisfaction.

StatiCalcs functions as the central intervention, offering computational features and step-by-step problem-solving support. The quality of users' interactions with the system is evaluated through three outcome variables: usability, accessibility, and satisfaction. Usability pertains to the efficiency and ease with which users navigate and perform tasks within the platform. Accessibility evaluates the system's ability to accommodate diverse users, devices, and learning conditions. Satisfaction measures the overall acceptance of the tool and the extent to which it meets user expectations.

Overall, the framework posits that students' and teachers' experiences with *StatiCalcs* directly shape their perceptions of its usability, accessibility, and satisfaction, thereby informing the system's effectiveness as a supplementary learning tool.

1.6 Definition of Terms

Accessibility	Accessibility is the design of products, systems, or environments that can be used by people of all abilities, including those with disabilities, to perceive, understand, navigate, and interact effectively.
Civil Engineering	Civil engineering is the professional discipline that deals with the design, construction, and maintenance of the physical and naturally built environment. It encompasses the analysis and development of structures such as buildings, bridges, roads, dams, and water systems to ensure safety, sustainability, and functionality in society. This refers to the academic program in which the target population of the study is enrolled. It includes students who are currently taking the subject *Statics of Rigid Bodies*, which is one of the fundamental courses in the Civil Engineering curriculum.

Digital Natives	Digital natives are individuals who have grown up during the age of digital technology, such as computers, smartphones, and the internet, and are thus comfortable using these tools in daily life. These refer to the generational group that represents the target population of the study. They are individuals who have grown up in the age of digital technology and are highly familiar with the use of computers, the Internet, and web-based applications.
Distributed Loads	A distributed load acts continuously over a region of a structure such as a beam or surface, unlike a concentrated load that acts at a single point. It is characterized by intensity (force per unit length or area) and is represented by a load distribution diagram.
Dynamics of Rigid Bodies	Dynamics of rigid bodies is a field of mechanics that studies the motion of bodies that do not deform under applied forces. It involves analyzing translational and rotational motion using Newton's laws and principles of energy and momentum.

Equilibrium	Equilibrium refers to the condition of a body when the sum of all forces and the sum of all moments acting upon it are equal to zero, meaning the body remains at rest or moves with constant velocity.
Force Systems	A force system is defined as a collection of forces acting on a body or system of bodies. The location, magnitude, and direction of these forces determine their resultant and the conditions for equilibrium.
Free Body Diagram (FBD)	A Free Body Diagram (FBD) is a simplified graphical representation of a body or system isolated from its surroundings, showing all external forces and moments acting on it. It is used to visualize and solve problems involving equilibrium.
Mechanics of Deformable Bodies	Mechanics of deformable bodies (also called the mechanics of materials) deals with the behavior of solid bodies that deform under the action of external forces. It explains how stresses and strains are distributed within materials and how these deformations relate to material properties.

Perception	Perception is the process by which individuals interpret and organize sensory information to create meaning and understanding of their environment. In educational research, it often refers to how learners view or experience a certain tool, concept, or environment.
Physics	Physics is the branch of science concerned with the study of matter, energy, motion, and the fundamental forces of nature. It aims to understand the behavior of the physical universe through observation and experimentation.
Statics of Rigid Bodies	Statics of rigid bodies is a branch of engineering mechanics that deals with the study of forces and their effects on bodies that are assumed to remain perfectly rigid. It focuses on determining the conditions of equilibrium, where the sum of all forces and moments acting on a body equals zero to ensure structural stability. This is the course that serves as the primary focus of the web-based learning tool developed by the researchers. It involves the study of forces, moments, and their effects on bodies that are assumed to remain perfectly rigid.

Static Refers to a state or condition characterized by the absence of motion or change. It describes systems, bodies, or conditions that remain at rest or in equilibrium, with all forces balanced and no acceleration occurring.

Structures Structures are physical systems composed of interconnected elements designed to support and transmit applied loads safely to the ground, maintaining stability and integrity under various conditions.

Satisfaction Satisfaction refers to the degree to which users feel content or fulfilled with a product, service, or experience, often reflecting how well it meets their expectations and needs.

Supplementary Supplementary refers to something that is added to complete, enhance, or support something else. In the context of education or research, supplementary materials or tools provide additional information or resources that aid in understanding, reinforcement, or enrichment of learning.

Usability	Usability refers to the degree to which a product, tool, or interface allows users to achieve specific goals effectively, efficiently, and satisfactorily in a defined context.
Web-Based	Web-based refers to tools, applications, or platforms that operate over the internet and are accessible through web browsers. In education, web-based systems facilitate learning, communication, and collaboration online.
Web-Based Learning Tool	A web-based learning tool is an interactive educational platform or software accessible through the internet, designed to facilitate learning through engagement, visualization, and feedback.

Generation Z	Generation Z refers to the demographic cohort born roughly between the mid-to-late 1990s and the early 2010s. They are characterized by their familiarity with digital technology, internet connectivity, and social media from an early age. Generation Z is often described as tech-savvy, socially aware, and highly engaged with online communication and learning environments. These refer to individuals belonging to Generation Z, the target population of the study. They grew up in the digital age, making them highly adept at using technology, the Internet, and web-based learning platforms.

Chapter 2
Review of Related Literature

2.1 Statics of Rigid Bodies in Engineering Education

Statics of Rigid Bodies is a fundamental area of Engineering Mechanics concerned with understanding how forces and moments act on bodies that remain in equilibrium. As a foundational subject, Statics develops the analytical reasoning necessary for advanced topics such as Dynamics, Strength of Materials (Mechanics), Structural Analysis, and Fluid Mechanics.

In the Civil Engineering curriculum of Mindanao State University – General Santos (MSU-Gensan), as stated in MSU Board Resolution No. 375, s. 2017, Statics of Rigid Bodies (ENS161) is formally designated as a foundation course and a prerequisite for higher engineering subjects. Its role as a gateway subject underscores the need for students to develop strong problem-solving, visualization, and mathematical reasoning skills before moving on to more complex engineering analyses.

For Civil Engineering students, mastery of Statics is essential because it directly relates to designing structures that safely resist loads. Failure to grasp the principles of force systems, equilibrium, and moment calculations may hinder students' academic progression and reduce their preparedness for professional engineering practice (I. E. Salami et al.). Its foundational role in engineering education highlights the need for effective teaching approaches and supportive learning resources.

2.2 Conceptual Difficulties in Learning Statics

Learning Statics poses substantial conceptual challenges for students, mainly because the subject requires interpreting forces and interactions that are not directly observable. Students frequently struggle to visualize force directions, understand moment effects, and connect theoretical principles to real-world mechanical behavior. These conceptual gaps often lead to incorrect assumptions about how forces act on objects and how equilibrium conditions are achieved.

One of the most common sources of difficulty is the abstraction involved in translating a real object into a simplified engineering model. Students must isolate bodies, idealize supports, and mentally detach systems from their environment—steps essential to constructing valid *Free Body Diagrams (FBDs).* When learners are unable to visualize these relationships clearly, their problem-solving accuracy decreases significantly.

Misconceptions about force components, resultant forces, and moment calculations further contribute to students' struggles. Many learners also find it challenging to distinguish between couples, force systems, and distributed loads. These conceptual difficulties suggest the need for instructional approaches that enhance visualization, provide immediate feedback, and reduce students' dependence on rote memorization.

2.3 Procedural and Analytical Challenges

In addition to conceptual issues, I. Salami and Perry emphasized that students often face procedural difficulties when applying Statics principles to computational tasks. Many struggle to correctly break forces into components, apply equilibrium equations, or follow systematic steps when solving problems. These challenges frequently arise from gaps in prior mathematical knowledge, particularly in algebra and trigonometry.

Procedural errors also occur when students attempt to construct FBDs without fully understanding the physical systems involved. Incorrect or incomplete diagrams often lead to errors that persist through the entire solution process. According to I. Salami and Perry, procedural weaknesses combined with conceptual misunderstandings contribute to persistent difficulties in Statics, even among higher-year students.

Students also tend to rely on memorized formulas without understanding their derivations or applications. This approach hampers their ability to transfer knowledge to unfamiliar problem types or adapt to more complex engineering tasks. Such procedural weaknesses highlight the need for supplementary learning resources that guide students step by step and reinforce systematic problem-solving habits.

2.4 Mathematical Readiness in Statics

A strong mathematical foundation is a prerequisite for success in *Statics of Rigid Bodies*. However, many incoming engineering students lack proficiency in algebra, geometry, trigonometry, and vector operations—skills essential for analyzing forces and moments. Felix reports that declining math preparedness among first-year students negatively affects performance in computation-heavy engineering subjects.

Wenceslao conducted a study assessing the mathematical and analytical readiness of incoming first-year engineering students in Eastern Visayas, Philippines. The study revealed that 57% of students were not mathematically college-ready, demonstrating significant deficiencies in key areas such as calculus, trigonometry, and algebra, which are essential for problem-solving in engineering disciplines like *Statics*. Students struggled particularly with integration, derivatives, and trigonometric identities, indicating gaps in foundational skills needed to manipulate equations, solve simultaneous equations, resolve forces, and understand vector relationships. These weaknesses often lead to frustration, disengagement, and errors in calculating resultants, determining moment arms, and resolving angled forces.

The findings underscore the need for early interventions, remedial support, digital or supplementary learning tools that scaffold mathematical procedures, reducing the cognitive burden of complex computations and allowing learners to focus on conceptual understanding and practical application in *Statics*. Digital resources that automate or guide mathematical procedures may help students focus more on conceptual interpretation and problem comprehension.

2.5 Math Anxiety and Its Impact on Engineering Students

Math anxiety is a widely documented factor that affects students' performance in technical subjects. Incierto et al. found that students with higher levels of anxiety tend to perform poorly in mathematics-related courses, including engineering subjects that rely heavily on quantitative skills. This emotional barrier often causes learners to avoid practicing mathematical problems, ultimately reducing their mastery of essential skills.

In *Statics*, where problem-solving requires applying multiple mathematical steps, anxiety can impair students' ability to think clearly, interpret diagrams, and follow procedural logic. Reducing math anxiety is therefore an important aspect of improving student performance.

Several studies suggest that allowing students to use calculators, digital tools, or guided computational aids can mitigate anxiety by reducing the pressure associated with manual calculations. Segarra and Cabrera-Martínez found that structured calculator use improves students' confidence and accuracy, enabling them to concentrate more on conceptual understanding than on arithmetic manipulation.

2.6 Importance of Free Body Diagram Construction

The *Free Body Diagram (FBD)* is one of the most critical tools in *Engineering Mechanics*. It serves as the foundation for analyzing *force interactions*, solving equilibrium equations, and understanding mechanical behavior. Despite its importance, many students struggle to construct accurate FBDs, often omitting forces, misrepresenting directions, or misidentifying support reactions (I. Salami and Perry).

Errors in FBD construction typically result in incorrect *equilibrium equations*, making the entire solution process invalid. Researchers emphasize the need for learning tools that support FBD visualization, provide real-time diagrams, and reinforce correct diagramming techniques. Visual learning tools and graphical simulations have been shown to improve performance and deepen understanding in *Statics*.

2.7 Visualization and Spatial Ability in Engineering

Spatial reasoning is a key competency in engineering, particularly in *Statics*, where students must interpret diagrams, imagine 3D *force interactions*, and understand geometric relationships. Learners with weak spatial ability often struggle with vector representation, force decomposition, and moment visualization (Fontaine and Vallabh).

Visualization tools, including interactive diagrams and simulations, help develop these skills by allowing students to manipulate variables and observe changes in real time. Zeichner argues that simulations enhance student motivation and conceptual understanding, particularly in visually demanding subjects such as *Statics*. Given that *Statics* requires a combination of spatial and analytical skills, web-based learning tools that incorporate visualization are essential for supporting diverse learning needs.

2.8 Technology-Based Learning for Engineering Student

The concept of digital natives, introduced by Prensky (2001), describes individuals who have grown up immersed in digital technology, such as computers, smartphones, and the internet. This group generally includes those born from the 1980s onward, commonly identified as Millennials, Generation Z, and Generation Alpha. These generations grew up during the rapid advancement of technology, which has profoundly influenced their lifestyles, behaviors, and learning preferences. Since they have never known a world without digital connectivity, technology has become an integral part of their identity and daily lives. According to Szymkowiak et al., educators should combine traditional teaching methods with modern, internet-based learning tools, including mobile applications and online videos, to accommodate the learning preferences. Zeichner similarly found that learning through simulation fosters a deeper understanding of abstract principles and concepts compared with conventional instruction. These findings are supported by De La Hoz et al., who observed that traditional lecture-based teaching in statics often fails to address students' learning barriers and problem-solving difficulties.

Also, a comprehensive literature review by Tawafak et al. highlights that the continuous exposure of Gen Z to digital environments has transformed their learning preferences and expectations in higher education. Their familiarity with interactive, technology-driven systems opens opportunities for educators to design more engaging, adaptive digital learning platforms. Collectively, these studies emphasize the importance of integrating interactive, technology-enhanced approaches into higher education to meet the learning needs of digital natives in modern academic settings and to improve student engagement, comprehension, and analytical skills, especially in conceptually demanding courses such as Statics of Rigid Bodies.

Technology-based learning enhances engagement, improves retention, and provides flexibility for self-paced study. Web-based learning tools have been shown to promote active learning, encourage repeated practice, and support independent problem-solving. These tools can supplement traditional lectures, which often lack interactivity and visualization. Given these advantages, integrating technology into Statics instruction is essential to address students' difficulties and enhance their learning experience.

2.9 Web-Based Learning in Engineering Education

Web-based learning has become a significant trend in modern education due to its accessibility, flexibility, and multimedia integration capabilities. Through internet-based platforms, students can access materials anytime, practice problems repeatedly, and receive immediate feedback. This is especially useful in technical subjects that require repeated exposure to problem-solving procedures.

The study of De La Hoz et al. states how self-explanation activities may support student learning in *Statics*. Specifically, this study examines the characteristics of student self-explanations of worked examples and their relationship with students' conceptual change. The findings suggest a relationship among the type of worked example, students' self-explanation approaches, and their conceptual change and problem-solving skills in *Statics*. To improve students' explanations and conceptual understanding, additional prompts or initial training in self-explanation may be required within the worked-examples context. The researchers suggest that interactive learning environments enhance conceptual understanding by prompting students to explain solutions and reflect on errors.

Research by Abumandour on the potential of e-learning as an educational system for engineering topics highlighted the rapid technological advancements of the 21st century, which have transformed educational delivery methods. The researcher noted that advances in technology have led to the emergence of e-learning as a modern instructional approach widely adopted by educational institutions, public organizations, and academic libraries. The researcher highlighted that engineering education is increasingly moving toward a blended learning model that effectively integrates traditional "face-to-face" instruction with computer-assisted methodologies and internet-based learning. This hybrid approach enhances accessibility, flexibility, and learner engagement.

The study also outlined several challenges and obstacles that stakeholders, including teachers, professors, and librarians, must address to develop and sustain effective e-learning systems fully. These challenges include ensuring technological readiness, maintaining instructional quality, and supporting both instructors and students in adapting to digital learning environments. The researcher further proposed recommendations to strengthen the connection between e-learning and engineering education, thereby promoting a more adaptive, innovative, and inclusive academic experience. The researcher highlights the growing need for digital tools in engineering education as institutions shift toward blended and online learning systems.

In the study of Söllradl, which aims to enhance digital learning in Engineering Mechanics across several departments, the researcher developed an automated, scalable system to generate individualized assignments for students, supporting a more efficient, interactive approach to learning. To accomplish this, the researcher used a Python-based framework that automatically generates, distributes, and solves assignments for beam structures. Instead of relying solely on numerical solutions, the system emphasized symbolic computation using the *Euler–Bernoulli beam theory* to formulate and solve linear systems of equations. This method provided learners with a clearer understanding of the mechanical behavior of beam structures by reinforcing analytical and theoretical principles rather than focusing only on numerical outputs. Through this approach, this study demonstrated how digitalization and automation can be effectively integrated into engineering education to promote personalized learning, reduce instructors' manual workload, and enhance students' analytical and problem-solving skills.

Another significant advancement in web-based learning was introduced by Gfrerer et al., who developed an automated correction system for individualized exercise assignments in *Engineering Mechanics* courses. Their work addresses long-standing challenges in large classes, where manually creating and grading assignments limits the variety of problems students can encounter. With smaller problem pools, learners may replicate solutions without developing genuine conceptual understanding, and instructors may struggle to assess independent problem-solving skills.

To overcome these issues, the researchers developed a scalable digital framework capable of generating, distributing, and automatically correcting personalized exercises in *Statics*, *Strength of Materials*, *Dynamics*, and *Hydrostatics*. Each student receives a unique set of problems, promoting academic integrity and encouraging active, self-directed learning. A quantitative survey among *Statics* students showed strong acceptance of the tool, with many reporting enhanced reflective learning and improved engagement. The authors concluded that automated correction systems significantly improve efficiency in mechanics education by reducing instructor workload while supporting deeper learner understanding.

Web-based tools allow for unified access across devices, making them ideal supplements for engineering subjects that require visual illustrations and computational support. These features align perfectly with the needs of *Statics* students who benefit from guided examples, diagrams, and automated computations.

2.10 Related Systems and Existing Educational Tools

Several digital tools and online platforms have been developed to support learning in mathematics and engineering, but each has limitations when applied explicitly to *Statics of Rigid Bodies*. Symbolab, for instance, provides automated, step-by-step solutions for algebra, calculus, and trigonometric problems. A study by Paulin and Jean Baptiste aimed to determine the effectiveness of the Symbolab Calculator in improving second-year students' ability to solve trigonometric equations. The findings suggest that Symbolab can enhance students' problem-solving skills and understanding of mathematical concepts. However, despite these benefits, Symbolab lacks dedicated features for statics topics such as equilibrium, force systems, and truss structures, limiting its direct applicability in engineering *Statics* courses.

GeoGebra offers dynamic and interactive visualizations for geometry and algebra. Its visual approach enhances students' spatial reasoning and understanding of mathematical relationships. However, GeoGebra does not include built-in tools for engineering Statics, such as truss analysis or 2D/3D equilibrium calculations.

More specialized platforms, such as SkyCiv, provide advanced structural analysis tools for 2D and 3D frames and trusses. While highly useful for engineering applications, many features require paid subscriptions, reducing accessibility for undergraduate students.

Other digital innovations, such as the automated correction systems developed by Gfrerer et al., focus on generating individualized problem sets and automated grading in *Engineering Mechanics* courses. These systems enhance self-directed learning but primarily support assessment rather than conceptual understanding. Similarly, symbolic computation tools developed by Söllradl emphasize automated and symbolic solutions for beam structures in Strength of Materials, but do not provide comprehensive coverage of fundamental statics topics.

Although these tools contribute significantly to engineering education, none provide an integrated, free, and *Statics*-specific learning environment that combines step-by-step solutions, real-time computations, and dynamic visualizations. This gap underscores the need for a specialized platform like *StatiCalcs*, designed for undergraduate *Statics* students, providing an accessible, interactive, and comprehensive learning tool that addresses both conceptual understanding and practical problem-solving.

2.11 Summary of Literature

The literature consistently shows that *Statics* is conceptually demanding, procedurally complex, and dependent on strong mathematical foundations. Students struggle with visualization, FBD construction, force interactions, and equilibrium analysis. Traditional instruction alone often fails to address these learning gaps.

Research also emphasizes the importance of digital tools, visual learning, and web-based platforms in enhancing student understanding, especially for digital-native learners. Existing tools such as Symbolab, GeoGebra, and SkyCiv offer partial support but do not provide a comprehensive *Statics* learning environment.

The reviewed literature clearly indicates the need for an accessible, interactive, and specialized web-based tool to support students' learning in *Statics*. This provides strong justification for developing *StatiCalcs*, which integrates visualization, computation, and conceptual understanding to address the gaps identified in previous studies.

Chapter 3
Methodology

This chapter presents the research method, respondents, locale, instrument, and procedure used in the study. It explains how the research will be conducted to determine the perceptions of Civil Engineering students and faculty toward *StatiCalcs*, an interactive web-based learning tool developed for the subject Statics of Rigid Bodies.

3.1 Research Method

This study will use a quantitative research method, which focuses on collecting and analyzing numerical data to describe patterns, relationships, and differences among variables. According to Apuke, quantitative research involves a systematic investigation that uses statistical techniques to produce objective and measurable results. This method is appropriate for the present study because it seeks to gather data from Civil Engineering students and instructors to assess and compare their perceptions of the developed web-based learning tool, *StatiCalcs*.

Specifically, a correlational quantitative approach will be applied. As defined by Creswell (2014), this approach examines the relationship or difference between two or more variables to determine whether a significant association exists. In this study, it will be used to determine the significant difference between the perceptions of students and instructors regarding the usability, accessibility, and satisfaction of *StatiCalc*. This method will allow the researchers to statistically analyze the degree to which these two groups differ in their perceptions, providing insights into the effectiveness and acceptance of the developed learning tool across users.

3.2 Research Respondents

The respondents of this study will be selected Bachelor of Science in Civil Engineering students and teaching faculty from the College of Engineering at Mindanao State University – General Santos (MSU-Gensan). The student respondents will include second-year and higher-level Civil Engineering students who are either currently enrolled in or have already completed the course Statics of Rigid Bodies (ENS 161). This selection ensures that participants have sufficient background and experience with the subject, allowing them to provide reliable feedback on the developed web-based learning tool, *StatiCalcs*. The faculty respondents, on the other hand, will consist of instructors who are currently teaching or have previously taught Statics of Rigid Bodies, as they can provide expert evaluation regarding the tool's usability, accessibility, and relevance to the course content.

3.3 Research Locale

This study will be conducted at the College of Engineering, Mindanao State University – General Santos (MSU-Gensan), located in Fatima, General Santos City. The college offers various engineering programs, including Civil, Mechanical, Electrical, and Agricultural and Biosystems Engineering. The research will primarily focus on the Engineering Building, where most classroom lectures, computer laboratory sessions, and faculty offices are situated. This location is ideal for the study since it houses both the student respondents taking Statics of Rigid Bodies and the faculty members teaching the subject.

3.4 Research Procedure

The researchers will conceptualize, design, and develop a web-based learning tool called *StatiCalcs*, an interactive platform with integrated calculators specifically designed for the subject Statics of Rigid Bodies. The system will undergo evaluation and approval by experts in the field to ensure its accuracy, functionality, and relevance to the course. A researcher-made questionnaire will then be developed to measure the level of perception of Civil Engineering students and instructors in terms of usability, accessibility, and satisfaction. Before data gathering, a formal letter of permission to conduct the study will be submitted to the Dean of the College of Engineering at Mindanao State University–General Santos.

The researchers will administer the questionnaire to the selected respondents composed of Civil Engineering students and faculty members. After data collection, the gathered responses will be encoded, organized, and subjected to statistical analysis.

3.4.1 Website Development Process

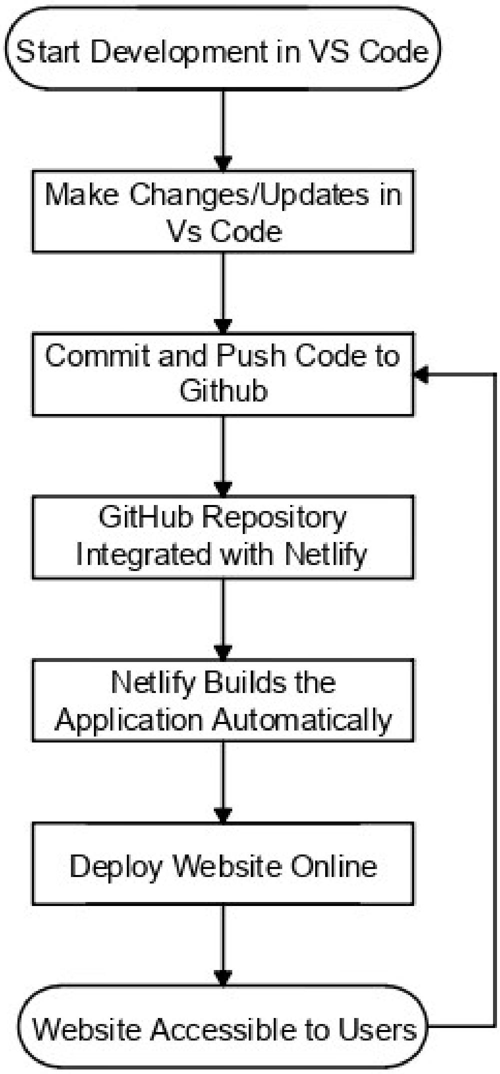

Figure 3.1: System Flow Chart

The website was developed using a modern workflow, beginning with the selection of Java as the backend language due to its reliability, security, and strong support for building large, complex web applications. GitHub was used as the code repository to manage versions, collaborate, and integrate with deployment tools. For the frontend, Tailwind CSS was chosen to create a clean, responsive, and consistent user interface using its utility-first styling approach. ChatGPT assisted throughout the development process by helping with code structuring, debugging, and design decisions, improving efficiency and workflow. Netlify was used as the hosting and deployment platform. By connecting the GitHub repository to Netlify, every update pushed to GitHub was automatically built and deployed online, ensuring continuous delivery and easy accessibility of the website to users.

3.4.2 Website Navigation and Functional Flow

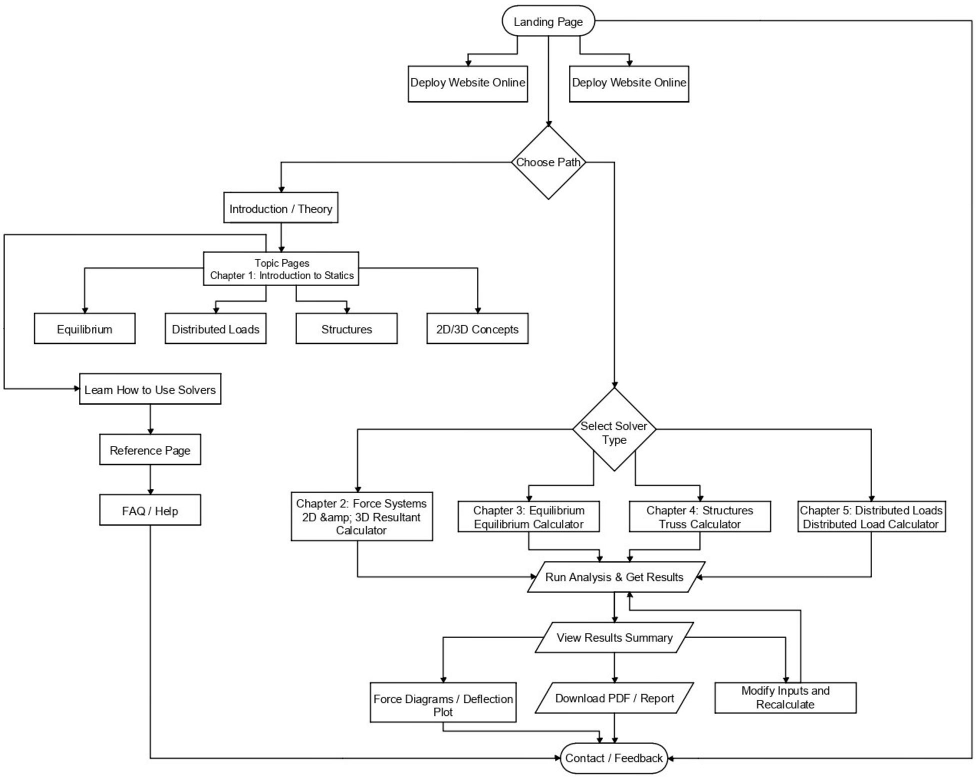

Figure 3.2: User journey flow chart

The website begins at the Landing Page, which acts as the main entry point for users. From this page, users are provided with navigational options to explore introductory sections such as About / Project Story, Meet the Developers, and Contact / Feedback. These sections help users understand the objectives of the project, know the creators behind the system, and provide a communication channel for inquiries or suggestions.

From the Landing Page, users encounter a decision point labeled Choose Path, where they decide whether to proceed to the Learning Section or directly access the Solver

Tools.

If the user selects the Learning Path, they are directed to the Introduction / Theory page, which presents foundational concepts in statics. Following this, users proceed to Topic Pages (Chapter 1: Introduction to Statics), which include lessons on essential topics such as Equilibrium, Distributed Loads, Structures, and 2D/3D Concepts. After gaining theoretical knowledge, users move to the Learn How to Use Solvers section, which offers instructional guides on how to properly use the computational tools for structural analysis.

To further support learning, users may visit the Reference Page, which contains formula compilations, example problems, and relevant learning materials. An FAQ / Help section is also available to address common issues and user concerns. If additional support is needed, users may contact the developers directly through the Contact Page.

Alternatively, if the user chooses the direct problem-solving pathway, they proceed to a second decision point called Select Solver Type. The available solver tools are aligned with the chapters covered in the theoretical section, including:

- Chapter 1: Introduction to Statics
- Chapter 2: Force Systems – 2D and 3D Resultant Force Calculator
- Chapter 3: Equilibrium – Equilibrium Calculator
- Chapter 4: Structures – Truss Analysis Calculator
- Chapter 5: Distributed Loads – Structural Analysis Calculator for Distributed Load Effects

After selecting a specific solver, the user proceeds to Run Analysis & Get Results. Following computation, a View Results Summary page displays the output in a clear and structured format.

From this results page, users have three options:

1. Generate and view Force Diagrams / Deflection Plot
2. Download results as PDF or formatted report
3. Modify input parameters and Recalculate to explore different solutions or optimize results

This structured flow allows users to either learn fundamental engineering concepts before solving problems or directly perform structural analysis based on their needs. The design ensures flexibility, user engagement, and accessibility while supporting both educational and analytical purposes.

3.4.3 Website System Architecture

The ***Components*** folder contains reusable elements of the website, specifically the Header and Footer, which help maintain consistent navigation and accessibility across all pages. The ***Header*** file inside this folder includes the main navigation menu with the ***Home*** button that redirects users to the homepage, along with a *Topics* dropdown that provides quick access to various chapters and calculators such as *Chapter 1: Introduction to Statics*, *Chapter 2: Force Systems with a 2D Resultant Solver*, *Chapter 3: Equilibrium with an Equilibrium Solver*, *Chapter 4: Structures with a Truss Calculator*, and *Chapter 5: Distributed Loads*. This dropdown is designed to make browsing easier and more efficient for users. The header also contains the *About* page that presents the purpose and background of the website. Meanwhile, the **Footer** file contains additional navigation links including ***About***, ***References***, ***Contact***, and ***Developers***. The ***About*** button directs users to the website's About page; the ***References*** page provides the sources used in developing the calculators and learning materials; the ***Contact*** page allows users to reach the proponents of the thesis; and the ***Developers*** page displays information about the creators of the website. These components together ensure that users can easily access important sections and navigate the site smoothly.

The ***Calcs*** folder contains the core Java code files that power the calculators integrated into the website. These files are responsible for performing the computational logic, processing user inputs, and generating the corresponding solutions based on engineering principles and formulas. Each *calculator*, such as those for force systems, equilibrium, truss analysis, and distributed loads, relies on the scripts stored in this folder to *accurately compute results*. This makes the Calcs folder an essential component of the website's functionality, as it handles the main calculation processes that support the learning and problem-solving features of the platform.

The ***App*** folder contains all the front-end code for all website pages, styled using Tailwind CSS, which controls their visual layout, responsiveness, and overall user interface. Each page inside the App folder is responsible for either displaying *calculators*, such as for 2D Resultant, 3D Solver, Equilibrium, Distributed Loads, and Structural Analysis, or for providing supporting information, such as *Introduction*, *References*, *About*, *Contact*, and *Developer* details. The Tailwind CSS classes ensure that all these pages are consistently designed, user-friendly, and visually appealing, making navigation smooth and calculator usage clear and efficient. In summary, the App folder manages the appearance, layout, and behavior of both the calculator and informational pages from the user's perspective.

3.5 Statistical Tools

A researcher-made instrument will be utilized in conducting this study. The tool will employ a five-point Likert scale to measure the level of perception of both students and instructors regarding the developed web-based learning tool, *StatiCalcs*. The survey will assess their perceptions in terms of usability, accessibility, and satisfaction. Each item in the questionnaire will be rated on a scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), allowing for quantitative analysis of the respondents' perceptions toward the tool's overall usability, accessibility, and user satisfaction.

References

Abumandour, El-Shaimaa Talaat. “Applying e-learning system for engineering education – challenges and obstacles.” *Journal of Research in Innovative Teaching & Learning*, vol. 15, no. 2, 6 Oct. 2021, pp. 150–69. https://doi.org/10.1108/JRIT-06-2021-0048.

Apuke, Oberiri. “Quantitative Research Methods : A Synopsis Approach.” *Arabian Journal of Business and Management Review (kuwait Chapter).*, vol. 6, 1 Oct. 2017, pp. 40–47. https://doi.org/10.12816/0040336.

De La Hoz, Jose Luis, et al. “Self-explanation activities in statics: A knowledge-building activity to promote conceptual change.” *Journal of Engineering Education*, vol. 112, no. 3, 2023, _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/jee.20531, pp. 741–68. https://doi.org/10.1002/jee.20531.

Felix, Criselda S. “Analyzing the Impact of Declining Math Skills on College Readiness for Incoming Freshmen.” Vol. 7, no. 1, 2023.

Fontaine, Maxine, and Chaitanya Vallabh. “Correlating Common Errors in Statics Problem Solving with Spatial Ability.” *2024 ASEE Annual Conference & Exposition Proceedings*. Proc. of 2024 ASEE Annual Conference & Exposition, ASEE Conferences, June 2024, p. 47079, https://doi.org/10.18260/1-2--47079.

Gfrerer, Michael H., et al. “Teaching mechanics with individual exercise assignments and automated correction.” *PAMM*, vol. 23, no. 3, Nov. 2023, e202300168. *arXiv*, arxiv.org/abs/2308.12694[physics], https://doi.org/10.1002/pamm.202300168.

Incierto, Theresa Christine, et al. “Mathematics Anxiety Level of The First Year Education Students in Manduae City College in The New Normal in Relation To Their Academic Performance \textbar PDF \textbar Correlation And Dependence \textbar Anxiety.” PhD dissertation. www.scribd.com/document/516791046/Mathematics-Anxiety-Level-of-the-First-Year-Education-Students-in-Manduae-City-College-in-the-New-Normal-in-Relation-to-Their-Academic-Performance-1. Accessed 22 Oct. 2025.

Paulin, Manirakiza, and Ndagijimana Jean Baptiste. “Effectiveness of the Symbolab Calculator in Improving Second Year Science and Mathematics Students Ability to Solve Trigonometric Equations.” *EAST AFRICAN JOURNAL OF EDUCATION AND SOCIAL SCIENCES*, vol. 4, no. 6, 1 June 2024, pp. 29–38. https://doi.org/10.46606/eajess2023v04i06.0331.

Salami, Ibukunoluwa, and Logan Perry. “Challenges in Engineering Statics: Students’ Perceptions of Their Difficulties.” *2025 ASEE Annual Conference & Exposition Proceedings*. Proc. of 2025 ASEE Annual Conference & Exposition, ASEE Conferences, June 2025, p. 56077, https://doi.org/10.18260/1-2--56077.

Salami, Ibukunoluwa E., et al. “Exploring High DFW Rates in an Engineering Statics Course: Insights from Faculty and Teaching Assistants.” *2024 ASEE Midwest Section Conference Proceedings*. Proc. of 2024 ASEE Midwest Section Conference, ASEE Conferences, Sept. 2024, p. 49390, https://doi.org/10.18260/1-2-115.1139-49390.

Segarra, Jaime, and Abel Cabrera-Martínez. “Does the use of the calculator reduce anxiety in the study of differential and integral calculus?” *European Journal of Science and Mathematics Education*, vol. 12, no. 1, 1 Jan. 2024, pp. 97–111. https://doi.org/10.30935/scimath/13867.

Söllradl, Sophie. “Symbolic calculation of beam structures.”

Szymkowiak, Andrzej, et al. “Information technology and Gen Z: The role of teachers, the internet, and technology in the education of young people.” *Technology in Society*, vol. 65, 1 May 2021, p. 101565. https://doi.org/10.1016/j.techsoc.2021.101565.

Tawafak, Ragad M, et al. “Innovative Smart Phone Learning System for Graphical Systems within COVID-19 Pandemic.” *Contemporary Educational Technology*, vol. 13, no. 3, 2 May 2021, ep306. https://doi.org/10.30935/cedtech/10879.

Wenceslao, Perante. “Mathematical Readiness of Freshmen Engineering Students (K-12 2020 Graduates) in Eastern Visayas in the Philippines.” *Asian Journal of University Education*, vol. 18, no. 1, 14 Feb. 2022, p. 191. https://doi.org/10.24191/ajue.v18i1.17187.

Zeichner, Orit. “Using Simulations to Improve Achievements and Motivation in ICT Studies.” *Journal on School Educational Technology*, vol. 16, no. 1, 2020, Publisher: i-manager Publications ERIC Number: EJ1354679, pp. 11–24. https://doi.org/10.26634/jsch.16.1.17426.