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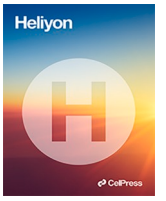

Research article

Fostering Design Thinking mindset for university students with NPCs in the metaverse

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ABSTRACT

This study investigates the efficacy of Non-Player Characters (NPCs) in the metaverse as a tool for enhancing the design thinking mindset of university students. Utilizing a controlled experimental design, we compared the design thinking competencies of two student groups: those who interacted with NPCs in the metaverse and those who did not. Over design thinking mindset questionnaire and four assignments, we measured dimensions of design thinking, including Human centeredness, Empathy, Mindfulness and awareness of process, Holistic view; Problem reframing; Team Working; Multi-/inter-/cross-disciplinary collaborative teams, Open to different perspectives/diversity, using a *t*-test for statistical significance. The findings reveal that NPCs significantly foster the development of Empathy, Problem reframing, and Open to different perspectives/diversity skills, which are essential to design thinking. In contrast, no significant effect was observed in the areas of human-centeredness, process awareness, team working, and collaboration in diverse disciplines. The use of NPCs was particularly impactful in complex tasks, as evidenced by the increasing effectiveness observed in later assignments. The results underscore the selective benefits of NPCs in metaverse learning environments, suggesting that their integration should be strategically targeted to enhance specific design thinking skills. The study suggests a potential for NPCs to play a significant role in long-term learning strategies, where a step-by-step skill acquisition could culminate in advanced design thinking tasks. These insights pave the way for educators to develop nuanced curricula that leverage the strengths of NPCs and for further research to optimize their use in educational metaverse platforms.

1. Introduction

In an educational landscape that is rapidly evolving with technological advances, the concept of design thinking has emerged as a pivotal framework for developing problem-solving and innovative skills in students [1–3]. Design thinking, with its empathetic and iterative approach, empowers learners to tackle complex problems by deeply understanding the user experience ideating creative solutions, prototyping, and testing [1,4]. The advent of the metaverse—an expansive virtual space with immersive, interactive capabilities—presents a new frontier for educational methodologies [5–9].

Studies in the field of education have mainly focused on investigating users' motivations and willingness to use or embrace the metaverse technology ([10,11]; B.-H. T. [12]). This emphasis has resulted in a lack of investigation into the practical implementation of the metaverse in educational environments to improve learning experiences. Prior research on the application of the metaverse in education has predominantly employed quantitative approaches, specifically utilizing surveys and statistical analyses to assess user

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intentions and adoption rates [10,13–15]. This trend has resulted in a notable deficiency in empirical investigation, which is essential for comprehending the tangible consequences and effectiveness of metaverse applications in educational environments. Experimental methodologies can provide more reliable and comprehensive understanding of how these technologies affect the processes and results of learning.

This paper explores the potential of the metaverse as a platform for enhancing the design thinking mindset among university students through experimental methodologies with the use of non-player characters (NPCs). NPCs are characters in a game or simulation that are not controlled by players/usersbut are operated by the system. The role of NPCs in learning and educational contexts is quite innovative and has been explored in various ways, particularly within the realm of digital game-based learning and simulations [16]. They can serve multiple purposes in creating engaging [17,18], immersive [19,20], and other educational experiences [21].

In particular, the integration of NPCs in the metaverse creates a dynamic environment where students can engage in simulated scenarios that closely mirror real-world complexities. According to the study of Hwang & Chien [5], the Metaverse stands out by offering an ongoing, lifelike experience where learners can engage with intelligent NPC tutors, peers, tutees, and other human participants. NPCs in the Metaverse are capable of learning and evolving based on their interactions with users. They can remember users' dialogues and behaviors, creating a personalized and dynamic learning experience. This is in contrast to VR, where virtual characters interact with users in a pre-defined manner without the ability to adapt or learn from user interactions.

The impetus for this research stems from the need to adapt educational practices to better prepare students for the demands of the modern workforce, where design thinking is increasingly recognized as an essential skill [22,23]. In an era defined by rapid change and technological integration, fostering a design thinking mindset is not merely an academic exercise but a necessity for innovation and adaptability in various professional fields ([24,25]; R. [26,27]).

This paper begins by delineating the theoretical underpinnings of design thinking and the pedagogical significance of the metaverse. It then delves into the role of NPCs as mediators of experiential learning, facilitating the development of empathy, one of the core tenets of design thinking. The investigation is situated within the context of university education, where the shaping of future innovators and problem-solvers is most critical.

Through this research, we aim to address the following question:

Research Question: How does the interaction with NPCs in the metaverse influence the acquisition of a design thinking mindset in university students?

For this research question, we form two hypotheses as follows.

- Hypothesis 1 (H1): NPCs will significantly enhance students' perceptions of their design thinking mindset.
- Hypothesis 2 (H2): NPCs will significantly improve students' performance in design thinking mindset

As we traverse the intersection of digital technology and educational practice, this study seeks to contribute to a growing body of knowledge that supports innovative teaching strategies. It proposes a novel approach to learning that aligns with the digital native tendencies of contemporary students, potentially revolutionizing the way design thinking is taught and applied in an academic setting.

2. Literature review

2.1. Design thinking and metaverse

Design thinking is a human-centered approach [1,4] to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success [1–3]. According to the study [3,28], it involves five key phases: empathize with users, define the problem, ideate by challenging assumptions and creating ideas for innovative solutions, prototype to start creating solutions, and test to try out those solutions.

The metaverse is a collective virtual shared space, created by the convergence of virtually enhanced physical reality, augmented reality [23] and the internet [5,29–31]. It's a space where users interact within a computer-generated environment and with each other through digital avatars [32].

Design Thinking and the Metaverse are intertwined concepts that serve as potent instruments for innovation and resolving complex issues. Central to both is the principle of empathy, which facilitates a deep understanding of user needs and fosters the interconnectedness essential for collaborative problem-solving. Design Thinking, in particular, is a user-centric problem-solving approach that initiates with a thorough grasp of the user's requirements, proceeding to cultivate novel solutions that address these needs.

Empathy is at the core of Design Thinking [33]; it is not just about recognizing but also valuing the needs and emotions of users. This empathetic approach is the starting point for ideating innovative solutions that are user-focused [34]. Design Thinking is a systematic process that blends creativity with strategy to solve problems, considering the user's experience at every stage.

Parallel to this is the concept of the Metaverse, a term that conjures the notion of a vast, interconnected virtual space. The Metaverse concept suggests an expansive digital universe where users can navigate, engage, and exert influence [35–37]. This virtual cosmos is envisioned as a collaborative sandbox, where ideas can be exchanged and iterated upon, leading to cutting-edge solutions for intricate challenges.

2.2. Design thinking mindset

Design thinking is becoming an increasingly popular method for fostering creativity, characterized by a distinct mindset. Those who seek to innovate and improve experiences, products, and services for their users or customers can greatly benefit from adopting specific attitudes that enhance their thinking and creativity [22,38,39].

Design thinking focuses on modifying, altering, or enhancing the mentalities of students, or even teachers, to build a complex thought mindset in the classroom (T.-H. [40,41]). Many studies explain that the design thinking mindset is an approach for students to develop creative confidence and face challenges in building creativity by fostering empathy, encouraging a tendency to action, promoting idea generation, developing metacognitive awareness, and cultivating creative problem-solving [42]. Driven by the effort to incorporate 21st-century learning capabilities, the design thinking mindset must be integrated into the curriculum [41].

Lor [43] divides the design thinking mindset into seven dimensions: empathy, human-centeredness, process awareness, prototype culture, experimentation, collaboration, and optimism in building creativity and innovation in teaching. These dimensions help construct a comprehensive theoretical framework for design thinking, enabling students and teachers to develop the necessary skills to succeed in modern learning and working environments.

Fig. 1 explains the seven dimensions in Design Thingking Mindset, which are the abilities that form skills in P21 and will result in the development of creativity and innovation and problem solving skills among students.

2.3. The use of NPCs in educational metaverse

NPCs in the metaverse are virtual entities designed to enhance user experiences within these expansive, interconnected digital environments. These NPCs, often controlled by advanced artificial intelligence, interact dynamically with users, contributing to the realism and interactivity of the metaverse. Leveraging natural language processing (NLP) technologies, such as OpenAI's GPT-3, these NPCs can comprehend and generate natural language responses, facilitating intuitive and meaningful dialogues with users. Machine learning algorithms enable NPCs to adapt and refine their interactions based on user behavior, thereby enhancing their engagement and realism.

According to the recent study of Hwang & Chien [5], in the Metaverse, NPCs serve three key educational roles to enhance learning (Fig. 2).

(1) NPC Tutors or Advisors: For areas where expert human users are unavailable, intelligent NPCs act as knowledgeable guides. They offer advice and solutions in specialized fields, like medicine, where a learner might struggle to find human help.
(2) NPC Tutees/Students; NPCs can also play the role of students, allowing learners, such as pre-service teachers, to practice teaching and mentoring skills. This is especially useful when real-world teaching practice opportunities are limited.
(3) NPC peers in the Metaverse are essential for learning through social interactions, as suggested by social constructivism. They act as virtual classmates, allowing learners to collaborate and discuss, even when real peers are not available. These NPC peers can also serve as role models, ensuring that learners always have the opportunity for essential social learning experiences

Despite these advancements, there remains a gap in the literature regarding the systematic integration of NPCs within the metaverse specifically for the purpose of teaching and reinforcing a design thinking mindset in university students. This gap calls for focused research to understand the nuances and impacts of such an integration.

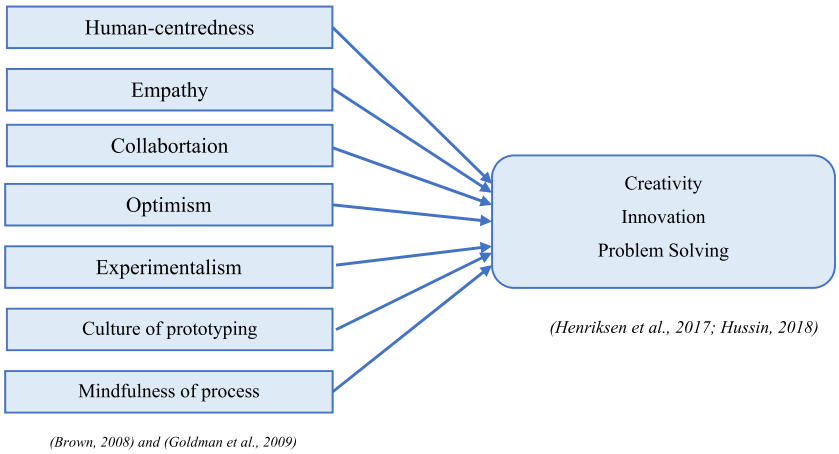

Fig. 1. Design Thinking Mindset, adapted from study of [38].

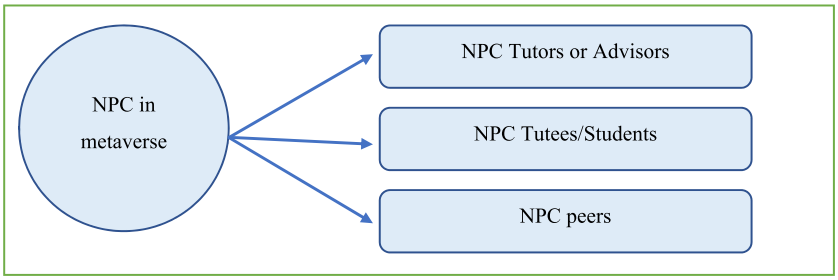

Fig. 2. Role of NPC in Metaverse. Adapted from study of Hwang & Chien [5].

3. Methodology

3.1. Experiment procedure

In order to assess the impact of NPCs in the metaverse among university students, a structured comparative analysis was conducted. The study involved 388 university attendees within the age range of 20–23 years, all enrolled in two Soft Skills courses from October 2022 to January 2023 at a university in Vietnam. These students were systematically divided into control (N = 198) and experimental (N = 196) groups. Both cohorts were instructed by the same instructor and had access to the same learning materials and class activities. As per the course requirements, students were given access to a comprehensive self-review guide for course content through the LMS system. This guide includes various learning resources such as video lectures, reading materials, and quizzes.

To initiate the experiment, we conducted a 3-h online face-to-face warm-up session in the metaverse. During this session, students were introduced to problem-solving skills and the Design Thinking process, as well as how to apply Design Thinking to address real-life issues. Following this introduction, the Pre-Design Thinking Mindset questionnaire was distributed to all students for completion. Over the next two months, with sessions held biweekly, students were presented with different assignment sections (described section 3.2.2), which they had to solve in groups inside the metaverse. In this study, we selected framevr.io as the metaverse platform, culminating in written reports as outputs. In total, we managed 20 sub-groups across both the control and experimental groups, with

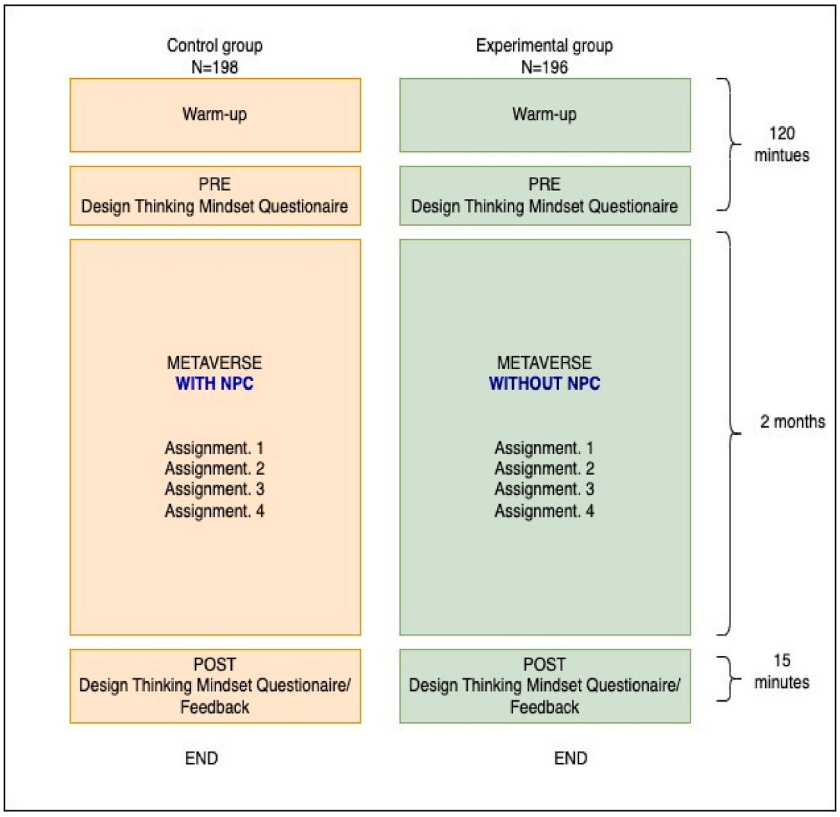

Fig. 3. Experimental procedure.

each group required to submit a total of four reports during the experiment. Upon conclusion, we distributed the Post-Design Thinking Mindset questionnaire and conducted brief interviews with selected students to further understand certain phenomena revealed by the findings. The experiment procedure is illustrated Fig. 3 below.

3.2. Instruments

3.2.1. Design thinking mindset questionnaire

We chose a selection of questions for the Design Thinking mindset questionnaire from the study of Dosi et al [44]. The descriptions of each dimension are as follows:

Human-Centeredness: Focuses on understanding human behaviors, needs, and values as key elements in solving complex strategic problems.

- Empathy: Essential in a human-centered design approach, involving the ability to see situations from different perspectives, connect with customers, and understand experiences from another's viewpoint to grasp their motivations.
- Mindfulness and Process Awareness: Design Thinkers remain mindful of the design process, understanding whether they are in a converging or diverging phase, and the need to balance creative thinking with focusing on a single solution path.
- Holistic View: Involves considering the entire problem, including socioeconomic dynamics, interrelationships, customer needs, technical feasibility, organizational constraints, regulatory factors, competitive influences, resource availability, strategic implications, and the costs and benefits of different solutions, to gain a comprehensive understanding.
- Problem Reframing: Entails redefining the initial problem in a meaningful way, broadening its scope, challenging assumptions, and using all insights to achieve an accurate understanding.
- Teamwork: Emphasizes collaboration, knowledge sharing, and using visualization tools to communicate and clarify ideas within multidisciplinary teams.
- Openness to Different Perspectives/Diversity: Involves working with diverse teams and integrating various perspectives throughout the design process to foster inclusivity and expand the range of insights and solutions.

The original questionnaire had 83 items that assessed 19 different aspects. However, in this report, we chose 28 items that fall into the eight aspects that were most relevant to this research (Apendix).

All items are rated on five-point Likert-scale, ranging from not at all in agreement (1) to completely in agreement (5). These 28 items are set out in Table 1 below.

3.2.2. Assignments

To offer students chances to hone their design thinking skills and access the design thinking mindset, we have structured 4 assignments. The assignments provided outline a series of Daily Life Challenges aimed at enhancing university students' life by addressing practical issues such as commuting, meal planning, time management, and mental health support through innovative and empathetic approaches. To complete the assignment, student works in group, inside metaverse with support from instructor (we selected framevr.io as metaverse platform in this study, as shown in Fig. 4).

In the first assignment, students tackle commuting challenges, conducting traditional surveys and interviews to understand the difficulties their peers face, like transportation inadequacies and traffic congestion. An experimental group employs NPCs in a virtual setting to conduct empathy interviews.

The second assignment shifts focus to meal planning habits. Groups are tasked with uncovering students' dietary preferences and budget constraints, using either conventional data collection methods or collaborating with NPCs in a digital realm for creative brainstorming and data analysis.

The third assignment addresses the critical issue of mental health among university students. Groups explore stress, anxiety, and loneliness, seeking to develop initiatives that support mental well-being. The control group undertakes independent research, while the experimental group engages in metaverse-facilitated discussions that simulate counseling sessions, focusing on empathetic communication and self-care practices.

Lastly, Time management is the focus of the fourth assignment, where students research and test various strategies to overcome common challenges such as procrastination and the juggling of academic and personal duties. While one group works independently,

Table 1
Design Thinking mindset questionnaire (selected from study [44]).

Instrument	Studying tactics	Number of items
Design Thinking Mindset Questionnaire	1. Human centeredness	3
	2. Empathy	4
	3. Mindfulness and awareness of process	3
	4. Holistic view	3
	5. Problem reframing	3
	6. Team Working	3
	7. Multi-/inter-/cross-disciplinary collaborative teams	4
	8. Open to different perspectives/diversity	4

Fig. 4. Converstation between students and NCP (in vietnamese).

the other collaborates with NPCs to facilitate virtual workshops, aiming to refine and improve time management tools.

The goal for each assignment is to evaluate the design thinking mindset of students within two distinct groups. The culmination of their efforts will be to produce a detailed report that succinctly outlines the challenges they have pinpointed, the valuable insights they have extracted, and their innovative solutions and strategies, all underpinned by a concrete plan for action and critical assessment.

3.2.2.1. Evaluation matrix. The Evaluation Matrix assesses various aspects of student performance across four assignments focused on understanding daily life challenges and applying design thinking principles. Adapted from the previous studies of [28,38,44], we selected and evaluated two key criteria for assessing the design thinking mindset in student reports: "Empathy" and "Ideation." Each criterion has a maximum score of 5 points, leading to a total of 10 points maximum. This matrix outlines the scoring system for these two key criteria (Table 2).

3.3. Data analysis

After collecting and synthesizing the questionnaire data, the research team systematically classified and analyzed it using Excel and SPSS software. Initially, Excel was used for data preprocessing, including cleaning the data and removing outliers. To evaluate the reliability of the measurement scale, Cronbach's Alpha coefficient was calculated. Additionally, to ensure the accuracy and reliability of the assignment scores, which were independently assessed by two researchers, inter-rater reliability was evaluated using SPSS. To test our hypothesis, the team used SPSS to perform an independent *t*-test on the questionnaire responses and four assignments, aiming to identify differences in design thinking mindset between the two groups.

Table 2
Design thinking mindset evaluation matrix.

Score	EMPATHY involves understanding the needs, desires, and pain points of users through research, observation, and interaction.	IDEATION involves generating a variety of ideas to solve a problem, using creative techniques and fostering an open-minded approach.
1	No or minimal user research. Limited understanding of user needs.	Limited or narrow ideation. Few ideas generated, with early judgment.
2	Basic user research but lacking depth or diversity. Limited use of empathy mapping.	Basic user research but lacking depth or diversity. Limited use of empathy mapping.
3	Adequate user research and empathy mapping. Some insights into user needs, but with gaps.	Adequate ideation with a reasonable range of ideas. Some creativity but could be more diverse.
4	Strong user research with diverse perspectives. Detailed empathy mapping and significant insights into user needs.	Strong ideation with a broad range of ideas. Demonstrates creativity and innovation.
5	Comprehensive user research with a wide range of perspectives. Deep empathy mapping and a thorough understanding of user needs, leading to user-centric solutions. Ideation	Exemplary ideation with a wide range of creative and innovative ideas. Open-minded approach with no early judgment.

4. Results and discussion

In this section, we will analyze both quantitative and qualitative results. The quantitative data are derived from the outcomes of the survey and the design thinking mindset score from 4 assignments between two groups. The qualitative data originate from the feedback from students regarding their experiences with NPCs.

4.1. Design thinking mindset

This Table .3 provides the descriptive statistics and results of the survey. It should be noted that with this questionnaire, we only got total of 183/198 students in control group, and 184/196 students in experimental group returning this survey.

The cronbach Alpha for each dimension are Human centeredness (0.861), Empathy (0.819); Mindfulness and awareness of process (0.843); Holistic view (0.853); Problem reframing (0.883); Team Working (0.842); Multi-/inter-/cross-disciplinary collaborative teams (0.850); Open to different perspectives/diversity (0.850), which signifies a high degree of correlation among the questionnaire items, thereby affirming the scale's reliability.

We ran T-test on pre/post questionnaire data, and found there are no significant differences on design thinking mindset score at the beginning of the experiment. However, in the post questionnaire, there are acknowledged differences in Table .3 below.

Table 3 above showed among 8 research variables, there are statistically significant differences in 3 research variables which is Empathy, Holistic view, Problem Refarming, and Open to different perspectives/diversity. In following sub-section, we will discuss these differences.

The findings suggest that incorporating NPCs in the metaverse can positively influence certain aspects of students' design thinking mindset, particularly Empathy, Problem reframing, and Openness to diverse perspectives. Interacting with NPCs may provide students with unique learning experiences, such as simulating real-world user interactions and receiving feedback from virtual stakeholders.

However, it's essential to note that the impact of NPC facilitation varied across different dimensions of design thinking mindset. While significant improvements were observed in empathy, problem reframing, Holistic view and openness to diverse perspectives, other dimensions, such as Human centeredness and Mindfulness and awareness of process, did not show significant differences between the experimental and control groups.

4.1.1. Empathy

In the context of the research, "Empathy" refers to the ability of students to understand and relate to the experiences, emotions, and perspectives of others, particularly virtual users within the metaverse. The evaluation of empathy assessed the extent to which students in both the experimental and control groups demonstrated this empathetic understanding during their interactions and problem-solving tasks.

The statistical analysis revealed a statistically significant difference in the 'empathy' mindset perceptions between students in the two groups, with the experimental group ($M = 3.71$) and the control group ($M = 3.27$) showing variance ($p = .000^{***} < 0.001$).

This suggests that the presence of NPCs in the metaverse, who likely simulated various user personas and provided feedback, had an impact on students' ability to empathize with virtual users' perspectives and needs.

This finding suggests that the experimental group's exposure to a wide array of virtual personas allowed them to better empathize with users' perspectives, leading to a more inclusive and user-centered design outcome. The students who interacted with NPCs could ask questions, receive immediate feedback, and witness firsthand the virtual users' reactions, which provided them with a richer understanding of the users' experiences. As a result, they were able to design an app that catered to a broader spectrum of needs and preferences, reflecting their enhanced ability to empathize and innovate within the design context.

Table 3
T-test on design thinking mindset questionnaire (POST).

Variables	Group Type	N	Mean	Df	Sig. two-tail
Human centeredness	Control	183	3.68	365	0.488
	Experimental	184	3.63		
Empathy	Control	183	3.27	365	0.000***
	Experimental	184	3.71		
Mindfulness and awareness of process	Control	183	3.64	365	0.159
	Experimental	184	3.51		
Holistic view	Control	183	3.65	365	0.424
	Experimental	184	3.73		
Problem reframing	Control	183	3.27	365	0.000***
	Experimental	184	3.70		
Team working	Control	183	3.87	365	0.153
	Experimental	184	3.75		
Multi-/inter-/cross-disciplinary collaborative teams	Control	183	3.74	365	0.882
	Experimental	184	3.76		
Open to different perspectives/diversity	Control	183	3.46	365	0.013*
	Experimental	184	3.68		

Notes. P* < 0.05; p** < 0.01. p*** < 0.001.

In line with our findings, Rueda & Lara [45] demonstrated in their work that interactive virtual environments can enhance the empathetic abilities of participants. Their study, proposed an alternative approach to enhancing empathy through the virtual embodiment in avatars, which allows users to experience different perspectives more directly. Furthermore, the role of virtual avatar in fostering empathy was also explored by [46] who claimed that utilize principles from psychology to enhance video game players' emotional connections with NPCs, thereby providing them with a richer gaming experience and increasing their engagement over time. This convergence with the observations by [47], who showed that the visual design of the virtual character can significantly affect users' cognition, empathy, and immersion perception. It suggests that such digital interactions can be an integral component of a design thinking curriculum, as they provide a safe yet realistic platform for students to practice and enhance their empathetic engagement with users' experiences.

Besides, the feedback from participants underscores the profound impact of NPC interactions on empathy development within the design thinking process. Student ID 278 expressed, "Interacting with NPCs allowed me to step into the shoes of diverse user personas, enhancing my ability to empathize with their needs and experiences." Similarly, Student ID 323 noted, "The NPC interactions prompted me to consider perspectives different from my own, fostering a deeper sense of empathy and understanding." These direct quotes highlight how NPC-facilitated experiences provided students with valuable opportunities to empathize with virtual users, enhancing their capacity to design solutions that truly address user needs. This finding emphasizes the crucial role of NPC interactions in cultivating empathy, a fundamental component of the design thinking mindset, and suggests the potential for such experiences to foster greater empathy in real-world design contexts as well.

4.1.2 Problem reframing

In the context of the research, "Problem reframing" refers to the ability of students to critically analyze and redefine the initial problem statement in a meaningful and holistic manner, potentially leading to innovative and effective solutions. The evaluation of problem reframing assessed how well students in both the experimental and control groups approached and addressed the design challenges presented to them.

The statistical analysis revealed a statistically significant difference in problem reframing between the experimental ($M = 3.70$) and control groups ($M = 3.27$) ($p = .000^{***} < 0.001$). This indicates that the presence of NPCs in the metaverse, likely providing guidance and feedback on problem-solving strategies, had a notable impact on students' ability to reframe and reinterpret the design problems they encountered.

Interpreting this finding, it can be inferred that the interaction with NPCs facilitated a more comprehensive and creative approach to problem reframing among students in the experimental group. By engaging with virtual characters who may have posed challenging questions, offered alternative perspectives, or encouraged exploration of unconventional solutions, students were likely prompted to think critically about the underlying issues and consider innovative ways to address them.

This convergence with the observations by J. H. Lee et al. [48] and Chang [49] who noted that virtual reality could somehow promote problem solving process. It suggests that such digital interactions can be an integral component of a design thinking curriculum, as they provide a safe yet realistic platform for students to practice and enhance their empathetic engagement with users' experiences.

Upon reviewing the participants' feedback, it's evident that the interaction with NPCs in the metaverse significantly influenced their design thinking experience. "Student ID 212 expressed, "The NPC interactions were engaging and thought-provoking, providing valuable insights." Similarly, Student ID 197 stated, "The NPC guidance encouraged me to explore new ideas and approaches." Student ID 323 noted, "The NPCs challenged me to reframe problems and consider alternative solutions, improving my problem-solving skills." Furthermore, "Student ID 78901 emphasized, "Interacting with NPCs helped me understand diverse user perspectives better, fostering empathy." Student ID 234 highlighted, "Effective communication and coordination within teams during NPC tasks were crucial for our success." Lastly, Student ID 189 shared, "The NPC interactions provided a valuable learning experience, and I advocate for their continued integration." These direct quotes from students affirm that NPC-facilitated experiences play a pivotal role in cultivating a design thinking mindset, enhancing problem-solving skills, empathy, collaboration, and reflective practice among participants.

4.1.3. Openness to diverse perspectives

In the context of the research, "Openness to diverse perspectives" refers to the willingness and ability of students to consider and incorporate a wide range of viewpoints, backgrounds, and experiences into their design thinking process. This dimension assesses the extent to which students in both the experimental and control groups demonstrate openness and receptivity to diverse perspectives when tackling design challenges within the metaverse.

The statistical analysis revealed a statistically significant difference in openness to diverse perspectives between the experimental ($M = 3.68$) and control groups ($M = 3.46$) ($p = .013^{*} < 0.05$). This suggests that the presence of NPCs in the metaverse, likely providing diverse perspectives and feedback, had a notable impact on students' willingness to consider and integrate various viewpoints into their design thinking process.

Interpreting this finding, it can be inferred that the interaction with NPCs facilitated a more inclusive and diverse approach to problem-solving among students in the experimental group. By engaging with virtual characters representing different backgrounds, expertise, and preferences, students were likely exposed to a broader range of perspectives and insights. This exposure to diverse viewpoints may have encouraged students to challenge their own assumptions, broaden their understanding of the problem space, and consider alternative solutions that they may not have otherwise explored.

Additionally, the research by Earle & Leyva-de la Hiz [50] and Chang et al. [51] showed that training in digital environments indicated that students exposed to virtual simulations, especially NPCs, displayed better problem solving skills when compared to

those who underwent traditional training methods, aligning with our experimental group's improved performance.

In addition to statistical analysis, qualitative feedback further illuminates the impact of NPC interactions on students' openness to diverse perspectives. Student ID 278 reflected, "Engaging with NPCs representing various backgrounds challenged my assumptions and encouraged me to consider viewpoints different from my own." Similarly, Student ID 223 remarked, "The diverse perspectives presented by NPCs broadened my understanding of the problem space, prompting me to explore alternative solutions." These direct quotes underscore how NPC-facilitated experiences provided students with exposure to a range of viewpoints, fostering a more inclusive and open-minded approach to problem-solving. Furthermore, Student ID 334 highlighted, "*Interacting with NPCs from different backgrounds encouraged collaboration and enriched our team's discussions, leading to more comprehensive solutions*." This qualitative feedback reinforces the statistical findings, emphasizing the significant role of NPC interactions in promoting openness to diverse perspectives within the design thinking process.

4.2. Design thinking score in four assigments

This Table 4 and Fig. 5 below presents the average scores of 20 subgroups in both the control and experimental classes across the four assignments. This grading was carried out independently by two researchers, with the inter-rater reliability being 0.752, ensuring the accuracy and reliability of the scores.

The *t*-test results provided reflect the analysis of the impact of working with NPCs in the metaverse on fostering a design thinking mindset, as measured by scores across four different assignments.

In the initial assignments (1 and 2), the presence of NPCs did not show a statistically significant difference in fostering the design thinking mindset, as indicated by the p-values of 0.398 and 0.057, respectively. These results suggest that early in the learning process, NPC interaction may not markedly influence students' grasp of design thinking. It is possible that students are still acclimating to the metaverse environment or that the assignments did not fully leverage the potential of NPCs in these early stages.

However, as students progressed to more advanced assignments, the influence of NPCs became more apparent. Assignment 3 showed a positive trend ($p = 0.074$), hinting at a potential impact of NPCs that approached but did not reach conventional levels of statistical significance. This suggests a building momentum where the continuous interaction with NPCs might begin to resonate more with the students.

The most compelling evidence comes from Assignment 4, where the meanscore of control group's $M = 7.5$ and the experimental group's ($M = 8.4$) significant score improvement ($p < 0.001$) strongly indicates that NPCs played a critical role in deepening the students' design thinking mindset. This dramatic shift in significance points to the cumulative effect of NPC interaction over time, which aligns with the iterative and experiential nature of the design thinking process itself.

The conclusion drawn from these findings is that NPCs, when well-integrated into a metaverse learning experience, can be a potent tool for fostering a design thinking mindset, particularly as students advance in their learning journey and become more immersed in the environment. The significant impact noted in the latter part of the study underscores the potential of NPCs to contribute meaningfully to the development of skills that are crucial for innovation and problem-solving.

In assignment 4, to understand the time management challenges faced by students, a group of students engaged with NPCs, assigning them specific roles to mimic different student personas. By developing structured interview scripts, students interacted with NPCs in a virtual setting to gain insights into various time management issues. These interactions allowed for detailed observation of NPC behavior, offering a window into the complexities of academic pressure, extracurricular activities, part-time work, and personal responsibilities. Through role-playing, NPCs simulated realistic scenarios such as preparing for exams and coordinating group projects, helping students capture nuanced responses and reactions. This information was used to create empathy maps, providing a comprehensive understanding of the thoughts, feelings, and behaviors of different student personas. The NPCs' diverse perspectives informed the ideation process, allowing students to generate a broad range of solutions while encouraging creativity and innovation. Additionally, students incorporated NPC feedback during brainstorming sessions, leading to more user-centric solutions. Overall, the use of NPCs in this context significantly enhanced the students' ability to empathize with and ideate for students, contributing to a more refined approach to design thinking.

In summary, the findings of our study provide substantial support for both hypotheses (Table 5), indicating that interaction with NPCs in the metaverse positively influences the acquisition of a design thinking mindset in university students.

Table 4
T-test on design thinking mindset score.

Variable	Group	N	Mean	Df	Sig. (two-tailed)
Assignment 1	Control	20	7.8	38	0.398
	Experimental	20	8.1		
Assignment 2	Control	20	8.1	38	0.057
	Experimental	20	7.7		
Assignment 3	Control	20	7.5	38	0.074
	Experimental	20	7.8		
Assignment 4	Control	20	7.5	38	0.000***
	Experimental	20	8.4		

Notes. P* < 0.05; p** < 0.01. p*** < 0.001.

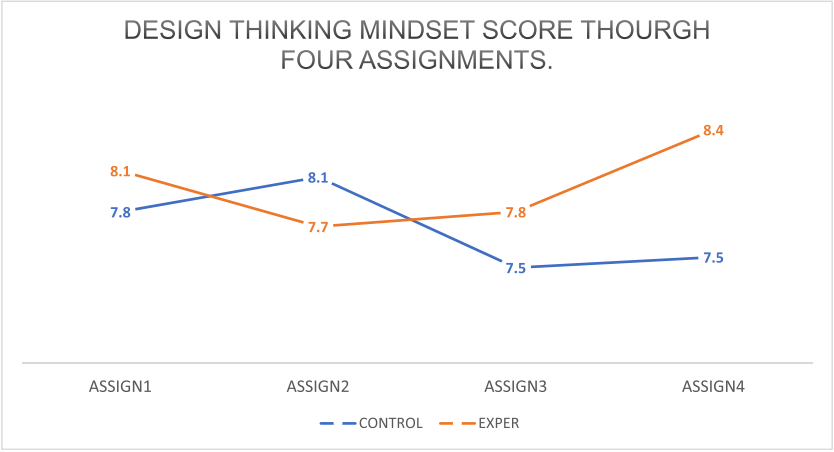

Fig. 5. Design Thinking mindset score thourgh four assignments.

Table 5
Is hypothesis supported?

Hypothesis	Is hypothesis supported?
• *Hypothesis 1 (H1):* NPCs will significantly enhance students' perceptions of their design thinking mindset.	⇨ Supported: The experimental group showed significantly higher mean scores in key aspects of the design thinking mindset compared to the control group: - *Empathy*: Experimental group mean = 3.71 vs. Control group mean = 3.27 (p = 0.000) - *Problem Reframing*: Experimental group mean = 3.70 vs. Control group mean = 3.27 (p = 0.000) - *Openness to Different Perspectives:* Experimental group mean = 3.68 vs. Control group mean = 3.46 (p = 0.013) *Qualitative Data*: Direct comments from students (e.g., Student IDs 278, 323) highlighted that NPC-facilitated experiences provided opportunities to empathize with virtual users. This enhanced their capacity to design solutions that address user needs.
• *Hypothesis 2 (H2):* NPCs will significantly improve students' performance in design thinking mindset	⇨ Supported The impact of NPCs on students' performance in design thinking mindset became more apparent over time: - Initial Assignments (1 and 2): No significant differences (p = 0.398 and 0.057) - Assignment 3: Positive trend (p = 0.074) -Assignment 4: Significant improvement (Control group mean = 7.5, Experimental group mean = 8.4, p < 0.001)

5. Discussion and conclusion

In this study, we explored how NPCs in the metaverse contribute to shaping the design thinking mindset of university students. Our findings show that while NPCs positively influence students' empathy and problem reframing skills within simulated scenarios, their impact on other design thinking aspects like teamwork and interdisciplinary collaboration is limited. For example, students interacting with NPCs learned to understand diverse perspectives but struggled to translate this understanding into collaborative design processes. This highlights the need for careful NPC integration to target specific educational outcomes effectively.

Implications: The findings of this study significantly contribute to understanding the role of the metaverse in education, particularly in using NPCs to enhance empathy and problem-reframing skills among students. In areas with a teacher shortage, NPC tutors could partially address this issue. Gradually incorporating NPCs into the curriculum can scaffold students' learning and mastery of design thinking principles. For instance, educators can create scenarios where NPCs simulate various user personas, prompting students to iterate on solutions based on virtual feedback. Collaborative projects involving NPCs from different fields can help students develop interdisciplinary skills. NPCs can create a dynamic and engaging learning environment by simulating real-world challenges and providing immediate, personalized feedback.

The findings also highlight the need for comprehensive training programs for faculty and staff to effectively implement these technologies in the classroom. Professional development workshops focused on using AI and virtual environments pedagogically will ensure educators are well-equipped to guide students through new learning paradigms.

Personalized learning can be significantly enhanced through NPCs, which can adapt to individual student needs and provide tailored feedback and support. This approach can help address diverse learning styles and improve overall educational outcomes. In Vietnamese classrooms, where there is a wide range of student abilities, NPCs can offer differentiated instruction, allowing each student to progress at their own pace.

By addressing these practical implications, the study provides actionable recommendations for enhancing the quality and effectiveness of education, especially in Vietnam. The integration of NPCs aligns with the country's goals of modernizing education and equipping students with digital age skills. Future research should explore the long-term impacts of these technologies on student learning and development and the potential challenges and ethical considerations of their widespread adoption.

Limitations & future study: While NPCs show promise in enhancing certain aspects of design thinking, challenges remain in transferring learned skills to real-world contexts and overcoming limitations in NPC intelligence and autonomy. Educators must balance leveraging NPCs' strengths with addressing their constraints when designing NPC-enabled learning environments. Further research is needed to explore optimal design principles and pedagogical strategies for maximizing NPC benefits in the metaverse.

Availability of data and material

Not available.

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Ethics and consent

All participants in this study volunteered to take part, and we obtained written consent from each of them. The author assures that all personal information is kept confidential and is excluded from the analysis.

CRediT authorship contribution statement

Nguyen-Thi Huyen: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Nguyen Thi Huyen reports financial support was provided by Vietnam Ministry of Education and Training. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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