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Tailoring Gamification in a Science Course to Enhance Intrinsic Motivation in Preservice Primary Teachers

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Abstract: This study examines the intrinsic motivation of preservice primary teachers in a science education course designed with player-type personalization in gamification strategies. Using a mixed-methods approach, a one-group post-test-only design was combined with qualitative analysis. Game elements were personalized based on the HEXAD user typologies, aligning with Self-Determination Theory to support autonomy, competence, and relatedness. Quantitative data from the Intrinsic Motivation Inventory revealed high median scores across these psychological needs, suggesting that customization fostered deeper engagement. Key elements included cooperative challenges, branching narratives, and flexible participation pathways. Qualitative findings reinforced these results, highlighting students' increased sense of agency, social connection, and investment in learning. The structured integration of narrative played a crucial role in contextualizing academic tasks, transforming the learning process into an immersive experience. Overall, the findings indicate that well-designed, personalized gamification strategies effectively bolster preservice teachers' intrinsic motivation in this science education course. By demonstrating how player-type personalization optimizes motivation in gamified teacher education, this study contributes to the growing body of research on tailored gamification.

Keywords: tailored gamification; teacher education; science education; intrinsic motivation; player types; FantasyClass; narrative; self-determination theory

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1. Introduction

In science education, students often face persistent negative attitudes and low levels of motivation, which act as barriers to engagement and effective learning (Krapp & Prenzel, 2011; Masnick et al., 2010). Over time, these challenges deepen, negatively impacting academic performance and diminishing interest in science-related fields (Tytler & Ferguson, 2023). This issue is particularly concerning in primary teacher education programs, where preservice teachers' attitudes and motivation play a critical role in shaping their future teaching practices (Brígido et al., 2009; Sánchez-Martín et al., 2018). If unaddressed, these negative perceptions risk perpetuating cycles of disengagement, as teachers unintentionally transfer their frustrations to their students (Sasway & Kelly, 2020). Given the importance of teacher preparation in influencing broader educational outcomes (Mammadov & Çimen, 2019), it is imperative to develop strategies that improve their attitudes toward science and foster sustainable motivation to learn and teach it effectively.

1.1. Gamification and Motivation

Gamification has emerged as an innovative and widely studied educational strategy, integrating game elements into learning environments to transform students' attitudes

and enhance their motivation (Hamari et al., 2014; Putz et al., 2020). However, its success depends heavily on thoughtful and intentional design. Poorly implemented gamification not only risks disengagement (Hong et al., 2024; Sailer et al., 2017) but can also diminish pre-existing motivation (Tohidi & Jabbari, 2012) by encouraging an over-reliance on extrinsic rewards (Erdogdu & Karatas, 2016). While these rewards may effectively capture attention in the short term, they often lead to superficial engagement, hindering the development of deeper cognitive connections with the subject matter (DeLong & Winter, 2002). Consequently, gamified systems that fail to move beyond external incentives can undermine intrinsic motivation, which is essential for sustained learning and meaningful engagement (Hong et al., 2024; Oliveira & Bittencourt, 2019). These challenges underscore the need for gamification designs that prioritize deeper motivational needs.

Intrinsic motivation, defined as the inherent drive to engage in activities for their own sake, is a cornerstone of meaningful and lasting learning experiences (Ryan & Deci, 2000). Unlike extrinsic motivation, which depends on external rewards or pressures, intrinsic motivation is associated with deeper cognitive engagement and greater persistence (Deci & Ryan, 1985). As established by the Self-Determination Theory (SDT), intrinsic motivation is fostered by satisfying three fundamental psychological needs: autonomy, competence, and relatedness (Deci & Ryan, 1985, 2000). Autonomy involves the experience of volition and alignment with personal values and interests; competence refers to the perception of being capable and effective in achieving meaningful goals; and relatedness involves a sense of connection and belonging with others (Ryan & Deci, 2000).

Building upon this theoretical framework, gamification has the potential to meet these psychological needs by incorporating well-designed game elements. Customizable avatars can promote autonomy by allowing learners to personalize their experience and express their individuality (Zainuddin et al., 2020), challenges and structured feedback mechanisms can support competence by helping learners achieve mastery through meaningful accomplishments (Sailer et al., 2017), and team-based activities can enhance relatedness by stimulating social bonds and collaboration (Klock et al., 2020). However, educators and designers should carefully balance these elements to avoid unintended negative outcomes. For example, while group competition can enhance engagement, it may also create unintended frustrations in lower-performing teams, highlighting the need for designs that balance competition with cooperation (Van Roy & Zaman, 2019). Conversely, when all three needs are supported, cumulative positive effects amplify intrinsic motivation, improving learning outcomes (Rigby & Ryan, 2011). Therefore, gamified designs must adopt a holistic approach, ensuring that autonomy, competence, and relatedness are supported in harmony to sustain and maximize the motivational benefits of gamification.

A key strength of narrative as a gamification element is its ability to simultaneously fulfill all three psychological needs of the SDT. Prior research has highlighted how well-crafted narratives engage learners by creating immersive experiences that support autonomy, competence, and relatedness (Bormann & Greitemeyer, 2015; Xi & Hamari, 2019). Narrative-based gamification provides thematic coherence that integrates learning experiences, fostering deeper engagement (Koivisto & Hamari, 2019; Sailer et al., 2017). Additionally, narratives play a transformative role in science education by contextualizing abstract scientific concepts, making them more relatable to students' personal experiences and professional aspirations (Avraamidou & Osborne, 2009; Prins et al., 2017). This contextualization helps bridge the gap between theoretical scientific concepts and practical applications, enhancing students' perceptions of relevance in science education (Kokkotas et al., 2010). By embedding learning objectives within a cohesive storyline, narratives create structured and meaningful learning contexts, increasing students' investment in the learning process.

1.2. Player-Type Personalization in Gamification

At the same time, ensuring that gamified approaches resonate with all learners requires careful consideration of their individual differences. In educational settings, acknowledging students' unique characteristics is essential, as their experiences and performance can vary significantly depending on how educational systems are designed (L. Zhang et al., 2020). This is particularly relevant in gamified education, where the effectiveness of game elements depends on individual preferences and motivational profiles. For this reason, tailoring gamification to learners' needs has been widely recognized as a key factor in enhancing its motivational impact (Hallifax et al., 2019; Klock et al., 2020). By aligning game elements and tasks with individual needs, personalized gamification supports meaningful and engaging learning experiences that resonate with learners' intrinsic motivations (Lavoué et al., 2018; Monterrat et al., 2017; Oliveira & Bittencourt, 2019; Tondello et al., 2017). The careful selection of game elements not only shapes how students interact with gamification but also determines its overall effectiveness, emphasizing the importance of context-sensitive and adaptable approaches (Nacke & Deterding, 2017). Factors such as age, cultural background, and prior knowledge influence how students engage with gamified environments. Among these, player type has emerged as one of the most influential variables in shaping the impact of gamification, making it a critical factor to consider in game-based instructional design (Rodrigues et al., 2021; Klock et al., 2020).

Player-type taxonomies offer a structured framework for understanding how individuals engage with gamified systems, providing valuable insights into their preferences and behaviors. Bartle's taxonomy (Bartle, 1996), which categorizes players into Achievers, Socializers, Killers, and Explorers, remains a foundational reference in the field. However, its focus on multi-user dungeon games limits its applicability in broader contexts. In contrast, the Gamification User Types HEXAD taxonomy (Marczewski, 2015) was explicitly designed for gamification contexts, offering six distinct user types aligned with the SDT: Philanthropists, Socializers, Free Spirits, Achievers, Players, and Disruptors. The HEXAD model is widely regarded as the most suitable user typology for tailoring gamification to diverse preferences and needs (Hallifax et al., 2019).

However, despite the usefulness of player taxonomies, designing effective gamification requires more than simply assigning players to predefined categories. A key challenge remains in determining how specific game elements align with different user motivations to maximize engagement and learning outcomes. Previous studies have attempted to establish direct connections between individual game mechanics and player types (Klock et al., 2020), but no clear consensus has been reached regarding which elements are most effective for each category of user. Recent research suggests that instead of engaging with isolated game mechanics, players interact with clusters of inter-related game elements that shape their overall experience (Tondello et al., 2016). In their study, Tondello et al. (2016) examined the correlation between HEXAD user types and groups of game elements, not only validating but also refining and expanding upon the associations originally proposed by Marczewski (2015). Their findings led to an improved association model that better aligns user types with game elements based on empirical data, demonstrating that players interact more meaningfully with clusters of game elements rather than individual features. Expanding on this work, Tondello et al. (2017) conducted an exploratory factor analysis to formally classify game elements into broader categories based on user preferences (socialization, assistance, immersion, risk/reward, customization, progression, altruism, and incentive), suggesting that structured sets of game elements are more effective in engaging users than standalone features.

This shift in perspective has been reinforced by the gamification taxonomy proposed by Toda et al. (2019), which systematically classifies twenty-one game elements into five

dimensions: Performance, Social, Ecological, Personal, and Fictional. Unlike Tondello et al. (2017), whose categorization was based on user preference, Toda et al.'s framework also incorporates a sense of accomplishment in the effectiveness of game dimensions, offering a structured framework for designing gamified educational environments. Further advancing this line of research, Santos et al. (2021) explored the relationship between HEXAD user types and these five dimensions, identifying which elements align best with specific player motivations:

- The Performance dimension includes points, progression, levels, stats, and acknowledgement as game elements, all of which provide direct feedback on user progress and achievement. These elements reinforce competence by allowing users to track their improvement and reach measurable goals. Achievers exhibit a strong positive association with this dimension, as it aligns with their intrinsic motivation for mastery and skill development.
- The Social dimension includes social pressure, competition, reputation (social status), and cooperation, fostering interaction and collaboration among users. These elements support relatedness by creating opportunities for teamwork, peer recognition, and competition. Socializers are the most positively associated with this dimension, as their engagement is primarily driven by social interaction. Achievers also respond positively, particularly to competition-based mechanics, which offer external validation of their skills. Disruptors, on the other hand, may engage with Social elements to challenge or reshape the system rather than for direct collaboration.
- The Ecological dimension consists of chance, imposed choice, economy, rarity, and time pressure, which introduce environmental constraints and strategic decision making into gamified systems. These elements are particularly engaging for users who enjoy unpredictability and system-based challenges. Players, whose motivation is closely linked to transactional and reward-based interactions, exhibit the strongest positive association with this dimension.
- The Personal dimension includes sensation, objectives, puzzle (challenge), novelty, and renovation, all of which foster autonomy, creativity, and self-expression. Players, and to a lesser extent Socializers, show a positive association with this dimension.
- The Fictional dimension encompasses narrative and storytelling, which create immersive and thematic experiences that embed users in meaningful contexts. Socializers exhibit the strongest positive association with this dimension, likely because narrative structures enhance engagement by fostering user interaction and emotional investment in the storyline.

According to Santos et al. (2021), Philanthropists did not exhibit a significant association with any gamification dimension. However, their motivation, rooted in purpose and altruism, closely aligns with the SDT need for relatedness. They derive fulfillment from supporting others and contributing to a larger goal, making collaborative and impact-driven activities particularly effective for this group (Krath et al., 2023; Lavoué et al., 2018; Marczewski, 2015). Similarly, Santos et al. (2021) did not find a positive association between Free Spirits and any gamification dimension. Free Spirits prioritize autonomy, aligning strongly with the SDT need for independence and self-expression. They may be attracted to open-ended narratives, customizable avatars, and exploratory tasks, as these elements cater to their intrinsic desire for freedom and creativity (Krath et al., 2023; Marczewski, 2015).

Moreover, effective gamification design must strike a delicate balance between addressing the diverse needs of player types and aligning with overarching educational objectives, as an excessive focus on engagement at the expense of learning outcomes can compromise the educational value of gamification (Lavoué et al., 2018). By incorporating a variety of motivational triggers and ensuring their careful integration within the gamified

system, educators can create environments that satisfy students' psychological needs for autonomy, competence, and relatedness across all dimensions of the SDT (Klock et al., 2020; Marczewski, 2015). Personalized gamification strategies should not only meet these needs but also enhance students' sense of belonging and relevance within the learning process, fostering deeper engagement and promoting meaningful learning outcomes. This dual focus on motivation and educational alignment ensures that gamified systems remain both effective and pedagogically sound, addressing individual learner profiles while contributing to broader educational goals

1.3. Study Aim and Research Question

This study aims to explore the intrinsic motivations of preservice primary teachers in a science education course designed with player-type personalization in gamification strategies. The importance of embedding personalized gamification into teacher education programs cannot be overstated, as research has shown that the methodologies experienced by preservice teachers during their training significantly influence their future teaching practices (Korthagen et al., 2006). By carefully selecting gamification dimensions and appropriate game elements, this research investigates how tailored approaches fulfill psychological needs for autonomy, competence, and relatedness. Specifically, the study seeks to answer the following question: What are the intrinsic motivations of preservice primary teachers in a science education course that has been taught with player-type personalization in gamification strategies? Understanding these motivations will provide valuable insights into the design of more effective gamified learning environments in teacher education, ensuring that gamification not only increases engagement but also aligns with meaningful educational outcomes.

2. Materials and Methods

This research employed a mixed-methods approach, combining quantitative and qualitative data collection and analysis. The quantitative component was framed within a one-group post-test only design. The qualitative component, on the other hand, was designed to triangulate and complement the quantitative findings.

2.1. Participants

The group of participants consisted of 23 students (19 women and 4 men, mean age = 21.0; median = 20) in their fourth year of the bachelor's degree in primary education at the University of Barcelona (Spain), enrolled in the course "Recreational and Everyday Science in the School" (RESC). Therefore, this is a convenience-based group of participants.

The bachelor's degree in primary education is a four-year program (240 ECTS) that provides future educators with comprehensive training in educational methodologies, child development, and curriculum design, qualifying them to teach children aged 6 to 12. Within this program, the RESC course is a 15-week, in-person elective offered in the fourth year. Two years earlier, the students completed a mandatory course on the fundamental methods of teaching physics and chemistry in primary education, which serves as a foundation for RESC. Building upon this foundation, RESC engages students in everyday and recreational applications of physics and chemistry, enriching their teaching repertoire for future classroom use. Additionally, the degree program includes courses dedicated to biology and geology and their didactics, ensuring a well-rounded science education component.

2.2. Procedure

Following the need for structured approaches in tailored gamification design (Oliveira et al., 2023), this study adopted the framework proposed by Marczewski (2015), which

consists of two phases. First, the dominant player types among participants were identified. Then, the selection of game elements was guided by the dimensions proposed by Toda et al. (2019), taking into account the positive associations identified by Santos et al. (2021) between these dimensions and the prevalent player types in terms of preference or perceived sense of accomplishment.

To achieve the first phase, the HEXAD-12 questionnaire (Krath et al., 2023) was administered digitally on the first day of the course through its creator's website (Marczewski, n.d.). The results revealed that Socializers were the most prevalent type (29.3%), followed closely by Philanthropists and Players (both at 24.4%). Achievers accounted for 14.6% of the participants, while Free Spirits represented a smaller subset (7.3%), and Disruptors were entirely absent. These percentages were calculated based on the total number of identified player types rather than on the number of participants, as each participant could be assigned more than one player type in the HEXAD-12 questionnaire.

Based on these results and the theoretical considerations outlined in the Introduction, the Social, Fictional, and Ecological dimensions were prioritized in tailoring the gamified course. Social elements were emphasized due to the predominance of Socializers, Philanthropists, and Achievers. The Fictional dimension was included given its strong association with Socializers. Finally, the Ecological dimension was relevant due to its appeal to Players. Free Spirits, despite being the smallest group, were accounted for by ensuring customization and autonomy-driven mechanics, aligning with their preference for exploration and flexibility (Klock et al., 2020).

To implement the selected game elements throughout the course, we used FantasyClass (https://fantasyclass.app/), a free digital gamification platform designed to integrate game elements into educational settings (Figure 1). FantasyClass engages students in immersive learning through avatars, challenges, rewards, and progression systems while providing instructors with a flexible set of functionalities that can be selectively activated (Jiménez-Valverde et al., 2024). This flexibility allowed the gamified experience to be aligned with the dominant player types identified through the HEXAD-12 questionnaire. Table 1 presents an overview of the selected game elements, categorized according to the game dimensions proposed by Toda et al. (2019), along with the corresponding FantasyClass functionalities that facilitated their implementation.

Table 1. Overview of the selected game elements categorized according to the dimensions proposed by Toda et al. (2019) and the corresponding FantasyClass functionalities that facilitated their implementation.

Dimension	Element	FantasyClass Feature
Social	Cooperation	Teams Roles Battles Collections Cards
	Competition	Leaderboards Cards Skills
Fiction	Narrative	Themes
	Storytelling	Challenges

Table 1. *Cont.*

Dimension	Element	FantasyClass Feature
Ecological	Chance	Events Wheel Cards Skills Cards Collections
	Economy	Shop Collections
	Rarity	Cards Collections

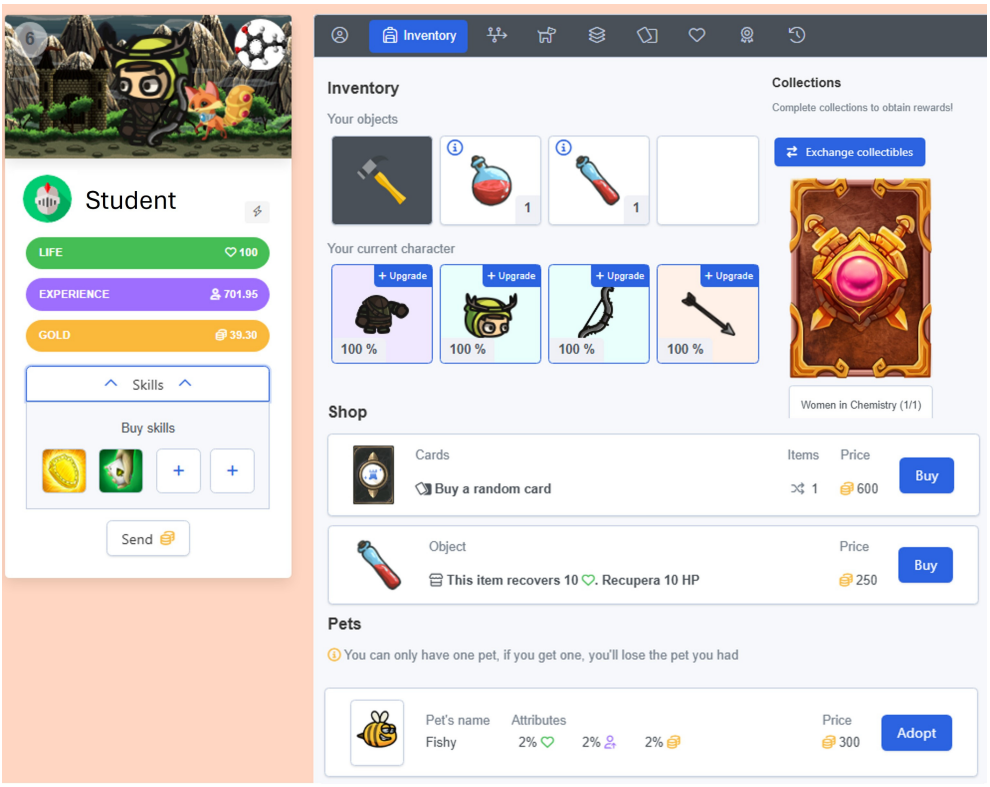

Figure 1. Student interface in FantasyClass. The platform provides a gamified learning environment through various game elements, including avatars, experience points, virtual currency (gold), inventory management, skills, and collectibles. These features allow for a personalized and engaging learning experience. The use of this screenshot has been authorized by the creator of FantasyClass.

The Social dimension was structured around the adoption of both cooperation and competition as fundamental elements. While both elements contribute to motivation, research suggests that cooperation tends to be more effective in educational settings (Ke & Grabowski, 2007). For this reason, cooperation was a core principle of the gamified course design, ensuring that students engaged in structured, collaborative interactions within six stable teams of three to four students. Each team had designated roles—such as coordinator, secretary, supervisor, and spokesperson—managed through FantasyClass to facilitate teamwork. Roles were assigned through internal team agreements based on members' preferences and perceived strengths. Most course challenges were team-based cooperative tasks, where the students worked together to solve problems, complete missions, and advance in the gamified narrative. Additionally, FantasyClass's battles, a form of quiz-based competition, were implemented as collective challenges in which all students

collaborated to defeat a common adversary by correctly answering questions posed by the instructor. The game's card system further reinforced cooperation by allowing the students to assist their teammates during battles in exchange for in-game rewards.

Although the gamified environment primarily emphasized collaboration, certain elements were strategically introduced to incorporate a balanced degree of competition. Leaderboards ranked the students based on their accumulated experience points, providing a constant benchmark that encouraged self-improvement while allowing them to compare their progress with peers. Additionally, certain cards and skills in FantasyClass introduced competitive interactions, enabling players to penalize rivals, such as secretly deducting gold coins. Competition was also integrated into specific challenges, where teams occasionally competed to achieve the highest performance in a given task. Research suggests that when collaboration and competition are thoughtfully combined, they can enhance motivation and engagement (Buckley & Doyle, 2017). Moreover, well-designed competitive elements can provide positive learning experiences by fostering metacognitive skills, strengthening teamwork, and even reducing negative attitudes toward competitiveness (Glover, 2013; Licorish et al., 2018). In this study, competitive moments were carefully structured and limited in scope to prevent potential demotivation, ensuring that competition remained a motivating factor rather than a source of frustration.

The Fictional dimension was integrated into the gamified design through two key elements in this course: narrative and storytelling. Previous research has emphasized the importance of a coherent narrative in increasing engagement (Iacono et al., 2020), underscoring the need for a well-structured storyline to sustain student interest throughout the gamified learning process. Therefore, the decision to incorporate narrative as a core element had to be made in advance, as crafting an immersive and cohesive storyline and embedding it into all course activities requires extensive development time. Beyond the previously discussed benefits of implementing a narrative in science courses, a preliminary trial of a narrative-driven gamification strategy was conducted in a single course module during the previous academic year, where students engaged in story-based challenges embedded within a limited portion of the curriculum (Heras-Paniagua et al., 2022). The results were highly positive, with the students rating the narrative 4.65 out of 5 in terms of perceived motivation, reinforcing its potential as an effective motivational tool. Given the complexity and time-intensive nature of narrative design in this study, the development process began months before the HEXAD-12 questionnaire was administered, ensuring that the storyline was carefully constructed while still allowing for subsequent refinements based on the player types identified through the HEXAD-12 results.

The chosen medieval-themed narrative was structured around four kingdoms, each corresponding to a thematic block of the RESC course curriculum. The Kingdom of Science, ruled by Clarissa of Curiosity, introduced fundamental aspects of the Nature of Science. The Kingdom of Chemistry, led by Elixia of Essence, engaged the students in hands-on activities on acids and bases, polymers, chromatography, and soap making. The Kingdom of Energy, under Beric the Brilliant, explored light, sound, heat, magnetism, and electricity. And for the Kingdom of Challenges, ruled by the antagonist Morgana the Schemer, the overarching conflict of the narrative revolved around Morgana's invasion, which plunged the four kingdoms into chaos, disrupting the balance of scientific knowledge. To restore order, the students embarked on an epic journey across the four kingdoms, where they had to collaborate, investigate, and overcome challenges. The story followed a three-act structure inspired by Campbell's (1968) hero's journey, culminating in a final challenge at Morgana's castle. There, the students had to present a final project, and if successful, they would defeat Morgana and restore peace to the kingdoms. FantasyClass facilitated the integration of this narrative-driven gamification, offering customizable themes, avatars,

audiovisual elements, and role-based interactions, ensuring seamless alignment between game elements and pedagogical content while enhancing engagement and immersion.

Storytelling played a pivotal role in enhancing narrative immersion, ensuring that the gamified experience extended beyond thematic elements to influence the structure and delivery of course activities. The narrative was introduced through a cinematic video on the first day of class (www.youtube.com/watch?v=QVUiM_H6PXQ, accessed on 14 January 2025), setting the stage for the students' journey and establishing the central conflict against Morgana the Schemer. Throughout the course, the instructor took on an active storytelling role, creating and presenting video messages in character, where he—appropriately characterized through digital filters—acted as the narrator and guide, unveiling each challenge and reinforcing the story's progression (Figure 2). Furthermore, all classroom activities were systematically adapted to align with the storyline, ensuring that academic tasks were seamlessly integrated into the narrative framework.

Figure 2. Screenshot from one of the videos in which the instructor (narrator) presents the challenge of the day (www.youtube.com/watch?v=eICq_fOLZ0U, accessed on 14 January 2025).

The Ecological dimension in FantasyClass was implemented through chance, economy, and rarity elements, each fostering unpredictability, resource management, and engagement. Chance introduced dynamic and unexpected outcomes through random events triggered daily by the instructor, which could benefit or challenge students, and the virtual wheel, which randomly awarded gold coins to students. The economy element was embedded in the virtual store, where the students strategically spent their gold coins on cards (with random rewards), avatar upgrades, and collectible packs, encouraging thoughtful resource allocation to influence their progression. Rarity, on the other hand, was particularly evident in both cards and collectibles, with adjustable drop rates set by the instructor. Unlike cards, which had immediate gameplay effects, collectibles reinforced course content through thematic collections (e.g., female scientists, polymers, types of radiation, etc.). Completing a collection granted students in-game rewards, further incentivizing participation. Additionally, the students could freely trade collectibles, fostering collaboration beyond their assigned teams and promoting social interaction within the gamified learning environment.

In addition to the key game elements associated with the Social, Fictional, and Ecological dimensions, the gamified design incorporated experience points (XPs) and levels as integral academic tools for continuous assessment. These elements were not introduced

merely as motivational features but were explicitly designed to provide a structured and transparent system for evaluating student progress. All activities throughout the course awarded XPs based on their relevance and the performance demonstrated by students, ensuring that academic achievement and engagement were consistently monitored. As students accumulated XPs, they progressed through levels, with their final level contributing to a portion of their overall course grade. Given that XPs and levels belong to the Performance dimension, their inclusion also naturally aligned with the motivations of Achievers. Additionally, elements of customization and choice were embedded in the gamified system. FantasyClass allowed the students to customize their avatars, while the narrative featured branching paths, enabling them to make meaningful decisions that shaped their journey. Research suggests that narrative engagement is strongest when player choices actively shape the unfolding story rather than merely advancing a pre-written plot (Dickey, 2015). This emphasis on choice extended beyond the narrative, as some laboratory sessions also provided flexibility in designing experimental procedures, fostering an open-ended approach to scientific inquiry. While these elements were not specifically implemented to cater to any particular player type, they naturally aligned with the preferences of Free Spirits, the smallest subset of students, who value autonomy and exploration.

2.3. Instrument

To investigate the impact of the gamified RESC course on intrinsic motivation among preservice primary teachers, the Intrinsic Motivation Inventory (IMI) was utilized (Self-Determination Theory, n.d.). The IMI is a post-test measurement questionnaire designed to assess participants' subjective experiences related to specific target activities (Ryan, 1982; Ryan et al., 1983). It has been widely validated and employed in studies exploring intrinsic motivation (Deci et al., 1994; Ryan et al., 1990). The questionnaire is structured into subscales that measure distinct dimensions of motivation and psychological experience.

The IMI includes a 7-point Likert-type scale, ranging from 1 = not at all true to 7 = very true, with a midpoint of 4 = somewhat true. Participants rate their agreement with various statements designed to assess their experiences during a specific activity. While the IMI consists of seven subscales, only four subscales were selected for this study due to their alignment with the research objectives and the context of the gamified RESC course: enjoyment, perceived competence, perceived choice, and relatedness. The enjoyment subscale was included as the primary measure of intrinsic motivation, given its direct alignment with the emotional and affective engagement promoted by gamification. Perceived competence, perceived choice, and relatedness were chosen since they represent the three psychological needs associated with SDT: competence, autonomy, and relatedness, respectively.

The questionnaire was administered digitally at the end of the course, and the wording of the items was adapted to refer specifically to the experience of the gamified RESC course. For example, the original item "I enjoyed doing this activity very much" was adapted to "I enjoyed taking this course very much" to ensure contextual relevance without compromising the instrument's reliability or validity. Past research suggests that such modifications are acceptable and do not adversely affect the psychometric properties of the instrument (Deci et al., 1994). The internal consistency of the complete questionnaire was strong, with a Cronbach's alpha of 0.825, indicating good reliability across all items. The internal consistency of each subscale was similarly robust: enjoyment: 0.875, perceived competence: 0.823, perceived choice: 0.868, and relatedness: 0.832.

Given that the IMI is specifically designed to capture participants' subjective experiences during or immediately after an activity, it was applied only as a post-test instrument following established research practices (Mekler et al., 2017; Sailer et al., 2017). Because its items assess intrinsic motivation in relation to a concrete learning experience, administering the IMI before the course began or at the start would not have provided meaningful baseline data (Ryan & Deci, 2000).

Additionally, an open-ended question was included: "How has the gamification of this course motivated you?" This qualitative component allowed participants to elaborate on their experiences, providing deeper insights into the specific aspects of gamification that influenced their motivation.

2.4. Data Analysis

IBM SPSS Statistics v.27 software was used for quantitative data analysis. Initially, the normality of the data distribution was assessed using the Shapiro–Wilk test, which indicated that the data did not follow a normal distribution ($p < 0.05$). Consequently, non-parametric statistics were used. The quantitative results were analyzed by reporting the median values and interquartile range (IQR) for each item within the four subscales analyzed from the IMI. The median values were reported as whole numbers, reflecting their direct alignment with the ordinal nature of the Likert-type response scale. The IQR values appear as whole numbers or with a single decimal place (0.5) when the computed quartile values fall between two adjacent response options as a consequence of averaging these values. Negatively worded items were analyzed individually in their original form to preserve their distinct phrasing and ensure accurate interpretation. To facilitate a comprehensive assessment, an adjusted global median score for each subscale was calculated by inverting the Likert scale values for negatively worded items (e.g., a response of 1 was converted to 7, 2 to 6, etc.) to ensure that all responses aligned in the same direction regarding motivation. After reversing these items, the median was computed across all items within each subscale, providing a single representative value for each motivational dimension. Additionally, the IQR across all items in each subscale was computed to assess response variability, providing insight into the consistency of student perceptions. This analytical approach allowed for both a granular understanding of specific items and a broader perspective on each subscale's overall trends.

Qualitative analysis was conducted through a content analysis (Krippendorff, 2019) with ATLAS.ti v.23 software. This analysis began with an initial familiarization phase, during which responses were reviewed multiple times to develop a comprehensive understanding of the data. Next, the responses were segmented into meaningful units and assigned preliminary codes, which were iteratively refined through multiple coding cycles. Emerging themes were identified based on recurring patterns and conceptual similarities, with codes being merged, split, or reorganized as necessary to ensure a coherent and representative categorization of the data. Following Krippendorff's (2019) approach to content analysis, categories were systematically derived from the data, and their frequencies were quantified to identify the most prominent themes. Since the responses were categorized into multiple themes when applicable, the total percentages reflect the distribution of themes rather than the number of participants.

3. Results

3.1. Quantitative Results

The findings indicate that the gamified RESC course was highly effective in fostering intrinsic motivation among participants, as reflected in the consistently high scores across the four subscales analyzed from the IMI. While all subscales yielded favorable results,

variations in the response patterns highlight individual differences in how students experienced competence, autonomy, and relatedness within the gamified environment. The following sections provide a detailed analysis of each subscale, starting with enjoyment, which received the highest overall endorsement.

The results from the enjoyment subscale (Table 2) strongly indicate that the gamified course elicited high levels of positive emotional engagement and satisfaction among participants, with positively worded items consistently achieving the maximum median score (7) and minimal dispersion, demonstrating widespread agreement on the course's enjoyable nature. The adjusted global median for the enjoyment subscale was also 7 (IQR = 0), reflecting a near-universal consensus that the course was engaging and pleasurable. Specifically, students overwhelmingly rated the course as enjoyable (Item 1: median = 7; IQR = 0) and fun (Item 2: median = 7; IQR = 0.5), with similar trends observed for their descriptions of the course as interesting (Item 5: median = 7; IQR = 0.5) and enjoyable overall (Item 6: median = 7; IQR = 0), reinforcing the effectiveness of the gamification design in fostering a positive learning experience. The minimal interquartile ranges suggest that virtually all participants reported similar levels of enjoyment, with no significant outliers or variations in engagement. A slightly wider distribution of responses was observed in Item 7 (median = 7; IQR = 1), which asked whether students consciously reflected on their enjoyment during the course, indicating that while perceptions remained highly positive, individual differences in self-awareness may have influenced how actively students recognized their engagement in real time. Conversely, negatively worded items were strongly rejected, with the lowest possible median values (1) and minimal dispersion (IQR = 0) for statements suggesting that the course was boring (Item 3) or failed to capture students' attention (Item 4). The complete lack of variability in these responses suggests that disengagement was virtually nonexistent among participants, further supporting the claim that gamification effectively enhanced emotional involvement.

Table 2. Enjoyment subscale.

Item Number and Statement	Mdn	IQR
1—I enjoyed taking this course very much.	7	0
2—This course was fun.	7	0.5
3*—I thought this was a boring course.	1	0
4*—The classes in this course did not hold my attention at all.	1	0
5—I would describe this course as very interesting.	7	0.5
6—I thought this course was quite enjoyable.	7	0
7—During the classes, I thought about how much I was enjoying the course.	7	1
Enjoyment adjusted global median	7	0

Note: Mdn: median; IQR: interquartile range. * = negatively worded.

The results from the perceived competence subscale (Table 3) indicate that the students generally felt capable and confident in their performance within the gamified course, although the responses exhibited slightly greater variability compared to enjoyment, suggesting individual differences in perceived effectiveness. The adjusted global median for this subscale was 6 (IQR = 1), reflecting a strong but somewhat diverse perception of competence among the participants. While the students rated their overall competence positively, median scores of 5 for self-assessments of their abilities (Item 8: IQR = 1.5) and their performance relative to peers (Item 9: IQR = 2) suggest that although many students felt confident, others experienced some uncertainty when comparing themselves to their classmates, likely influenced by differences in prior knowledge, learning styles, or familiar-

ity with gamification. A stronger sense of competence emerged in items related to direct experience with course activities, as students reported feeling competent after working on gamified challenges (Item 10: median = 6; IQR = 1), satisfied with their performance (Item 11: median = 6; IQR = 0.5), and skilled in the course (Item 12: median = 6; IQR = 1.5), indicating that the structured progression and feedback mechanisms embedded in the gamification framework played a key role in reinforcing students' academic self-perceptions. Similarly, negatively worded items reflected these trends, with students rejecting statements suggesting they could not perform well in the course (Item 13: median = 2; IQR = 1.5), although the slightly wider variability in this response suggests that a small subset of students may have struggled with self-efficacy, potentially due to pre-existing anxiety about science-related subjects or uncertainty regarding the gamified format. Overall, the findings demonstrate that the course provided a supportive environment in which most students felt competent and capable in their academic endeavors.

Table 3. Perceived competence subscale.

Item Number and Statement	Mdn	IQR
8—I think I am pretty good at this course.	5	1.5
9—I think I did pretty well at this course, compared to other students.	5	2
10—After working on the activities in this course for a while, I felt pretty competent.	6	1
11—I am satisfied with my performance at this course.	6	0.5
12—I was pretty skilled at this course.	6	1.5
13*—This was a course that I couldn't do very well.	2	1.5
Perceived competence adjusted global median	6	1

Note: Mdn: median; IQR: interquartile range. * = negatively worded.

The results from the perceived choice subscale (Table 4) highlight the strong sense of autonomy that the students experienced throughout the gamified course, with an adjusted global median of 6 (IQR = 1), indicating that they felt they had meaningful opportunities to direct their own learning. This was particularly evident in students' appreciation of their ability to make choices regarding participation (Item 14: median = 6; IQR = 1) and their endorsement of completing activities out of personal interest rather than obligation (Item 19: median = 6; IQR = 0.5), suggesting that the course design effectively fostered voluntary engagement. Negatively worded items further reinforced this conclusion, as the students overwhelmingly rejected the notion that they had no choice in how to complete tasks (Item 15: median = 1; IQR = 1) or participate (Item 16: median = 1; IQR = 0), with near-complete consensus indicating that they did not perceive the gamified structure as restrictive or coercive. However, slightly greater variability was observed in Items 17 and 18, which assessed whether the students felt constrained by specific requirements (Item 17: median = 2; IQR = 1) or completed activities due to obligation rather than personal choice (Item 18: median = 2; IQR = 1), suggesting that while most students felt autonomous, a subset may have perceived certain game mechanics—such as structured progression or required tasks—as imposing some limitations. Overall, these findings indicate that the course successfully balanced structure and flexibility, allowing the students to feel in control of their learning experience while still providing the necessary scaffolding to guide their progress.

Table 4. Perceived choice subscale.

Item Number and Statement	Mdn	IQR
14—I believe I had some choice in how I participated in this course.	6	1
15*—I felt like I had no choice in how to complete the tasks in this course.	1	1
16*—I didn't really have a choice about how to participate in this course.	1	0
17*—I felt like I had to complete the activities in a very specific way.	2	1
18*—I did the activities in this course because I had no choice.	2	1
19—I did the activities in this course because I wanted to.	6	0.5
20*—I did the activities in this course because I had to.	2	1
Perceived choice adjusted global median	6	1

Note: Mdn: median; IQR: interquartile range. * = negatively worded.

The results from the relatedness subscale (Table 5) highlight the course's effectiveness in fostering a strong sense of connection and trust among students, with an adjusted global median of 6 (IQR = 2), indicating that most participants felt socially integrated within the learning environment. The students reported meaningful interpersonal relationships, as reflected in the high median score for feeling close to their classmates (Item 28: median = 6; IQR = 2), although the variability suggests differences in the extent to which students experienced social cohesion. Similarly, the students expressed a strong desire for more opportunities to interact with peers (Item 24: median = 6; IQR = 2), reinforcing the generally positive reception of the cooperative structure while hinting that some participants may have wished for even greater engagement. Trust also emerged as a key factor, with students indicating confidence in their classmates' reliability (Item 23: median = 5; IQR = 2.5), although the wider interquartile range suggests that a subset of students experienced less certainty in their collaborative interactions. Negatively worded items further confirmed the overall sense of relatedness, as the students overwhelmingly rejected statements suggesting social disconnection, with low median scores for feeling distant from their classmates (Item 21: median = 2; IQR = 1.5) and an even stronger rejection of preferring not to interact with them in the future (Item 25: median = 1; IQR = 0), indicating near-universal agreement on the value of peer relationships beyond the course. Compared to other subscales, relatedness exhibited slightly greater variability, reflecting individual differences in the students' social experiences and interactions. While the majority reported strong peer connections, the broader IQR in some items suggests that a subset of students may not have felt as socially embedded.

Table 5. Relatedness subscale.

Item Number and Statement	Mdn	IQR
21*—I felt really distant from my classmates.	2	1.5
22*—I really doubt that my classmates and I could ever become friends.	2	1.5
23—I felt like I could really trust my classmates.	5	2.5
24—I'd like more opportunities to interact with my classmates.	6	2
25*—I'd really prefer not to interact with my classmates in the future.	1	0
26*—I don't feel like I could really trust my classmates.	1	1
27—It is likely that my classmates and I could become friends if we interacted more.	6	2
28—I feel close to my classmates.	6	2
Relatedness subscale adjusted global	6	2

Note: Mdn: median; IQR: interquartile range. * = negatively worded.

3.2. Qualitative Results

The students' responses highlighted how the gamified course significantly influenced their learning experience, fostering motivation, engagement, collaboration, enjoyment, and autonomy. While most comments emphasized the positive effects of this approach, a few participants also pointed out challenges, providing a balanced view of the impact of gamification and narrative on their educational journey.

The most prominent theme was the significant boost in motivation that students experienced due to the integration of FantasyClass. Many comments (29.1% of the total responses) described how the platform inspired students to actively engage with the course, emphasizing its positive impact on their overall commitment. One student shared, "FantasyClass motivated me a lot; I got involved in all the course activities". Another added, "It has been a very powerful motivation for the subject". The gamified mechanics not only sustained students' interest but also created a structure that encouraged them to stay focused and participate regularly. For some, the platform became a central part of their academic routine, as one student explained, "It motivated me to the point where I set alarms and schedules just for FantasyClass". These comments highlight the platform's success in creating a learning environment that was both engaging and intrinsically motivating.

FantasyClass also played a critical role in fostering social interaction and building relationships among classmates. Students frequently mentioned this aspect (21.8% of the total responses), noting how the platform encouraged collaboration and strengthened their sense of community. One comment stated, "FantasyClass allowed me to interact and connect more with my classmates, which made the experience truly enjoyable". Another explained, "It made me feel part of a team, and together we worked to overcome shared challenges". By integrating cooperative tasks and team-based elements into the course, FantasyClass not only enhanced peer relationships but also created a supportive and inclusive learning atmosphere that motivated students to stay engaged.

The narrative component of the platform emerged as another significant theme (18.2% of the total responses). The students consistently praised the storyline and its ability to immerse them in a dynamic and interactive learning experience. One participant remarked, "The narrative made it feel like we were living in another world, which made the process dynamic and fun". Another noted, "The characters and their involvement in the narrative made the experience feel more real and connected". This narrative immersion not only maintained students' interest but also encouraged them to invest effort in the course activities, as one student reflected, "The challenges within the narrative motivated me to give my best in all the sessions".

FantasyClass was also widely praised for enhancing students' enjoyment of the learning process (14.5% of the total responses). Several comments described it as a fun and engaging way to approach the course. One participant stated, "This was the part of the course that motivated me the most and made me truly enjoy it". Another added, "It made the classes more dynamic and enjoyable, which completely changed how I view education". By blending playful elements with academic content, FantasyClass transformed the learning experience into something exciting and enjoyable, alleviating the stress often associated with traditional coursework.

The platform also empowered students by promoting autonomy and self-directed learning (10.9% of the total responses). The participants valued the flexibility to use FantasyClass in ways that suited their preferences, enabling them to take control of their learning. One student explained, "Having the freedom to use the platform however I wanted made me feel like the protagonist of my learning". Another emphasized the sense of agency provided by the challenges, noting, "The flexibility in the tasks made the

experience feel personal and meaningful". This autonomy reinforced students' intrinsic motivation, making the course feel more tailored to their needs.

Lastly, a small proportion of comments (5.5%) expressed critiques related to the platform's time demands and perceived inequities. One participant commented, "I felt it wasn't fair for students who couldn't dedicate as much time outside of class". Another noted, "It rewards those who are always connected more than those who can't engage as frequently due to other responsibilities". These comments underscore the importance of balancing gamification elements with the diverse circumstances of students to ensure equity in participation.

4. Discussion

The findings of this study highlight the effectiveness of a carefully designed gamified approach in teacher education, particularly when personalized based on students' player types. The high median scores in enjoyment, perceived competence, autonomy, and relatedness suggest that the course successfully addressed the core psychological needs outlined by the SDT (Deci & Ryan, 1985, 2000), leading to a consistent motivational boost throughout the intervention. These results align with previous research demonstrating that gamification, when grounded in psychological principles, enhances intrinsic motivation, engagement, and learning outcomes (Subbash & Cudney, 2018). Notably, the integration of player-type personalization further strengthened engagement by aligning game mechanics with students' intrinsic motivational drives (Hallifax et al., 2019; Klock et al., 2020; Oliveira & Bittencourt, 2019). Prior research comparing generic versus tailored gamification supports this finding, indicating that adaptive game elements are more effective in sustaining motivation than one-size-fits-all approaches (Hamari et al., 2014; Seaborn & Fels, 2015).

The results from the enjoyment subscale revealed that the students found the gamified course highly engaging and emotionally rewarding. The combination of an immersive narrative, interactive group-based challenges, and structured engagement strategies contributed to this outcome. These findings support prior research indicating that game elements, when meaningfully integrated, foster sustained interest rather than transient entertainment (Koivisto & Hamari, 2019). The use of player-type-informed mechanics prevented superficial engagement or reliance on extrinsic incentives, a common pitfall in gamification design (Pink, 2018). In contrast with ineffective implementations where game elements function as mere add-ons—often referred to as "chocolate-covered broccoli" (Laurel, 2001)—this study highlights how a structured and context-sensitive approach can reinforce both enjoyment and educational value.

The broader debate regarding the role of fun in education is also relevant in interpreting these findings. While some researchers argue that enjoyment directly enhances learning by fostering engagement and reducing anxiety (Tews et al., 2017), others caution that gamification can sometimes lead to superficial entertainment without significant gains in learning outcomes (Belova & Zowada, 2020). In this study, however, the consistently strong results across all IMI subscales—enjoyment, competence, autonomy, and relatedness—suggest that the emotional engagement generated by gamification was not merely surface-level enjoyment but was deeply integrated into broader motivational processes. Given that competence, autonomy, and relatedness directly correspond to the basic psychological needs outlined by the SDT, their high ratings indicate that the gamified course promoted a form of engagement that extended beyond momentary enjoyment, supporting sustained intrinsic motivation.

Beyond enjoyment, which reflects the immediate affective response to the gamified experience, competence plays a crucial role in sustaining long-term engagement and self-efficacy (Bandura, 1997; Deci & Ryan, 1985). The findings from the perceived competence

subscale indicate that students felt confident in their abilities and satisfied with their achievements. Intra-group and inter-group challenges, immediate feedback, and progression mechanics ensured that students could track their improvement and develop a sense of accomplishment, supporting the notion that competence reinforcement is key to maintaining engagement in gamified environments (Hanus & Fox, 2015). These results align with prior studies emphasizing that structured feedback and mastery-based progression reinforce perceptions of competence (Sailer et al., 2017). These findings also have implications for teacher education, as prior research suggests that early perceptions of competence in science-related tasks influence preservice teachers' confidence and future instructional approaches (Klassen & Durksen, 2014).

While competence is essential for reinforcing confidence in one's abilities, autonomy ensures that learners feel in control of their educational journey, further strengthening intrinsic motivation (Deci & Ryan, 1985). The findings from the perceived choice subscale indicate that students experienced a strong sense of autonomy and decision-making freedom, aligning with SDT, which posits that autonomy-supportive environments enhance intrinsic motivation (Ryan & Deci, 2000). Importantly, students' ability to make meaningful choices within a structured narrative reinforced their engagement, confirming prior research that highlights the motivational benefits of autonomy-supportive mechanics, such as avatar customization and open-ended tasks (Zainuddin et al., 2020). Moreover, granting learners control over aspects of the game design—such as modifying visual elements—has been shown to enhance enjoyment by increasing perceived autonomy and intrinsic value (Peng et al., 2012). This aligns with our findings, as the ability to customize avatars and make narrative-driven choices contributed to students' motivation and engagement.

The findings from the relatedness subscale highlight the crucial role of collaboration and social interaction in fostering engagement within gamified learning environments. The high median score suggests that the cooperative mechanics embedded in the course successfully promoted teamwork and peer support, reinforcing prior research indicating that team-based game mechanics enhance social cohesion and motivation, particularly when they encourage positive interdependence and shared achievements (Kabat et al., 2023). In this study, structured group tasks, cooperative challenges, and shared decision-making moments played a pivotal role in creating meaningful peer relationships, cultivating a sense of belonging and community within the gamified setting (Koivisto & Hamari, 2019). The qualitative responses further support this interpretation, as many students emphasized how collaboration with peers increased their motivation and engagement. At the same time, competitive mechanics were intentionally limited to avoid excessive pressure while still providing moments of challenge and rivalry to stimulate engagement. This balanced approach ensured that competition complemented rather than undermined cooperation, aligning with research suggesting that a thoughtful integration of collaborative and competitive elements can optimize motivation (Buckley & Doyle, 2017; Morschheuser et al., 2017). By prioritizing teamwork over direct competition, the course established a supportive learning environment where students could engage in shared problem solving without feeling discouraged by excessive rivalry, ultimately strengthening their sense of relatedness and social engagement.

Beyond the dimensions assessed by the IMI, qualitative responses further emphasized the significant role of narrative immersion in sustaining engagement and motivation. The students consistently highlighted how the medieval-themed storyline contextualized their progress, making their academic journey more engaging and immersive. These findings align with previous research indicating that narrative-based gamification enhances emotional engagement by creating a cohesive and meaningful learning experience (Soares et al., 2023). The structured integration of storytelling elements allowed students to perceive their

learning journey as an unfolding adventure, reinforcing motivation through goal-directed engagement (Koivisto & Hamari, 2019). Similarly, Guimerà-Ballesta et al. (2024) found that embedding a structured and immersive narrative into a gamified science course for preservice early childhood teachers significantly enhanced their engagement and attitudes toward science, particularly by reinforcing the sense of purpose in learning activities. In this study, the narrative was not merely decorative but was fully embedded into all course activities, ensuring that learning objectives were seamlessly incorporated within the story. This approach likely contributed to the students' sustained motivation, as they perceived their academic progress as an integral part of the unfolding narrative, rather than as a series of disconnected tasks. This supports prior research suggesting that well-crafted narratives provide meaningful learning contexts, increase student investment, and enhance intrinsic motivation (Koivisto & Hamari, 2019).

In addition to fostering engagement, the narrative framework contributed to a sense of shared purpose and collaboration among students, further reinforcing relatedness as a key motivational factor. The findings indicate that the students experienced a strong connection between the storyline and the scientific concepts explored in the course, supporting the idea that narratives are most effective when they align with the knowledge or skills being taught (Ke, 2016). Additionally, the structured integration of narrative with gamification mechanics ensured that the students' decisions had real consequences in their learning experience, reinforcing goal-oriented motivation (Sailer et al., 2017). The qualitative data also suggest that embedding scientific content within a cohesive, immersive storyline helped the students situate their learning within meaningful, contextually relevant scenarios. This is particularly relevant for preservice primary teachers, who often struggle to connect abstract scientific concepts with practical applications (Avraamidou & Osborne, 2009; Prins et al., 2017). By linking scientific knowledge to a rich, immersive narrative, the gamified approach not only enhanced engagement but also provided a structured framework that facilitated deeper conceptual understanding.

Additionally, the role of digital gamification platforms in supporting engagement and motivation was evident in this study. The participants noted that FantasyClass provided a structured yet flexible system for tracking their progress, interacting with their peers, and engaging in gamified tasks, reinforcing prior research on the importance of user-friendly digital platforms in sustaining engagement (Loos & Crosby, 2017). The presence of progress-tracking mechanisms (e.g., experience points and levels) likely contributed to students' perceived competence, as they received clear feedback on their progress and achievements (Hanus & Fox, 2015). At the same time, customizable avatars and narrative-driven choices reinforced perceptions of autonomy, further supporting evidence that allowing personalization within gamified learning environments enhances intrinsic motivation (Dichev & Dicheva, 2017). These findings align with meta-analytic research by Q. Zhang et al. (2021), who found that Classcraft, a digital gamification platform similar to FantasyClass, enhances motivation by optimizing gamified learning experiences across various educational contexts. In this study, FantasyClass was carefully adapted to the needs of preservice teachers by selecting functionalities aligned with the most prevalent player types (Table 1) while omitting elements that, in previous studies, have shown limited motivational impact in this population, such as badges (Heras-Paniagua et al., 2023). This is consistent with broader research indicating that badges do not significantly enhance motivation in educational gamification settings (Law et al., 2024). These results emphasize the importance of tailoring gamified platforms not only by incorporating motivational features but also by making informed decisions about which elements to prioritize or exclude to optimize engagement in specific learning contexts.

Limitations and Future Directions

While this study provides valuable insights into the impact of personalized gamification on preservice teachers' intrinsic motivation, several limitations must be acknowledged. First, the study relied on self-reported data from the IMI, which, although widely validated, is inherently subject to social desirability bias and individual differences in self-perception. A mixed-methods approach incorporating additional behavioral or observational data could provide a more nuanced understanding of students' engagement. Second, the sample exhibited a significant gender imbalance (4 male vs. 19 female participants), limiting the ability to draw meaningful conclusions about potential gender-related differences in motivational responses to gamification. Third, a key limitation arises from the early decision to embed a comprehensive medieval-themed narrative. Although preliminary data (4.65/5 perceived motivation) strongly supported this choice, it restricted our capacity to modify core story elements once the course began. Consequently, changes were largely confined to adjusting mechanics (challenges, progression, and rewards) rather than shifting the fundamental narrative. Moreover, while the personalization of game elements was informed by the HEXAD framework, individual variations in player types may not have been fully captured, potentially leading to differences in engagement that were not accounted for in the analysis. Lastly, the study was conducted within a single preservice teacher education program, limiting the generalizability of the findings to other academic contexts, disciplines, or student populations. Future studies should aim to replicate these results across diverse educational settings to strengthen the external validity of the findings.

Building on the findings of this study, future research should explore the long-term effects of gamified and narrative-driven learning on preservice teachers' motivation and pedagogical approaches. Longitudinal studies could assess whether the positive motivational impact observed in this course translates into sustained engagement and innovative teaching practices once participants enter professional teaching roles. Research has already established that gender is one of the most studied factors in tailored gamification after player type (Klock et al., 2020). Future research should further investigate the potential influence of gender on preferences for game mechanics or customization, taking into account how the portrayal of female and male characters or roles might reinforce stereotypes or promote more inclusive images of science (Martín-Gámez et al., 2022).

In addition, expanding research to include a broader range of disciplines beyond science education would help determine whether gamification strategies are equally effective in other subject areas. At the same time, future research on narrative design could investigate more modular, theme-agnostic storylines that allow greater agility once player types are identified or adopt a flexible approach in which student feedback guides major narrative elements. Such adaptive gamification strategies, which dynamically adjust to real-time student performance and engagement patterns, could further enhance personalization. Moreover, examining different narrative structures (e.g., branching vs. linear) and varying degrees of student agency would help determine how these factors affect both motivation and learning outcomes across diverse learner profiles. Finally, future studies should investigate how different player types interact with various game mechanics over time, identifying which features most effectively support motivation across diverse learner profiles.

5. Conclusions

The results of this study underscore that a gamified approach, grounded in SDT and personalized through player-type adaptation, has significant potential to foster intrinsic motivation in preservice teacher education. The combination of narrative-driven engagement, cooperative and goal-directed challenges, and personalized game mechanics contributed

to strong positive outcomes in enjoyment, competence, autonomy, and relatedness. While variability in social engagement highlights the influence of individual differences in students' social dynamics, the overall findings support the value of gamification in fostering engaging and meaningful educational environments.

As teacher education programs continue to explore innovative pedagogical strategies, gamification presents not only a tool for enhancing student engagement but also a potential framework for reshaping future educators' approaches to teaching and learning. However, sustaining these benefits will require careful attention to learner diversity, equitable access, and curricular alignment. By continuously refining gamified approaches to balance engagement with pedagogical effectiveness, teacher education programs can harness the motivational power of gamification to prepare future educators to cultivate engaging, autonomy-supportive, and inclusive classrooms.

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Abbreviations

The following abbreviations are used in this manuscript:

ECTS	European Credit Transfer Accumulation System
IDP	Institute of Professional Development
IMI	Intrinsic Motivation Inventory
IQR	Interquartile range
Mdn	Median
RESC	Recreational and Everyday Science in the School
SDT	Self-Determination Theory
SPSS	Statistical Package for the Social Sciences
XPs	Experience points

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