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A Conceptual Framework For Integrating Design Thinking With Engineering Learning In Cloud Ecosystems

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Abstract**–** *This study introduces a conceptual framework for integrates Design thinking with engineering learning supported by the cloud ecosystem to enhance modern education. The proposed framework utilizes cloud-based platforms to facilitate personalized, collaborative, and adaptive learning environments. To bridge theoretical and practical knowledge, the framework integrates accepted learning theories such as constructivism, problem-based, cooperative, and experiential learning. This integration promotes critical skills such as creativity, artificial intelligence, and innovation, enabling learners to tackle complex real-world challenges. Furthermore, cloud technologies allow data to access, analysis, and collaboration, making education more dynamic and resourceful. Despite its potential, challenges such as data privacy and equitable access still need to be addressed for effective implementation.*

Index Terms**–** *Design Thinking, Engineering Learning, Cloud Ecosystem, Collaborative Learning, Adaptive Learning*

I. INTRODUCTION

In the digital age, where changes are rapid and broadly impact all sectors, integrating Design Thinking into engineering learning is essential [1]. Combining these two disciplines promotes integrated learning that emphasizes creative and effective problem-solving [2]. Engineering learning integrated with design thinking enables students to develop analytical thinking, critical thinking, and understanding of user needs, essential skills for engineers in this digital age [3].Cloud technology is a key tool in supporting the learning process in the digital age [4]. By providing an easily accessible and flexible platform, cloud technology allows students and teachers to access many tools and data quickly [5]. Using the cloud in engineering and design education increases collaboration and information-sharing opportunities between students and professionals worldwide, making the learning process continuous and relevant to real-world needs [6].Integrating Design Thinking and engineering learning through cloud-enabled platforms plays a key role in developing essential skills for engineers and designers in the digital age. Access to these powerful platforms not only enhances collaboration and leads to better outcomes but also enables effective responses to the rapidly changing challenges of our world. Therefore, cloud-enabled learning is key to innovating and pushing future engineering and Design boundaries.

This article presents a conceptual framework for integrating Design Thinking with Engineering Learning, using the Cloud Ecosystem as a primary support tool. Such integration draws on relevant knowledge and theoretical approaches to learning in various formats to demonstrate the potential for developing learners with both essential 21st-century skills and the development of comprehensive knowledge in multiple dimensions, emphasizing adaptive learning and innovation based on efficient and sustainable processes.

II. LITERATURE REVIEW

A. *Theoretical Frameworks*

Constructivism

Constructivism views learning as occurring when learners construct new knowledge through direct experiences. In design thinking and engineering, this approach allows learners to develop understanding and skills through trial and error to find the best solution. This fosters critical thinking and independent decision-making skills, essential in engineering and Design [7].

Problem-Based Learning (PBL)

Problem-based learning (PBL) is a learning process in which learners are encouraged to solve complex real-world problems by analyzing and generating solutions. In engineering and Design, PBL allows students to connect theoretical knowledge with experiences that require creativity and innovation to address challenges and meet user needs [8].

Collaborative Learning

In collaborative Learning, students work together to achieve shared learning goals. Students can use a cloud platform to share and develop skills through interactions with other learners worldwide. This promotes innovation and the development of essential digital skills for the modern era [9].

Experiential Learning

Experiential Learning emphasizes learning from experiences and practices linked to real-world situations. In engineering, students can experiment and refine technical solutions in controlled conditions. This provides a means to observe the real-world impact of their design and engineering decisions [10].

These frameworks complement one another by providing a holistic approach to learning. Constructivism builds foundational knowledge through active engagement, while Problem-Based Learning (PBL) applies this knowledge to solve real-world problems. Collaborative Learning fosters teamwork and global interaction, and Experiential Learning bridges theory and practice, enabling learners to refine skills in realistic contexts.

B. Design Thinking

Recent research emphasizes that design thinking is an iterative, human-focused process that solves complex problems by fostering creativity, collaboration, and empathy. Integrating Design thinking into educational frameworks promotes innovative thinking and enhances problem-solving abilities. This approach shifts traditional models toward a more dynamic, user-centered approach aligned with today's educational challenges [11][12].Moreover, design thinking empowers students with critical thinking, adaptability, and digital proficiency, particularly in technology-enhanced educational environments. It enables students to approach challenges methodically while cultivating solutions tailored to real-world needs. This framework supports collaborative efforts between educators and learners to address challenges creatively and effectively [13][14].The research underlines the benefits of embedding design thinking in curricula, showcasing improved engagement, deeper learning, and preparation for evolving professional landscapes. The iterative process of empathizing, ideating, prototyping, and testing fosters academic and practical interdisciplinary competencies in learners [15].

Design Thinking Process

Design thinking is a user-focused, iterative process for problem-solving that fosters innovation and provides a competitive advantage. This structured approach emphasizes understanding user needs and creating tailored solutions to enhance experiences. The process consists of five key steps: empathizing, defining, ideating, prototyping, and testing. The Empathize step involves researching user behaviors, emotions, and frustrations through interviews and observations to gain insights. This leads to the Define step, where insights are synthesized to pinpoint core problems and innovation opportunities, setting a strategic direction. Ideation focuses on brainstorming and exploring diverse possibilities to address the defined issues. The prototype step involves creating tangible models to test the model's practicality and identify potential improvements. In the final Test phase, prototypes are presented to users to gather feedback, refine solutions, and validate their relevance to user needs.This iterative process integrates empathy and creativity, ensuring solutions align with user expectations and continuously improve. Design thinking enhances user engagement and fosters interdisciplinary skills, equipping learners and professionals to tackle complex challenges effectively in real-world scenarios [1][16]-[18].

C. Engineering Learning

Engineering learning integrates scientific, mathematical, and technological knowledge to solve real-world problems, focusing on systematic principles and their application through experiential methods such as project-based learning. Engineering learning emphasizes practical and creative skill development by incorporating continuous design processes. This approach, supported by iterative design and testing processes, helps students understand and apply engineering concepts in real-world contexts. The concept of "Problem Definition and Solution" marks a paradigm shift in engineering education, moving from what students need to learn as engineers to what they need to master to develop quality problem-solving processes [19][20].Integrating design and analysis knowledge in engineering education enables students to tackle complex challenges innovatively and effectively. Recent studies show that this shift highlights the importance of collaborative learning environments, technology integration, and interdisciplinary approaches in modern engineering curricula. By emphasizing these elements, engineering education prepares students for technical problem-solving, critical thinking, and adaptability in diverse professional settings [2][21].

D. Cloud Ecosystem

Cloud ecosystems have transformed education, offering scalable, cost-effective platforms that enhance accessibility and learning outcomes. By leveraging virtualization and multi-tenant architectures, cloud-based systems adapt to the needs of institutions and learners, facilitating personalized learning frameworks. This integration allows educators to design customized curricula and improve engagement by tailoring content to individual learners' needs. Furthermore, cloud systems enable remote and asynchronous learning, bridging global accessibility gaps for students [22]-[24].

Cloud-based Learning Management Systems (LMS), such as Moodle and Google Classroom, exemplify how the cloud supports educational processes. These platforms streamline content delivery, manage learning materials, and encourage collaboration. Real-time analytics in advanced LMS provide actionable insights into student performance, enabling targeted interventions. Additionally, gamification and interactive modules enhance motivation and retention, fostering engaging and effective learning experiences [24]-[26].Emerging technologies like IoT and machine learning enhance cloud ecosystems, enabling predictive diagnostics, adaptive learning, and innovative problem-solving in education. For instance, IoT applications in sports medicine facilitate real-time data collection for diagnostics and rehabilitation, showcasing the versatility of cloud systems beyond traditional learning. Cloud ecosystems seamlessly integrate formal and informal education through tools such as remote laboratories, social software, and collaborative platforms. These services facilitate adaptive learning environments, meeting the demands of a digitally driven society while improving accessibility, engagement, and collaboration for learners and educators alike [27]-[30].Cloud-based educational tools enhance learning and collaboration through various key categories. Networking tools like LinkedIn facilitate professional connections and development, while publishing platforms like WordPress enable content creation and sharing. Collaboration tools, including Dropbox, boost teamwork and productivity, and interactive assessment platforms like Kahoot engage learners through dynamic evaluations. These tools highlight the adaptability and innovation of cloud ecosystems, which are reshaping global education by enhancing access, collaboration, and application. As technology advances, cloud-based solutions foster inclusive and impactful learning experiences, creating opportunities for diverse communities worldwide [31]-[33].

These knowledge areas complement one another by integrating Design Thinking's user-centered innovation with Engineering Learning's systematic problem-solving, supported by the scalability of Cloud Ecosystems. They foster a dynamic, collaborative environment where learners apply iterative processes to solve real-world challenges, leveraging technology for enhanced engagement, accessibility, and adaptability. Thus, they prepare students for interdisciplinary and digitally driven professional landscapes.

E. Development of Key Skills

Creative Thinking

Creative thinking is a vital cognitive process for innovation and problem-solving, involving self-regulation to adapt strategies and generate novel ideas [34]. Education enhances learning and engagement, necessitating pedagogies that foster creativity [35]. Technology further augments creativity, aiding idea generation and refinement [36]. Together, these perspectives highlight the importance of nurturing creative thinking in personal and professional domains through educational practices and strategic technological integration, emphasizing its role in enhancing outcomes and driving innovation across fields.

Digital Intelligence

Digital Intelligence (DQ) is the ability to effectively and responsibly manage digital technologies, encompassing skills such as data literacy, cybersecurity awareness, and ethical technology use. El-Dahshan [37] highlights its importance in preparing children for the digital age, while Yusuf and Redzuan [38] advocate for integrating DQ into education through models like the flipped classroom. Anshari and Almunawar [39] emphasize upskilling and open innovation to enhance adaptability in the Fourth Industrial Revolution. Together, these studies underscore DQ's critical role in fostering individual competencies and organizational resilience in an evolving digital landscape.

Innovative

Innovation creates value by implementing new or significantly improved products, services, or processes. Taylor examines various definitions of innovation across disciplines, emphasizing its multifaceted nature and the importance of context in its application [40]. The Oxford Handbook of Innovation highlights that innovation is not a new phenomenon but an inherent aspect of human development, facilitating adaptation and problem-solving across diverse environments [41]. Additionally, the "Innovation, Meaning of" entry in SpringerLink discusses the association of innovation with economic processes, particularly in transforming production methods and contributing to economic growth [42]. These perspectives underscore innovation as a dynamic and context-dependent process integral to societal progress and economic development.

III. RESEARCH METHODOLOGY

This article presents a conceptual framework for Integrating Design Thinking with Engineering Learning in Cloud Ecosystems.

A. Research Approach

This study adopts a qualitative research approach to explore and conceptualize the integration of Design Thinking and Engineering Learning within a Cloud Ecosystem. By synthesizing relevant theoretical frameworks such as Constructivism, Problem-Based Learning (PBL), Collaborative Learning, and Experiential Learning, the research aims to develop a structured conceptual framework. The study involves a comprehensive literature review, focusing on theoretical and practical knowledge related to engineering education, design thinking, and cloud-based learning. This approach emphasizes understanding these domains' interrelations and impact on developing learners' skills and competencies in a digitally driven environment.

B. Methodological Steps

The development of the conceptual framework of this research followed a systematic methodology comprising the following steps:

1. Literature Review

Gathered and analyzed existing theories and frameworks related to Design Thinking, Engineering Learning, and Cloud Ecosystems to establish a theoretical foundation.

2. Synthesis of Frameworks

Integrated key principles of Constructivism, Problem-Based Learning, Collaborative Learning, and Experiential Learning to create a cohesive conceptual framework.

3. Identification of Key Components

Defined critical elements of Design Thinking (e.g., empathy, ideation, prototyping, and testing), Engineering Learning processes, and the role of cloud-based platforms in supporting these activities.

4. Development of a Conceptual Framework

Combined findings into a visual representation to illustrate the relationships between Design Thinking, Engineering Learning, and Cloud Ecosystems.

5. Validation through Case Analysis

Applied the conceptual framework to practical scenarios to evaluate its feasibility and effectiveness in addressing real-world educational challenges.

This stepwise approach ensures the framework's relevance and applicability in fostering creativity, digital intelligence, and innovation in educational contexts.

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IV. RESULT

This research proposes a conceptual framework for integrating design thinking and engineering learning within the cloud ecosystem. This innovative learning process uses design thinking principles and engineering learning methods, leveraging cloud technologies. These learning processes integrate learning theories to promote integrated learning, such as self-directed, problem-based, collaborative, and experiential learning. Under this conceptual framework, learners can achieve creative thinking, artificial intelligence, and innovation through this innovative framework.

To better understand the conceptual framework's approach, readers are encouraged to refer to Figure 1, which illustrates the relationship between learning processes and tools and their integration within the conceptual framework. In addition, Tables 1 and 2 provide detailed insights into the integration of design thinking and engineering learning, with the cloud ecosystem serving as a key learning tool.

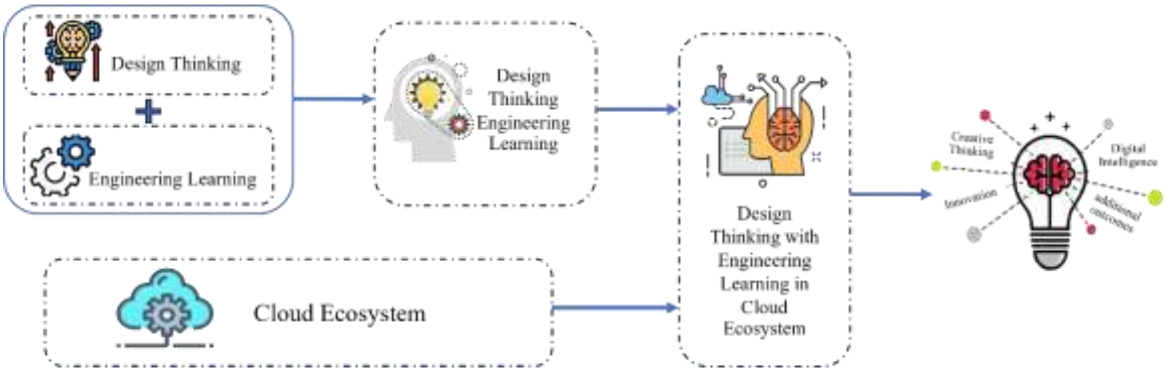

Figure 1. Illustrates a conceptual framework for integrating design thinking with engineering learning in cloud ecosystems.

Table 1. Synthesis of Design thinking process with engineering learning and cloud ecosystem.

Design Thinking	Engineering Learning	Cloud Ecosystem
1. Empathize: Understanding user problems and needs by observing, talking to, or collecting stakeholder data is crucial in building insight and empathy. ***2. Define:*** Analyze the data obtained from the first step to define the problem clearly. A precise problem definition lets the team focus on the right goals. ***3. Ideate:*** Brainstorm to generate multiple solutions without limitations, promoting creativity and generating diverse ideas. ***4. Prototype:*** Create a prototype of a solution to test in a real-world situation. Prototypes allow ideas to be	***1. Problem Identification***: Learners begin by identifying an apparent problem or need in an engineering context, such as a technical problem or a social challenge. ***2. Research and Information Gathering***: Research relevant theories, solutions, or technologies from various sources such as academic journals, online databases, or experts. This step focuses on building the database necessary for designing and developing the solution. ***3. Solution Design***: Conceptualize and design a solution using tools such as CAD or simulation software such as MATLAB. This Design may include creating prototype models to evaluate the solution's feasibility. ***4. Testing and Analysis***: Evaluate the solution in a controlled or real-world environment to assess its	***1. Learning Management Systems (LMS):*** Used to manage lessons, assign assignments, and track grades. Examples include Moodle, Canvas, and Google Classroom. ***2. Data Storage and Sharing:*** The cloud allows students and teachers to store data such as lessons, research, and document files in a secure, accessible format, such as Google Drive or Microsoft OneDrive. ***3. Collaboration Tools:*** To support online learning and collaboration, use platforms like Microsoft Teams, Zoom, or Google Meet. ***4. Data Analytics:*** The cloud supports learning data analysis to improve teaching, such as

quickly refined and developed. ***5. Test:*** This involves testing the prototype with users to get feedback and improve the solution. This stage focuses on learning from users to create a solution that truly meets their needs [43]-[46].	performance and identify areas for improvement. Leveraging simulation tools like ANSYS or Simulink enhances accuracy, safety, and efficiency during testing, providing valuable insights for refining the solution. ***5. Improvement and Optimization***: The data obtained from testing are used to refine the solution for optimum performance. This step may require revising the model or redesigning it as needed. ***6. Communication and Presentation***: Present solutions and outcomes to stakeholders through academic reports, technical presentations, or prototype demonstrations. Emphasis is placed on clear explanations and appropriate supporting data [47]-[52].	student grades or progress [22][34][53][54].

Table 2: Synthesizing the relationship between design thinking engineering learning process in cloud ecosystem tools

Design Thinking Engineering Learning Process	**Cloud Ecosystem**
Step 1: Empathize Problem Recognition Stage In this stage, instructors guide learners in understanding target users. Using cloud ecosystem tools, learners collaborate, discuss problems, and explore user needs to gain deeper insights.	Communication and Discussion tools
Step 2: Define the Problem Problem Definition Stage Learners use the insights gained from discussions with users to define the problem and propose potential solutions, which they then submit to the instructor.	Collaboration tools
Step 3: Imagine Creative Thinking Stage Learners collaborate to brainstorm diverse ideas for solving the problem and jointly select feasible concepts for creating innovative solutions.	Collaboration, Communication, and Discussion tools
Step 4: Plan Planning Stage In this stage, learners collaborate to develop detailed plans and gather necessary information, utilizing document management tools within the cloud ecosystem.	Collaboration tools
Step 5: Create Prototype Prototyping Stage Learners develop a prototype of the designed solution and collaborate using design application tools within the cloud ecosystem.	Collaboration, Information Sharing tools

Design Thinking Engineering Learning Process	Cloud Ecosystem
Step 6: Evaluate Evaluation Stage After creating and refining the prototype, the work is evaluated. Learners gather and accept feedback from others to further improve their solutions.	Testing and Evaluation tools
Step 7: Communicate Presentation and Dissemination Stage This stage involves presenting the work, sharing and exchanging methods used in the design process, and gathering feedback from others.	Presentation, Publishing, and Information Exchange tools

From Tables 1 and 2, the relationship can be analyzed as follows:

1. Design Thinking and Engineering Learning Process:

Both tables show that the steps in design thinking, such as empathy, definition, ideating, prototyping, and testing, are related to engineering learning processes, such as problem identification, solution design, testing, and optimization. Each step of Design Thinking supports and enhances the process of Engineering Learning, such as Prototype creation, allowing students to better test and improve solutions in an engineering context.

2. The role of Cloud Ecosystem in the process:

Cloud ecosystems act as a supporting platform, using learning management systems (LMS), data analytics, and collaboration tools to facilitate each step of design thinking and engineering learning.

3. Consistency in the learning process:

Table 2 shows a precise sequence of steps. It states that each step in design thinking and engineering learning can be more effective with support from cloud technologies, such as using collaboration tools in the empathy step to collaborate between learners and instructors.

4. Support for Skill Development:

Both tables emphasize the cloud's importance in supporting the development of skills such as Creative Thinking, Digital Intelligence, and Innovation through adaptive and collaborative learning.

5. Continuity of Integration:

Both tables illustrate the consistent integration sequence between Design Thinking, Engineering Learning processes, and the use of cloud tools to link theory and practice.

Tables 1 and 2 illustrate the relationship between Design Thinking and Engineering Learning processes supported by the cloud to enhance learning and develop essential skills in the digital age.

V. DISCUSSION

Integrating Design Thinking with Engineering Learning within a Cloud Ecosystem provides a transformative approach to enhancing educational practices. By utilizing cloud-based platforms, students and educators gain access to a flexible, scalable, and collaborative environment that fosters creativity, digital intelligence, and innovation. This integration is underpinned by Constructivist, Problem-Based Learning (PBL), Collaborative Learning, and Experiential Learning theories, which emphasize interactive and learner-centered methodologies. Research indicates that these approaches effectively promote critical thinking, problem-solving, and adaptability, essential skills for success in the digital age [34][47].Design Thinking's iterative process—empathizing, defining, ideating, prototyping, and testing—aligns with the practical demands of engineering education, enabling students to connect theoretical knowledge with real-world applications [1]. Studies highlight the role of cloud technologies in facilitating these stages, offering tools such as learning management systems (e.g., Moodle, Google Classroom), data analytics, and collaboration platforms to enhance learning outcomes [55][56]. For instance, gamified modules within LMS have increased student motivation and retention [25].Moreover, cloud ecosystems enable remote and asynchronous learning, bridging accessibility gaps for students globally. The integration of the

Internet of Things (IoT) and machine learning within cloud platforms further expands their potential, enabling predictive diagnostics, adaptive learning, and innovative solutions across various fields [27][28]. However, challenges such as data security, equitable access to resources, and technical infrastructure must be addressed to maximize the benefits of this integration.

The framework proposed in this study contributes to a growing body of research that advocates using technology-enhanced educational practices to foster holistic learning experiences. By emphasizing collaboration, adaptability, and innovation, it aligns with the evolving needs of learners and educators in the 21st century.

CONCLUSION

This study proposes a framework integrating Design Thinking and Engineering Learning within a Cloud Ecosystem to revolutionize education. By combining learning theories with advanced technologies, the framework fosters creativity, digital intelligence, and innovation through iterative, human-centered processes. Cloud technologies bridge theoretical and practical knowledge by offering resource-rich environments via LMS, data analytics, and collaborative tools, enabling learners to address complex, real-world challenges. Incorporating IoT and machine learning highlights the framework's adaptability across educational and professional contexts. While promising, challenges like data privacy, accessibility, and infrastructure must be addressed. Future research should validate the framework and explore its scalability across disciplines.

IMPLEMENTATION

To implement the proposed framework effectively, educational institutions can follow these steps:

1. Infrastructure Development

Establish a robust cloud-based infrastructure, including learning management systems (e.g., Moodle, Google Classroom), collaboration tools (e.g., Microsoft Teams, Zoom), and secure data storage solutions.

2. Curriculum Integration

Embed Design Thinking principles into engineering curricula, emphasizing empathy, ideation, prototyping, and testing. Integrate cloud tools to support these activities.

3. Training and Capacity Building

Provide professional development programs for educators to familiarize them with cloud technologies, collaborative tools, and Design Thinking methodologies.

4. Pilot Projects

Initiate pilot projects to test the framework in real-world educational settings. Gather feedback from students and educators to refine the approach.

5. Monitoring and Evaluation

Use cloud analytics to track student progress, engagement, and performance. Regularly evaluate the framework's effectiveness in achieving learning outcomes and make necessary adjustments.

6. Scaling and Adaptation

Scale the implementation to encompass broader academic programs and adapt the framework to accommodate diverse learning contexts and disciplines.

By systematically implementing the framework, educational institutions can enhance learning experiences, foster innovation, and prepare students to meet the demands of a rapidly evolving digital landscape.

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