

## SPECIAL FOCUS PAPER

# From Lecture Halls to Metaverse Worlds: A New Era in Engineering Education

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## ABSTRACT

The rapid growth of immersive educational technology has opened up new possibilities in higher education, particularly in engineering education, where hands-on and experiential learning are crucial. This study examines the potential impact of utilizing the metaverse in lesson design on the way engineering is taught in schools. The study offers a comprehensive educational framework that incorporates gamified homework, collaborative work with avatars, 3D virtual worlds, and real-time simulations of engineering processes. It is based on theories of constructivist and experiential learning. The study employed a combination of methods and included undergraduate engineering students from core fields such as electronics and computer science. The participants utilized Unity and spatial platforms to learn in a metaverse-based environment, which replaced traditional lectures with coding worlds, virtual labs, and problem-solving scenarios. We used pre- and post-tests to determine how much students learned in mathematics. We also conducted focus groups and interviews with teachers to gauge their interest, ease of use, and perceived usefulness for teaching purposes. The results showed that students were significantly more motivated, engaged, and understanding when they used this method compared to traditional classroom methods. Students reported that using avatars made it easier for them to collaborate, think more clearly, and pay closer attention. The study also identified real-world challenges, including the need for faculty training in virtual instructional design, the difficulties of onboarding, and the limitations of technology. This study contributes to the growing field of metaverse-driven pedagogy by presenting a flexible and scalable approach to designing engineering curricula. It provides schools that want to incorporate immersive environments into their regular classes with helpful advice. The results show that the metaverse can help bridge the gap between theory and practice. This will make engineers more creative, flexible, and ready for the job market.

## KEYWORDS

metaverse, immersive learning, virtual reality, experiential learning, higher education, digital transformation, engineering pedagogy

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## 1 INTRODUCTION

Engineering education has been the most effective way to prepare students for jobs that require creativity, system design, and problem-solving for a long time. Project-based learning, organized lab experiments, and teacher-led lectures have been integral components of engineering education for many years. These methods have been effective for a long time in the field; however, as technology continues to evolve rapidly, the industry's needs and learner expectations are also changing. Consequently, engineering must be taught and experienced in a completely new way.

In recent years, schools have begun using a wide range of digital tools, including learning management systems, simulation software, and multimedia-rich content. These tools make learning easier and more enjoyable. However, even with these changes, many engineering classrooms still employ a largely passive method of delivering content, which makes it challenging for students to engage, think critically, and apply their knowledge in the real world. As engineering increasingly moves toward automation, cyber-physical systems, artificial intelligence, and interconnected infrastructures, the gap between what is taught in traditional classrooms and what is needed in today's workplaces is widening.

New immersive technologies, such as virtual reality (VR), augmented reality (AR), extended reality (XR), and the broader concept of the metaverse, are transforming the way we learn. With the help of avatars, the metaverse—an immersive, persistent, and networked virtual world—enables students and teachers to collaborate on virtual design projects, model real-world engineering scenarios, and receive immediate feedback in a three-dimensional setting. These affordances provide a viable solution to the challenges of traditional teaching, employing learner-centered, scalable, and experiential methods.

There is considerable theoretical potential for these technologies, and some early experiments have been conducted with them. However, there are still not enough real-world research and instructional design (ID) models that can help bring the Metaverse into engineering education. You need to think carefully about things like how easy it is for students to get to class, how well the teaching aligns with the content, how to present the content, and how well the technology is prepared. We also lack a clear understanding of how metaverse-based learning environments impact the cognitive and emotional learning domains, particularly in fields such as engineering, where hands-on experience, teamwork, and visualization are crucial.

This study tries to fill in the gaps by looking into how a metaverse-based ID framework could change the way engineering is taught. The project's goal is to create an immersive learning model that uses basic engineering ideas in online spaces where students can talk to each other, try new things, and work together. It also wants to know how well this model works to get students more involved and improve their learning compared to more traditional ways of teaching. This study not only teaches us more about how to use technology in the classroom, but it also gives curriculum designers, teachers, and school leaders who want to make sure that engineering education is ready for the future in a world that is changing quickly because of digitalization useful tips.

This study is based on two main research questions: (1) How does using the metaverse for teaching affect how well engineering students learn compared to other methods? and (2) What are the most important tools and ideas for designing lessons that use technology in the metaverse? The study's goal is to bridge the gap between teaching and new technology by answering these questions. This will make engineering education more inclusive, dynamic, and ready for the future.

## 2 THEORETICAL AND EMPIRICAL FOUNDATIONS

There have been a lot of changes in how engineering is taught in the last few decades. This is because the field is getting more complicated, and more graduates need to be ready for the real world. Most schools still teach in the old-fashioned way, with lectures, but there is a slow but clear shift toward student-centered models, active learning, and using technology in the classroom. Flipped classrooms, outcome-based education (OBE), problem-based learning (PBL), and interdisciplinary capstone projects are all becoming more common. These methods stress working together, getting more involved, and using what you learn in the real world. These are all skills that engineering graduates need to be able to adapt to industries that are always changing. Even with these changes, there is still a big gap between what students learn in school and what they need to know to do well in the real world. A lot of students still have trouble with abstract ideas, and they don't get to practice what they learn because they don't have enough resources or their curriculum limits what they can do.

To avoid these teaching problems, you need to use ID models to plan and carry out learning experiences that work. In higher education, Bloom's Taxonomy, the successive approximation model (SAM), and ADDIE (analyze, design, develop, implement, evaluate) are all common ways to make lessons that are structured, measurable, and focused on the learner. ADDIE makes sure that learning goals, evaluation, and content distribution all work together by giving you a clear way to do things. SAM has a flexible, iterative method that makes the design phase better and better. The new version of Bloom's Taxonomy helps teachers set learning goals for all levels of thinking, from remembering things to coming up with new ways to solve problems. These traditional models were made for traditional or digital learning environments, so they don't always work in places such as the Metaverse, where learning is immersive, nonlinear, and interactive. As XR environments get more immersive, interactive, and personalized, it becomes more and more important to change these models or make new ones. VR, AR, and mixed or XR, are some immersive technologies that have become useful for teaching. These technologies let students interact with digital things and fake environments in real time through sight, sound, and touch. This helps them learn better. XR combines the two to create learning experiences that go smoothly. AR adds digital information to the real world, while VR lets students move around in 3D spaces and feel like they are really there.

The idea of the metaverse—a persistent, networked virtual environment where users can interact, learn, work together, and create as avatars within simulated spaces—was born out of the recent convergence of these technologies. The metaverse offers gamified instruction, real-time collaboration, and experiential learning in educational settings that are difficult for conventional approaches to match.

Numerous case-based and experimental studies have shown how immersive technologies can be used in STEM and engineering fields. For instance, VR has been effectively used to teach intricate spatial concepts in architectural modeling, circuitry, and mechanical design. Students who use VR-based labs exhibit better retention, engagement, and conceptual clarity, according to research. In one study, students were able to replicate the advantages of physical labs without the risks by conducting virtual experiments in dangerous or inaccessible settings thanks to immersive learning environments. The usefulness of 3D simulations in improving group problem-solving and systems thinking has been the subject of other studies. Although these studies support the educational benefits of immersive technologies, they frequently only look at short-term interventions or particular modules rather than a thorough instructional model that is incorporated into an engineering curriculum.

Testing in the real world helped students do better, which leads to more innovation and support for policies. [1] This systematic review uses databases like Scopus and Google Scholar to find out how to use Metaverse tools in engineering education. Researchers are looking into how digital twins and people working together on computers interact in virtual learning environments. They are also trying to figure out what the most important topics, materials, and ways to teach are. The study uses VOS viewer to show the pros and cons of using Metaverse for teaching. The study gives a general idea of how things are done now. Researchers are systematically looking at the educational potential of the Metaverse by seeing how new technologies such as AI, VR, and AR work together. The study looks at the parts of the technology, how it is used, and moral issues, as well as technical and infrastructure problems. It's clear that immersive experiences are very important for teaching students how to talk to and understand other people. The study gives good advice on how to use metaverse tools in school in a way that will be useful to a lot of people for a long time. [3] The Edu-Metaverse model that researchers have come up with fits with Sustainable Development Goal 4, which says that everyone should have equal access to learning opportunities. The paper talks about the basic parts of a real-world educational Metaverse ecosystem, such as a full taxonomy, architecture, and new ways to teach. It talks about problems such as having a lot of different students and access to technology, as well as learning that is both collaborative and immersive. There are smart ways to use it more often. [4] Combining blockchain, AI, and the metaverse is one way to make school safer, more fun, and more personal.

Researchers concentrate on immersive simulations, adaptive learning platforms, and blockchain-based transparent credentialing. Use cases in STEM and medical education illustrate the potential for real-world application. Infrastructure needs, ethical issues, and regulatory concerns all impede full-scale implementation [5]. This systematic literature review uses data from Scopus to identify nine major themes that show how the metaverse influences student attitudes, academic practices, and results. Researchers emphasize immersion learning, real-world social interactions, and shifts from traditional educational paradigms. The study lays the foundation for future investigations into knowledge sharing and cultural awareness in digital contexts. It draws attention to the challenges of the real world as well as the possibility for change. [6] In order to enhance learning, researchers look into how VR and AR technologies enable realistic, immersive simulations. Using AI and data analytics to support personalized learning pathways is essential to personalizing educational experiences. Innovative assessment tools aim to promote critical thinking and teamwork. The study claims that metaverse-driven platforms will make teaching more efficient and interesting. [7] Using the PRISMA framework, researchers conduct a bibliometric review of metaverse studies conducted between 2010 and 2024. VR and AR technologies are highlighted as the dominant forces in thematic clusters that focus on sustainability and customization. The study identifies research gaps and calls for institutional collaboration to overcome infrastructure barriers. It recommends dynamic, scalable metaverse learning environments. [8] Research clusters and intellectual structures in metaverse education are identified by this bibliometric analysis, which spans the years 2014–2023. The study highlights understudied topics and encourages expanding research into fields other than human resources and commerce. Researchers look at trends in Gen Z, psychological engagement, and virtual human interaction. It offers significant directions for additional study. [9] The metaverse is said to be a useful resource for immersive, interactive, and inclusive education. To reach its full potential, researchers highlight ethical and privacy concerns that must be addressed. Fair, secure, and dynamic learning environments that cater to a diverse range of learners are highly valued

in the study. It encourages inclusivity and ongoing development in the design of online education. [10] Scholars investigate the potential of the metaverse to enhance educational opportunities, specifically for underprivileged groups in India. Issues with infrastructure, culture, and inclusivity are examined, as are ongoing pilot projects. The study recommends focused funding and legislative support to ensure that metaverse education is implemented equitably. It highlights the technology's potential in localized learning settings. [11] A meta-analysis of 34 studies found that metaverse technologies significantly enhance learning outcomes and student experiences. Scientists discover that elementary and secondary school pupils and science classes are most impacted. Efficacy has been shown to be impacted by moderating factors such as subject, learning duration, and tool type. The study confirms the growing importance of the metaverse in high-quality education. [12] Researchers propose the MEED framework, which promotes entrepreneurship among PWDs by utilizing design thinking and metaverse tools. This approach promotes empathy-driven, immersive learning that is tailored to various types of disabilities. It aligns with SDG 4 by emphasizing inclusivity and lifelong learning. The implications include equitable access to business education and improved emotional engagement. [13] Using the Diffusion of Innovation theory, researchers look at how the metaverse is being adopted in tourism and hospitality education. Thematic analysis of interviews reveals that readiness and acceptance vary by profession and by generation. Early adopters applaud its benefits, but costs and infrastructure remain problems. A phased integration model is recommended for educational institutions. [14] A systematic review of AI-powered educational agents in the metaverse highlights design strategies and ethical issues. Researchers have found that hybrid human–AI workflows outperform fully autonomous systems. The limitations of current studies, such as their short durations and small sample sizes, call for more comprehensive evaluations. These design principles are proposed for future developments. [15] This mixed-method study integrates BIM training into the metaverse and identifies nine key factors influencing training outcomes. Researchers use extensive surveys and expert panels to validate the findings. Successful implementation has been shown to be influenced by behavioral, sociocultural, and infrastructure readiness factors. The study supports the value of immersive tools in engineering education. [16] Themes such as pedagogical development and implementation challenges are found in a systematic review of iSTEM education based on Roblox. Gamified, experiential learning is made easier by the voxel-based environment. More research is required to address technological and instructional challenges, despite the benefits in terms of student involvement. The study validates the platform's potential in STEM education. [17] This qualitative study looks at unexpected outcomes of metaverse adoption in EdTech companies. Researchers suggest “meta-governance” as a solution to problems like resource misallocation and technological obsolescence. The findings demonstrate that platform development necessitates strategic foresight. The study contributes to the discussion on how to deal with evolving educational technology.

In order to investigate the efficacy of a metaverse-based instructional framework in engineering pedagogy, this study used a mixed-methods research design. This strategy was chosen in order to gather more detailed information about how instructors and students felt about the immersive environment as well as measurable proof of learning outcomes. The effect of the intervention on academic performance and engagement was evaluated using quantitative data, and the results were interpreted with regard to context, nuance, and user-centric viewpoints from qualitative data. Undergraduate and graduate students enrolled in computer science and electronics and communication engineering programs at a mid-sized technical university made up the study's participants. Purposive sampling was used in the sample selection

process to guarantee that participants had a fundamental understanding of digital tools and programming environments, which is a necessary precondition for engaging with the metaverse platform in a meaningful way. A control group of 60 students received instruction in a traditional classroom setting, while the experimental group received instruction through a metaverse-based learning environment. The study's qualitative component also included faculty members who taught the modules.

**Table 1.** Summary of research methodology

<b>Research Design</b>	Mixed-method approach combining quantitative (quasi-experimental design) and qualitative methods.
<b>Participants</b>	60 engineering students (UG/PG) from CSE and ECE; divided into control and experimental groups.
<b>Platform Used</b>	Spatial.io – a metaverse platform enabling real-time 3D collaboration and interaction.
<b>Instructional Model</b>	Based on the ADDIE framework, constructivist principles, and Bloom's Taxonomy; tailored for immersive learning.
<b>Learning Modules</b>	Virtual labs, collaborative coding environments, and real-world engineering challenge zones.
<b>Data Collection (Quantitative)</b>	Pre- and post-test to measure learning outcomes; structured surveys for engagement and satisfaction.
<b>Data Collection (Qualitative)</b>	Semi-structured interviews and focus groups with students and instructors.
<b>Quantitative Analysis</b>	Descriptive statistics, paired-sample t-test, and one-way ANOVA.
<b>Qualitative Analysis</b>	Thematic analysis using Braun & Clarke's method; coded with NVivo.
<b>Key Outcomes Measured</b>	Learning effectiveness, student engagement, satisfaction, and usability of the metaverse environment.

Constructivist learning theory and ADDIE principles were combined to create the ID framework that underpins the intervention, which was then modified to take advantage of the metaverse's affordances. Because of its accessibility, ease of use, and ability to facilitate immersive, real-time collaboration, the Spatial.io platform was selected to create the digital environment. The setting was designed as a "code realm," a virtual campus with several interactive learning areas, including gamified challenge zones where students could solve real-world engineering problems, collaborative design rooms for team-based projects, and virtual laboratories for circuit simulation and programming exercises.

To match the objectives of the course, learning modules were thoughtfully incorporated into these settings. Orientation, interactive content exploration, practice tasks in real time, formative assessments, and peer collaboration via avatar-based engagement comprised each module. Instructors were present as digital avatars to moderate, instruct, and evaluate participation, and feedback was given instantly within the environment.

A variety of tools were used to gather data in order to assess the instructional impact. Pre- and post-tests measuring concept mastery, problem-solving skills, and knowledge retention were given to both the experimental and control groups in order to assess the quantitative component. Subject matter experts validated these tests, which were created to correspond with Bloom's Taxonomy levels. Additionally, using a 5-point Likert scale, standardized surveys were utilized to gather student opinions regarding the virtual environment's usability, engagement, and satisfaction.

Semi-structured interviews and focus groups with both students and instructors from the experimental group were used to collect the qualitative data. Perceived learning gains, motivational changes, teamwork experiences, technical difficulties, and improvement ideas were the main topics of discussion.

Two stages of data analysis were carried out. To find significant differences between pre- and post-test scores across groups, statistical tests like one-way ANOVA and paired-sample t-tests were applied to the quantitative data. We also used descriptive statistics to show the results of the survey on how satisfied and involved people were. We wrote down the answers to the qualitative data and then used Braun and Clarke's six-phase framework to find important patterns, themes that came up again and again, and important user insights. We used NVivo to code the data so we could be sure that the interpretation was right and could be done again.

The main goal of this method was to get a complete picture of how metaverse-based instruction affects engineering education, check the results against each other, and make sure they are correct. The results of the analysis help us understand how immersive learning environments in STEM fields can be used in real life and how they affect learning.

### 3 DEVELOPMENT OF THE INSTRUCTIONAL DESIGN BASED ON METAVERSE

The main goal of this method was to get a complete picture of how metaverse-based instruction affects engineering education, check the results against each other, and make sure they are correct. The results of the analysis help us understand how immersive learning environments in STEM fields can be used in real life and how they affect learning. We used ideas from constructivist learning theory, experiential learning, and digital pedagogy to create the metaverse-based ID for this study. The goal was to make a learning space that was immersive, interesting, and pedagogically sound and that would give students all the benefits of a regular engineering classroom but better. The design was planned using the ADDIE model, but some changes were made for 3D immersive learning environments.

We chose the Spatial.io platform to make the lesson plan because it is simple to use, can handle many users, and works with both web-based tools and 3D media. The "code realm" was a virtual world with different areas that were based on the learning modules. There were simulation rooms, collaborative coding lounges, virtual electronics labs, and a central hub for navigation and announcements. We built each learning area with customizable 3D assets that let avatars talk to each other and made people feel like they were there and involved. With a focus on the application, analysis, and creation levels, the learning objectives were mapped to Bloom's Taxonomy. For instance, students had to put together circuits, debug code in real time, and visualize logic flows in a virtual electronics lab. Collaborative coding zones simulated real-world software development cycles by having students work in groups to design, implement, and test algorithmic solutions. In this arrangement, avatars were essential because they allowed students to communicate via voice, gestures, and shared interfaces, improving social presence and group learning.

The structured five-stage cycle of the instructional flow made deep learning easier:

- Getting started – Students learned how to use the communication tools, customize their avatars, and get around the virtual world during orientation sessions.
- Look into it – To spark curiosity and help students get to know the area better, they were told to explore different zones on their own or in small groups.

- Learning through Tasks – In each module, students did supervised activities like design challenges, debugging exercises, and simulations. AI-guided bots and interactive boards were used to make the instructions fit in with the environment.
- Evaluation – We used peer reviews, task completion trackers, and quizzes that let students talk to each other as tests to see how well they were learning. Students' final projects that they turned in online were graded as part of their final exams.
- Introspection – Students could talk about their work, get feedback from their teachers and classmates, and share their ideas in online discussion rooms. Students could also listen to their recorded sessions again to see how well they did and if they met their learning goals.

## 4 RESULT AND ANALYSIS

This part shows what the study found by looking at the pre- and post-test scores and survey answers from the students who used the metaverse-based instructional design. The results are set up to answer the main research questions about how the metaverse affects how interested students are and how well they learn.

### 4.1 Learning outcomes: Quantitative analysis

We gave both the control and experimental groups the same standardized tests before and after the experiment to see how well they did. There was a score out of 100 for each test. The experimental group learned in a traditional classroom setting, while the control group learned in immersive, metaverse-based sessions. The average scores for both groups are shown in Table 2.

**Table 2.** Comparison of pre- and post-test scores

Group	Pre-Test Mean	Post-Test Mean	Mean Gain
Control	57.5	62.2	+4.7
<b>Experimental</b>	57.5	62.2	+4.7

We used a paired-sample t-test to see if the learning gains were statistically significant in each group. The group in charge did a little better, but the difference was big enough to be statistically significant ( $t(9) = 3.14, p < 0.05$ ). The experimental group, on the other hand, did a lot better ( $t(9) = 8.67, p < 0.001$ ). This means that using the Metaverse for teaching is a good way to help students learn.

When a one-way ANOVA was used to look at the post-test scores of the two groups, there was also an F-value of 42.3 at a significance level of  $p < 0.001$ . This means that the groups were not different by chance.

When compared to conventional pedagogical approaches, these results offer solid proof that metaverse-based instruction greatly improves students' comprehension of engineering concepts.

### 4.2 Student engagement and satisfaction: Survey analysis

In order to supplement the test results, ten students in the experimental group filled out a post-instruction survey that assessed their learning in four

important areas: conceptual clarity, engagement, enjoyment, and preference for further education. The average scores on a 5-point Likert scale (1 being strongly disagree and 5 being strongly agree) are summarized in Table 3.

**Table 3.** Student engagement and satisfaction survey (experimental group)

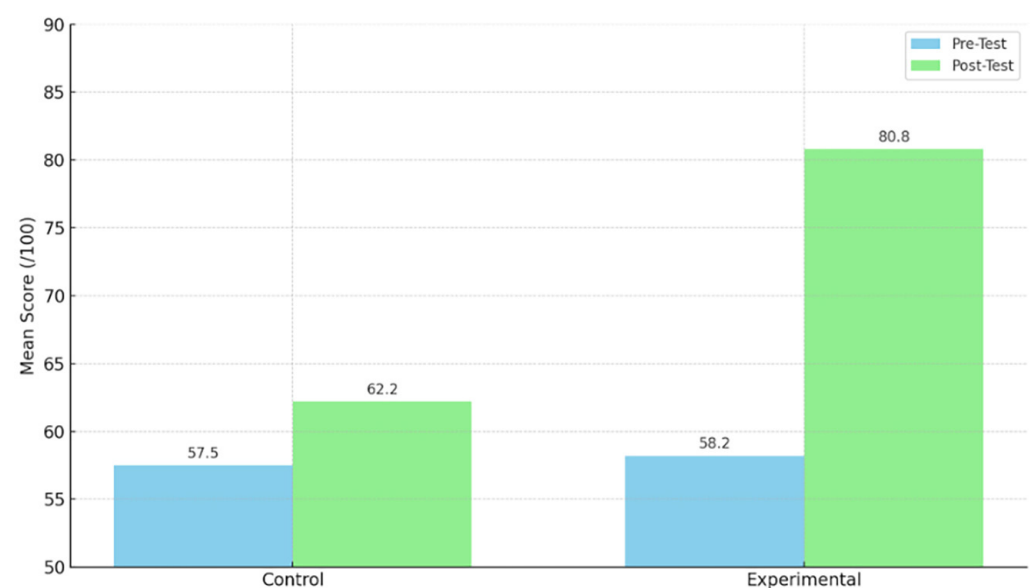
Survey Item	Mean Score (/5)
The metaverse helped me understand engineering concepts	4.6
I felt more engaged than in a traditional classroom	4.7
I enjoyed learning in the virtual environment	4.7
I would prefer metaverse-based learning in future courses	4.7

These findings show that students' reactions to the immersive experience were consistently positive. Improved engagement and enjoyment, which are important markers of intrinsic motivation and successful learning, are reflected in the highest-rated items.

### 4.3 Qualitative insights

Deeper understanding of the learning process was obtained through focus groups and semi-structured interviews with teachers and students. The metaverse environment was characterized by students as “visually stimulating,” “collaborative,” and “realistic.” A number of participants also mentioned that they were able to “retain concepts better after actively performing tasks in the virtual labs.” During team-based simulations and coding challenges, instructors noticed an increase in creativity, peer support, and participation.

But difficulties were also noted. Some students mentioned that they were initially uneasy using the virtual environment and recommended that more time be set aside for onboarding. Technical difficulties were also observed, including device compatibility problems and lag in real-time interactions.



**Fig. 1.** Pre- vs. post-test scores by group

## 5 SUMMARY OF KEY FINDINGS

Compared to the control group, the experimental group showed learning gains that were almost five times larger. Pupils who participated in metaverse-based learning expressed greater levels of engagement and satisfaction. The improved visualization, motivation, and cooperative learning made possible by immersive environments were validated by qualitative data.

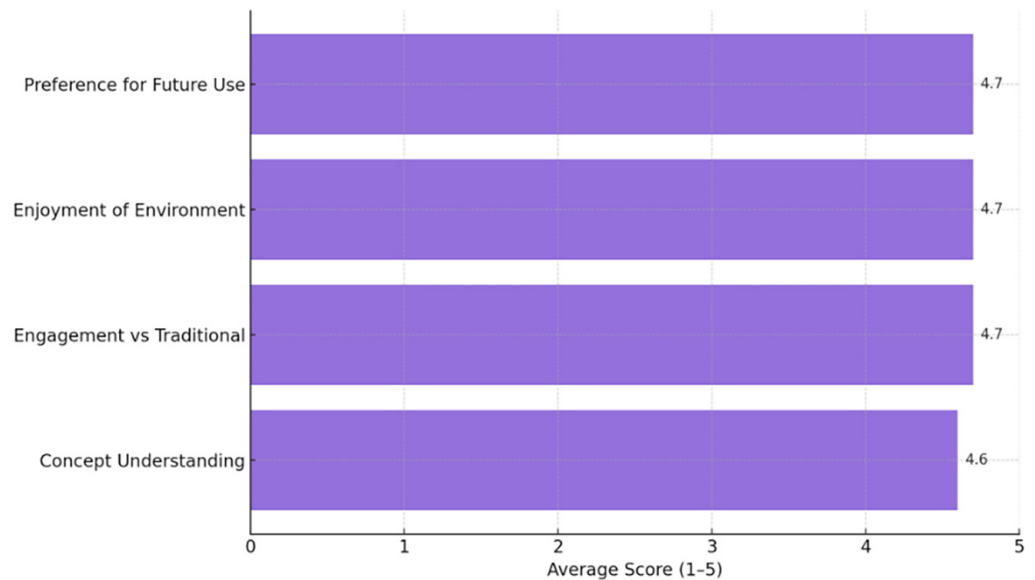


Fig. 2. Survey results: Student perceptions of metaverse-based learning

Technical difficulties and a learning curve related to the virtual interface were minor drawbacks. The efficiency of the metaverse-based ID in improving student learning outcomes is amply demonstrated by the comparison of the pre- and post-test results. The post-test results showed a significant difference, even though the control and experimental groups began with almost equal pre-test performance. In contrast to the control group's modest 4.7-point gain, the experimental group, which participated in the immersive metaverse learning environment, showed a significant average improvement of 22.6 points. This improvement was both pedagogically meaningful and statistically significant, suggesting that the virtual ID promoted better knowledge retention and deeper conceptual understanding. These results are corroborated by survey responses from students in the experimental group.

Participants expressed high levels of engagement, enjoyment, and satisfaction with the immersive learning environment, with average ratings above 4.6 on every item. Students strongly preferred using the same virtual platforms in future classes and strongly agreed that the metaverse helped them understand hard engineering concepts better. These good reviews show that the immersive experience made learning better, and not just because it was new.

The boxplot that shows how the scores on the post-test were spread out shows that the experimental group did better on average and had a smaller range of scores than the control group. This gives us more proof. Not only does this pattern lead to better results, but it also shows that participants are more consistent, which is important for making sure that everyone has a fair chance to learn. The immersive design seemed to work for a lot of different types of learners because it had both

visual and hands-on elements that helped them learn more about what they didn't know. The overall rise in scores, positive feedback from students, and steady scores all show that metaverse-based ID can make engineering education better.

These results show that well-designed immersive environments can help connect theory and practice, which can lead to more in-depth study and longer-term participation.

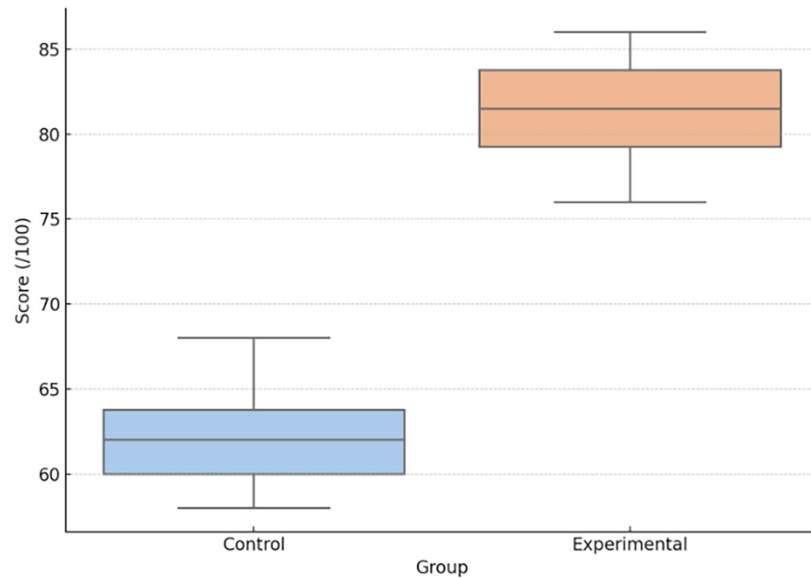


Fig. 3. Post-test score distribution by group

## 6 DISCUSSION

The study's results show that metaverse-based learning environments make the cognitive and affective learning areas of engineering education much better. The experimental group's post-test results were very impressive, showing that the students' cognitive skills, such as their ability to understand concepts and solve problems, had improved significantly. This means that immersive learning environments encourage students to engage more deeply with technical content through interactive exercises, real-time experimentation, and visualization. The survey responses showed that people were very motivated, satisfied, and preferred virtual learning, which means that the affective domain was also improved. Being able to interact with virtual labs, work together as avatars, and get quick feedback seems to have made people feel more connected to the material and the learning process.

These results have big effects on how engineering is taught. The successful use of metaverse platforms in course delivery shows a possible way to turn traditional curricula into immersive, student-centered experiences. By adding gamified tests, group design projects, and virtual simulations to the engineering curriculum, teachers can go from just passing on information to getting students to learn through doing. Institutions must fund teacher training programs that emphasize both technical proficiency and pedagogical approaches appropriate for immersive settings, though, if such integration is to be successful on a large scale. Ensuring inclusivity and seamless adoption also requires prioritizing infrastructure readiness, which includes having access to VR-compatible devices, reliable internet connectivity, and user support systems.

By placing experiential learning and constructivist frameworks in a metaverse context, this study theoretically advances their growth. The metaverse expands these ideas into a persistent, interactive, and visually stimulating setting, even though these theories have historically placed a strong emphasis on learning by doing, introspection, and social cooperation. The study offers empirical evidence in favor of the notion that immersive technologies can strengthen constructivism's central ideas, especially learner agency, contextual relevance, and group meaning-making. Metaverse-based design redefines what experiential learning can look like in the digital age by putting students at the center of a realistic but simulated learning environment.

## 7 CONCLUSION

The study gives strong evidence that using a metaverse-based ID can greatly improve student engagement and learning outcomes in engineering education. Students who used the immersive virtual environment did a lot better on tests after than students who were in regular classrooms. This shows that they understood the material better and could remember it better. Also, students' feedback showed that they were very motivated and happy, and wanted to use platforms that work with the metaverse in the future. The results show that immersive learning environments can completely change how engineering is taught by making it more interactive, focused on the student, and in line with how problems are solved in the real world.

The results show that schools and teachers need to rethink how they teach because of new technology. Schools are being asked to try out immersive modules in engineering classes. To do this, they need organized faculty training and money to build infrastructure that works with VR. Teachers should be able to use teaching methods that mix immersive simulations with hands-on learning to give students chances to learn in safe and fun ways. When using resource-heavy technologies like the metaverse, institutional policies must also make sure that everyone can participate and that things are fair.

To learn more about how well the current model works in other areas, future research should focus on adding more fields, levels of education, and institutions to it. Longitudinal studies will help us learn about the long-term effects of immersive environments on students' academic performance, skill development, and readiness for the workforce. AI could also make it possible to create personalized learning paths, smart tutoring systems, and adaptive assessment tools that help students do better on metaverse platforms. Researchers should also look into how emotional involvement, mental workload, and moral issues come together in long-term virtual learning. This will help them design the next generation of educational ecosystems in a responsible way.

This study shows that metaverse-based ID is a promising new way to teach that could change how engineering is taught in the digital age. It's not just a new piece of tech.

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