

Students as Game Designers: Fostering AI Literacy through Project-Based Learning and Design Thinking

Vasiliki Karampa¹, Vagia Kakava¹, Ageliki Mellou² and Foteini Paraskeva¹

¹Department of Digital Systems, University of Piraeus, Greece

²Department of Information and Electronic Engineering, International Hellenic University, Thessaloniki, Greece

bkarampa@unipi.gr

vagiakakava@gmail.com

agmellou@hotmail.com

fparaske@unipi.gr

Abstract: Artificial Intelligence (AI) is rapidly reshaping the digital landscape, highlighting the importance of cultivating AI literacy from an early age. Recognising the need to equip students with the competences required to navigate this new reality, contemporary educational curricula, including those in primary education, consider constructivist, innovative pedagogical approaches particularly effective. Among these, Project-Based Learning (PBL) is widely adopted, as it actively engages learners in processes of responding to authentic challenges, making decisions, and collaboratively creating meaningful outputs in the form of physical, digital, or hybrid artefacts. However, PBL usually follows linear pathways, which does not fully align with the inherently iterative nature of design and construction processes. Consequently, the integration of complementary methodologies that emphasise iteration and creative problem-solving is considered beneficial. Design Thinking (DT), which shares common pedagogical foundations with PBL, can be smoothly aligned with project-based practices, enriching them through iterative cycles of ideation, prototyping, and refinement. This study explores whether a combined PBL-DT approach can foster AI literacy in primary education through game design. The methodology was implemented in the context of an e-course lab delivered to primary school students and was further enriched with design tactics proposed by the Room2Educ8 framework. The students assumed the role of designers and collaboratively developed an augmented escape board game, addressing key aspects of AI literacy. The intervention adopted a pre/post-test design, and its findings indicate that engagement in the PBL-DT workflows seem to support the enhancement of students' AI literacy effectively. This work contributes by proposing a practical and scalable instructional model that aligns with current educational priorities. It also contributes empirical evidence to the growing field of education for AI literacy and provides insights for researchers and practitioners interested in fostering AI competences using curriculum-aligned, student-centred, game-design methodologies at early stages of education.

Keywords: AI literacy, Project-based learning (PBL), Design thinking (DT), Room2Educ8 framework, DigComp 3.0, Primary education

1. Introduction

In the contemporary digital era, Artificial Intelligence (AI) has transitioned from a specialised scientific field to a ubiquitous presence in children's daily lives through technologies like voice assistants, social media, and educational tools (Relmasira, Lai and Donaldson, 2023; Yim and Su, 2025). Consequently, there is a global strategic objective to equip the next generation with AI literacy – an instrumental set of competences in order to live, work, and effectively collaborate with AI (Yim and Su, 2024). This involves more than technical proficiency; it requires a conceptual understanding of AI's mechanisms and a critical evaluation of its societal impacts (Dai, 2025; Relmasira, Lai and Donaldson, 2023). However, as Dai (2025) and Yim and Su (2025) note, introducing these complex concepts to primary school students presents a pedagogical challenge as traditional instructional methods often prove too abstract or unengaging for young learners.

To address this challenge, current educational policies and curricula are shifting toward competency-based, humanistic approaches that prioritise active engagement over traditional instruction (Herrero-Martín et al, 2025). Grounded in constructivist and constructionist theories, these methodologies posit that students learn most effectively by creating tangible artifacts that serve as mediators for knowledge construction (Dai, 2025; Yim, 2024), with Project-Based Learning (PBL) being one of the most prominent approaches (Aravantinos et al, 2024; Busuttill, 2025). The literature indicates that PBL supports active engagement, collaboration, and authentic problem-solving, enabling learners to construct knowledge through meaningful projects (Bell, 2010). However, PBL often follows linear phases of implementation (Markula and Aksela, 2022), which may not fully capture the inherently iterative nature of design and construction processes. Design Thinking (DT), which shares common pedagogical foundations with PBL, enriches project-based practices through iterative cycles of empathising, ideating, prototyping, and testing (Henriksen, Richardson and Mehta, 2017). The combined PBL-DT model has emerged as a powerful student-centred paradigm, fostering essential 21st-century skills such as

critical thinking, collaboration, and problem-solving (Arantes do Amaral and Gamez, 2023; Jia, Jalaludin and Rasul, 2023; Kee, Kuys and King, 2025).

At the same time, researchers highlight the pedagogical value of board games as innovative tools for skill cultivation, both cognitive and socio-emotional, in primary education (Herrero-Martín et al, 2025). In the same vein, Educational Escape Rooms (EERs) provide immersive environments where learners solve narrative-driven puzzles linked to specific educational objectives (Fotaris and Mastoras, 2022; Wszolek et al, 2025). Research suggests that the collaborative and playful nature of EERs significantly enhances motivation and helps bridge the gap between theory and practice (Fotaris and Mastoras, 2022). Furthermore, the process of designing such games aligns closely with Design Thinking principles, empowering students to transition from passive consumers to active makers of technology (Fotaris and Mastoras, 2022; Wszolek et al, 2025).

Despite these developments, empirical evidence regarding AI literacy interventions in primary education is scarce (Aravantinos et al, 2024; Yim, 2024). Most existing frameworks focus on secondary or higher education, often emphasising technical skills that are inappropriate for younger students without a technical background (Yim, 2024; Yim and Su, 2025). Consequently, there is a need for age-appropriate pedagogical frameworks that integrate conceptual, technical, and ethical dimensions of AI for the primary context (Dai, 2025; Yim and Su, 2025).

This research aims to address this gap by investigating the extent to which primary school students' participation in a collaborative e-course lab, based on a unified PBL-DT framework, contributes to the cultivation of AI literacy, specifically as defined by the DigCompEdu 3.0 framework. Utilising design tactics from the Room2Educ8 framework (Fotaris and Mastoras, 2022), students assumed the role of designers to develop an augmented escape board game, engaging with key dimensions of AI literacy.

2. Background

2.1 AI literacy and the European Digital Competence Framework (DigComp) 3.0

AI literacy has emerged as a multifaceted set of competences, comparable to traditional reading and writing, required to navigate an AI-infused society (Casal-Otero et al, 2023). Ng et al (2021) conceptualise AI literacy as essential for 21st-century learning for K-12 and beyond, proposing a four-part framework inspired by Bloom's taxonomy: know and understand AI basics, use and apply AI in various contexts, evaluate and create via higher-order activities, and ethical issues such as fairness, bias, and societal impact.

A key reference framework for operationalising such competences is the European Digital Competence Framework (DigComp) 3.0, which serves as a technology-neutral reference point for learners and educators alike (Cosgrove and Cachia, 2025). The DigComp 3.0 framework serves as a foundational standard for digital citizenship by systematically and transversally integrating AI competences across five competence areas: (1) information search, evaluation, management, (2) communication and collaboration, (3) content creation, (4) safety, wellbeing, and responsible use, and (5) problem identification and solving. These are assessed across four proficiency levels: Basic, Intermediate, Advanced, and Highly Advanced, grounded in cognitive demand and autonomy. While previous versions focused on broader digital skills, DigComp 3.0 explicitly addresses the disruptive nature of AI by categorising learning outcomes into AI-explicit and AI-implicit statements. This shift ensures that AI literacy is viewed not as an isolated module but as an integral layer of modern digital citizenship.

Recent research has applied the framework to map AI literacy as an extension of general digital literacy (Yim, 2024). A study by Aleksic, Mandić and Ivanović (2025) has further demonstrated that AI literacy is strongly associated with higher-order digital competences as defined in the DigComp framework, particularly those related to problem-solving, data processing, and creative thinking. Georgopoulou and colleagues (2024) have also proposed extending the framework specifically to empower educators in fostering critical engagement with Large Language Models (LLMs) and other AI tools.

2.2 Project-based Learning and Design Thinking

Project-Based Learning (PBL) is a student-centred methodology grounded in constructivist principles, where learning is active, context-specific, and achieved through social interaction and the sharing of knowledge (Kokotsaki, Menzies and Wiggins, 2016). It is defined by two primary components: an authentic problem that triggers students' natural curiosity and leads to an extended inquiry process, and the creation of tangible artifacts that culminate in a final solution (Bell, 2010). PBL promotes deep conceptual knowledge and self-

regulated learning, honing 21st-century competences, such as communication, negotiation, and creative problem-solving (Bell, 2010; Kokotsaki, Menzies and Wiggins, 2016).

Similarly, Design Thinking (DT) is a human-centred problem-solving approach particularly effective for addressing complex, wicked problems that lack linear solutions (Panke, 2019). While various models exist, the Stanford d.school framework is widely adopted in educational settings, involving five stages: Empathise, Define, Ideate, Prototype, and Test (Henriksen, Richardson and Mehta, 2017). DT nurtures creative confidence and self-efficacy by reframing failure as an opportunity for reflection and iterative improvement (Henriksen, Richardson and Mehta, 2017).

The present study employs a unified PBL-DT model as an innovative pedagogical synthesis connecting the structural strengths of project management and the humanistic focus of design (Jia, Jalaludin and Rasul, 2023). In this model, DT serves as a scaffold that guides students through the phases of project development, providing direction for decision-making and team building (Jia, Jalaludin and Rasul, 2023; Kee, Kuys and King, 2025). Empirical findings suggest that combining these frameworks creates a feedback loop where iterative prototyping enhances problem-solving abilities, which in turn intensifies student motivation (Arantes do Amaral and Gamez, 2023).

2.3 Educational Board Games and Educational Escape Rooms

Board games are generally understood as rule-governed systems involving the movement of pieces on a designated surface to achieve defined objectives (Othman, Mat and Sim, 2024). In educational settings, they serve as pedagogical tools instrumental in cultivating 21st-century competences, including problem-solving and collaborative inquiry (Herrero-Martín et al, 2025). Additionally, by offering an interactive and playful alternative to conventional instruction they bolster motivation and engagement (Yuliani and Juhana, 2025), providing a safe learning environment where students feel confident to experiment and learn from mistakes without the fear of negative evaluation (O'Neill and Holmes, 2022). Empirical evidence across studies confirms that integrating board games into the curriculum effectively enhances learning outcomes in diverse fields, ranging from scientific literacy to social responsibility and AI literacy (Choi and Park, 2021; Ding and Holland, 2025; Othman, Mat and Sim, 2024; Yuliani and Juhana, 2025). Moreover, research indicates that enabling students to become the designers of their own board games promotes higher-order creativity and knowledge construction (Kuo et al, 2023).

Beyond educational board games, current scholarship has also highlighted the value of Educational Escape Rooms (EERs) as immersive, team-based environments that foster 21st-century competences like critical thinking and collaboration by aligning challenges with explicit learning outcomes (Fotaris and Mastoras, 2022; Moffett and Cassidy, 2023). Researchers have further suggested that EER pedagogy mirrors DT by providing authentic learning experiences that effectively bridge the gap between theory and practice (Moffett and Cassidy, 2023). In particular, the Room2Educ8 framework developed by Fotaris and Mastoras (2022) provides structured heuristics for designing EERs based on DT principles, allowing educators and students to co-create narratives and puzzles linked to specific learning objectives, without requiring prior experience. The framework follows a nine-stage iterative cycle: (1) empathising and observing, (2) defining the problem, (3) contextualising, (4) designing puzzles, (5) briefing and (6) debriefing the participants, (7) prototyping and playtesting, (8) documenting the design process, and (9) evaluating the EER experience (Fotaris and Mastoras, 2022). Furthermore, Room2Educ8's use of generative AI tools like ChatGPT simplifies ideation and asset creation, reducing cognitive load and allowing designers to focus on high-level pedagogical objectives (Fotaris, Mastoras and Lamas, 2023).

3. Research Method

3.1 Research Objective and Research Questions

This study aims to investigate the enhancement of primary school students' AI literacy according to the DigComp 3.0 five competence areas, when they follow the workflows of the PBL-DT model enriched by Room2Educ8 game design tactics for constructing educational escape board games. To this end, the following Research Questions (RQs) were formulated:

RQ1. Following the workflows of PBL-DT and Room2Educ8 framework, do primary school students enhance their AI literacy according to the five competence areas of DigComp 3.0 framework?

- RQ1.1 Following the workflows of PBL-DT and Room2Educ8 framework, do primary school students enhance the DigComp 3.0 Information search, Evaluation and Management competence area (Comp_Area1)?
- RQ1.2 Following the workflows of PBL-DT and Room2Educ8 framework, do primary school students enhance the DigComp 3.0 Communication and Collaboration competence area (Comp_Area2)?
- RQ1.3 Following the workflows of PBL-DT and Room2Educ8 framework, do primary school students enhance the DigComp 3.0 Content creation competence area (Comp_Area3)?
- RQ1.4 Following the workflows of PBL-DT and Room2Educ8 framework, do primary school students enhance the DigComp 3.0 Safety, Wellbeing, and Responsible use competence area (Comp_Area4)?
- RQ1.5 Following the workflows of PBL-DT and Room2Educ8 framework, do primary school students enhance the DigComp 3.0 Problem identification and solving competence area (Comp_Area5)?

3.2 Applying PBL-DT and Room2Educ8 Framework to Educational Practice

The research questions were addressed through an educational intervention in the form of an e-course lab entitled "WebTales", which was designed, developed, and delivered to 22 primary school students aged 8-12 years old, in order to address issues related to internet safety in primary education. In particular, the e-course lab aimed to underline the use of AI, emphasising its role in today's digital age, thus cultivating AI literacy. The expected learning outcomes were aligned with DigComp 3.0 and are presented in Figure 1. The learning design was based on PBL-DT, which was further enriched with design tactics proposed by the Room2Educ8 framework, since the project's deliverable was the construction of an EER in the form of an educational escape board game concerning internet safety and AI (Figure 2). While PBL typically unfolds through broader phases, the integration with DT and Room2Educ8 enhances the learning process by enabling an iterative structuring of workflows. DT and Room2Educ8 steps can be performed simultaneously, repeated, reflected upon, and circled back to at any point during the process by the students-designers.

Expected Learning Outcomes			
AI-supported escape board game on an internet safety topic (misinformation, personal data, privacy, and copyright issues) – aligned with DigComp 3.0			
Learning Domain	Expected Learning Outcomes By the end of the course students will be able to...	Design Thinking Steps	DigComp 3.0 Areas of Competences
 Cognitive (Knowledge & Understanding)	• Search, evaluate and filter information from digital/AI sources, recognizing misinformation. • Recognize risks and apply principle of safe and responsible use of the internet and AI. • Apply problem-solving strategies and evaluate alternative solutions.	Empathize/ Define	COMP_AREA1
		Empathize	COMP_AREA4
		Test	COMP_AREA5
 Psychomotor/ Technological (Skills & Application)	• Use digital and AI tools and appropriate prompts to search for and create content. • Create and improve digital content (texts, images, puzzles, cards) for the board game. • Follow an organized process of design, testing, and improvement using digital/AI tools.	Define/ Prototype	COMP_AREA1, COMP_AREA3
		Prototype/ Launch	COMP_AREA3
		Prototype/ Test	COMP_AREA3, COMP_AREA5
 Socio-Emotional/ Social (Attitudes & Values)	• Collaborate and exchange ideas, information and prompts using digital/AI tools. • Express and accept different opinions with respect during teamwork. • Develop a responsible attitude towards the use of AI and digital technologies.	Ideate	COMP_AREA2
		Ideate	COMP_AREA2
		Empathize	COMP_AREA4
 Metacognitive (Self-regulation & Reflection)	• Check and evaluate the results produced by AI tools before using them. • Try alternative solutions and revise the produced results. • Reflect on their learning process and identify ways to improve.	Define	COMP_AREA1
		Test	COMP_AREA5
		Test	COMP_AREA5

Figure 1: Expected Learning Outcomes aligned with DigComp 3.0

According to Han and Bhattacharya (2001) using PBL in instruction involves three phases. Two subphases make up the first phase of "Planning" (1), where conditions for inquiry, collaboration, and active engagement should be established at the first subphase of developing the "Overall Climate" (1.1). The second subphase of "Inquiry" (1.2) involves selecting themes and topics as well as sharing resources. In the current study it included the investigation of topics related to misinformation, personal data, privacy, and copyright issues. Since investigation is a demanding process, this subphase was aligned with the DT Step 1-Empathise workflows to help students define the problem more accurately. Therefore, to deliver meaningful EER learning experiences, students investigated demographics, backgrounds, motivations, skill level, frustrations, and goals of their target users, i.e. their peers, as well as their previous knowledge and expectations regarding board

games, filling out instruments in the form of personal interviews. In addition, they used digital/AI tools and appropriate prompts to find information for EERs and internet safety. They assessed the prompt outputs for reliability, filtering and keeping the most useful and important, cultivating skills related to the first competence area of DigComp 3.0 framework, which is Searching, Evaluating, and Managing information. Further, since the fourth competence area focuses on Safety, Wellbeing, and Responsible use, students were taught to recognise risks associated with digital/AI tools (e.g. not sharing personal data, double checking AI errors, avoiding excessive use) and to be responsible for AI use, so that they and others do not suffer harm.

The subsequent PBL “Creating” phase (2) incorporates both data analysis and collaborative idea generation as well as the development of the project product. In particular, the first subphase is “Analyzing Data” (2.1), where students make decisions about their projects, while the second subphase is “Collaboration” (2.2), which in turn involves all necessary communications and collaborations to come up with a solution. Furthermore, the third subphase of “Developing Thoughts” (2.3) involves constructing the artifacts, assembling, and building the final product. In this phase, the remaining iterative DT and Room2Educ8 workflows are incorporated, which mainly involved collaborative activities for pairs. To cultivate competences related to the second DigComp 3.0 area, that is Communication and Collaboration, student pairs employed digital/AI tools for exchanging ideas and prompts and sharing files and information digitally. In DT Step 2-Define, students analysed the information they had gathered and defined the core concept of their game, concluding after voting to the topic of misinformation. Brainstorming determined the following set of constructs: problem statement, learning objectives, constraints, required knowledge. As far as group size, game type, playtime length and game position within the curriculum are concerned, the students decided that their game would target a maximum number of students (20-25) within a class, it would be a collaborative activity between a small group and competitive at the level of many groups, and it would be played within two periods including game setup, briefing, game over and debriefing, in the context of their ICT course. This was followed by DT Step 3-Ideate, and contextualizing, during which students developed and framed ideas in worksheets, related to the game’s theme, setting, narrative, characters, environment, puzzle design, hint and scoring system, and mechanics, by using the “Who”, “When”, “Where”, “Why” and “How” technique. A total of 11 proposals were submitted with the help of appropriate AI prompts, using smart titles, such as “Escape from ChatGPT”, “The haunted house of misinformation”, etc., as well as game settings and various narratives based on fictional stories and cartoon characters, e.g. Minecraft or robot characters, able to enhance problem-solving and decision-making skills. In terms of plot and mechanisms, most game proposals utilised mazes, locked gates with padlocks that could be unlocked by solving sequential puzzles, boss fights, missions and cards, passwords, various codes, and so on.

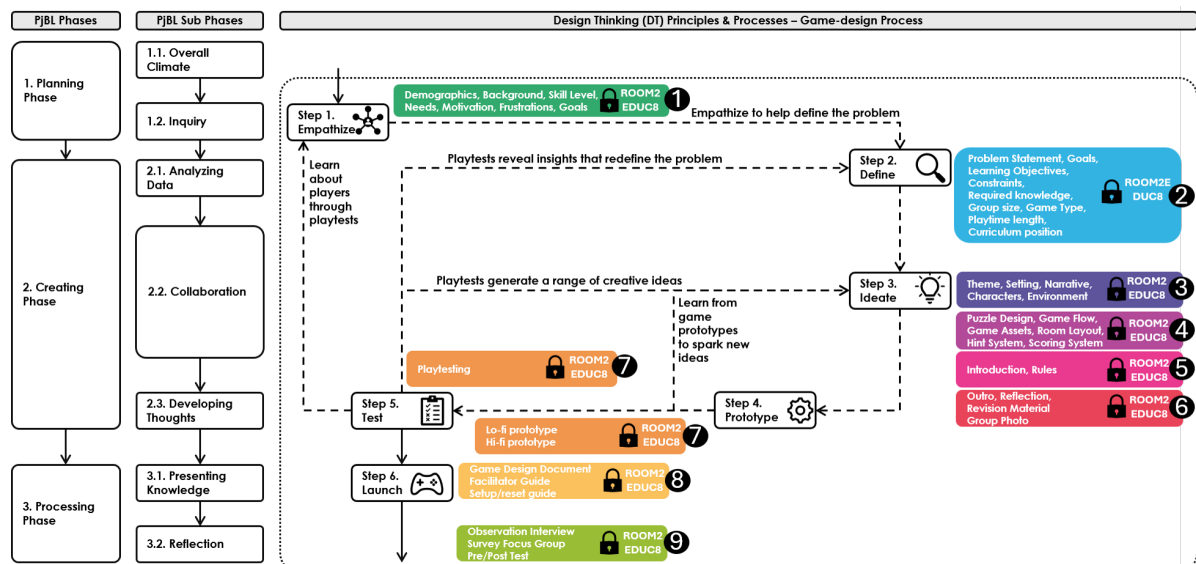


Figure 2: Applying PBL-DT and Room2Educ8 framework

For each game proposal, workflows, puzzle designs, game flow and rules, introduction and reflections need to be determined before proceeding to the next phase, “Developing Thoughts”, so that students can create preliminary versions of their escape board games by completing DT Step 4-Prototype. Due to the fact that the construction of all of these games would be quite expensive and time-consuming at the prototype level, since there was no funding and all games had a common theme, it was jointly decided to evaluate the 11 proposals

using the Plus-Minus-Interesting (PMI) approach and reach an agreement as to the best idea to be used to construct one collaborative board game. Through this technique, the students identified the sixth proposal as the optimal and created a game titled "The Mind Trap of Lord BlabberLier in Foodland", which incorporated all the positive and interesting elements of the remaining proposals. According to this game, in Foodland, the AI-controlled microwave NOUS is hijacked by Lord BlabberLier to spread nutritional misinformation. Five popcorn ingredients —Corni, Salty, Billy, Butter, and Candy—use critical-thinking superpowers to defeat him. Players work in teams, solving puzzles, collecting clues, verifying nutritional claims, and choosing paths to unlock NOUS. A MicroMacQueen robot guides them, while the unreliable AI chatbot provides misleading hints. In the Boss Fight, players decide whether to disable or repair NOUS, discovering that critical thinking, truth, and vigilance protect health from deception. DT Step 3-Ideate and DT Step 4-Prototype were the most iterative workflows of the entire process, since students formed new ideas through trial-and-error attempts. Following multiple sessions of DT Step 3 and DT Step 4, students play-tested their final game through DT Step 5-Test, in which they worked in groups of five, to identify issues and further improve their designs. In terms of DigComp 3.0 alignment, students were encouraged to express their opinions respectfully, while accepting those of their peers in digital discussions, which included prompts in AI tools during collaborative and content creation processes as well as problem identification and solving.

The third and final PBL phase of "Processing" (3) includes two sub-phases. In the first sub-phase, "Presenting Knowledge" (3.1), the project is presented to the learning community and then disseminated to a wider audience. This sub-phase is also linked with DT Step 6-Launch, namely the final game and workflows of game documentation, game setup and facilitator guides. "Reflection" (3.2) also includes reflection and follow-up, during which students reflect on their work, the work of other groups, and the entire learning process. In this study, students engaged in evaluation and reflective activities for their work, such as observations, discussions with their classmates, and post assessments.

3.3 Data Analysis and Results

An improvised pre/post questionnaire was given to the students before and after the intervention, for the purposes of this study. A total of 20 items were assessed using a 5-point Likert scale (1 = Strongly disagree to 5 = Strongly agree), based on competence statements emerged from the five competence areas of DigComp 3.0, adapted specifically to relate to the use of AI tools instead of general digital technologies. Based on DT steps, the 20 items were organized as shown in Figure 3.

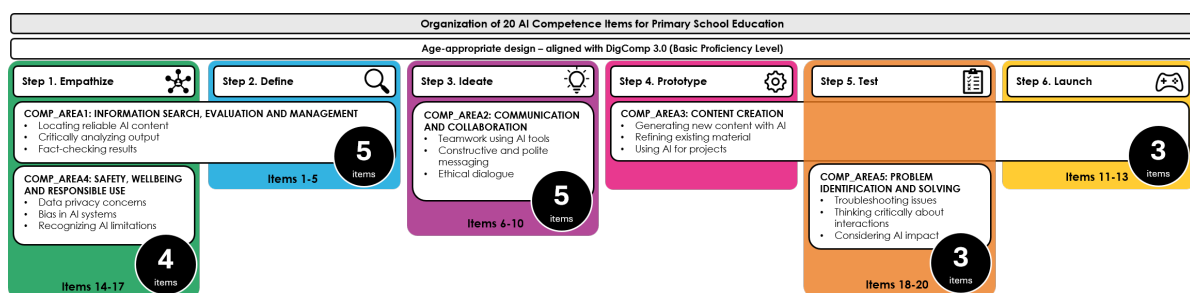


Figure 3: Organization of 20 AI competence items for primary school education

IBM SPSS version 31.0.1.0 was used for data analysis and statistical testing. A total of five factors was formulated for pre- and post-testing. A reliability check was conducted for these factors. Cronbach's alpha (AI_Lit_PRE = 0.828, AI_Lit_POST = 0.800) indicated that factor reliability before and after the intervention is considered good for AI Literacy (Mallery and George, 2000).

Table 1: Paired samples statistics

Paired Samples		N	PRE		POST	
			Mean	Std. D	Mean	Std. D
Pair1	Comp_Area1	22	3.700	0.825	4.209	0.677
Pair2	Comp_Area2	22	3.256	0.771	4.027	0.682
Pair3	Comp_Area3	22	3.348	0.787	4.136	0.664
Pair4	Comp_Area4	22	4.239	0.696	4.705	0.398
Pair5	Comp_Area5	22	3.879	0.647	4.470	0.614
Pair6	AI_Lit	22	3.684	0.524	4.309	0.431

Furthermore, paired sample statistics were calculated to reveal the average response across participants (mean) and gauge dispersion or variation in responses (Std. D) before and after the intervention (Table 1).

Table 2: Paired samples t test

Paired samples t test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. D	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Comp_Area1_PRE & Comp_Area1_POST	-.50909	.28100	.05991	-.63368	-.38450	-8.498	21	<.001
Pair 2	Comp_Area2_PRE & Comp_Area2_POST	-.77273	.27112	.05780	-.89294	-.65252	-13.368	21	<.001
Pair 3	Comp_Area3_PRE & Comp_Area3_POST	-.78788	.28257	.06024	-.91316	-.66259	-13.078	21	<.001
Pair 4	Comp_Area4_PRE & Comp_Area4_POST	-.46591	.33890	.07225	-.61617	-.31565	-6.448	21	<.001
Pair 5	Comp_Area5_PRE & Comp_Area5_POST	-.59091	.36993	.07887	-.75492	-.42689	-7.492	21	<.001
Pair 6	AI_Lit_PRE & AI_Lit_PSOT	-.62530	.13910	.02966	-.68697	-.56363	-21.086	21	<.001

The mean values for the five factors improved before and after the intervention, according to paired samples statistics. In addition, a paired samples t test was performed (Table 2). All mean values of the factors after the intervention were significantly higher than before, and the level of significance associated with all differences was 0.001, suggesting a statistically significant improvement.

4. Conclusion

In conclusion, this study demonstrates that the integration of Project-Based Learning and Design Thinking, further enriched by the Room2Educ8 framework, can provide an effective pedagogy for fostering AI literacy in primary education. By following the model's structured procedures, moving from user-centred empathy to final evaluation, the students transitioned from passive consumers to active designers of an escape board game, cultivating their competences in understanding, applying, and ethically evaluating AI technologies. The empirical findings seem to validate this student-centred approach as a solution to the current lack of age-appropriate AI pedagogies, offering a practical and scalable instructional model that aligns with modern digital competence standards like DigComp 3.0. A limitation of this study is the relatively small sample size and the specific educational context of the e-course lab which may limit the extent to which the findings can be generalised. Future work should focus on scaling the intervention to larger, more diverse student populations. Ultimately, this research provides a foundation for practitioners and researchers to implement curriculum-aligned, game-design methodologies that empower young learners to become informed and responsible digital citizens through the role of game designers.

Ethics Declaration: Informed consent was obtained from the students' parents/guardians, and participation was voluntary and anonymous.

AI Declaration: AI was used to assist in language editing and refinement of academic phrasing.

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