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Unleashing Engagement: Gamifying Adders and Subtractors in Digital Logic with Design Thinking

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Abstract: Adders and Subtractors are fundamental components of digital electronics, essential in nearly every technology. Mastering these elements is crucial for proficiency in digital electronics. This paper explores the design thinking process to create efficient learning resources for Adders and Subtractors. We utilized the five phases of design thinking—empathize, define, ideate, prototype, and test—to develop a user-centric prototype. Our interactive website provides access to various materials and simulations, featuring a user-friendly interface for seamless navigation. Users can build their own logic circuits, promoting hands-on learning, exploration, and innovation in digital logic design. The 2D game, built using Unity with C# scripts, enhances conventional teaching methods by addressing the deficit of hands-on practice. Integrating project-based learning (PBL) ensured continuous feedback and real-world applicability, encouraging deep engagement with the subject matter. PBL fosters active learning, critical thinking, and problem-solving skills, and its collaborative nature enhances teamwork and communication. Our project not only imparts technical knowledge but also prepares students for real-world challenges, making the learning experience comprehensive, engaging, and effective. This platform increases intrinsic motivation, enabling students to stay focused and retain information longer. PBL provided the elements for the learning process whereas Design thinking enhanced the creative process.

Keywords: Design thinking, Adders, Subtractors, Digital electronics, Digital learning, eLearning, Gamification. *JEET Category*—Choose one: Practice

I. INTRODUCTION

When faced with difficult and abstract problems without proven answers, Design Thinking (DT) is an open-minded, creative technique that helps solve these problems. In a design thinking process, we perform a series of nonlinear steps, which are: empathy phase, point of view and problem statement, ideation phase, prototype building phase, and testing. Evaluating the needs of different users is necessary to design and develop a feasible product. DT fosters a deeper understanding of the problem and possible solutions. Our prototype's 2D learning environment, centered on adders and subtractors, is founded on a design thinking approach. It aims to create a better learning environment for end-users.

In digital learning environments, educators and teacher communities are increasingly using media technology to improve collaboration and support asynchronous workflows. Integrating gamification into digital learning environments enriches student learning experiences and expands their opportunities. Gamification of learning fosters high levels of student engagement and commitment to the learning process. This type of training is implemented in a way that is more interesting and motivating for the students.

To ensure an effective educational process, it is essential to create digital learning environments that meet the needs of the learners and cope with the transforming challenges in education. An ideal digital educational environment should offer high-quality content, interactivity, and the ability to customize the learning process for everyone.

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II. LITERATURE SURVEY

The following work chronicles the conduction of a thorough review of multiple articles on design thinking, eLearning, digital electronics, and the use of gamification in learning. This allowed us to gain a comprehensive grasp of the existing tools, techniques and technology. Further details of our discoveries are provided below:

The study by Mahajan et al (2021) examines the impact of incorporating the design thinking process into project-based learning (PBL) for mechanical engineering students. By implementing PBL with design thinking, the study aimed to enhance students' ability to handle real-world problems by applying their theoretical knowledge. Students participated in community-based projects, where they identified and solved local issues using engineering solutions. This approach improved their problem-solving skills, teamwork, and technical knowledge. The study highlights the effectiveness of design thinking in structuring PBL to achieve practical, innovative outcomes and suggests further research to quantify its benefits.

Waidelich et al (2018) have discussed the design thinking methodology. It is used during the problem-solving phase of the design process. In this case, the designer's approach to problem-solving is more significant than the outcome that the designer creates. By rephrasing the problem, incorporating different perspectives, coming up with original ideas, and building a prototype, one can increase the end-user empathy. A practical illustration of the DT method is also provided in the paper. Despite the widespread use of design thinking, this paper identifies a lack of standardized models, highlighting the variation in how different models structure the DT process.

Kernbach et al (2018) highlighted the significance of visualization in design thinking, highlighting its role in externalizing thoughts, improving cognitive performance, and encouraging team engagement. It maps specific visualization methods to design thinking phases, aiming to enhance team efficacy through educated visual strategies.

Patil et al (2024) explore the integration of a Design Thinking for Social Innovation (DTSI) course into the curriculum at a technological university in Karnataka. It finds that the course enhances students' creativity, problem-solving abilities, empathy, and teamwork, enhancing their understanding of engineering's societal role and leadership skills.

The study by Govil et al (2020) explores the integration of advanced mind mapping techniques in project-based learning (PBL) to enhance engineering education. It highlights how mind mapping, a tool developed by Tony Buzan, can significantly improve students' cognitive abilities, creativity, and understanding by providing a clear, visual representation of complex information. The study showcases its application in a third-year course on design thinking and innovation at SR University, demonstrating that mind mapping aids in brainstorming, problem-solving, and ideation processes. The feedback indicates that mind mapping effectively supports learning by making abstract concepts more tangible and improving student engagement and productivity.

Velaora et al. (2022) mention that digital design should be taught with hands-on practices, focusing on students' motivation and the transition from knowledge-based to competency-based learning. Five surveys were carried out from 2017 to 2021, evaluating students' educational outcomes and using ready-made digital games to assess satisfaction. Feedback from previous surveys helped adapt to new teaching methods, allowing students to actively participate in learning, developing skills, and solving problems.

Senthil Kumar et al (2012) described the need for an effective user interface design in a multimedia learning system that employs 3D animation. They discovered a high demand for voice support, text, and 3D animation. The system was created with Autodesk MAYA software, and usability was improved through usability analysis checklists.

Aleksić-Maslać et al (2023) compare learning methods before and during the COVID-19 pandemic, highlighting the effectiveness of e-learning in delivering content and engaging students despite physical limitations. Their paper mentions that the Zagreb School of Economics and Management has successfully transitioned to online classes, achieving improvements in dynamic and additional standards, despite minor changes in static and administrative standards. The successful transition to online classes exemplifies good practice in maintaining education quality during challenging times.

In 2007, the definition of Open Educational Resources (OER) was outlined by the Organization for Economic Co-operation and Development (OECD) as materials that have been digitized and are freely accessible for educators, students, and self-learners to utilize and repurpose for the purposes of teaching, learning, and research.

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In a study by Issa et al (2020), a survey was carried out on 385 students attending three universities in Kwara State, Nigeria. The purpose of the survey was to investigate the perspectives of undergraduate students regarding the utilization of Open Educational Resources (OER) for educational purposes. The findings of the research indicated that undergraduate students generally hold a positive opinion of OER, and there were no significant differences in attitudes based on the students' area of study. Nonetheless, male students displayed slightly more favorable views towards the adoption of OER in comparison to their female peers.

The analysis conducted by Hilton III (2018) combined studies carried out from 2015 to 2018 to explore the connection between Open Educational Resources (OER), student effectiveness, and user attitudes. The analysis revealed a strong link between OER utilization and student effectiveness, showing that OER could increase students' confidence in their skills. Additionally, positive user perceptions of OER were observed, indicating their potential to improve learning and teaching experiences. This study emphasized the significance of OER in education and its ability to empower students while enhancing educational outcomes.

Zhang et al (2021) discuss the use of e-learning in educational platforms, highlighting its effectiveness in monitoring learning groups and boosting student motivation in their paper published in 2021. The advent of digital e-learning platforms contributed to the informatization of higher education by transforming traditional teaching resources, methodologies, models, evaluation, and management.

Nasution et al (2022) used the Design Thinking process to create a web application called 'Ideln'. The primary goal was to improve education in Indonesia through online courses. The System Usability Scale method was used for usability testing, resulting in a score of 90 for the app. This demonstrates effectiveness and user satisfaction.

Vranešić et al (2019) described the role of gamification in motivating and engaging students. Gamification enhances student motivation and engagement by using game elements. Reward systems like leaderboards, prizes, and achievements boost engagement and performance. A Croatian ICT group with a Kahoot score reward system showed higher performance and engagement, while an English ICT group did not.

Hamdi et al (2022) explore the effectiveness of integrating gamification elements into e-learning platforms for medical training. Their study reviewed 23 papers, revealing that gamification significantly enhances medical competence by incorporating game elements such as badges, points, levels, and leaderboards. These elements were found to improve user motivation, attention, and learning outcomes. However, the paper also highlighted a gap in creating an engaging and enjoyable learning experience, suggesting that future research should focus on identifying the most effective game types and techniques for medical education. The review concluded that gamification is a promising method to make medical learning more interactive and effective, though further research is needed to optimize its application.

Staneva et al (2023) present how interactive games can turn students from passive to active learners by increasing effective learning, motivation, and student achievement. It highlights the potential of e-learning, where teachers and students interact in a virtual space, replacing traditional methods. Gamification in education uses game elements to engage students, promoting analytical and problem-solving skills, time management, and stress reduction. This approach can be extremely beneficial for students who are at risk of dropping out of school.

Velaora et al (2021) have described the design of virtual labs and corresponding educational material based on gamification and educational videos to strengthen students' motivation. The Greek government has shifted its focus to distance learning, integrating virtual labs into courses like logic design. These labs offer advantages such as savings, flexibility, multiple access, and damage resistance. However, they lack seriousness and accountability compared to physical labs. Digital simulators and platforms like SDLDS can provide practice-based learning, supervised hands-on practice, and automatic task evaluation. The integration of educational videos and gamification in virtual labs can increase motivation and attract students' attention. The approach is described as pleasant and well-designed, fostering curiosity and rewarding efforts.

Martin et al (2011) focused on designing interactive learning routes to enhance the teaching and learning of digital electronics in high schools and distance learning universities. They developed and tested these interactive tools to enhance student engagement and comprehension. The study concluded that these interactive learning objects effectively supported digital electronics education, leading to improved student understanding and engagement in both traditional and distance learning environments.

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Anil Kumar et al (2010), present a system which enhances the current e-Learning methods using collaborative 2D animations. It aids in providing live conceptual and laboratory experience to the student. Collaborative 2D animations are useful for explaining concepts and ideas in live online interactive classes for distance education. As a prototype it shows how the collaboration of existing 2D objects and animations in a chemistry laboratory can be used in a live class for distance education.

Borodzhieva et al (2020) used computer-based tools to teach adders and subtractors, engaging students with real-time operation, Logisim, and FPGA implementation. This helped develop essential skills like problem-solving, teamwork, and project-based learning, emphasizing the need for active learning strategies in universities.

This survey emphasized on the work carried out through DT process for identification of the problems and PBL approach for execution/implementation of the work. It is evident from the survey that a blend of DT and PBL process results in effective problem identification and solving. However while using PBL techniques, learners were challenged with different phases of complexity in execution that provided depth of knowledge and at the same time struck interest in solving the problems. Also explored this technique in the exhibition mode to have strong competition amongst the peers and good feedback from mentors and industry experts.

B. Organization of Paper

The following sections document our DT process, the details of the prototype we developed as an outcome of the process, and the conclusion for our work. Section (II) describes our work during DT. It details all the five steps of DT and the specifications of our final implementation using PBL. In section III all of our work is concluded.

III. DESIGN THINKING PROCESS

Five phases of the DT process were followed for this work and the same is explained below:

A. Empathy phase

The main goal of this phase is to identify the key stakeholders and survey them to discover what the requirements of the potential consumer base are.

Identification of stakeholders: Students, teachers, and professionals are key stakeholders in learning. Students are active participants, providing valuable feedback for academic success. Teachers educate students and have a role to play beyond providing knowledge in the design of educational environments. They contribute to curriculum development. While professionals, such as digital circuit designers and electrical engineers, drive innovation and shape the future of electronics and computing. Fig.1 and 2 show the empathy maps of students and teachers respectively, these capture the key findings after the respective interviews. It describes what they think and feel about the resources available to them and what they need to do. It describes their pains and gains.

Requirements identified: After posing different types of questionnaires to each category of our stakeholders, the needs to develop a solution were identified. Through the surveys, we found that visualization and simulation were the most prioritized. Mapping the concept to the real world and solving hands-on problems were required. Students shared that there was a lack of hands-on practice and thought that held them back. Teachers saw the possibility of efficient teaching that gets rid of repetition using eLearning or other technologies.

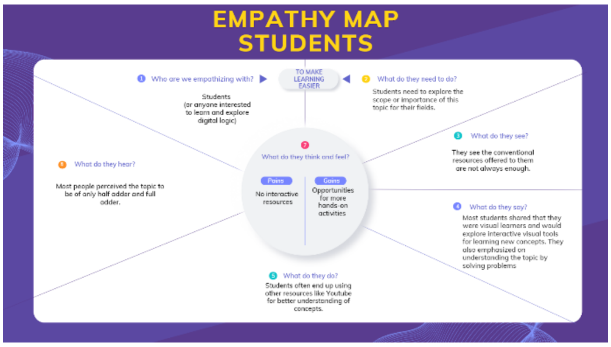

Fig. 1. Student's empathy map

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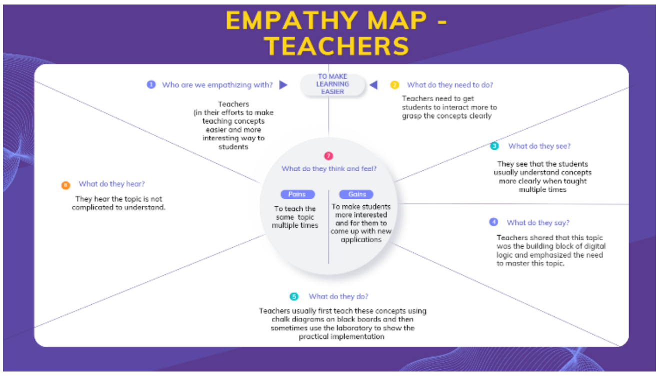

Fig. 2. Teachers' empathy map

B. *Point of view and Problem definition*

The next step in the design thinking process is ‘Define’. After we gathered all the data from the empathy phase, we began to analyze the responses of our stakeholders and define them into a clear and actionable problem statement. We drafted Point of View (POV) statements, which provided us with the direction for the problem definition. We also drafted a series of “How Might We Questions” to guide us in the process. These HMW questions helped us frame problems as opportunities.

The problem statement we defined is: To develop a learning environment for teaching using visual tools. This interactive environment should offer students better opportunities to learn and grasp concepts effectively.

C. Ideation phase

This phase follows the definition phase. In ideation, we discuss and generate possible solutions or ideas corresponding to the previously defined problem statement. This is the core element of the DT method.

We employed eight ideation techniques: – Brainstorming, Brain Walk, Mind mapping, Sketch storming, Worst Possible Idea, Movement, SCRAMPER, Story Boards and Customer Journey maps. Each technique played a crucial role in bringing out ideas across the spectrum. First, mind mapping helps us visualize and organize our thoughts. This helped to bring structure to our thinking process. Fig. 3 depicts the mind map, showing the flow of our ideas. We explored the importance of the concept, the requirements of the users, the teaching methods already in place, some challenges faced by our stakeholders, and potential ways to solve these challenges. Brainstorming is a creative problem-solving technique that helps generate many ideas in a group setting. The primary goal here is to create a free flow of ideas. Using this technique, we came up with an array of ideas.

Brain walk is a technique where we generate ideas by moving around in a designated space. It is an extension of brainstorming, and it allows us to improve on each other’s ideas and make them better. We created three idea spaces and jotted down ideas by walking from one to the other. Fig. 3 depicts the mind map made to understand the challenges and requirements of the users in understanding the concept. In Movement, we took various “what if?” approaches to overcoming obstacles in ideation and finding attributes towards reliable solutions. We explored three “what if?”s: What if we made a movie? What if we created a device? And what if we organized skill development sessions?

The Worst Possible Idea is an ideation method where we purposefully seek the worst solutions in ideation sessions. This “reverse” search process helped us relax, boosted our confidence, and allowed us to create more. SCAMPER, which stands for 'Substitute', 'Combine', 'Adapt', 'Modify', 'Put to another use', 'Eliminate', and 'Rearrange/Reverse', is another method we employed. This technique led us to think with a specific action word, thus giving us different perspectives.

Sketch-storming is a new take on brainstorming that uses sketching to generate ideas. It helped us visualize our ideas by going through possible solutions without implementation details in mind. We used storyboards to depict various abstract elements crucial to the solution design, like people’s thoughts, emotions, and actions. Figure 3 depicts the mind map for the dissemination of adders and subtractors.

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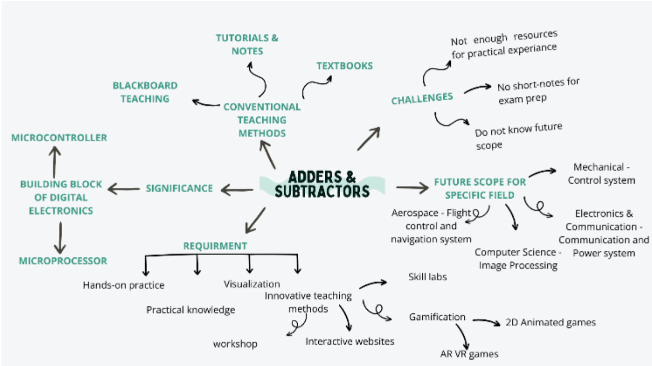

Fig. 3. Mind map for dissemination of adders and subtractors

Customer Journey Map

Fig. 4 represents the Customer Journey Map. We used this map to visualize and understand the user experience. We identified the stakeholders' actions, touchpoints, experiences, emotions, pain points, and solutions along four phases of the journey to buy a product. These four phases are: Awareness- the customer becomes aware of the product; Consideration- he compares it with similar products and considers buying that product; Decision- he decides to buy the product and Retention- he keeps on using the product.

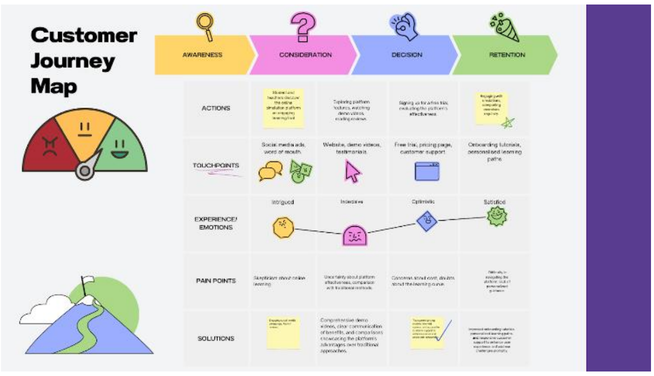

Fig. 4. Customer journey map

(1)

D. *Prototype*

A lot of ideas were generated in the ideation phase to build our product. We came up with a list of prototypes, which includes AR and VR models, Animations, Video lectures, Dynamic websites, and Documentary movies.

AR and VR increase the efficacy of the learning process as the user engages in interactive simulations, thus being able to understand better and retain information for a longer period. Here, education is more engaging and effective. Games seem to be an essential tool for effective learning, motivation, and persistence among students. They promote active learning with less workload for teachers. Games could convert schooling into engaging procedures. That is why it finds its place in education, allowing students to upgrade and visualize electronic content. Animations simplify complex topics, helping to clarify abstract concepts and enhance comprehension and engagement. The dynamic content enhances retention. Video lectures enable flexible learning, i.e., the students can access the content at their own pace. The use of visual and auditory components simplifies the understanding of complex concepts. The user can access the lectures anytime, and the replay option facilitates assessment and reinforcement of knowledge. Students consider educational videos motivating, satisfying, enjoyable, helpful, and effective. The dynamic website provides all kinds of resources for learning the topic. The users will now have access to the resources at their fingertips. Documentary movies provide visual demonstrations, real-life examples, and historical context, making abstract concepts more tangible and engaging for learners.

We discovered that virtual and augmented reality models, as well as dynamic websites, were more viable and adapted to the needs of our stakeholders. The dynamic website is shown below in Fig. 5. On this website, users can learn about

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adders and subtractors, as well as their various types. The website additionally offers simulations to enhance the user experience. Therefore, we created a 2D learning space that encourages student participation in simulations, aiding their comprehension of circuit operations. This is embedded within a dynamic website where all the resources for learning adders and subtractors are available. Their functionality, types, and applications are all available in one place. It has a user-friendly interface designed for seamless navigation.

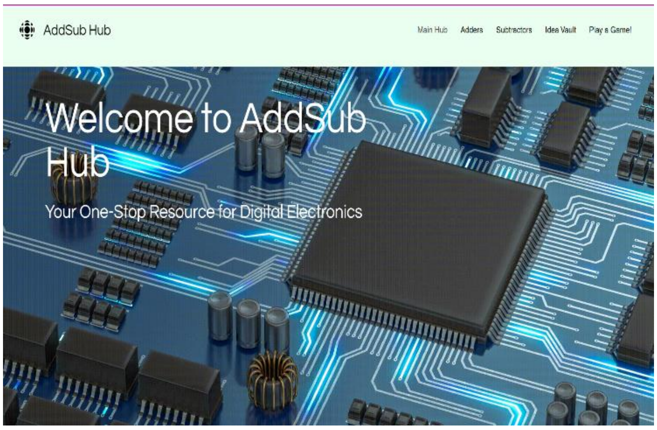

Fig. 5. Prototype of eLearning website (home page)

E. *Testing*

Testing is crucial to any design-thinking process. Testing is the assessment of the prototype to gather feedback and validate assumptions. Through various testing methods, we aim to understand user preferences and the accessibility of our prototype, allowing for improvement and refinement. We applied three different testing methods: usability testing, which focuses on the user's ability to interact with our prototype; concept testing, which assesses the overall appeal of the idea; and A/B testing, which presents two variations to the user to determine the most effective solution.

Through usability testing, we determined that the user interface needed significant work, especially in the areas of functionality and navigation. Concept testing revealed strong user engagement with the features, suggesting an alignment with user needs. A/B testing showed that the newer prototype was significantly favored. The feedback we gathered told us that most of the users did not previously use online platforms for implementing logical circuits, so they could not easily grasp how to use our prototype. It emphasized the need for an instruction manual or page. Some users felt a change in font and styling would make the interface more appealing; others anticipated that it would be difficult to use our platform for complex circuits. Fig. 6. represents the changes made in the interface for a better user experience. Some users also mentioned how helpful it would be to have a resource to understand the concepts in a better way before putting them into practice. In addition to assisting us in improving user satisfaction, the insights we obtained made it clear that testing is necessary to provide a comprehensive user experience.

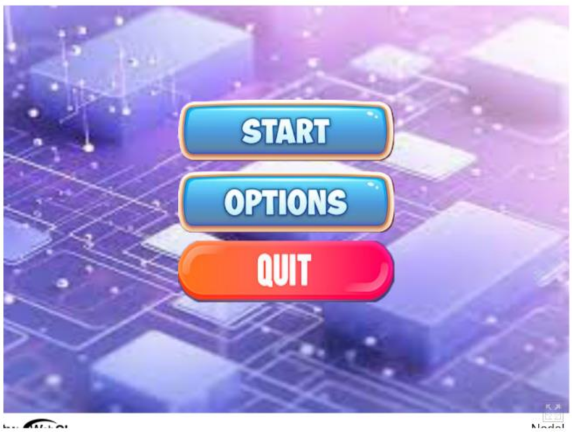

Fig. 6. 2D learning platform for practicing logical circuits.

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Figs. 7 and 8 illustrate the feedback from our prototype. The users found our website helpful and gave some constructive feedback, which helped us make improvements.

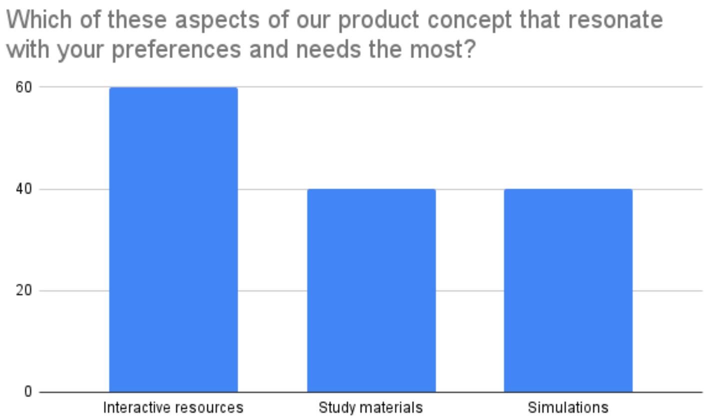

Fig. 7 Bar chart illustrating the responses to a question from the testing questionnaire.

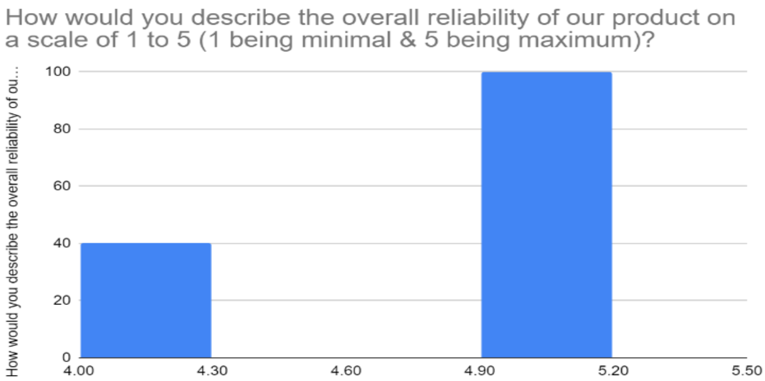

Fig. 8 Bar graph describing the reliability of our product to users

Fig. 9 illustrates the total number of website sessions. We infer from this data that we have recurrent traffic from returning users, indicating that users revisit the site. Link to our website: https://addsubhub.wixsite.com/addsub-hub

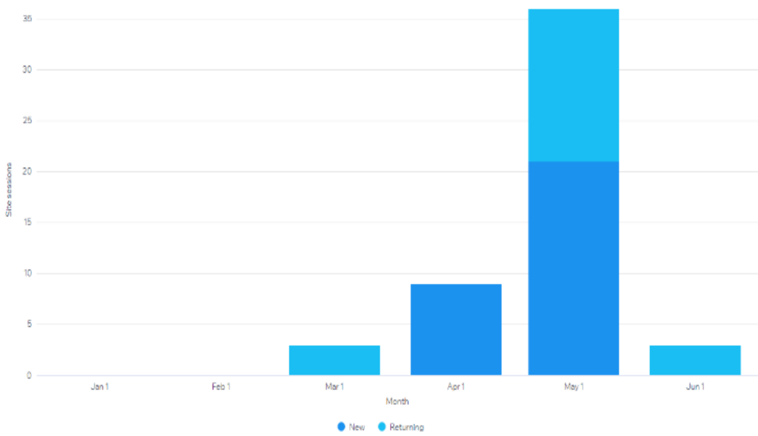

Fig. 9 Overall sessions on the website AddSubHub

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PBL was used for the implementation of the project, in which the problems were identified using the DT process. There was a perfect strike between DT and PBL. PBL was practiced to solve the problems in two different phases. In the first phase, the rubrics were basic, and in the second phase the complexity of proving the projects was increased. The second phase was conducted in exhibition mode which added value with deep insights into the work carried out.

The testing phase of the Design Thinking process revealed that the developed prototype, a 2D interactive learning environment, effectively engaged students and enhanced their understanding of adders and subtractors. Feedback from users was integral in refining the prototype, demonstrating the importance of iterative testing and user involvement in creating a successful educational tool. Our website offers a dynamic and accessible educational experience. The users will have an easier time understanding complex topics and will retain information for a longer period. This platform also has a **blog site**, which encourages engagement among students and professionals. Additionally, it complements traditional teaching techniques by aiding educators in providing students with information through an array of advanced visualization tools. It is accessible to users with varied degrees of expertise. As a result, it makes learning easier and more enjoyable. Project-based learning (PBL) was integral to t0his development process, as it allowed us to create and refine our website based on real-world needs and continuous user feedback. Through PBL, we not only built a robust educational tool but also fostered a collaborative and innovative learning environment for both students and educators. It allows for the simplification of complex subjects, improves information retention, and increases student engagement. The website is accessible to users of all expertise levels, with advanced visualization tools and a blog site supporting a comprehensive and enjoyable learning experience.

IV. CONCLUSION

In conclusion, this paper demonstrates the effective application of Design Thinking and Project-Based Learning (PBL) in creating a dynamic, user-centric educational platform for teaching adders and subtractors. By following the five phases of Design Thinking—empathize, define, ideate, prototype, and test—we developed a prototype that addresses the identified needs of students and educators. The resulting 2D interactive learning environment, complemented by a comprehensive website, enhances traditional teaching methods through engaging simulations and hands-on practice. This approach not only fosters deeper understanding and retention of digital logic concepts but also encourages critical thinking, problem-solving, and collaboration, making the learning process more engaging, effective, and enjoyable.

REFERENCES

[1]. Aleksić-Maslać, K., Vranešić, P., & Sinković, B. (2023). From classroom to online environment — The comparison analysis of the e-learning standards before and during the COVID-19 pandemic. In 2023 46th MIPRO ICT and Electronics Convention (MIPRO) (pp. 688-692). https://doi.org/10.23919/MIPRO57284.2023.10159637
[2]. Anil Kumar, T. P., Nidhina, K., Vijith Krishnan, V., Bijlani, K., & Anu, P. (2010). Collaborative 2D animations in e-Learning paradigm and its applications. In 2010 International Conference on Technology for Education (pp. 248-249). Mumbai, India. https://doi.org/10.1109/T4E.2010.5550113
[3]. Borodzhieva, A. N., Stoev, I. I., Tsvetkova, I. D., Zaharieva, S. L., & Mutkov, V. A. (2020). Computer-based education in the course "Digital electronics" teaching the topic "adders-subtractors". In 2020 43rd International Convention on Information, Communication and Electronic Technology (MIPRO) (pp. 705-710). https://doi.org/10.23919/MIPRO48935.2020.9245149
[4]. Govil, A., Govil, V., Srikar, K., Reddy, V. S., & Lohith, M. (2021). A Pellucid Approach for PBL using Advanced Mind Mapping. *Journal of Engineering Education Transformations*, 34(Special Issue), 675-680.
[5]. Hamdi, L. F., Hantono, B. S., & Permanasari, A. E. (2022). Gamification methods of game-based learning applications in medical competence: A systematic literature review. In 2022 International Symposium on Information Technology and Digital Innovation (ISITDI) (pp. 50-54). https://doi.org/10.1109/ISITDI55734.2022.9944535
[6]. Hilton, J. (2020). Open educational resources, student efficacy, and user perceptions: A synthesis of research published between 2015 and 2018. Education Tech Research Dev, 68, 853–876. https://doi.org/10.1007/s11423-019-09700-4
[7]. Issa, A. I., Ibrahim, M. A., Onojah, A. O., & Onojah, A. A. (2020). Undergraduates' attitude towards the utilization of open educational resources for learning. International Journal of Technology in Education and Science (IJTES), 4(3), 227-234.
[8]. Kernbach, S., & Svetina Nabergoj, A. (2018). Visual design thinking: Understanding the role of knowledge visualization in the design thinking process. In 2018 22nd International Conference Information Visualisation (IV) (pp. 362-367). https://doi.org/10.1109/iV.2018.00068

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ≋ Peer-reviewed & Refereed journal ≋ Vol. 13, Issue 2, February 2024
DOI: 10.17148/IJARCCE.2024.13253

[9]. Kumar, B. S., & Jayasimman, L. (2012). A study on the user interface design for a multimedia learning system with emphasis on 3D animation. In IEEE-International Conference On Advances In Engineering, Science And Management (ICAESM -2012) (pp. 110-115).
[10]. Mahajan, H., Naik, S. M., Sreeramulu, M., Kannaiah, C., & Majeedullah, S. (2021). Impact of project-based learning for improving students' skills by incorporating design thinking process. *Journal of Engineering Education Transformations, 34*(Special issue).
[11]. Martin, S., Fabuel, J. J., Sancristobal, E., Castro, M., & Peire, J. (2011). Work in progress — Design of interactive learning objects for improvement of digital electronics teaching and learning in high school and distance learning universities. In 2011 Frontiers in Education Conference (FIE) (pp. T4C-1-T4C-2). https://doi.org/10.1109/FIE.2011.6142794
[12]. Nasution, W. S. L., & Nusa, P. (2022). UI/UX design web-based learning application using design thinking method. ARRUS Journal of Engineering and Technology, 1(1), 18-27.
[13]. OECD. (2007). Giving knowledge for free: The emergence of open educational resources. OECD Publishing. https://doi.org/10.1787/9789264032125-en
[14]. Senthil Kumar, B., & Jayasimman, L. (2012). A study on the user interface design for a multimedia learning system with emphasis on 3D animation. In IEEE-International Conference On Advances In Engineering, Science And Management (ICAESM -2012) (pp. 110-115).
[15]. Staneva, A., Ivanova, T., Rasheva-Yordanova, K., & Borissova, D. (2023). Gamification in education: Building an escape room using VR technologies. In 2023 46th MIPRO ICT and Electronics Convention (MIPRO) (pp. 678-683). https://doi.org/10.23919/MIPRO57284.2023.10159923
[16]. Velaora, C., & Kakarountas, A. (2021). Game-based learning for engineering education. In 2021 6th South-East Europe Design Automation, Computer Engineering, Computer Networks and Social Media Conference (SEEDA-CECNSM) (pp. 1-6). https://doi.org/10.1109/SEEDA-CECNSM53056.2021.9566215
[17]. Velaora, C., Dimos, I., Tsagiopoulou, S., & Kakarountas, A. (2022). Game-based learning approach in digital design course to enhance students' competency. Information, 13(4), 177. https://doi.org/10.3390/info13040177
[18]. Vranešić, P., Aleksić-Maslać, K., & Sinković, B. (2019). Influence of gamification reward system on student motivation. In 2019 42nd International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO) (pp. 766-772). https://doi.org/10.23919/MIPRO.2019.8756848
[19]. Waidelich, L., Richter, A., Kölmel, B., & Bulander, R. (2018). Design thinking process model review. In 2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC) (pp. 1-9). https://doi.org/10.1109/ICE.2018.8436281
[20]. Zhang, B. (2021). Research on educational informatization platform based on e-learning platform. In 2021 IEEE Asia-Pacific Conference on Image Processing, Electronics and Computers (IPEC) (pp. 1043-1046). https://doi.org/10.1109/IPEC51340.2021.9421207

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