TechTrends (2025) 69:1023–1039
https://doi.org/10.1007/s11528-025-01094-w

ORIGINAL PAPER

Exploring Content Integration in Educational Video Games

Amogh Joshi[1] · Samin Shahriar Tokey[2] · Noah Glaser[1] · Dominic Kao[3]

Accepted: 22 May 2025 / Published online: 5 July 2025

Abstract
Educational game designers face persistent challenges in integrating learning activities seamlessly into gameplay. Existing content integration strategies, such as intrinsic and extrinsic integration, often struggle to balance motivation, engagement, and learning outcomes effectively. This paper addresses these long-standing challenges by proposing a novel content integration approach that combines the benefits of both strategies while offering players flexibility and choice in engaging with learning activities. The study examines students' intrinsic motivation, player experience, and learning outcomes while playing a game featuring Java programming puzzles. Results demonstrate that the novel approach motivated students to engage with learning tasks, improved their understanding of Java programming, and provided a positive player experience. These findings have significant implications for advancing learning content integration methods and enhancing the design of educational games.

Keywords Content integration · Learning mechanics · Parsons puzzles

Introduction

One of the key challenges when designing an educational game is how domain-specific learning activity is integrated within gameplay (Arnab et al., 2015; Ke, 2016; Ke et al., 2019). Games are meant to be playful, casual and inconsequential for the "real world." Learning environments, on the other hand, are designed for serious, structured inquiry, and have implications for learners' educational attainment and overall well-being (Samuel et al., 2013). Educational game designers need to navigate the tension between the world of play and world of work (Garris et al., 2017) to create games that succeed in engaging students over time. The art of designing educational games therefore, is a delicate balance between *integrating moments of play with learning* (Garris et al., 2017).

A key recommendation in the literature is to design educational games holistically (Natucci & Borges, 2021). Focusing either on entertainment or educational design components alone can create games where players may be distracted by gameplay or disengaged because the learning elements reduce player enjoyment (Garris et al., 2017; Ke et al., 2019). This recommendation becomes difficult to implement because educational game designers may lack the skills to transform the learning content into a gaming task (Nelson & Kim, 2020; Theodosiou & Karasavvidis, 2015). Conversely, game designers interested in making educational games may lack knowledge regarding the design of educational content for effective learning.

An effective learning content integration approach can therefore help educational game designers simplify game design decisions by providing clear guidelines on aligning game mechanics with educational objectives, ensuring that gameplay fosters meaningful engagement while reinforcing learning outcomes. This paper addresses the challenge of learning content integration by examining two existing approaches proposed in the literature, identifying their strengths, and developing a novel integration method. The new approach is then evaluated to understand its impact on

✉ Amogh Joshi
ajvxt@missouri.edu

Samin Shahriar Tokey
sstokey@wpi.edu

Noah Glaser
noah.glaser@missouri.edu

Dominic Kao
kaod@purdue.edu

[1] School of Information Science & Learning Technologies, University of Missouri, Columbia, MO, USA

[2] Interactive Media and Game Development, Worcester Polytechnic Institute (WPI), Worcester, MA, USA

[3] Computer & Information Technology, Purdue University, West Lafayette, IN, USA

players' experiences and students' learning outcomes. Both qualitative and quantitative findings reveal a positive gameplay experience and improved learning outcomes in Java programming. This study offers valuable insights and implications for the design of educational games.

Literature Review

Recent systematic reviews and meta-analyses indicate that educational games can improve learning outcomes (Talan et al., 2020). However, researchers emphasize that the design of the game-including elements such as narrative, player choice, interactivity, and feedback-is a critical factor influencing those outcomes (Zhonggen, 2019). As a result, scholarly attention has increasingly focused on how specific design influences experience of learners in the game. Prior research has examined a range of design elements, including avatar representation (Kao & Harrell, 2015, 2016), game genre (Chu, 2004), player agency (Bodi, 2021; Joshi et al., 2025; Taub et al., 2020), and visual fidelity (Kao, 2020), all of which influence player experience and engagement which consequently shapes the learning outcomes.

Zhonggen (2019) identifies narrative context, realism, adaptivity, interactivity, and debriefing-based feedback as particularly impactful design features. Among these, the interaction between the game, the player, and the context is frequently cited as a foundational mechanism by which learning outcomes are shaped (Caceffo et al., 2019; Mayer, 2018). In this paper, we focus specifically on the interaction between the player and the learning content embedded in the game system. The following section reviews scholarly work on content integration in educational games-how instructional material is embedded within gameplay-and how this integration mediates player interaction and learning outcomes.

Content Integration in Games

Malone was the first to present a way to integrate learning activities and gameplay (Ke, 2016). In the seminal works (Malone, 1980, 1981), Malone contrasted two ways fantasy of the game can be used to integrate learning activities: Intrinsic and Extrinsic fantasy. Games with intrinsic fantasy present the problem (i.e., the learning activity) with the help of objects (game-elements) that are part of the game-world (Malone, 1980). In other words, learning activity is weaved into the game world such that the skill of the player changes the fantasy of the game and vice-versa. In games that employ extrinsic fantasy, the skill changes the fantasy but not vice-versa (Malone, 1980), suggesting that the learning activity is disconnected with the game (e.g., solving arithmetic problems to progress in the *Maths Blaster* game (Davidson & Associates, 1983). The learning activities in extrinsic fantasy games can be replaced with a different one without affecting the fantasy of the game (Habgood & Ainsworth, 2011).

More recently, Habgood and Ainsworth have focused on the mechanics present in the games (instead of game fantasy) as a basis for learning activity integration (Habgood et al., 2005; Habgood & Ainsworth, 2011). Game mechanics are actions that players can perform in the game (Jagoda & McDonald, 2018). The change of focus from game fantasy to game mechanics means that educational game designers look at the moment-to-moment interaction of the players in the game (Salen et al., 2004). As such, authors argue that integrating learning activities into game mechanic not only allows educational game designers to generate motivational effects (e.g., feelings of challenge, control, competition, etc.) but also to engender flow experience (Habgood et al., 2005). To this end, authors (Habgood & Ainsworth, 2011) present extrinsic and intrinsic integration, defined in relation to core game mechanics.

Intrinsic and Extrinsic Integration of Learning Content

Intrinsic integration embeds learning activities within core game mechanics, making gameplay synonymous with learning (Habgood & Ainsworth, 2011; Habgood et al., 2005). In contrast, *extrinsic integration* separates learning activities from gameplay, often presenting them as textbook-style exercises that do not meaningfully influence the gameplay (Vandercruysse et al., 2017).

Examples of intrinsic integration in educational games are well-documented in the literature. For instance, Habgood and Ainsworth (2011) describe a math RPG where players must select the correct sword number to divide an enemy's number while engaging in combat. This mechanic intrinsically integrates mental arithmetic with core gameplay. Similarly, Vandercruysse et al. (2017) designed a proportions game where players use drag-and-drop mechanics to place objects, such as soda bottles, based on math questions displayed on the screen. Here, the game's mechanics directly align with the educational content. In another example, Echeverría et al. (2012) present a physics game where players interact with electrostatics concepts like polarity and Coulomb force through character movements, integrating physics learning into the gameplay.

A concept closely related to intrinsic integration is *tightly coupled context (TCC)*, which involves embedding learning materials within dialogue mechanics. For instance, Huang et al. (2021) describe an RPG where players acquire English vocabulary through conversations with non-playable characters (NPCs). Based on these examples, we describe intrinsic integration diagram. A key feature of intrinsic integration is the simultaneous use of game and learning mechanics to progress from the beginning to the end of a level. See Fig. 1.

In contrast, *extrinsic integration* separates learning activities from the core mechanics. For example, Habgood and Ainsworth (2011) describe a math game where learning activities are presented as end-of-level quizzes, disconnected from the primary gameplay. Likewise, Vandercruysse et al. (2017) detail a game where students solve proportion problems to unlock subsequent gameplay. Ku et al. (2022) provide examples of loosely coupled contexts, such as *Battleship* and *Math Kicker*, where arithmetic problems are solved in a separate interface before triggering actions in the game, like planting bombs or scoring goals. Based on these examples, we describe extrinsic integration diagram. A key feature of extrinsic integration is the separate nature of the learning activity from the game world. Players must complete the learning content in order to progress further. See Fig. 2.

While games with intrinsic integration are expected to be more engaging and effective for learning, the literature offers mixed results regarding their impact on motivation and learning outcomes (Habgood & Ainsworth, 2011; Huang et al., 2021; Vandercruysse et al., 2017). Consequently, the optimal integration of learning content into gameplay remains an open question for educational game designers.

Impact of Learning Content Integration on Player Outcomes

Only a handful of studies have compared behavioral and learning outcomes resulting from interaction with educational games that embody an intrinsic or extrinsic learning content integration. Habgood and Ainsworth compared learning gains and motivation of students when playing the game that intrinsically or extrinsically integrated the learning activity (division) (Habgood & Ainsworth, 2011). The study found that students in the intrinsically integrated game condition had higher intrinsic motivation and learning gains compared to students who played extrinsically integrated game. On the other hand, Vandercruysse et al. (2017) found that the learning gains, intrinsic motivation and percieved usefulness of the game that featured extrinsic integration as significantly higher than the game where the math activity was intrinsically integrated.

A key reason why the results differ across the two studies may be explained by the cognitive load experienced by the players in the game. Habgood and Ainsworth note that intrinsically integrated games presents a greater cognitive load because players have to cope with two competing demands simultaneously: the learning and gameplay (Habgood & Ainsworth, 2011). Extrinsically integrated games separates gameplay and learning activities (i.e., asynchronous interaction) which lowers the cognitive load (Vandercruysse et al., 2017), making it easier for students to learn. This design may be particularly beneficial for at-risk learners (Huang et al., 2021; Vandercruysse et al., 2017). Huang et al. (2021) found that prior knowledge of participants (as measured by standardized test scores) played a role in determining the learning gains made while playing a game that intrinsically or extrinsically integrated the learning activity. Students who were classified as having low prior-knowledge scored significantly higher in the post-test in the extrinsically integrated game condition but not in intrinsically integrated game condition. On the other hand, students who were classified as having a high-prior knowledge had significantly higher post-test scores irrespective of the game condition.

While prior research has outlined the theoretical benefits and limitations of intrinsic and extrinsic content integration, the empirical findings remain mixed. Intrinsically integrated

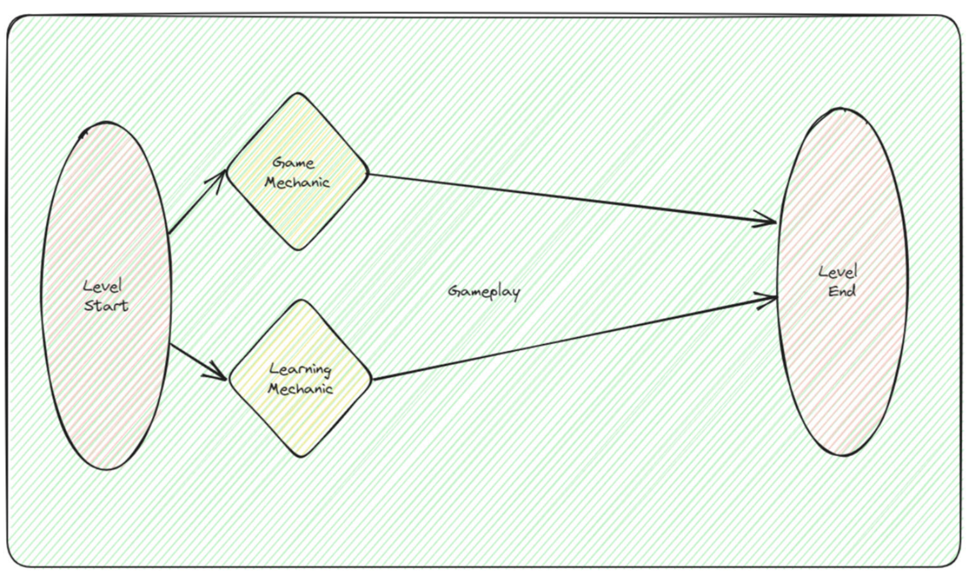

Fig. 1 Intrinsic integration conceptual diagram based on the studies above. The green block represents gameplay. Players use game and learning mechanics simultaneously to progress toward the goal of the game (e.g., the end of the level)

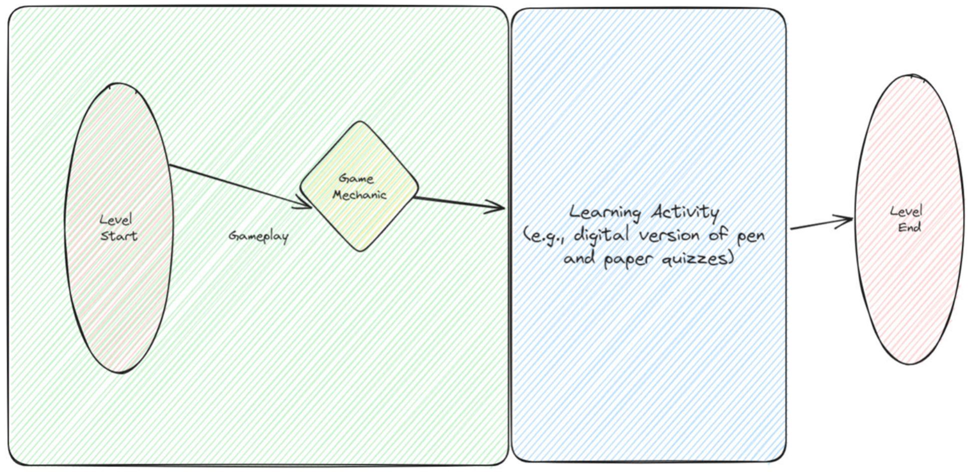

Fig. 2 Extrinsic integration conceptual diagram based on the studies above. The green block represents gameplay, and the blue block represents the learning activity. The learning activity is 'adjacent' to the game and has no impact on the game world. Before reaching the level end, players need to complete the learning activity in order to progress further

games may offer more immersive and engaging learning experiences but at the cost of increased cognitive load, particularly for learners with low prior knowledge (Habgood & Ainsworth, 2011; Huang et al., 2021). Conversely, extrinsically integrated games reduce cognitive demands but risk disengaging players by separating the learning content from the core gameplay (Vandercruysse et al., 2017). These trade-offs suggest that neither approach is universally optimal.

To address this unresolved tension, we propose a hybrid content integration design that seeks to combine the motivational affordances of intrinsic integration with the cognitive accessibility of extrinsic integration. This design is implemented in Parsons Game, a Java programming game that embeds code-tracing and debugging tasks within an interactive puzzle environment. While the puzzles reflect intrinsic integration by embedding content into the game mechanic, the narrative and reward structure offer extrinsic support to reduce cognitive demands.

This study is guided by the conceptual framework of content integration in educational games (see Figs. 1 and 2), which shaped both the design of the game and our analysis of how learners interact with educational content. Specifically, we examine how this hybrid integration strategy influences player experience, intrinsic motivation, and learning outcomes, thereby extending prior work on game-based instructional design. In the next section, we describe our game ('Parsons Game') followed by the methods for investigating these outcomes.

Parsons Game

We developed a 2D platformer game, Parsons Game, featuring two core mechanics: platforming and enemy destruction. The platforming mechanic included movement (←/→ or A/D keys) and jumping (space bar, W, or ↑ key), allowing players to navigate levels and collect coins for high scores. The enemy destruction mechanic let players eliminate obstacles by triggering Java programming puzzles, integrating learning with gameplay.

To progress through the game's three levels, players collected treasure chests and keys. Treasure chests unlocked waypoints to new level sections, while keys opened doors to subsequent levels. The 'destroy enemy' mechanic, integral to gameplay, prompted players with a programming puzzle when clicked. Successful puzzle completion destroyed enemies, tying the learning activity to the game's core mechanic and altering the game state.

We focused on the core game mechanics in order to situate the learning activity so that it embodies the features of extrinsic and intrinsic integration (Habgood et al., 2005; Habgood & Ainsworth, 2011). A central feature of intrinsic integration is situating the learning content as a part of core game mechanics (Habgood & Ainsworth, 2011). The proposed design integrates the learning activity as a core game mechanic (i.e., destroy-enemy mechanic) within the game. At the same time, we draw on the strength of extrinsic integration where non-simultaneous interaction with the learning content to balance cognitive demands. When players use the destroy-enemy mechanic (core-mechanic), the game triggers a puzzle solving activity where the players construct solutions to Java programming problems. The puzzles were crafted as playful problem-solving tasks rather than traditional, pen-and-paper exercises. When the puzzles are solved successfully, the enemies are destroyed in the game-world. Solving the learning activity, affects the game-world thereby promoting engagement while maintaining their connection to the game's mechanics and goals. This asynchronous use of core-mechanics embodies the strengths of intrinsic and extrinsic integration approaches. See Fig. 3.

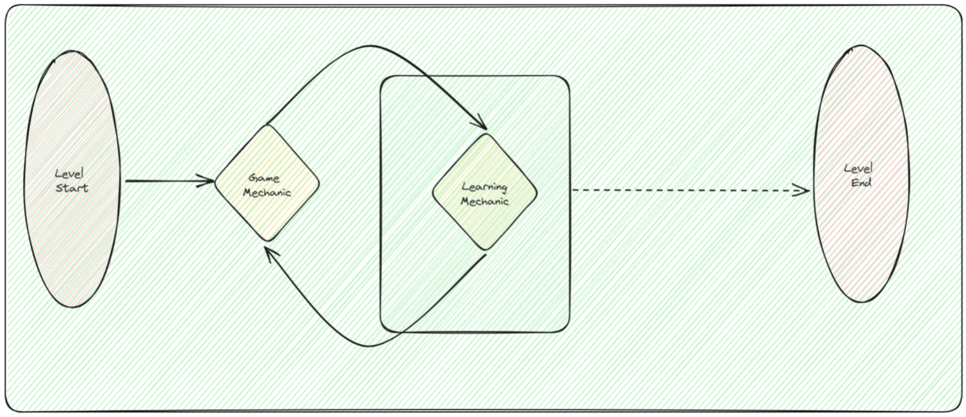

Fig. 3 Overview of the proposed novel content integration approach. This integration strategy combines the strengths of intrinsic and extrinsic integration by embedding learning activities within core game mechanics. Players use the two mechanics sequentially, instead of simultaneously

Gameplay Description

In *Parsons Game*, players collect coins as part of their gameplay objective, using the platformer mechanic. Figures 4 and 5 illustrate Level 1.

In Fig. 4, players navigate their character to collect a treasure chest (top-left), which unlocks a waypoint. However, enemies block access to the waypoint (top-right). To proceed, players must use the destroy enemy mechanic by clicking on an enemy, triggering a dialogue box (bottom-left). Solving the accompanying puzzle changes the game state, removing the enemy (bottom-right).

Figure 5 shows the next section of Level 1. Here, players can collect the key (top-left) without interacting with enemies (top-right). Collecting the key (bottom-left) opens the door to the next level (bottom-right). Players can also collect all coins without using the destroy enemy mechanic, offering flexibility in how they complete the level. However, colliding with an enemy resets the player to the level's start, erasing progress. This design allows players to balance risk and strategy while achieving their objectives.

In this way, each level was designed where: a) the players needed to solve at least one puzzle in order to progress to the next level and b) other types of enemies were present in the

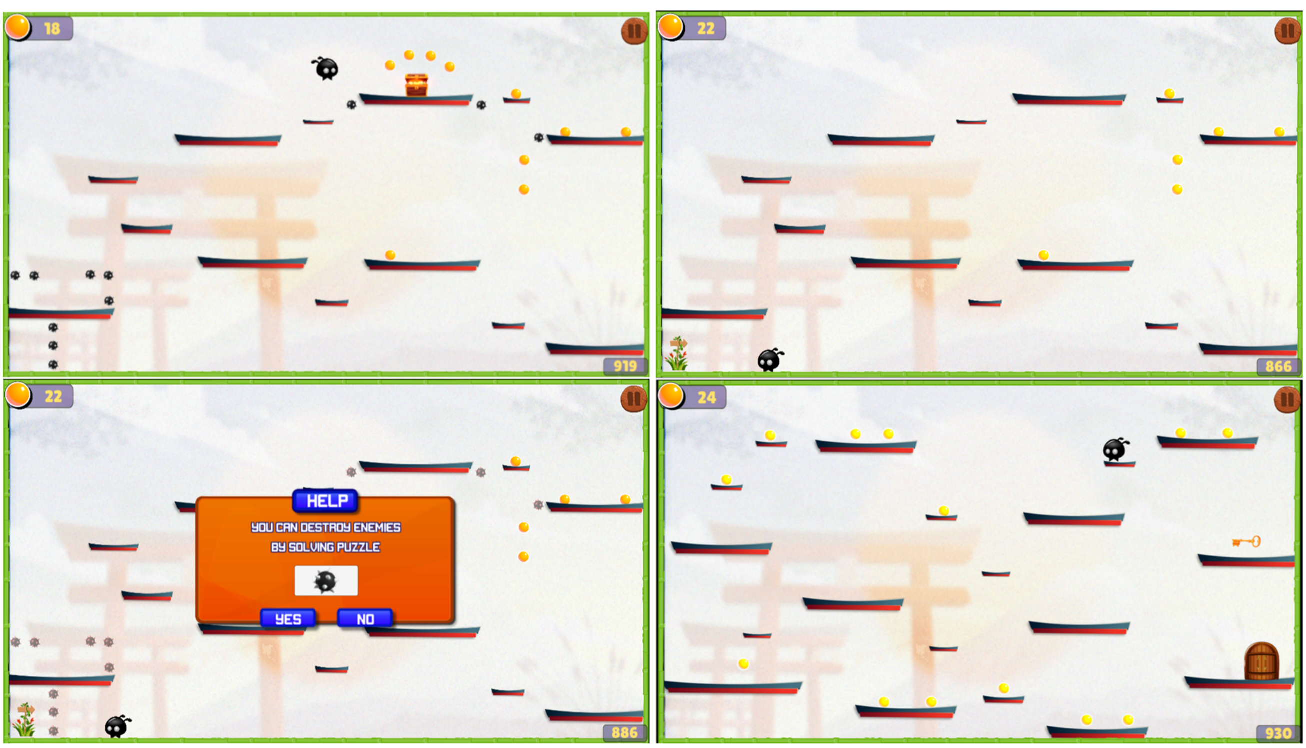

Fig. 4 Player collects the treasure chest (top-left), revealing the waypoint (top-right). In a separate scenario (bottom-left), the player engages with the "destroy enemy" game mechanic to remove enemies obstructing the waypoint, which then allows progression to the next section of Level 1 (bottom-right)

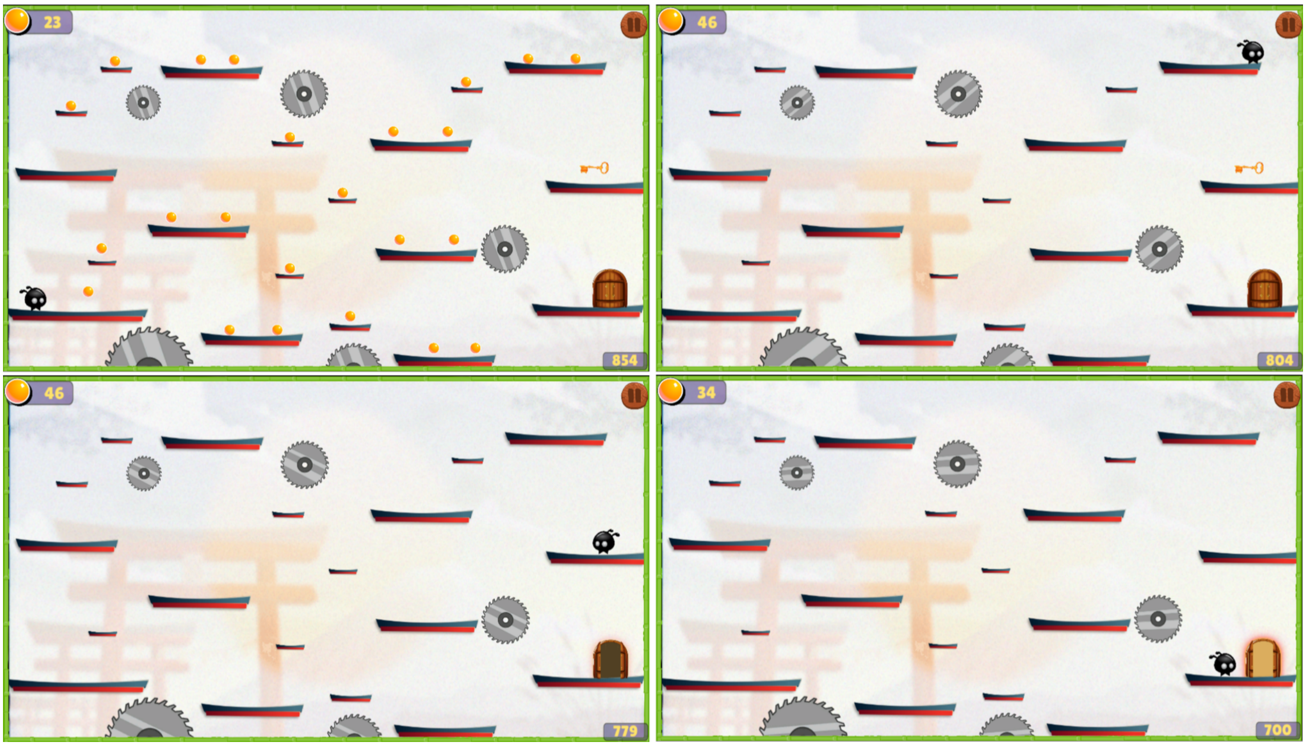

Fig. 5 Level 1 continued. Players navigate their game-character to collect the key (top-right). Collecting the key unlocks the door (bottom-left). Players navigate to the door and progress to the next level (bottom-right)

level that did not *necessarily* obstruct players' progression and offered a choice to the players. Players could choose to solve the puzzles so that it was easier to collect the coins or they could navigate their game character adeptly, avoiding the enemies to collect all the coins.

Parsons Problems

Parsons problems (also known as Parsons Puzzles, code scramble, code mangler, etc.) involve rearranging pre-written code snippets to construct a solution (Parsons & Haden, 2006; Weinman et al., 2021). The problem space includes a "problem window" with code snippets and a "solution window" where learners drag and drop snippets to build a solution (Du et al., 2020). Learners can then "submit" their code to receive feedback. Unlike block-based programming environments, Parsons problems are typically implemented using specific programming languages such as Python (Karavirta et al., 2012).

Parsons problems feature three key elements: scaffolding, distractors, and feedback (Du et al., 2020; Bender et al., 2022). Scaffolding adjusts how puzzles are presented, either providing structured solutions or randomizing snippets to obscure program flow. Distractors add complexity, including syntax or logic errors and unrelated snippets, helping identify misconceptions (Du et al., 2020; Harms et al., 2016). Feedback highlights errors, aiding conceptual understanding (Denny et al., 2008). These features are operationalized in various ways in the literature (see (Du et al., 2020) for a review).

In our game-based learning environment, we operationalized these features as follows:

- **Scaffolding**: The puzzles displayed the correct structure of the solution program (see Fig. 6).
- **Distractors**: We implemented "paired distractors," presenting incorrect snippets alongside correct alternatives to offer a binary choice (Denny et al., 2008; Du et al., 2020).
- **Feedback**: Upon clicking "submit," incorrectly placed blocks were highlighted in red using "line-based feedback" (Helminen et al., 2012; Karavirta et al., 2012). After three failed attempts, a "view solution" button became available to reveal the correct solution.

The learning activity included six programming puzzles, triggered through the "destroy enemy" game mechanic, integrating problem-solving directly into gameplay.

Parsons problems were originally developed to offer an engaging introduction to programming languages and to facilitate syntax practice (Parsons & Haden, 2006). Over time, researchers have applied Parsons problems in vari-

Fig. 6 The game features a puzzle environment where players drag and drop code snippets from the problem pane into the solution pane. Upon clicking submit, the program evaluates their solution and highlights any incorrect code snippets (top-right). Players can access the correct solution (bottom-left) and finalize the code puzzle (bottom-right)

ous contexts, including aiding students in program design (Garcia et al., 2018), identify student difficulties (Du et al., 2020), develop computational thinking skills (Bender et al., 2022), and address student misconceptions (Helminen et al., 2012). In the digital space, parsons problems have been implemented in interactive e-books (Ericson et al., 2015), web applications (Kumar, 2018), and mobile-based learning environments (Karavirta et al., 2012)). Parsons problems have also been investigated as a pen and paper question in classroom exams (Lopez et al., 2008).

Oyelere et al. (2017) introduced a turn-based mobile tabletop game, “Ayo,” where players earn points by winning against their opponent. Each round begins with a puzzle task, and players are awarded points upon solving a Parsons problem. This design exemplifies extrinsic integration, as players solve code puzzles to unlock gameplay rewards. To the best of our knowledge, no study has explored integrating Parsons problems into games in this manner.

Methods

Because we designed a game that merged the beneficial properties of extrinsic and intrinsic integration, we wanted to evaluate the impact of this novel content integration approach on players’ subjective experiences and learning outcomes. To this end, we ask two research questions:

- RQ1: How do player engagement metrics and subjective experiences inform the evaluation of novel educational content within a game-based learning environment?
- RQ2: What is the impact of the novel learning content integration approach on students’ learning outcomes?

We used data triangulation to answer the research questions. The three sources of data were: self-report measures, game analytics and semi-structured interview. These data sources are described in the section below. A sequential design approach was followed wherein we first collected quantitative data from the participants (n=50). We then interviewed participants who had consented for a follow-up study (n=5) to describe their player experience, motivation, and their learning experience.

Quantitative and Qualitative Measures

Player Experience Inventory (PXI)

The PXI inventory has 10 constructs that measure the experience of the player at a functional and psychosocial levels.

At the functional level (comprising of 5 constructs), the inventory asks the player to detail their experience at during the gameplay (e.g., Ease of Control, Audio Visual Appeal). At the psychosocial level (comprising of 5 constructs), the inventory elicits emotional experiences by the player while playing the game (e.g., Autonomy, Mastery). The PXI comprises of 30 items and the order of questions was randomized (Vanden Abeele et al., 2016). All responses range from -3 (Strongly Disagree) to 3 (Strongly Agree). In general, a higher score indicates a better player experience for a given construct.

The PXI has demonstrated content and construct validity in prior studies involving diverse cultural contexts and game genres (Abeele et al., 2020; Graf et al., 2022; Vanden Abeele et al., 2016). The inventory's ten-factor structure has been consistently replicated using confirmatory factor analysis and has shown a high internal consistency $\alpha = 0.70 - 0.92$. In this study, the overall internal consistency was $\alpha = 0.92$.

Intrinsic Motivation Inventory (IMI)

The Intrinsic Motivation Inventory (IMI) is a widely used instrument for assessing participants' subjective motivation and has strong construct validity across domains such as education, healthcare, sports, and game-based learning (Bosch, 2024; Cocca et al., 2022; McAuley et al., 1989). It consists of multiple subscales, with Interest/Enjoyment serving as the primary measure of intrinsic motivation toward a given activity.

Empirical studies have consistently reported high internal consistency for these subscales, with Cronbach's alpha values typically ranging from $\alpha = 0.7 - 0.93$ (Bosch, 2024; Cocca et al., 2022; McAuley et al., 1989).

In this study, we used the IMI to measure participants' intrinsic motivation to engage with the learning activity embedded in the game. The inventory was administered once, following the gameplay session. Participants rated their responses on a 7-point Likert scale (1 = not true at all to 7 = very true), with higher scores indicating greater intrinsic motivation for solving Java programming puzzles. The internal consistency for the Interest/Enjoyment subscale, which served as the primary indicator of intrinsic motivation, was high in our sample, with a Cronbach's alpha of $\alpha = 0.91$, indicating strong reliability.

Java Concept Inventory (JCI)

The Java Concept Inventory (JCI) was a self-developed inventory aimed to measure students' knowledge about Java programming concepts. The inventory comprised six questions. The first two questions address basic programming tasks, such as identifying correct syntax (e.g., recognizing a missing semicolon) and the proper use of built-in functions (e.g., determining the length of a string). The remaining questions target more complex programming tasks related to functions, including understanding how to call a function with appropriate arguments (e.g., `string` vs. `string[]`) and comprehending the return type (e.g., `void` return type). Each question required participants to select the correct answer from four multiple-choice options, a format commonly used in the course examinations.

To develop the concept inventory, we conducted a content analysis of instructional materials-course lectures, assignments, quizzes, and major exams (midterm and end-semester)-from an introductory Java programming course. Based on consultations with lab instructors who each had over two years of teaching experience, we identified "functions" as a critical transitional concept. It consistently emerged as a conceptual bottleneck, both in formative assessments and classroom troubleshooting. The decision to focus on this area was supported by prior literature identifying persistent misconceptions in early Java instruction (Caceffo et al., 2019). As such, the focus on instructional alignment as well as the basis in coverage of conceptual topics provide a strong evidence of content validity. See Appendix A for the complete inventory.

The concept inventory was administered twice: once before and once after participants played the educational video game. Each question was worth one point, with no points awarded for incorrect answers.

Game Puzzles

The game featured Parsons problems, and the puzzles were based on the six questions in the JCI. Each puzzle reflected a unique misconception that was present in the JCI. However, the puzzles did not resemble pen-and-paper questions but a playful exercise where learners can construct solutions based on the pre-written code snippets for a given problem.

A notable distinction between the questions in the concept inventory and the puzzles in the game lies in the transformation of the code to align with the intrinsic fantasy of the game environment (Malone, 1981). For example, learners were tasked with creating a program featuring a class named "Destroy Enemy." Code statements (e.g., print statements) were thematically integrated with the description and functionality of the "destroy enemy" game mechanic, encouraging participants to view puzzle-solving as analogous to destroying enemies within the game. This method of embedding intrinsic fantasy is similarly employed in popular online games such as CodeCombat (Winter, NA; Yücel & Rızvanoğlu, 2019), where player actions (e.g., jump, attack) are represented as functions (e.g., `player.jump()`, `player.attack()`).

Game Analytics

The game automatically logged gameplay data which included a number of metrics such as the total coins collected in each level, number of levels cleared, number of attempts, and number of puzzles solved. With regards to our research question, we define two variables based on the gameplay metrics: Goal Adherence and Motivation to Engage with the Learning Activity.

Goal Adherence

The goal for the players in the game was to collect all the coins so as to get a high score. The game analytics logged coins collected in each attempt for a given level. Since it was possible for participants to make multiple attempts to clear a given level, we chose to focus on selecting the *attempt where the participants completed the level (i.e., a successful attempt).* For example, if a participant successfully completed the level 1 in their fourth attempt, we calculated the total number of coins collected for that attempt. This way, we selected participants' successful attempt for all the three levels and calculated the total number of coins collected for their gameplay session.

Goal adherence was then constructed by calculating the proportion of coins collected by the players to the sum total coins present in each level. For example, if a participant collected 28 coins out 30 coins present in the level, their goal adherence was said to be 0.93 (~93.3%).

Motivation to Engage with the Learning Activity

The game contained four levels (including a tutorial level). The levels were designed so that the participants needed to solve at least four puzzles—one puzzle per level—to progress further in the level (see 3.1 for more details). Table 1 shows the the range of puzzles solved by participants per level per attempt.

For a given attempt, the game analytics tracked the puzzles solved by participants for a given level. Theoretically, participants could attempt the level as many times as they wanted. This would mean that if we account for total attempts for a given level, the participants could have solved more puzzles than the maximum puzzles indicated in the Table 1. As such, we operationalize motivation to engage with the learning activity by calculating the number of puzzles solved for an *attempt where the participants completed the level (i.e., a successful attempt).* We view players' willingness to solve more puzzles than a minimum threshold as indication of motivated behavior (Kao, 2021).

Table 1 Distribution of puzzles across levels

Level	Minimum Puzzles	Maximum Puzzles
Tutorial	1	2
Level 1	1	2
Level 2	1	3
Level 3	1	2
Total	**4**	**9**

Qualitative Study

All interviews were conducted by the first author, with each session lasting approximately 15-20 minutes. Participants were interviewed once, and the interviews were audiotaped, transcribed, and entered into a note-taking software for coding, sorting, and data retrieval purposes. The interview questions aimed to explore how participants described their learning experience (e.g., "Did you feel like you learned anything from solving the puzzles?" and "Did any puzzle challenge or change your understanding of Java programming?") and their motivation to solve the puzzles (e.g., "What motivated you to solve the puzzles in the game?"). Follow-up questions were tailored to participants' initial responses (e.g., "What was confusing about the puzzles?" and "Talk to me about your experience destroying enemies in the game.").

To ensure participants felt comfortable sharing their authentic experiences without undue pressure to report only positive gameplay feedback, we clarified the interview's purpose and the nature of the reward before starting. Participants were explicitly informed that their partial course credit was not contingent on their responses. This approach aimed to foster openness and authenticity in their feedback.

At the conclusion of each interview, we conducted member checking (Merriam & Tisdell, 2015; Tracy, 2010) by paraphrasing participants' comments back to them. This allowed participants to reflect on or add to their responses and served as a reliability and validity check for the qualitative data.

Six participants consented to the follow-up study. However, one participant's recording was lost due to technical issues. The remaining transcripts (n=5) were analyzed using a thematic analysis approach (Braun & Clarke, 2006). All coding was conducted by the first author. A codebook was iteratively developed and refined to ensure consistency in theme generation. To enhance analytical rigor, previously coded transcripts were revisited during each round of coding to confirm category stability. Discrepant interpretations were resolved through reflexive memoing and theme comparison. Although only one coder was involved, the member checking process described earlier contributed to the trustworthiness of the interpretations. Coding was conducted manually using a note-taking software (Table 2).

Procedure

Participants first filled an IRB-approved consent form. The consent form informed participants regarding the purpose of the study, the nature of data collected and their rights during the study. As a part of their rights, participants were informed that they could withdraw from the study at any given time without penalty.

After providing consent, participants first answered the inventories listed in the section above. Participants first watched the video that explained their goal in the game and provided an overview of how to solve Java programming puzzles to successfully activate the "Destroy Enemy" game mechanic. Participants were also informed that could exit the game at any time after playing for 1000 (~17 minutes) seconds [1]. After watching the video, the participants then played the game on the web-browser. The participants were provided a set of disposable headphones and used the headphones when watching the video and playing the game. The qualtrics web survey collected analytics data from the user during watching the video and playing the game. The analytics data was used to validate if the participants had actually watched the video and played the game.

After playing the game, the participants completed post-test questionnaires. This included JCI, PXI and IMI. Participants who consented for the follow-up interview were asked to reflect on their play and learning experience.

Table 2 Participants in the qualitative study

Participant Pseudonym	Year	Gender	Ethnicity
P1	Junior	Male	Korean
P2	Sophomore	Male	Asian Indian
P3	Sophomore	Female	Chinese
P4	Sophomore	Male	White
P5	Sophomore	Male	Chinese

Note: All participants in the table are assigned a pseudonym to protect their identity

Results

The three data sources (self-report measures, game analytics and semi-structured interviews) were used to answer each of the research questions. One participant was excluded from the analysis due to an incomplete data set.

RQ1: How do Player Engagement Metrics and Subjective Experiences Inform the Evaluation of Novel Educational Content within a Game-Based Learning Environment?

We examined a combination of gameplay metrics, self-reported player experience and intrinsic motivation, and qualitative feedback to understand the effect of the novel content integration approach on player experience and intrinsic motivation.

We first examined whether the participants continued to play the game after the minimum time duration of 1000 seconds (~17 minutes). Participants were instructed that they could either stop or continue playing for as long as they wished after the 1000 seconds had elapsed. As such, continuing to play after the stipulated time indicates motivated behavior (Kao, 2021). On average, participants played for 1023 seconds (SD=306). A one-sample t-test was conducted to determine whether the mean of *Total Time Played* (M) was significantly different from the hypothesized value of 1000. The results indicated that the mean difference was not statistically significant, $t(48) = 0.53, p = 0.596$. We observed that the participants stopped playing after the minimum time, which might indicate a lack of motivation and interest to continue.

To understand their behavior more deeply, we examined if the participants quit the game before the game was complete. The game analytics data indicated that 49 of the 50 participants had completed the game. Furthermore, the goal adherence metric demonstrated a high level of goal commitment. On average, participants collected 92.4% of coins in level 1, 92.3% in level 2, and 86.3% in level 3, resulting in an overall collection rate of 90.3%. This indicates that participants exhibited a strong adherence to the game's objectives and were engaged with the gameplay.

The Player Experience Inventory (PXI) captured participants' overall experience with the game. The PXI uses a scale ranging from −3 to 3, where higher scores indicate a better player experience. Participants rated Clarity of Goals highest ($M = 2.65, SD = 0.61$), followed by Ease of Control ($M = 2.27, SD = 0.84$), Progress Feedback ($M = 2.14, SD = 0.84$), and Enjoyment ($M = 2.14, SD = 0.85$). Ratings for Enjoyment, specifically (e.g., "I had a good time playing this game"), averaged around 2 ("agree"), suggesting an overall positive experience. Other constructs, such as Audio Visual ($M = 2.09, SD = 0.86$) and Mastery ($M = 2.07, SD = 0.96$), also scored above the 2, further

[1] We arrived at this minimum playtime based on the pilot study. We observed that participants, on average, arrived at the second level after approximately 1000 seconds. Therefore, we felt that requiring a minimum playtime of 1000 seconds was optimal for investigating overall motivation, given that participants would have a choice to continue playing on to the third level or quit playing the game after the minimum playtime.

supporting the notion of an engaging and enjoyable player experience. See Fig. 7.

Intrinsic Motivation to Engage with the Learning Content

Participants were asked to rate their intrinsic motivation while solving puzzles in the game, with higher scores indicating greater intrinsic motivation to solve Java programming puzzles. On average, participants reported a moderate to high level of intrinsic motivation ($M = 5.23$, $SD = 1.68$), corresponding to a range between 4 (*somewhat true*) and 7 (*very true*).

The motivation of the participants to solve puzzles was operationalized as described in Section 4.1.5. Participants, on average, solved 7.84 (SD=2.18) puzzles in the game. We employed one-sample t-test to investigate if participants' motivation to engage with the learning activity was significantly different the minimum number of puzzles required to be solved in the game (see Table 1). This difference was statistically significant, $t(48) = 15.5$, $p < 0.001$.

Qualitative Insights into Gameplay Experience

Qualitative interviews provided valuable insights into how participants interacted with the game's mechanics, including the learning mechanic. Participants were asked to describe their experience with the mechanics ("Please describe your experience using the mechanics while playing the game") and their motivation to solve puzzles in the game ("What motivated you to use the destroy-enemy game mechanic?"). Two key themes emerged from their responses: strategic use of game and learning mechanics and the use of learning mechanics to achieve in-game objectives.

Participants described the game's mechanics as intuitive and well-integrated, allowing for seamless transitions between gameplay and learning content. P1 noted, "I thought the idea of the way the learning was put into it [the game] was a good idea as far as just destroying enemies. But you have to answer the questions [puzzles] correctly." Similarly, P3 appreciated the design, stating, "It was cute how it was set up." This ease of interaction empowered participants to use the mechanics strategically to achieve their gameplay objectives. P5 remarked, "It was faster and, like, easier to complete a level if you just destroy the enemies first." Another participant, P4, shared a similar perspective, saying, "If I solve a puzzle early, that decreases my time to complete the level... I was just trying to do it in like a speed run." These statements highlight how the mechanics allowed participants to personalize their playstyle and strategically approach the game.

The flexibility in using the mechanics also contributed to a sense of accomplishment, motivating further engagement. Audio and visual cues, such as treasure chest sounds and progress indicators, enhanced the rewarding nature of the experience. As P4 explained, "The treasure chest sound gave a little extra oomph of confidence or accomplishment."

Participants were motivated to engage with the destroy-enemy mechanic primarily because it facilitated the completion of in-game objectives, such as collecting coins,

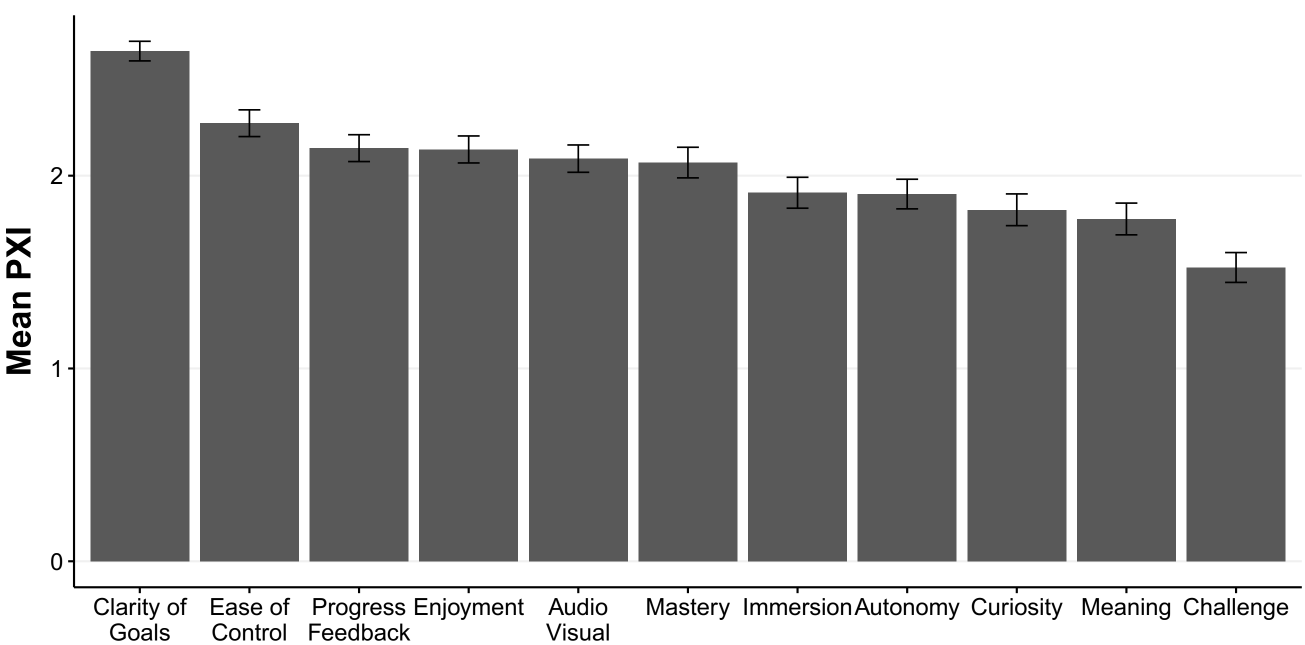

Fig. 7 Player Experience Inventory. Scores range from -3 (Strongly Disagree) to 3 (Strongly Agree). Error bars represent standard errors

progressing through levels, and avoiding player death. For example, P4 mentioned, "It's just the objective of collecting coins, things like that…It was easier to solve [puzzles] than thinking and doing the arrows [moving the game character with arrow keys]. I don't have that much of skill to play with the computer right now. I am kind of very, very basic."

While solving puzzles was not always mandatory, participants often chose to engage with them. P5 shared, "It would have been a little dangerous when I was trying to collect the top coins…there was one level where they [coins] were on the bottom. That was one where I thought I could probably do it without it. But I just did it anyway, because it's part of the game." P1 also expressed enjoyment in solving puzzles for their educational value, saying, "I really enjoyed solving the puzzles... Because, you know, it's always much better to learn something by playing fun activities."

Qualitative findings from the data reinforced the positive experiences reported by players during gameplay and puzzle-solving and helps to triangulate findings from the quantitative data, highlighting both a positive player experience and high levels of intrinsic motivation to engage with the puzzles in the game.

RQ2: What is the Impact of the Novel Learning Content Integration Approach on Students' Learning Outcomes?

The JCI was administered twice to participants (pre-test and post-test). We conducted paired sample t-test with JCI scores as the dependent variable. The learning outcomes significantly increased from the pre-test (M=2.9,SD=1.31) to the post-test (M=3.48,SD=1.37); $t(48) = 4.34$, $p < 0.001$, $d = 0.62$.

The game analytics data supports the learning outcome. On average, participants solved, approximately 8 puzzles. The six puzzles in the learning environment were designed to cover the six questions asked by the JCI. As such, the results from the game analytics data supports the findings of the learning gains documented measured by the JCI. Five participants consented for a follow-up interview. We asked participants to describe their learning experience in the game. More specifically, we asked two questions ("Did you feel like you learned anything from solving the puzzles?" and "Did any puzzle challenge or change your understanding of Java programming?"). We followed up on the initial questions depending on the response of the participant ("What was confusing about the puzzles?").

Two themes emerged when asked to elaborate on the puzzle solving experience: participants described learning Java programming concepts through making mistakes and revising what they had already learned in classroom environment.

Theme 1.1: Learning Java Programming Concepts Through Making Mistakes

Participants described making mistakes while constructing a solution for a given puzzle problem. These mistakes were related to syntax and constructing functions in Java programming language.

When describing problems with syntax, students noted particular functions that they chose incorrectly in the game (P1: "The length command, I just messed up and then I went back and kind of had the more solid idea about that"). P2 mentioned how the puzzle environment brought mistakes regarding syntax and logic to his notice, "Every time I'm continuing the lab [assignments], I always get it wrong. I have to have like four or five rounds [attempts] to get it right. This [puzzle environment] kind of helps it a lot as this deals with lot of syntax errors." Participants also described mistakes they made while constructing functions. P3 described, "I kept trying to put them [the return statement] in the wrong area." Frequently, students would put the code snippets after closing the function with the curly brackets (i.e., outside the function). All participants described making this mistake. P1 described, "I messed up my brackets just as far as ending putting two in the wrong place…the one that had the first function." These mistakes extended to the misconceptions that were present in the code puzzles. When constructing functions, students also needed to select the correct argument or the return type to solve the puzzles successfully. These functions looked identical but had different arguments or return types, something that the students needed to understand and critically think about. P1 described, "there was a couple of variations of the same kind of function call. That was something that you had to think about even if it's something you really experienced, and you can still mess it up."

In making mistakes, the puzzle environment provided feedback which led the students to reflect on their mistakes and to correct their misconceptions. P3 described how she understood how to construct Java functions better after looking at one solution, "After I looked at that first solution, that's when I realized how it was laid out. And then I was able to do it." P4 similarly described, "I got the error message and then I finally figured out that, that I didn't need that [pointing to the incorrect code snippet]. It just needed to be string [as opposed to `string[]`]." The feedback also helped students grasp how Java functions and programs in general were structured. P1 described, "you really felt confident ability to put together Java syntax as far as calling functions. And what goes with it."

Theme 1.2: Revising what is Learned

Participants also described how the puzzle environment provided a refresher on the concepts they had recently learned in the classroom. P1 described, "It was just a really nice kind of refresher slash solid learning. I mean, it's, we have the class right now. So but it was just a good way to kind of solidify some of the ideas that maybe we've progressed past." P4 similarly mentioned, "it definitely reinforces some of the basic concepts that I know."

Discussion

This study investigated how a novel content integration strategy in an educational game influenced participants' learning outcomes, intrinsic motivation, and overall player experience. By combining beneficial aspects of extrinsic and intrinsic integration, the game provided players with flexibility in deciding when and how to engage with learning activities. This choice, a critical design feature, allowed participants to experiment with strategies, fostering autonomy and enhancing their overall engagement with the game.

The results showed a significant increase in participants' conceptual understanding of Java programming (RQ2). This improvement, with a medium effect size (Cohen's d = 0.62), suggests that engaging with Parsons problems helped participants identify and correct misconceptions about Java programming concepts. Qualitative data reinforced these findings, with participants describing how the game helped them clarify programming errors, particularly in functions, return statements, and program flow. The iterative feedback system embedded in the game allowed participants to learn through trial and error, further supporting their conceptual understanding. Additionally, participants highlighted learning areas not captured by the JCI, such as correcting mistakes in function structure and flow. The findings underscore how the novel content integration approach supported learning outcomes for the students. These findings align with prior research showing that intrinsic integration can support engagement and learning when game actions carry meaningful consequences for progress (Habgood & Ainsworth, 2011). However, unlike purely intrinsic models, our design gave learners control over when to engage with content, potentially reducing cognitive overload (Huang et al., 2021; Vandercruysse et al., 2017).

The overall player experience was also rated positively. Participants' scores for constructs such as Clarity of Goals, Progress Feedback, Ease of Control, and Enjoyment fell between 2 (agree) and 3 (strongly agree). However, constructs like Challenge, Curiosity, Meaning, and Immersion scored lower, averaging between 1 (somewhat agree) and 2 (agree). These scores align with the game and the experiment design. For example, most participants interacted with the learning mechanic to destroy enemies and as a consequence, may have perceived the levels as less challenging. Additionally, extensive video tutorials provided prior to the game may have reduced the curiosity of the participants. The absence of narrative or other immersive elements, omitted to focus on the study's main objective of examining the integration of learning content, may explain the lower meaning and immersion scores.

The participants were also highly motivated to engage with the learning environment (RQ1). Evidence of this intrinsic motivation was seen in the significantly higher number of puzzles solved (M = 7.84, SD = 2.18) compared to the minimum required puzzles (3). In interviews, participants reported that their motivation stemmed from in-game objectives, such as collecting coins, navigating the character more efficiently, and avoiding losing progress. Self-reported measures of intrinsic motivation (interest/enjoyment) were similarly positive (M = 5.23, SD = 1.68), with participants averaging scores between 4 (somewhat true) and 7 (very true). Together, these results suggest that the game effectively motivated participants to engage with the learning activity, supporting the content integration strategy present in the game.

A critical insight from this study is that the flexibility provided by the novel content integration strategy played a significant role in fostering positive outcomes. Unlike traditional intrinsic integration, where learning is "always on," or extrinsic integration, which forces learning tasks at specific points, the game allowed players to engage with learning mechanics at their discretion. This non-simultaneous interaction reduced cognitive load, enabling participants to balance gameplay and learning effectively. For example, embedding the learning activity within the destroy-enemy mechanic, a core gameplay feature, allowed participants to see the utility of solving puzzles while progressing through the game. This design encouraged participants to view the learning tasks as integral to their success in the game, further enhancing their motivation and engagement. Player choice appears to have been a critical factor in maintaining engagement, as learners could decide when and how to interact with the puzzles. This aligns with prior findings that agency enhances motivation and perceived autonomy in educational games (Joshi et al., 2025; Taub et al., 2020).

Content Integration and Its Implications

This study advances the field of educational game design by reconceptualizing content integration not as a binary between intrinsic and extrinsic forms, but as a flexible continuum.

Our findings show that learning content can be meaningfully integrated into gameplay without enforcing constant, simultaneous interaction (as in intrinsic integration) or resorting to disconnected quiz-based tasks (as in extrinsic integration). Prior work has noted that intrinsic integration may increase cognitive load due to concurrent demands (Habgood & Ainsworth, 2011; Huang et al., 2021; Vandercruysse et al., 2017), while extrinsic integration often reduces motivation because the learning task feels separate from the core gameplay loop (Habgood & Ainsworth, 2011). Our hybrid design approach mitigates both issues by giving players the choice of when to engage with learning mechanics embedded within meaningful gameplay actions.

Our study's findings (RQ1 and RQ2) validate this "mixed" content integration strategy. The embedded learning mechanic not only impacted gameplay but also supported conceptual understanding of programming concepts. This approach holds promise for educational games involving both simple tasks (e.g., arithmetic, vocabulary) and more complex learning objectives, such as debugging or constructing code. Furthermore, this integration model resonates with design practices already seen in commercial games. For instance, titles like Watch Dogs (Ubisoft, 2014, 2016) and Spider-Man (Santa Monica Studio, 2018) feature in-world mechanics that trigger dedicated puzzle-solving interfaces, with outcomes that meaningfully alter gameplay. Our findings suggest that such "triggered learning mechanics" could be intentionally adapted for educational purposes, enhancing both engagement and learning.

These results have implications for both design and research. From a design perspective, learning mechanics that are optional but incentivized allow players to remain immersed while still benefiting from content interaction. From a research perspective, this study highlights the importance of player agency in moderating cognitive load and motivation. Future studies could explore how varying degrees of coupling between gameplay and learning content impact learners with different prior knowledge or learning needs.

Limitations

An ideal way to ascertain the advantages of one integration approach over another would be to compare students' motivational and learning outcomes across educational games that embody the three approaches. In the present study, we limited our scope to investigate students' motivation and learning outcomes across a single, yet, novel content integration strategy. We made this decision, in part, because of the lack of clarity on how to design intrinsic and extrinsic variation. For instance, the learning content can be situated as an end-of-level activity that the players must complete before playing further. While this adheres to the extrinsic learning content integration approach, the nature and function of the destroy enemy game mechanic becomes unclear. Similarly, it is challenging to envision a game design where players destroy the enemy simultaneously solving puzzles. Previous games utilizing intrinsic integration featured simple arithmetic (Habgood & Ainsworth, 2011; Vandercruysse et al., 2017) or vocabulary exercises (Huang et al., 2021) instead of a complex programming task such as constructing a program for a given problem. While this represents a limitation of this work, it is unclear how we can evaluate motivational and learning outcomes of students in game designs that are not similar.

Unlike quantitative studies, low sample size in qualitative studies is not, by in itself, a limitation. Sample sizes for qualitative research are governed by the scope of inquiry, the number of research questions and the data collected (Merriam & Tisdell, 2015). We acknowledge that collecting more qualitative data can undoubtedly highlight additional themes for the two research questions and constitutes a limitation for this study.

Participants in this study were recruited from an undergraduate course, and their ages ranged from 18-24. Evaluating players' motivation and learning outcomes with a more diverse student population (e.g., older participants) can help us better understand the degree to which the results of this study are generalizable. We designed a 2D platformer game for research purposes which featured a unique pair of core game mechanics. However, educational games have a wider variety of game genres with core mechanics different than the mechanics described in this study. As such, the generalizability of our results to other games is not established.

Conclusion

In this paper, we presented a content integration strategy that combined beneficial features of extrinsic and intrinsic learning content integration. We investigated students' learning outcomes and motivation when playing this game (called *Parsons Game*). Results indicate that the students were motivated to engage with the learning activity, increased their knowledge of Java programming language, and had an overall positive player experience. The study has implications for the learning content integration approach and its relevance to educational game design.

Appendix Java Concept Inventory

Options choices in **bold** highlight the correct answer.

Q1: What should be the output of the following code below?

```
public class Test {
    public static void main(String args[]) {
        System.out.println("Hello World")
    }
}
```

- **Compilation Error**
- Hello World
- "Hello World"
- ("Hello World")

Q2: What option choice can be put in place of X to correctly print out the length of string variable `name`?

```
public class Main {
    public static void main(String args[]) {
        String name = "What is my length?";
        System.out.println(name.X);
        //What is the correct option in place of X?

    }
}
```

- **length()**
- length
- size
- size()

Q3: What would be the output of the program below?

```
public class Test {
    public static void main(String args[]) {
        String str = giveMeAString();
        System.out.println(str);
    }
    static void giveMeAString()
    {
        return "Here You Go!";
    }
}
```

- Here You Go!
- "Here You Go!"
- null
- **Compilation Error**

Q4: What option choice can be put in place of X to correctly print out the string variable "str" to the console?

```
public class Test {
    public static void main(String args[]) {
        String str = giveMeAString();
        System.out.println(str);
    }
    //What is the correct option in place of X?
    static X giveMeAString()
    {
        return "Here You Go!";
    }
```

- **String**
- String[]
- char
- char[]

Q5: What would be the output of the program below?

```
public class Test {
    public static void main(String args[]) {
        String newString = "Here You Go!";
        giveMeAString(newString);
    }
    static void giveMeAString()
    {
        System.out.println(str);
    }
}
```

- Here You Go!
- "Here You Go!"
- null
- **Compilation Error**

Q6: What option choice can be put in place of X to correctly print out the string variable `str` to the console?

```
public class Test {
    public static void main(String args[]) {
        String newString = "Here You Go!";
        giveMeAString(newString);
    }
    //What is the correct option in place of X?
    static void giveMeAString(X str)
    {
        System.out.println(str);
    }
}
```

- **String**
- String[]
- char
- char[]

Declarations

Ethics Statement Informed consent was obtained from all the individual participants included in the study.

Research Involving Human Participants and/or Animals This study, which involved human participants, was in accordance with the ethical standards of the institutional research committee.

Financial Interests The authors declare they have no financial interests.

Conflict of Interest There were no conflicts of interest in this research.

References

Abeele, V. V., Spiel, K., Nacke, L., Johnson, D., & Gerling, K. (2020). Development and validation of the player experience inventory: A scale to measure player experiences at the level of functional and psychosocial consequences. *International Journal of Human-Computer Studies, 135*, Article 102370. https://doi.org/10.1016/j.ijhcs.2019.102370

Arnab, S., Lim, T., Carvalho, M. B., Bellotti, F., de Freitas, S., Louchart, S., Suttie, N., Berta, R., & De Gloria, A. (2015). Mapping learning and game mechanics for serious games analysis: Mapping learning and game mechanics. *British Journal of Educational Technology, 46*(2), 391–411. https://doi.org/10.1111/bjet.12113

Bender, J., Zhao, B., Dziena, A., & Kaiser, G. (2022). Learning Computational Thinking Efficiently: How Parsons Programming Puzzles within Scratch Might Help. *Australasian Computing Education Conference, 66–75*,. https://doi.org/10.1145/3511861.3511869

Bodi, B. (2021). *Agency in and around videogames*.

Bosch, C. (2024). Assessing the psychometric properties of the intrinsic motivation inventory in blended learning environments. *Journal of Education and e-Learning Research*, *11*(2), 263-271. https://doi.org/10.20448/jeelr.v11i2.5468

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Caceffo, R., Frank-Bolton, P., Souza, R., & Azevedo, R. (2019). Identifying and validating Java misconceptions toward a CS1 concept inventory, 23-29. https://doi.org/10.1145/3304221.3319771

Chu, K. C. (2004). Gender reactions to games for learning among fifth and eighth graders. *Citeseer*.

Cocca, A., Veulliet, N., Niedermeier, M., Drenowatz, C., Cocca, M., Greier, K., & Ruedl, G. (2022). Psychometric Parameters of the Intrinsic Motivation Inventory Adapted to Physical Education in a Sample of Active Adults from Austria. *Sustainability, 14*(20), 13681. https://doi.org/10.3390/su142013681

Davidson & Associates. (1983). *Math Blaster!*

Denny, P., Luxton-Reilly, A., & Simon, B. (2008). Evaluating a new exam question: Parsons problems. Proceeding of the Fourth International Workshop on Computing Education Research - ICER '08, 113-124. https://doi.org/10.1145/1404520.1404532

Du, Y., Luxton-Reilly, A., & Denny, P. (2020). A Review of Research on Parsons Problems. *Proceedings of the Twenty-Second Australasian Computing Education Conference, 195–202*,. https://doi.org/10.1145/3373165.3373187

Echeverría, A., Barrios, E., Nussbaum, M., Améstica, M., & Leclerc, S. (2012). The atomic intrinsic integration approach: A structured methodology for the design of games for the conceptual understanding of physics. *Computers & Education, 59*(2), 806–816. https://doi.org/10.1016/j.compedu.2012.03.025

Ericson, B. J., Guzdial, M. J., & Morrison, B. B. (2015). Analysis of Interactive Features Designed to Enhance Learning in an Ebook. *Proceedings of the Eleventh Annual International Conference on International Computing Education Research, 169–178*,. https://doi.org/10.1145/2787622.2787731

Garcia, R., Falkner, K., & Vivian, R. (2018). Scaffolding the Design Process using Parsons Problems. Proceedings of the 18th Koli Calling International Conference on Computing Education Research, 1-2. https://doi.org/10.1145/3279720.3279746

Garris, R., Ahlers, R., & Driskell, J. E. (2017). Games, motivation, and learning: A research and practice model. In: Simulation in Aviation Training (pp. 475-501). Routledge.

Graf, L., Altmeyer, M., Emmerich, K., Herrlich, M., Krekhov, A., & Spiel, K. (2022). Development and Validation of a German Version of the Player Experience Inventory (PXI). *Mensch Und Computer, 2022*, 265–275. https://doi.org/10.1145/3543758.3543763

Habgood, M. P. J., Ainsworth, S. E., & Benford, S. (2005). Endogenous fantasy and learning in digital games. *Simulation & Gaming, 36*(4), 483–498. https://doi.org/10.1177/1046878105282276

Habgood, M. P. J., & Ainsworth, S. E. (2011). Motivating Children to Learn Effectively: Exploring the Value of Intrinsic Integration in Educational Games. *Journal of the Learning Sciences, 20*(2), 169–206. https://doi.org/10.1080/10508406.2010.508029

Harms, K. J., Chen, J., & Kelleher, C. L. (2016). Distractors in Parsons Problems Decrease Learning Efficiency for Young Novice Programmers. Proceedings of the 2016 ACM Conference on International Computing Education Research, 241-250. https://doi.org/10.1145/2960310.2960314

Helminen, J., Ihantola, P., Karavirta, V., & Malmi, L. (2012). How do students solve parsons programming problems?: An analysis of interaction traces. Proceedings of the Ninth Annual International Conference on International Computing Education Research - ICER '12, 119. https://doi.org/10.1145/2361276.2361300

Huang, B.-G., Yang, J. C., & Chen, S. Y. (2021). An investigation of the approaches for integrating learning materials and digital games: A prior ability perspective. *Universal Access in the Information Society, 20*(1), 57–68. https://doi.org/10.1007/s10209-020-00710-1

Jagoda, P., & McDonald, P. (2018). Game Mechanics, Experience Design, and Affective Play. In J. Sayers (Ed.), *The Routledge Companion to Media Studies and Digital Humanities* (1st ed., pp. 174-182). Routledge. https://doi.org/10.4324/9781315730479-17

Joshi, A., Mousas, C., Tokey, S. S., & Kao, D. (2025). Exploring player agency in educational video games. *Entertainment Computing, 52*, Article 100754. https://doi.org/10.1016/j.entcom.2024.100754

Kao, D. (2020). The effects of juiciness in an action RPG. *Entertainment Computing, 34*, Article 100359.

Kao, D. (2021). The effects of observation in video games: How remote observation influences player experience, motivation, and behaviour. *Behaviour & Information Technology, 41*, 1905–1927. https://doi.org/10.1080/0144929X.2021.1906321

Kao, D., & Harrell, D. F. (2015). Toward avatar models to enhance performance and engagement in educational games, 246-253.

Kao, D., & Harrell, D. F. (2016). Exploring the Effects of Dynamic Avatar on Performance and Engagement in Educational Games.

Karavirta, V., Helminen, J., & Ihantola, P. (2012). A mobile learning application for parsons problems with automatic feedback. Proceedings of the 12th Koli Calling International Conference on Computing Education Research - Koli Calling '12, 11-18. https://doi.org/10.1145/2401796.2401798

Ke, F. (2016). Designing and integrating purposeful learning in game play: A systematic review. *Educational Technology Research and Development, 64*(2), 219–244. https://doi.org/10.1007/s11423-015-9418-1

Ke, F., Shute, V. J., Clark, K. M., & Erlebacher, G. (2019). Design of Gameplay for Learning, 75-98. https://doi.org/10.1007/978-3-030-04339-1_4

Ku, O., Chen, S. Y., Wu, D. H., Lao, A. C. C., & Chan, T.-W. (2022). The Effects of Game-Based Learning on Mathematical Confidence and Performance: High Ability vs. Low Ability, 15.

Kumar, A. N. (2018). Epplets: A Tool for Solving Parsons Puzzles. Proceedings of the 49th ACM Technical Symposium on Computer Science Education, 527-532. https://doi.org/10.1145/3159450.3159576

Lopez, M., Whalley, J., Robbins, P., & Lister, R. (2008). Relationships between reading, tracing and writing skills in introductory programming. Proceeding of the Fourth International Workshop on Computing Education Research - ICER '08, 101-112. https://doi.org/10.1145/1404520.1404531

Malone, T. W. (1980). What makes things fun to learn? heuristics for designing instructional computer games. Proceedings of the 3rd ACM SIGSMALL Symposium and the First SIGPC Symposium on Small Systems, 162-169. https://doi.org/10.1145/800088.802839

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive science, 5*(4), 333–369.

Mayer, R. E. (2018). Computer Games in Education.

McAuley, E., Duncan, T., & Tammen, V. V. (1989). Psychometric Properties of the Intrinsic Motivation Inventory in a Competitive Sport Setting: A Confirmatory Factor Analysis. *Research Quarterly for Exercise and Sport, 60*(1), 48–58. https://doi.org/10.1080/02701367.1989.10607413

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. Hoboken: John Wiley & Sons.

Natucci, G. C., & Borges, M. A. F. (2021). The Experience, Dynamics and Artifacts Framework: Towards a Holistic Model for Designing Serious and Entertainment Games. *IEEE Conference on Games (CoG), 2021*, 1–8. https://doi.org/10.1109/CoG52621.2021.9619144

Nelson, B., & Kim, Y. (2020). 12 Multimedia Design Principles in Game-Based Learning. Handbook of game-based learning, 307.

Oyelere, S. S., Suhonen, J., & Laine, T. H. (2017). Integrating parson's programming puzzles into a game-based mobile learning application. Proceedings of the 17th Koli Calling International Conference on Computing Education Research, 158-162. https://doi.org/10.1145/3141880.3141882

Parsons, D., & Haden, P. (2006). Parson's programming puzzles: A fun and effective learning tool for first programming courses. Proceedings of the 8th Australasian Conference on Computing Education-Volume 52, 157-163.

Salen, K., Tekinbaş, K. S., & Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. Cambridge: MIT press.

Samuel, R., Bergman, M. M., & Hupka-Brunner, S. (2013). The interplay between educational achievement, occupational success, and well-being. *Social Indicators Research, 111*(1), 75–96.

Santa Monica Studio. (2018). *Spider-Man*.

Talan, T., Doğan, Y., & Batdı, V. (2020). Efficiency of digital and non-digital educational games: A comparative meta-analysis and a meta-thematic analysis. *Journal of Research on Technology in Education, 52*(4), 474–514. https://doi.org/10.1080/15391523.2020.1743798

Taub, M., Sawyer, R., Smith, A., Rowe, J., Azevedo, R., & Lester, J. (2020). The agency effect: The impact of student agency on learning, emotions, and problem-solving behaviors in a game-based learning environment. *Computers & Education, 147*, Article 103781. https://doi.org/10.1016/j.compedu.2019.103781

Theodosiou, S., & Karasavvidis, I. (2015). Serious games design: A mapping of the problems novice game designers experience in designing games. 11 (3).

Tracy, S. J. (2010). Qualitative Quality: Eight "Big-Tent" Criteria for Excellent Qualitative Research. *Qualitative Inquiry, 16*(10), 837–851. https://doi.org/10.1177/1077800410383121

Ubisoft. (2014). Watch Dogs [Ubisoft, Paris, France.].

Ubisoft. (2016). Watch Dogs 2 [Ubisoft, Paris, France.].

Vanden Abeele, V., Nacke, L. E., Mekler, E. D., & Johnson, D. (2016). Design and preliminary validation of the player experience inventory, 335-341.

Vandercruysse, S., ter Vrugte, J., de Jong, T., Wouters, P., van Oostendorp, H., Verschaffel, L., & Elen, J. (2017). Content integration as a factor in math-game effectiveness. *Educational Technology Research and Development, 65*(5), 1345–1368. https://doi.org/10.1007/s11423-017-9530-5

Weinman, N., Fox, A., & Hearst, M. A. (2021). Improving Instruction of Programming Patterns with Faded Parsons Problems. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 1-4. https://doi.org/10.1145/3411764.3445228

Winter, N. (NA). Coding games to learn python and javascript. https://codecombat.com/

Yücel, Y., & Rızvanoğlu, K. (2019). Battling gender stereotypes: A user study of a code-learning game, "Code Combat," with middle school children. *Computers in Human Behavior, 99*, 352–365. https://doi.org/10.1016/j.chb.2019.05.029

Zhonggen, Y. (2019). A meta-analysis of use of serious games in education over a decade. *International Journal of Computer Games Technology, 2019*(1), 4797032.