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Gamifying Teacher Education with *FantasyClass*: Effects on Attitudes towards Physics and Chemistry among Preservice Primary Teachers

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Abstract: This study investigates the impact of structural gamification, using the digital platform *FantasyClass*, on the attitudes and motivation of preservice primary education teachers towards physics and chemistry. Employing a mixed-methods approach, the research combined quantitative and qualitative data collection and analysis involving 65 second-year university students over a 14-week course. The quantitative component was framed within a quasi-experimental pre-post design, allowing for the comparison of students' attitudes and motivations before and after the gamified intervention. The qualitative component was designed to complement the quantitative findings. Quantitative analysis revealed significant improvements in students' perceptions and motivation, with notable increases in positive attitudes towards these sciences. Qualitative data further highlighted enhanced interest and enjoyment, with students reporting greater engagement and a shift in their perception of physics and chemistry as accessible and enjoyable. The study also noted an increase in self-confidence among future teachers and improved teaching self-efficacy. The findings suggest that integrating gamification in initial primary science teacher education can effectively foster more favorable attitudes, enhance motivation towards science, and improve teaching confidence. Future research should explore long-term impacts, as well as personalized gamification approaches to cater to different types of learners and maximize educational effectiveness.

Keywords: gamification; motivation; science education; initial teacher training; *FantasyClass*

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1. Introduction

Attitude can be defined as a learned state that predisposes individuals to respond consistently to specific objects, encompassing affective, cognitive, and behavioral components, where these "objects" include values, courses of action, persons, or things [1]. Promoting favorable attitudes towards science is a fundamental challenge in education, as such attitudes foster belief in science and promote its survival and development within society [2,3]. Moreover, they enable students to achieve better grades and be better prepared in these fields [4]. This is crucial for training future generations to be aware of environmental issues [5] and to lead healthier lives [6]. Establishing a solid knowledge base in science is crucial for protecting individuals from fake news and conspiracy theories [7], which can impair understanding and decision-making.

Several factors may influence students' attitudes towards science, including individual gender, class/teacher characteristics, subject choice, and the perceived difficulty of the topics studied [8]. There is a general trend of increasing negative attitudes towards science as age increases, particularly during the transition from primary to secondary education [1,9], and this trend is independent of academic success, as students with high academic potential in science often do not pursue careers in this field due to lost interest during schooling [10]. This loss of interest has been linked to traditional teaching methods [11] and a mismatch between school science and the variables that stimulate interest [12]. According to Vázquez and Manassero [13], there is widespread disillusionment and disenchantment with science among both students and teachers in compulsory education, which can lead to young people acquiring a negative perception of scientific careers, viewing them as uncreative and not people-oriented [14].

At the university level, this tendency persists as teacher trainees often harbor negative perceptions towards science [15], commonly linked to insecurities about teaching the subject [16]. Confidence in teaching science is crucial and requires adequate content training [17,18]. Teacher education students frequently begin their studies with limited scientific knowledge, which can often be an obstacle to developing sufficient competencies for teaching science during their university training. This poses a significant problem since the quality of teacher training directly impacts their teaching practices [19], and any initial training deficiencies translate into low teaching effectiveness in the future [20]. Besides training, negative attitudes alone can also hinder the process of facilitating scientific understanding among students [21]. Notably, several studies have indicated that most students in the Primary Teacher Education program harbor negative emotions towards physics and chemistry [22,23], and these emotions lead them to avoid teaching these subjects when they teach [24]. Fortunately, attitudes towards sciences are not fixed but evolve over time and are related to the type of exposure to sciences and its quality [25]. Proper teacher training can be reflected in improvements in students' attitudes towards sciences [26], and good science practices in schools can foster interest in these disciplines and the choice of future careers related to them [27]. Therefore, it becomes necessary to rethink and improve the teaching practices carried out at the university level to prepare future teachers for quality science teaching. In this process, it is important to understand the emotions experienced in relation to science teaching [28].

It has been found that some of the factors that can improve students' attitudes towards sciences include teacher behavior [29], knowledge, and attitudes towards these disciplines [30], as well as the teaching methodologies employed [31]. In this context, what can really improve these perceptions is not so much the transmission of information in classes [16] but involving students in collaborative learning and personal discovery processes [32]. This type of learning, known as active learning, which engages students in their own learning process based on their prior knowledge, interests, and experiences, and allows them to put into practice what they learn, has been shown to stimulate motivation, academic performance, and understanding of content [33], as well as positive emotional states that enhance learning and student engagement [34]. In the context of teaching physics and chemistry, this is particularly relevant since it is essential to generate sufficiently strong positive emotions to counteract the negative emotions that may have been generated during schooling in these subjects [15,35]. These characteristics make active learning an effective method for properly training future professionals in developing skills such as teamwork, collaboration, proactivity, and entrepreneurship [36]. According to Murillo et al. [37], despite the numerous benefits of active learning, it is still not sufficiently implemented, especially in higher education, and according to Esteve and Solbes [38], its incorporation into initial teacher training can be key to fostering greater interest and more positive attitudes among students towards sciences.

One of the rising methodologies associated with active learning is gamification. Educational gamification can be defined as the use of game elements in educational contexts to enhance motivation [39]. Game elements, which are the building blocks of games and play a crucial role in gameplay, are used in gamification not to create a game, but to encourage learners to engage with the content and progress toward a goal [39,40]. Gamification can be of two types: content gamification, where game elements are directly applied to the content to make it more game-like, or structural gamification, where it is the structure around the content that becomes game-like, in order to motivate learners to engage with the content, which remains unaltered [40]. Motivation is a theoretical construct that explains the initiation, direction, intensity, persistence, and quality of behavior directed towards a goal [41]. That is, it is an indicator of the time and energy an individual is willing to spend on a specific action [42]. In the educational context, it is crucial to increase student motivation as it has been linked to better understanding of content [43] and to achieving higher qualifications [44]. Some authors argue that it is one of the most important elements in the learning process [45]. A motivated student is characterized by showing interest in tasks, better handling the adversities and difficulties that arise during the learning process, and not showing boredom [42]. Specifically, it has been seen that if students are motivated by sciences, they enjoy learning and take responsibility for their own learning process [46]. Moreover, there is a positive relationship between attitude and motivation [47]. Both can feed into each other, where, for instance, a student's attitude towards a subject due to their social context (e.g., family and friends' influence) can be pivotal in their motivation for it [48]. On the other hand, scientific activities that stimulate student motivation can also change their attitudes towards the sciences [49]. Some authors argue that motivation and positive attitudes must coexist for optimal learning experience [50]. It has been shown that gamification can stimulate motivation and provide numerous benefits in educational settings in general [51–53]. Specifically in the teaching of sciences, it can foster motivation [54], facilitates scientific thinking [55], and supports other methodologies inherent to teaching this discipline, such as inquiry-based learning [56].

In their review on educational gamification, Zainuddin et al. [57] found that the most frequently cited theory was the Self-Determination Theory (SDT) [58]. According to this theory, individuals need to satisfy their psychological needs for competence, autonomy, and relatedness to promote intrinsic motivation, which is a genuine type of motivation involving engagement in an activity simply because it is perceived as enjoyable and interesting, thereby stimulating quality learning [59]. Competence involves feeling effective and successful when interacting with the environment, autonomy pertains to the sense of freedom and volition in completing a task, and social relatedness involves feelings of belonging and connection within a group of significant others [60]. If these needs are met, personal growth and development occur, and genuine enjoyment of the activity is experienced, regardless of the specific content, complexity, or type of activity. Conversely, when these needs are not met, negative emotions can arise, undermining motivation [61]. Thus, teachers should design activities that ensure the challenges posed are achievable and that constant feedback is provided to the student (competence), promote students' decision-making capacity (autonomy), and encourage collaborative work (relatedness) [62].

Most studies on gamification applied in educational settings focus on its implementation within digital contexts, where digital gamification specifically refers to the use of digital tools and platforms to implement game elements [63]. Some advantages associated with it include its low cost and appealing support [64], improved visualization [65], and better memorization of content [66], as well as greater stimulation and autonomy for students [67] and enhanced learning [68] compared to traditional methods. Although teacher trainees are comfortable using digital technologies in their daily lives [69], most have limited knowledge of how to use them in an educational context [70]. These resources are highly suitable for fostering active participation, collaborative learning, real-world contexts, and immediate feedback [71]. In some cases, it has been observed that using technology improves attitudes towards sciences compared to groups of students where it has not been implemented [72]. In line with Garmendia [73], who suggests the need to promote the use of innovative methodologies in teacher training and the relevance of facilitating teaching models that students can reproduce, applying gamification in teacher education degrees is particularly pertinent. Therefore, digital gamification in this context has the dual advantage of potentially motivating teacher trainees towards sciences and providing them with tools for their future professional careers.

Building on the insights from Kalogiannakis et al. [62], which underscored the need for more research on gamification in science education, the objective of this research is to evaluate the impact of a gamified course, using a digital structural gamification platform (*FantasyClass*), on the motivation and attitudes of preservice primary education teachers towards physics and chemistry. This research intends to explore how structural gamification, applied throughout an entire course over a semester, can enhance educational experiences, and foster more positive attitudes towards these scientific disciplines, contributing to the limited yet growing body of evidence on effects of gamification strategies in initial teacher training. The specific research question guiding this study is: how does the implementation of structural gamification through the *FantasyClass* platform influence the attitudes and motivation of preservice primary education teachers towards physics and chemistry?

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 quasi-experimental [74], pre-post design. This design allowed for the comparison of students' attitudes and motivations before and after the gamified intervention, providing a means to measure changes over time within the same group of participants. The qualitative component, on the other hand, was designed to triangulate and complement the quantitative findings.

2.1. Sample

The sample consisted of 65 students (56 women and 10 men, mean age = 21.0; median = 20) in their second year of the bachelor's degree in primary education (preservice primary teachers) at the University of Barcelona, enrolled in the compulsory in-person course "Didactics of Matter, Energy and Interaction" (DMEI). This is, therefore, a convenience sample [75].

The DMEI course is their only compulsory didactics course focused on the content of physics and chemistry, with another optional advanced course in the fourth year. The semester prior, students complete a course on the didactics of biology and geology. The physics and chemistry content in DMEI is simplified compared to typical university-level courses, as the primary objective of the course is to teach the didactic and pedagogical methods that our students will use when they teach physics and chemistry to primary school children, aged between 6 and 12 years old.

2.2. Procedure

Throughout the 14-week DMEI course, structural gamification was implemented using *FantasyClass* (https://fantasyclass.app/, accessed on 24 June 2024), a free digital platform. Points are the basic element of this platform and there are three types: health points, experience points, and gold coins. Students accumulate health points for positive classroom actions (punctuality, completing tasks, cooperative behavior, etc.), while negative actions (using a phone, tardiness, etc.) result in the loss of health points and some privileges. Academic progress can be evaluated by awarding experience points based on the quality of completed tasks. This continuous feedback system operates such that crucial activities can be worth 20 points, with the quality of execution determining whether the student earned the full points or only a part. Less relevant activities can be worth 10 points, with a similar evaluation based on performance. Accumulating experience points allows students to ascend levels, with their final level correlating to a portion of their final course grade. Gold coins are earned through various activities and can be used to purchase items, avatar upgrades, skills or pets in the virtual store (Figure 1). These elements incentivize students to maintain positive behavior and progress in the course. Classroom behavior tracking and academic progress is managed through the *FantasyClass* platform, allowing detailed control of student actions and ensuring constant and meaningful engagement with course content.

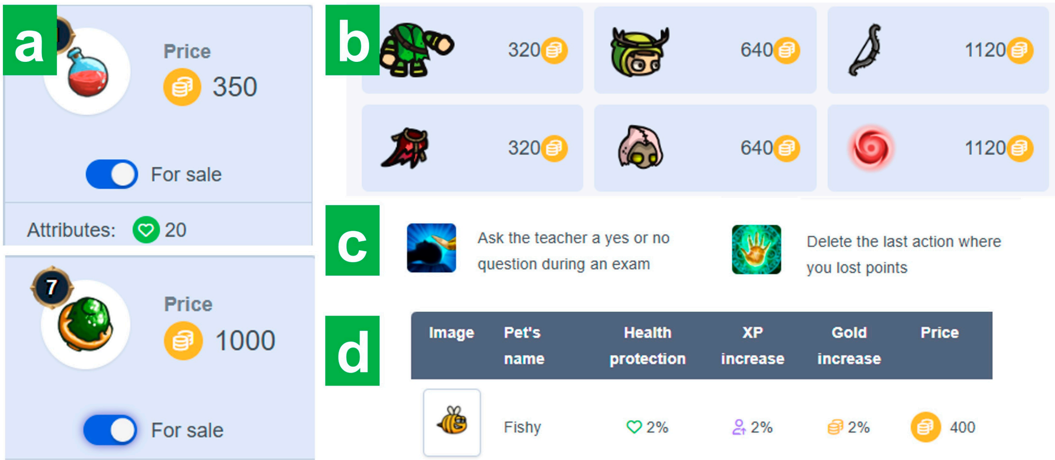

Figure 1. Some items available in the virtual store. (**a**) Consumable items, such as health restoration. (**b**) Avatar equipment upgrades, enhancing various attributes. (**c**) Skills, which grant special abilities. (**d**) Pets, which boost avatar attributes and require care and feeding.

FantasyClass allows for the adoption of various themes, and for this course, a medieval theme was chosen to gamify the content through a narrative [76]. This transformed our students into warriors and heroines tasked with restoring peace and order in four fictional kingdoms, each representing a thematic block of the course: Didactics, Matter, Energy, and Interaction. The narrative served as the guiding thread for the course activities, which had been transformed into challenges that students had to overcome to earn various rewards, giving them a more active role in the course and providing an immersive context that gave meaning to all course activities.

On the first day of class, the instructor introduced the gamification methodology to the students. This introduction included an explanation of the basic features *of FantasyClass* and a video detailing the narrative of the gamified adventure (https://www.youtube.com/watch?v=5WKgNsoqCQo, accessed on 24 June 2024). Students registered on *FantasyClass*, choosing avatars that corresponded to specific character types—warriors, archers, and wizards—each with unique attributes focused on health points, experience points, and gold, respectively (Figure 2). They formed groups of four, maintaining this structure throughout the course to foster intra-group cooperation and inter-group competition mechanics, following the approach supported by Cardenas and Mantilla [77], who emphasize that small group formations enhance cooperative learning within groups while promoting healthy competition between groups, which can lead to improved motivation and engagement among students.

FantasyClass is equipped with several functionalities designed to promote active participation and manage the game elements incorporated into the course structure [78]. For example, treasure cards (Figure 3a), which can also be randomly purchased in the virtual store, can trigger random events that can either benefit or challenge the students, as well as a fortune wheel that provides a random amount of gold coins, adding an element of surprise and maintaining student interest. This uncertainty, reflected in the randomness of some rewards and events, is an essential ingredient in gamification [40]. *FantasyClass*'s card collections are another key feature of the platform, allowing students to reinforce specific course vocabulary through card collection, organized into different themes such as female scientists, laboratory equipment, or Sustainable Development Goals. Students can buy packs of themed trading cards with their gold coins, and upon completing these collections, they receive additional rewards that increase their experience points and advantages. This encourages interactive learning of specific concepts and fosters extended collaboration, since students could trade cards with any classmate, irrespective of group alignments. Skills grant students' special abilities like instant health point restoration, gold coin theft, or extended protection against health point loss and coin theft. Finally, the monster battles, configured as whole-class competitions against a common enemy (Figure 3b), can reinforce the spirit of class collaboration and joint learning. During these battles, students earn experience points and gold coins by correctly answering questions from a monster, promoting active and collaborative learning. The implementation of *FantasyClass* extended beyond classroom activities to include tasks and activities outside class hours, fostering constant participation and continuous learning.

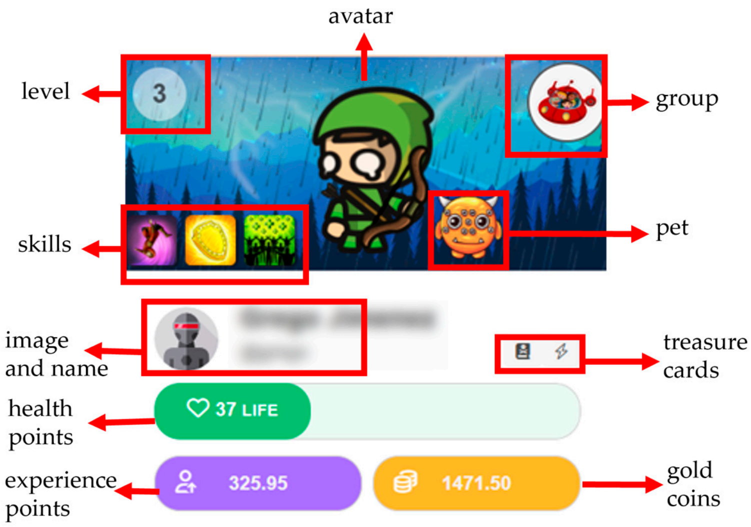

Figure 2. Student profile in *FantasyClass*, showing its avatar: an archer as the character type.

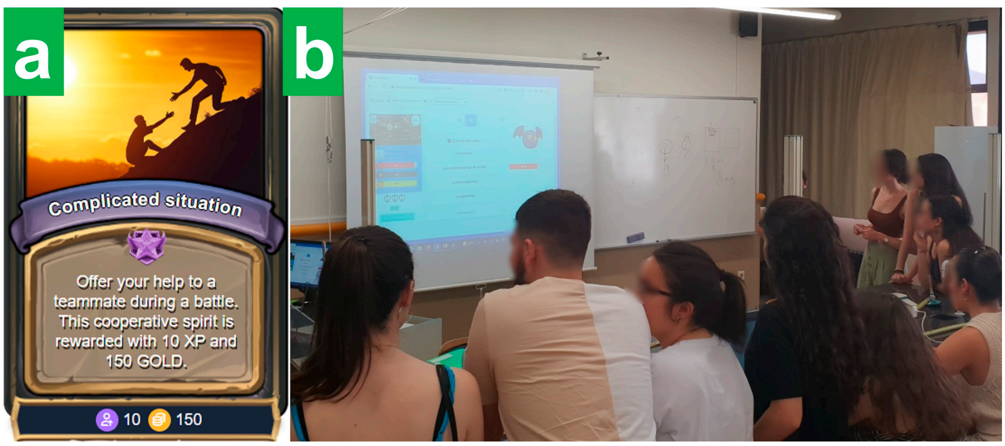

Figure 3. (**a**) Example of a treasure card, "Complicated situation", which allows students to seek help during a monster battle, rewarding cooperative spirit with 10 experience points and 150 gold coins. (**b**) Students engaging in a class-wide battle against a monster using the *FantasyClass* platform.

Throughout the implementation of *FantasyClass*, the gamification mechanics have been designed to foster an interactive and engaging learning environment. This approach aligns with the broader framework of mechanics, dynamics, and aesthetics (MDA) [79,80]. Mechanics within *FantasyClass*, such as challenges, chance, competition, cooperation, and rewards, drive player engagement and facilitate both individual and collective interactions within the student community, promoting competitive and cooperative dynamics. Dynamics, including progression, emotions, narrative, and relationships, unfold through an ongoing storyline and structured challenges. These elements encourage student involvement and emotional engagement, with the medieval narrative serving not only as a motivational backdrop but also enriching the educational experience by linking academic efforts to a grander epic. The aesthetics of the medieval theme and the immersive narrative not only provide a compelling context for these interactions but also evoke specific emotional responses from the students, such as curiosity, excitement, and satisfaction. These aesthetic elements make the educational experience enjoyable and memorable, further enhancing the effectiveness of the gamification. This integration of mechanics, dynamics, and aesthetics goes beyond a simpler PBL (points, badges, and leaderboard) system and showcases a holistic, effective gamified educational environment designed to maximize engagement and student satisfaction.

2.3. Instrument

To study the impact of the gamified course on motivation towards physics and chemistry among primary education teacher candidates, the "Questionnaire on Attitude and Motivation of Preservice Primary Education Teachers Towards Physics and Chemistry" [81] was used. This instrument consists of 22 statements on which students indicate their level of agreement or disagreement using a five-point Likert scale, where 1 represents "strongly disagree" and 5 represents "strongly agree". The questionnaire is organized into three temporal dimensions: past, present, and future. In the past dimension, participants are encouraged to reflect on and evaluate their previous experiences with physics and chemistry, providing a retrospective perspective. The present dimension focuses on assessing the current perceptions of the students, both in their role as active members of society and as university students. Finally, the future dimension invites participants to project their visions and expectations towards their future role as primary education teachers.

For this study, the questionnaire was administered digitally at the beginning (pretest) and at the end (posttest) of the course. In the posttest, the wording of the items in the past dimension was slightly modified to refer to the experience in the DMEI course. For example, the statement for item one "In physics and chemistry class, I got answers to questions that intrigued me" (pretest) was reworded to "In DMEI, I got answers to questions that intrigued me" (posttest). The internal consistency calculated for the complete questionnaire was 0.864 in the pretest and 0.881 in the posttest. Additionally, the Cronbach's alpha values for the dimensions were as follows: past: 0.875 (pretest), 0.804 (posttest); present: 0.815 (pretest), 0.840 (posttest); future: 0.760 (pretest), 0.838 (posttest). These values indicate good internal consistency of the questionnaire throughout the study and for each of its dimensions.

In the posttest, two additional items (statements 23 and 24) were added to specifically evaluate the impact of *FantasyClass*: "*FantasyClass* made me more engaged in the subject" and "I would have shown the same interest and motivation towards the subject without the gamification of *FantasyClass*". Additionally, two open-ended questions were included: "How has your view of physics and chemistry in Primary Education changed after taking DMEI"? and "Evaluate the implementation of *FantasyClass* in DMEI. What has it meant for you"?

2.4. Data Analysis

IBM SPSS Statistics v.27 software was used for quantitative data analysis. Qualitative analysis was conducted using a content analysis approach [82] with ATLAS.ti v.21 software. Content analysis involved systematically coding and categorizing the textual data from open-ended survey responses to identify recurring themes and patterns related to students' perceptions and experiences with the gamified course. This method allowed for an in-depth understanding of the qualitative impact of *FantasyClass* on students' attitudes and motivation, providing valuable context to the quantitative findings.

3. Results

3.1. Quantitative Results

Firstly, the normality of the data distribution was evaluated using the Shapiro–Wilk test. This test indicated that the data do not follow a normal distribution ($p < 0.05$); therefore, subsequent analyses were based on non-parametric tests. The Wilcoxon signed-rank test was primarily used to analyze the data, and the results are presented along with median values and interquartile ranges (IQR) for each dimension—past, present, and future. Detailed results for each dimension, including these statistical measures, are provided below.

In the past dimension (Table 1), which compares students' previous experiences with physics and chemistry to their experiences in the DMEI course, significant changes were observed across multiple items. Items one, two, and six, which measure satisfaction, participation, and enjoyment, respectively, all showed notable improvements, with medians increasing from 3.0 to 5.0 ($p < 0.001$). Item three, which measures perceived autonomy, showed a median increase from 3.0 to 4.0 ($p = 0.002$). Items four and five, related to interest and ease of study, also displayed positive changes, with medians increasing from 3.0 to 4.0 ($p < 0.001$). Additionally, item seven, assessing comprehension of everyday phenomena, showed improvement with the median increasing from 4.0 to 5.0 ($p < 0.001$), and item eight (negatively worded), assessing perceived difficulty, showed a decrease in median from 3.0 to 2.0 ($p < 0.001$). While most items in this dimension exhibited a reduction in IQR, reflecting less dispersion in responses, item eight showed an increase in IQR, indicating varying degrees of change in students' perceptions.

Table 1. Changes in attitudes and motivation towards physics and chemistry before and after a gamified course: past dimension.

Item Number and Statement	Pretest		Posttest		W	*p*
	M	IQR	M	IQR		
1—In physics and chemistry class, I got answers to questions that intrigued me	3	(1)	5	(1)	0.0	<0.001 *
2—In physics and chemistry class, I could express my own ideas	3	(2)	5	(1)	10.5	<0.001 *
3—I could get good grades in physics and chemistry without the help of the teacher	3	(2)	4	(1)	289.0	0.002 *
4—Physics and chemistry classes fascinated me	3	(2)	4	(1)	25.5	<0.001 *
5—Physics and chemistry lessons were easy to study	3	(1)	4	(1)	30.0	<0.001 *
6—I had fun learning physics and chemistry	3	(2)	5	(1)	0.0	<0.001 *
7—Physics and chemistry allowed me to understand everyday phenomena	4	(1)	5	(0)	32.0	<0.001 *
8—For me, it was difficult to learn physics and chemistry	3	(1)	2	(2)	155.0	<0.001 *

Note: M: median, IQR: interquartile range, W: Wilcoxon signed-rank test statistic, *p*: *p*-value. Asterisks (*) indicate statistical significance at the 5% level.

Several significant changes emerged in the present dimension (Table 2), which evaluates students' current attitudes towards physics and chemistry. Item nine, assessing the relevance of physics and chemistry to daily life (negatively worded), showed a decrease in median from 2.0 to 1.0 ($p < 0.001$), indicating a significant shift in recognizing their everyday relevance. Item 10, recognizing the importance of these sciences, maintained a median of 5.0 with a statistically significant improvement ($p = 0.012$) due to a more consistent agreement among students, as evidenced by the reduced IQR. Item 11, concerning learning through media like social media and YouTube, maintained a median of 3.0 in both the pretest and posttest, but with a statistically significant reduction in IQR ($p = 0.031$), indicating a more consistent agreement among students. Items 12 (interest in physics and chemistry), 13 (interest in explanations of phenomena), and 15 (perceived benefits over adverse effects), all maintained medians of 4.0 with significant increases ($p < 0.05$), indicating sustained and reinforced positive perceptions and interest. Item 14, reflecting the practical benefits of physics and chemistry, showed an increase from a pretest median of 4.0 (IQR 2.0) to a posttest median of 5.0 (IQR 1.0) ($p < 0.001$), reflecting better appreciation and a more uniform agreement among students. Lastly, item 16, confidence in the potential of these disciplines to address global issues, showed an increase in median from 4.0 to 5.0 ($p = 0.002$).

Table 2. Changes in attitudes and motivation towards physics and chemistry before and after a gamified course: present dimension.

Item Number and Statement	Pretest		Posttest		W	*p*
	M	IQR	M	IQR		
9—Physics and chemistry have no connection to my life	2	(1)	1	(1)	94.0	<0.001 *
10—Understanding physics and chemistry is important for everyone	5	(1)	5	(0)	84.5	0.012 *
11—I like to read and learn about physics or chemistry through social media, YouTube, or other media	3	(2)	3	(1)	215.0	0.031 *
12—I think physics and chemistry are interesting	4	(1)	4	(1)	144.0	<0.001 *
13—I am interested in explanations of physical and chemical phenomena	4	(1)	4	(1)	206.5	<0.001 *
14—Physics and chemistry make our lives healthier, easier, and more comfortable	4	(2)	5	(1)	171.0	<0.001 *
15—The benefits of physics and chemistry outweigh the potential adverse effects	4	(1)	4	(1)	228.0	0.044 *
16—Physics and chemistry can solve environmental problems	4	(1)	5	(1)	75.0	0.002 *

Note: M: median, IQR: interquartile range, W: Wilcoxon signed-rank test statistic, *p*: *p*-value. Asterisks (*) indicate statistical significance at the 5% level.

Particularly notable changes are observed in the future dimension (Table 3), which projects students' expectations and self-assessments as future primary teachers. Item 17 (negatively worded), measuring the opinion that physics and chemistry should not be taught in primary school, maintained a median of 1.0 but showed a significant reduction in IQR from 1.0 to 0.0, indicating a stronger consensus in rejecting this idea ($p = 0.002$). Item 18, which assesses the perceived need for more time devoted to these subjects in primary school, showed an increase in median from 3.0 to 4.0, with an increase in IQR, reflecting varied levels of agreement after the intervention ($p < 0.001$). Item 19 (negatively worded), related to perceived boredom in teaching these subjects, showed a decrease in median from 2.0 to 1.0 ($p = 0.029$), indicating reduced perceptions of boredom. Item 20, assessing the perceived importance of physics and chemistry for future professional development, was the only statement in the entire questionnaire that showed no significant difference ($p = 0.699$) between pretest and posttest results, suggesting students consistently viewed this aspect as very important throughout the course. Lastly, item 21, measuring self-confidence in teaching physics and chemistry to primary school children, and item 22, related to self-assessed knowledge to teach the content, both showed a significant increase in median from 2.0 to 4.0 ($p < 0.001$), indicating substantial improvement in perceived self-efficacy and more consistent agreement among students due to the reduction in IQR for both items.

To complement the tabular data presented above, Figure 4 provides a visual summary of the differences in median scores from pretest to posttest across all questionnaire items. This figure, which includes bootstrap confidence intervals, offers a clear and immediate understanding of the overall trends and magnitudes of change resulting from the gamified intervention. The largest differences in median scores are observed in the past dimension, followed by the future dimension, while the present dimension shows more modest changes.

Table 3. Changes in attitudes and motivation towards physics and chemistry before and after a gamified course: future dimension.

Item Number and Statement	Pretest		Posttest		W	*p*
	M	IQR	M	IQR		
17—Physics and chemistry should not be taught in primary school	1	(1)	1	(0)	24.0	0.002 *
18—More time should be devoted to physics and chemistry in primary school	3	(1)	4	(2)	123.0	<0.001 *
19—I think teaching physics and chemistry to primary school children must be boring	2	(1)	1	(1)	135.0	0.029 *
20—The physics and chemistry I can learn is important for my future professional development as a primary school teacher	5	(1)	5	(1)	174.0	0.699
21—I feel capable of teaching physics and chemistry content to primary school children	2	(2)	4	(0)	8.0	<0.001 *
22—I consider that I have sufficient knowledge to teach the physics and chemistry content of the primary education curriculum	2	(2)	4	(1)	20.0	<0.001 *

Note: M: median, IQR: interquartile range, W: Wilcoxon signed-rank test statistic, *p*: *p*-value. Asterisks (*) indicate statistical significance at the 5% level.

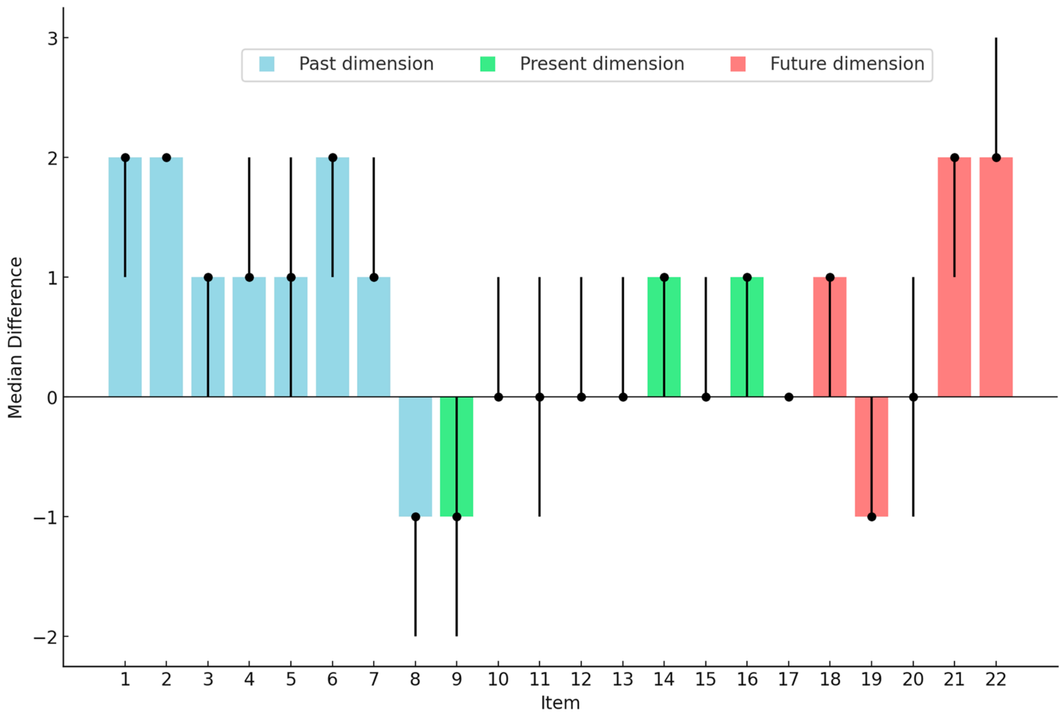

Figure 4. Differences in median scores for attitudes and motivation toward physics and chemistry among preservice primary education teachers: pretest and posttest comparison with bootstrap confidence intervals. Note: items 8, 9, 17, and 19 are negatively worded.

The responses to the additional items in the posttest highlight the perceived impact of *FantasyClass* on student engagement and motivation. For item 23, "*FantasyClass* made me more involved in the subject", students reported a median response of 4.0 (IQR of 1.0), with 89.2% agreeing or strongly agreeing, indicating a strong consensus on increased involvement due to gamification. Conversely, for item 24, "I would have shown the same interest and motivation towards the subject without the gamification of *FantasyClass*", the median response was 2.0 (IQR of 1.0), with 80.0% disagreeing or strongly disagreeing, suggesting that most students felt *FantasyClass* was crucial to their increased interest and motivation in the subject. These findings underscore the significant role of *FantasyClass* in enhancing student engagement and motivation.

In the analysis of gender differences, the Mann–Whitney U test reveals that, although no significant differences were observed between men and women in most items, the structural gamification intervention significantly impacted some specific areas. Before the intervention, women showed a greater perception of the importance (item 20, $p = 0.001$) and necessity (item 18, $p = 0.006$) of physics and chemistry compared to men. After the intervention, men showed a greater interest in learning about these subjects (item 11, $p = 0.041$), while women increased their confidence in their ability to teach these contents (item 22, $p = 0.022$). Gamification appears to have equalized perceptions in some aspects, improving self-confidence in women and interest in men. It is important to note the disparity in the number of participants by gender, which could have influenced the results, and therefore, the conclusions should be interpreted with caution.

3.2. Qualitative Results

To complement the quantitative findings, a qualitative analysis was carried out, focusing on two open-ended questions. The first question, which asked students to reflect on how their views on physics and chemistry or the teaching of science in primary education had changed after taking the DMEI course, reveals several recurring themes. These themes will be presented in the following paragraphs in order of decreasing frequency. Overall, the responses indicate a substantial shift in how future teachers perceive physics and chemistry, highlighting changes in their personal interest and pedagogical approaches.

The most frequently mentioned theme in the responses is the impact of gamification on students' perceptions. Students attributed much of their new motivation and interest to the gamified strategies used in DMEI. One student expressed, "Thanks to the gamifications, my view has changed for the better", while another stated, "Honestly, it has changed for the better. The gamified course made me much more motivated and interested in the course content". These statements emphasize how the incorporation of playful and competitive elements not only increases motivation but also facilitates greater understanding and retention of content.

Closely related to this, another prominent theme is the increased interest in physics and chemistry. Many students mentioned that before taking DMEI, these subjects did not seem interesting to them or were considered difficult to understand. However, the experience with the course and the methodologies used, including gamification, allowed them to develop a new appreciation for these sciences. One student commented, "Before taking this course, I found physics and chemistry very difficult, but thanks to gamification and the comparison with our daily lives, I found it much easier and enriching". This quote underscores how the practical and contextual application of scientific concepts can transform the perception of difficulty into an enriching and accessible experience.

In addition to the increase in interest and motivation, several students emphasized the importance of teaching physics and chemistry in a dynamic and fun way. Many mentioned that they previously considered these subjects to be theoretical and boring, but now see the possibility of teaching them through experiments and interactive methods. One student noted, "I have seen that the subject should not be taught only conceptually, but that there are various ways to explain physics and chemistry in a more fun and dynamic way". This comment reflects a paradigm shift in teaching, where the focus shifts from mere transmission of theoretical knowledge to facilitating active and meaningful learning experiences.

The methodology employed in DMEI also seems to have influenced the self-confidence of future teachers. Several students mentioned that they now feel more capable and confident in teaching physics and chemistry. One student stated, "It has been the first course in the degree that has truly been didactic. Very grateful and happy, I have finally seen progress in my confidence when teaching". This increase in self-confidence is crucial, as the perception of teaching competence can directly influence the effectiveness of teaching and student learning.

Another frequent observation was the appreciation of the relevance of physics and chemistry in daily life. Some students indicated that they did not previously see the connection between these sciences and their daily lives, but now recognize their importance and constant presence. One student commented, “It made me see that Chemistry is much more present in our lives than we think, constantly, and that it is very important for us”. This new perception not only increases interest in the subject but can also enhance future teachers’ ability to make relevant and meaningful connections for their students.

Regarding pedagogical approaches, some students highlighted the usefulness of experiments and practical activities for teaching scientific concepts. One student mentioned, “I realized that many things can be taught through experiments and more meaningful learning rather than just explaining the theory”. This statement underscores the importance of incorporating active and experimental teaching methods that not only facilitate the understanding of concepts but also foster interest and curiosity.

Lastly, a few students noted that their perception did not change significantly, as they were already familiar with gamification or already had a positive view of physics and chemistry. However, these comments also reflect a consolidation of their previous perceptions and an appreciation of the new tools and strategies they could integrate into their future teaching practice.

The content analysis of students’ responses to the second open question about their evaluation of the implementation of *FantasyClass* in DMEI reveals several recurring themes, which will be presented in the following paragraphs in order of decreasing frequency. Overall, the responses indicate a largely positive experience, characterized by a significant increase in motivation, engagement, and enjoyment of learning.

The most frequently mentioned theme is the increase in motivation and interest in the subject. Several students mentioned how *FantasyClass* helped them stay motivated and engaged with the course. For example, one student stated, “The implementation of *FantasyClass* has been a great motivation for me towards the subject”, while a classmate commented, “*FantasyClass* has motivated me a lot. The collections helped me learn vocabulary and I liked them very much”. This quote reflects how the mechanics of collecting cards not only incentivized participation but also facilitated the learning of key concepts. These statements underline how gamification can transform students’ attitudes towards subjects that they previously found less attractive.

The competitive aspect of the gamification was also positively valued. One student expressed, “an extra motivation since I am very competitive in all areas, and it has made me engage much more in the subject”. This comment highlights how friendly competition can be a powerful driver for academic engagement. Another student noted, “*FantasyClass* made me eager to come to class and do activities” indicating that gamification can positively influence attendance and class participation.

Specific functionalities of *FantasyClass*, such as card collections, random events, and battles, were frequently mentioned as favorite aspects. One student said, “The collections and the fortune wheel are the things I liked most about *FantasyClass*”. These features not only added variety and fun but also fostered active learning and collaboration. Another student commented, “I loved using this platform because it motivated me in every way, making me want to come to classes and engage at home by buying collectible card packs to earn points”. This quote underscores how gamification can extend learning beyond the classroom, encouraging students to voluntarily dedicate additional time to study.

The narrative was also highly valued. One student mentioned, “The narrative adds mystery and excitement to the concepts we are working on. It turns the subject into an enjoyable adventure”. This quote highlights how narrative can make learning more immersive and meaningful. Another student noted, “Thanks to the narrative, many of us have been able to change this view, and we are increasingly attracted to science”, indicating that contextualizing concepts through stories can change pre-existing negative perceptions of science.

Cooperation and teamwork were also mentioned as significant benefits of the gamification. One student highlighted, "It has been a unique experience at the university. The best part of *FantasyClass* was the cooperative work with the group and the narrative of the contents". This quote emphasizes how gamification can foster important social and collaborative skills, as well as promote a sense of community and mutual support among students.

Continuous assessment and the use of rewards were also positive aspects mentioned by some students. One student commented, "The fact that it was continuous assessment made me stay on top of the content every day and increased my interest in the subject". Another student noted, "The motivation to get rewards in the game. I find it a very useful methodology for working on the content of the subject". These quotes reflect how gamification can stimulate constant and active engagement with learning, using rewards to incentivize participation and continuous effort.

Finally, a few students provided constructive criticisms, mentioning technical difficulties or aspects that could be improved. One student suggested, "The platform's fluidity could be improved and options for internal battles against classmates could be added". Regarding the structure and presentation of the subject, some students suggested that the introduction to *FantasyClass* could be more gradual to avoid feeling overwhelmed at the beginning. One student mentioned, "I think the way it is presented on the first day can be improved, as I felt a bit stressed and overwhelmed with the amount of information received". Another student commented, "It is a bit frustrating not to be able to sell duplicate cards". These observations indicate that while the overall experience was positive, there are technical and functional areas that could be optimized to improve the user experience.

4. Discussion

The aim of this study was to analyze the impact of a gamified course on the attitudes and motivation towards physics and chemistry among preservice primary education teachers. The findings indicate that the implementation of structural gamification with *FantasyClass* in the DMEI course significantly enhanced the students' motivation and attitudes towards these subjects across all three studied dimensions: past, present and future.

Statistical analysis of the pre- and post-intervention differences showed significant changes in nearly all questionnaire items, with some items (e.g., items 1, 2, 6, 21, and 22) exhibiting differences of two levels in the median scores. The additional posttest items (items 23 and 24) and the qualitative analysis of student comments further underscore the heightened engagement and self-perceived motivation attributed to *FantasyClass* and the narrative structure of the activities. These findings are consistent with other studies that have suggested gamification can enhance student motivation [83–88]. For instance, Castaneda et al. [89], in a quasi-experimental study without a control group, found that the dynamics of gamification and continuous assessment through Information and Communication Technologies achieved high levels of student participation and motivation in a university physical education course.

To further reinforce the impact of gamification specifically in preservice primary teachers, it is insightful to consider findings from a previous investigation [81]. This earlier study applied the same questionnaire to students at the same university and degree program, but under different conditions. Data were collected from second-year students who had not yet taken the DMEI course and from fourth-year students who had completed the non-gamified DMEI course two years prior. Notably, this previous analysis revealed significant differences in only four of the 22 questionnaire items. Specifically, two items from the present dimension (items 13 and 14) indicated increased interest and perceived relevance of physics and chemistry, while two items from the future dimension (items 19 and 20) also showed enhanced commitment to teaching these subjects and recognizing their importance in primary education. The limited number of significant differences suggests that the non-gamified version of DMEI did not substantially alter students' retrospective perceptions or significantly impact their attitudes towards physics and chemistry.

In stark contrast, the current study, despite lacking a control group, demonstrates significant changes across 21 of the 22 items, indicating a profound impact on student motivation and attitudes when the course is gamified. This robust effect is further corroborated by the positive findings from additional items 23 and 24, which specifically inquired about the impact of *FantasyClass* on their engagement and motivation. The qualitative analysis conducted also supports these findings, with many student comments explicitly highlighting the key role *FantasyClass* played in increasing their motivation towards physics and chemistry. Consistent with previous studies with preservice primary teachers [22,23], our students, despite recognizing the importance of physics and chemistry in society, initially perceived these subjects as difficult and unmotivating. Similar challenges in engaging students with these subjects have been reported across various educational programs and settings worldwide [1,8,9]. Following the path outlined by prior experiences showing how gamification can improve these attitudes [54], the results of this study show that after completing the gamified course, students perceive physics and chemistry as more accessible, fascinating, and enjoyable. These impressions are indicators of intrinsic motivation, related to the pleasure of learning for its own sake, independent of external agents, and thus linked to high-quality meaningful learning [59].

In examining the role of structural gamification across various educational frameworks, it is insightful to first delve into research that utilized digital platforms *like FantasyClass*. Other researchers have studied *Classcraft*, a digital gamification platform similar to FantasyClass, to gamify different educational contexts [90–93]. These studies illustrate how *Classcraft* enhanced student engagement and motivation through a gamified framework that integrated educational content with role-playing game mechanics. Further exploration into non-digital structural gamification approaches brings us to the work of other researchers [87,94] who implemented gamification in science education without a specific digital tool. They used a points-based system and rankings that encouraged both competitive and collaborative dynamics among students, particularly in scientific disciplines. These studies reported significant increases in student motivation and engagement, suggesting that non-digital and traditional gamification methods remain effective in fostering educational growth. This comparison highlights the flexibility of the structural gamification approach, whether they are digitally facilitated or traditionally executed, to significantly impact student learning experiences across different educational settings and subjects.

Apart from increasing motivation, gamification also impacts learning and the development of self-efficacy. It is essential that the elements of the gamified environment align with the content to be taught. In this work, the platform's potential was always used in line with the course objectives and content. An example is the collectible cards designed to help students learn and reinforce new vocabulary. The results indicate that this element of the game contributed to an enhanced understanding and increased confidence in their teaching abilities, as reflected in the positive comments in the open-ended responses.

The self-efficacy of future teachers also appears to have significantly improved due to gamification, as reflected in both quantitative data and qualitative analysis. This perceived competence is crucial, as previous studies have shown that teacher self-efficacy is strongly correlated with teaching effectiveness and student learning outcomes [95,96]. Increasing teachers' scientific knowledge [97] and self-efficacy [16] is linked to improved attitudes and teaching methods. A motivated and more prepared teacher is more likely to invest time in teaching a subject, whereas a teacher with negative attitudes towards science is likely to spend less time teaching it [98].

The positive impact of *FantasyClass* extends beyond motivation and self-efficacy. The qualitative analysis reveals that this digital platform fostered greater cohesion and collaboration within the classroom. Collaboration is a key component of effective learning, and intragroup cooperation provided a structured framework that encouraged peer interactions [99], which has been shown to positively impact student motivation and performance [100,101]. Additionally, the platform's features, such as the ability to trade collectible cards and the cooperative monster battles, further promoted a collaborative learning environment. These elements not only enhanced social interactions but also supported cooperative problem-solving and team-based strategies, contributing to a more engaging and cohesive classroom experience.

The platform's contextualization and immersive narrative played a crucial role in changing students' perceptions of physics and chemistry. The narrative provides a rich context that increases personal relevance and fosters a greater sense of belonging, making scientific learning more memorable [102]. This emotional connection enhances intrinsic motivation [103,104] by satisfying the psychological need for relatedness, as posited by the SDT. It achieves this by offering students meaningful roles within the story, emphasizing the importance of their actions for their group's performance [60], and fostering a shared goal within the gamified environment [104], thereby enhancing their sense of social connection [105]. Moreover, providing learning paths that resonate with students' preferences and interests allows them to influence the story or game outcomes, addressing the SDT need for autonomy [105] and increasing satisfaction [106]. This approach also aligns with constructivist learning theory, emphasizing the importance of contextualizing learning to make it relevant for students [107,108].

Inter-team competition, facilitated by *FantasyClass*'s game mechanics, was also a significant factor for many students. Competition can be a powerful motivator in educational contexts, provided it remains within healthy limits [79,109,110]. In this case, inter-team competition fostered deeper engagement and increased participation in the course, consistent with the findings of other researchers [111]. Social competition generated in gamified environments must be well-designed to foster positive stress, motivating task completion without causing anxiety [112].

Gaming elements are central to gamification [60], significantly affecting student motivation by providing multiple avenues for interaction and engagement, which are particularly beneficial in educational settings [39]. Features of *FantasyClass*, such as battles, random events, and collectible cards, were frequently mentioned as student favorites. A complementary study [78] validated these findings, showing that narrative, storytelling, gold coins, random events, and leveling up were highly motivational. The progression system, allowing students to monitor their advancement through levels and compare it with peers, was impactful. This visibility likely stimulated the basic psychological needs for competence and relatedness, as posited by SDT. Seeing their progress in terms of levels and comparing it with others provided a sense of accomplishment (competence) and fostered belonging and social connection (relatedness) as peers recognized their achievements [113]. These components significantly enhanced student engagement, highlighting the platform's ability to enrich the educational experience through gamification.

Students widely appreciated the *FantasyClass* platform for creating an engaging and enjoyable learning environment, transforming the course into a favorite subject for some. However, it is essential to note that achieving these positive results is not inherent to gamification [60]. Effective implementation requires careful design; otherwise, it can be counterproductive [114]. A key factor for success is aligning gamification closely with learning objectives [115]. In this study, the structural gamification approach seems to have been appropriate, as it successfully increased students' curiosity about science, appreciation of its benefits, and awareness of its importance in solving environmental problems. Sensitizing future primary teachers to these issues is crucial so they can convey a positive view of science, as negative attitudes will likely be transmitted to their students [116].

Limitations and Future Directions

This study presents some limitations that should be considered when interpreting the results. Firstly, the absence of a control group limits the ability to attribute the observed changes exclusively to the gamification intervention. However, a mixed-method approach was used, combining quantitative and qualitative data to help determine if the increased motivation resulted from gamification. The qualitative analysis provided additional insights that support the conclusion that gamification was a key factor. Additionally, two specific items (23 and 24) were added to the post-intervention Likert questionnaire to directly inquire about the impact of *FantasyClass* on student motivation and engagement, reinforcing this perception. Including a control group in future research could provide more comprehensive insights and allow for a clearer comparison of the intervention's effectiveness. Moreover, it would be beneficial to assess the long-term impact of gamification on motivation and its applicability in different educational contexts and disciplines. Although we observed indications that the psychological needs of competence, autonomy, and relatedness could have been met, it is crucial to investigate the specific nature of the motivation perceived by students, whether intrinsic or extrinsic, to better understand the underlying motivational mechanisms. Future research could explore the impact of personalization of gamification based on variables that might affect the interest or motivation induced by different game elements of *FantasyClass*, considering that different types of players are motivated by different game elements. This would allow for the optimization of gamification to maximize its educational effectiveness.

5. Conclusions

This study highlights the substantial positive impact of structural gamification through *FantasyClass* on the motivation and attitudes of preservice primary education teachers towards physics and chemistry. The results demonstrate that the gamified approach significantly enhanced student engagement and self-perceived motivation across all dimensions examined. Key elements like the immersive narrative, collaborative aspects, and competitive mechanics of FantasyClass were crucial in transforming students' perceptions and fostering a deeper interest in scientific subjects. These findings suggest that integrating gamification in teacher education programs can effectively prepare future educators to employ innovative and engaging teaching strategies, thereby enhancing science education in primary schools.

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