

Physiotherapy education and game-based learning: developing the SPINE framework

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ABSTRACT

Innovative pedagogical approaches are increasingly essential in physiotherapy education to foster engagement and competency development. This multicenter cross-sectional study explored physiotherapy students' perceptions of game-based learning (GBL) across six Portuguese higher education institutions. A total of 208 students completed a structured questionnaire assessing attitudes toward GBL in teaching-learning contexts and competency development. Results indicated generally positive perceptions of GBL, emphasizing its value for motivation, engagement, and integration of theoretical and practical learning. Transversal competencies—such as teamwork, communication, and empathy—were consistently recognized across academic years, while perceived benefits for technical skills increased with clinical exposure. Female students and those with prior health-related experience reported more favorable attitudes. However, students also highlighted limited curricular implementation and the need for clearer alignment between game activities and learning objectives, suggesting barriers at the institutional and pedagogical levels. These insights point to a gap between students' enthusiasm and current educational practices, underlining the importance of structured guidance for integrating GBL effectively. Building on these findings, the student-perceived integration for novel education (SPINE) framework is proposed as a decision-making model to guide the pedagogically grounded GBL in physiotherapy curricula, emphasizing evidence-informed, context-sensitive, and sustainable implementation.

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1. INTRODUCTION

Educational innovation has become essential for higher education to adapt to the rapid transformations of healthcare systems and to meet contemporary social demands [1], [2]. This shift represents a paradigm change, moving away from traditional educational models, which are often passive and limit student engagement, toward more dynamic, student-centered approaches [3]. Active learning strategies, including team-based learning and the flipped classroom, have been widely adopted to foster higher-order cognitive processes such as reflection, analysis, synthesis, and evaluation, enhancing academic performance and problem-solving skills [4], [5].

Within this context, collaborative learning (CL), game-based learning (GBL), and gamification, encompassing analogue, digital, and role-play games, have gained prominence in higher education which promote social interaction, discussion, joint problem-solving, and the development of cognitive, social, emotional, and motivational competencies [3], [6]. Although GBL and gamification share the use of playful mechanisms, they differ in pedagogical scope: GBL employs complete games or structured play environments in which gameplay itself constitutes the learning process, promoting knowledge construction through active problem-solving and feedback, whereas gamification refers to the application of isolated game design elements—such as points, levels, or badges—within non-game contexts to enhance engagement and motivation [7]. Both approaches have demonstrated the improvement of students' intrinsic motivation, engagement, and satisfaction. These approaches are particularly relevant in health education, where integrating technical knowledge with transversal and socioemotional competencies is essential for preparing competent and reflective professionals [8], [9]. In physiotherapy education, students are expected to develop both technical competencies, such as assessment, diagnosis, and treatment planning, and transversal competencies, including teamwork, communication, empathy, leadership, and decision-making, which are crucial for patient-centered care and interprofessional collaboration [10]. Evidence suggests that cooperative and gamified learning strategies enhance these skills by engaging students in active, participatory educational experiences [11]. For instance, cooperative learning has been associated with improved leadership, motivation, and organizational abilities, while socio-emotional competencies such as empathy and assertiveness can be influenced by factors like gender and prior professional experience [12], [13]. By embedding gamified elements and interactive learning activities, physiotherapy programs can create authentic clinical scenarios in which students apply theoretical knowledge, practice problem-solving, and receive immediate feedback, reinforcing both technical and transversal competencies [14].

Although research has demonstrated the benefits of GBL in medical and nursing education [4], [14], studies examining its application in physiotherapy remain limited, particularly in Portugal. Moreover, there is a lack of evidence regarding how physiotherapy students perceive the utility of GBL for developing both transversal and technical competencies across different academic stages. Understanding these perceptions is critical, as learner engagement and acceptance are key determinants of successful implementation and curriculum design [4], [15].

The present multicenter study addresses this gap by examining Portuguese physiotherapy students' perceptions of GBL, with particular emphasis on its contribution to transversal and technical competencies. Additionally, the study explores potential variations in these perceptions according to academic year, gender, and prior health-related experience. By systematically investigating students' perspectives, this research aims to generate empirical evidence to support the development of a conceptual model for integrating gamified and interactive learning strategies in physiotherapy education.

2. METHOD

2.1. Study design

This was a cross-sectional descriptive study designed to investigate physiotherapy students' perspectives on the use of games in physiotherapy curricula. Participants were undergraduate students enrolled in the 1st to 4th years of physiotherapy programs across six higher education institutions in Portugal. Data were collected through a single self-administered online questionnaire that explored students' perceptions of the application of games for teaching–learning purposes, as well as their potential contribution to the development of both transversal and technical competencies in physiotherapy training. The questionnaire also gathered demographic, educational, and occupational background information to examine possible associations with students' perceptions. The study was designed and reported in accordance with the strengthening the reporting of observational studies in epidemiology (STROBE) guidelines for cross-sectional studies, adapted to the context of online questionnaire-based research. Participation was voluntary and anonymous, and informed consent was obtained electronically prior to data collection.

2.2. Participants and recruitment

Participants were undergraduate physiotherapy students (N=208) recruited from six higher education institutions across Portugal. Between March and May 2025, formal invitations to participate were sent to the course coordinators of eight physiotherapy programs, who subsequently disseminated the invitation internally to their students. Six institutions responded positively and were included in the study, representing a mix of public and private higher education institutions from different regions of the country. Eligibility criteria included current enrolment in the physiotherapy program and provision of informed consent. Students who were not actively enrolled or who declined participation were excluded. All participants completed the questionnaire once during the study period.

2.3. Measures/instruments

Data were collected through a structured questionnaire specifically developed for this study, consisting of two main parts. The first part addressed sociodemographic and educational characteristics (6 items), including age, gender, year of study, and previous academic or health-related experience. The second part assessed students' perceptions regarding the use of games (GBL) in higher education and physiotherapy practice, with items rated on a 7-point Likert scale (1=strongly disagree to 7=strongly agree). Perception items were organized into three domains: i) transversal competencies (5 items)—capturing perceived impact of games on skills such as critical thinking, communication, teamwork, and problem-solving. Example item: “using games in class helps me develop my problem-solving skills”; ii) technical competencies (5 items)—evaluating perceived usefulness of games in enhancing discipline-specific knowledge and practical skills relevant to physiotherapy. Example item: “games help me better understand physiotherapy techniques”; and iii) professional application contexts (18 items)—assessing the perceived appropriateness of using games in various physiotherapy-related settings, including case discussion, group projects, team management, private and public practice, and specific clinical areas such as neurology, pain management, musculoskeletal rehabilitation, sports, palliative care, mental health, and health education. Example item: “using games is relevant for designing interventions in adult neurology.”

The questionnaire was developed based on consultations with four experts: two physiotherapy educators and two specialists in GBL. Their input guided the formulation and refinement of items to ensure relevance, clarity, and comprehensive coverage of the domains, making the instrument suitable for the target population. The instrument was reviewed by four experts in learning innovative contexts, who reached full agreement regarding the clarity, coherence, and relevance of all items, ensuring strong content validity. A pilot test was conducted to verify the internal consistency of the scale. The internal consistency was found to be acceptable (Cronbach's $\alpha=0.73$ overall), indicating satisfactory reliability for research purposes. Further analysis demonstrated excellent internal consistency across domains, with Cronbach's α values of 0.94 for transversal competencies, 0.95 for technical competencies, and 0.97 for professional application contexts, indicating strong reliability for research purposes.

2.4. Procedure/data collection

The questionnaire was administered between March and May 2025. Course coordinators from the participating institutions were contacted and invited to disseminate the study. After agreeing to collaborate, they introduced the project to their students during classes and circulated the questionnaire link via institutional email lists. Students were able to complete the questionnaire electronically via the link provided. Participation was voluntary, responses were anonymous, and informed consent was obtained before completing the questionnaire.

2.5. Data analysis

Descriptive statistics (means, standard deviations, and frequencies) were used to characterize the sample. Group comparisons across years of study were conducted using the Kruskal–Wallis test. Differences between two groups (gender, previous course attendance, health-related experience) were examined using Mann–Whitney U tests. Correlations between age and perceptions were analyzed using Spearman's rho. Bonferroni corrections were applied for multiple comparisons in post hoc analyses to control for Type I error. All reported p-values reflect Bonferroni-adjusted significance. All analyses were conducted using IBM SPSS Statistics, version 27.0 (IBM Corp., Armonk, NY), with the significance level set at $p<0.05$.

3. RESULTS AND DISCUSSION

A total of 208 physiotherapy students were recruited from six different institutions across Portugal. The sample included 25 students from Leiria, predominantly in the third year ($n=17$); 6 students from Lisbon, distributed across the third and fourth years; 52 students from Gaia, with 30 in the second year and 22 in the fourth year; students from Porto ($n=43$), mostly in the fourth year; students from Bragança ($n=36$), evenly distributed across the first, second, and third years; and students from Algarve ($n=46$), predominantly in the first year. The sample included students from all four years of the course (1st year: $n=58$; 2nd year: $n=52$; 3rd year: $n=44$; 4th year: $n=54$). The mean age increased progressively across years, ranging from 19.17 years ($SD=3.59$) in the 1st year to 23.41 years ($SD=3.29$) in the 4th year. Gender distribution was unbalanced, with a predominance of female students in all years. The proportion of male students varied between 15.5% (3rd year: 9/44) and 48.1% (4th year: 26/54). Most students had not previously attended other courses, although a slightly higher percentage of 4th-year students reported such a background (20.4%) compared with the earlier years (ranging from 1.7% in the 3rd year to 9.6% in the 2nd year). Regarding prior experience in the health sector, the majority of students reported no previous experience. Nevertheless, experience tended to be slightly more frequent in later years (12.9% in the 2nd year and 13.0% in the 4th year), compared with

only 3.4% in the 1st year and 9.1% in the 3rd year. Table 1 presents the demographic characteristics and educational/occupational background of the physiotherapy students.

Table 1. Sociodemographic and educational characteristics

Years of physiotherapy course	Age (mean±SD)	Gender	Other courses	Previous experience in the health sector
1st (n=58)	19.17 (3.59)	22; 36	56; 2	53; 5
2nd (n=52)	20.59 (3.17)	14; 38	47; 5	45; 7
3rd (n=44)	20.45 (0.90)	9; 35	43; 1	40; 4
4th (n=54)	23.41 (3.29)	26; 28	43; 11	47; 7

Note: age- years; gender-male; female; other courses-no; yes; previous experience in the health sector-no; yes

3.1. GBL in physiotherapy education: valued by students but underutilized in curricula

Students expressed generally positive views regarding the integration of games into higher education and physiotherapy training. Their responses indicated neutral to moderately positive attitudes toward the pedagogical use of games, with mean scores ranging between 3.24 and 5.61 on a 7-point Likert scale. The highest levels of agreement were observed for the need to increase opportunities to use games in both theoretical ($M=5.32$, $SD=1.54$) and practical classes ($M=5.37$, $SD=1.60$), as well as for the perceived importance of games in health-related courses ($M=5.09$, $SD=1.58$) and within the physiotherapy degree ($M=5.03$, $SD=1.61$). This finding reflects a strong awareness among students of the potential of games to enhance learning engagement, motivation, and the integration of both cognitive and practical skills in healthcare contexts [9], [16], [17]. From a pedagogical perspective, the preference for increased game usage in both theoretical and practical settings underscores students' understanding that GBL can bridge the gap between abstract knowledge and applied clinical practice. Moreover, the perceived importance of GBL across both theoretical and practical components may reflect students' appreciation for a holistic integration of learning modalities [18], where interactive and participatory methods complement traditional lectures and clinical placements. These results align with evidence suggesting that the meaningful incorporation of games into curricula can enhance both motivation and self-efficacy, leading to improved engagement and knowledge retention in health professions education [16], [17], [19].

Conversely, lower agreement levels were reported regarding the adequacy of current game use in teaching-learning contexts ($M=3.51$, $SD=1.73$), suggesting that students consider existing opportunities insufficient. This feedback is important as it may reflect the various limitations associated with the relatively limited adoption of GBL strategies in physiotherapy education, such as limited educator training, insufficient resources, lack of alignment with curricular objectives, and time constraints [20], [21]. Recognizing these constraints provides a valuable opportunity for educators and curriculum designers to reflect on how future curricula could better integrate GBL approaches and foster practices that support the systematic adoption of these strategies, ultimately enhancing both student engagement and learning outcomes. As summarized in Table 2, these results collectively highlight students' recognition of the educational potential of games, despite limited implementation in current curricula. No statistically significant differences were observed between academic years for any of the items (all $p>0.05$).

3.2. Integrating GBL in physiotherapy: transversal skills across the curriculum, technical skills through clinical experience

Students consistently perceived GBL as a valuable approach for developing both transversal and technical competencies in physiotherapy education. Mean scores exceeded 5 on a 7-point scale across all academic years, indicating generally positive attitudes toward the educational value of games. As detailed in Table 3, students reported high and stable recognition of transversal competencies such as idea generation, leadership, empathy, communication, collaboration, and motivation, with no significant differences across academic years ($p>0.05$).

For technical competencies, patterns were more heterogeneous. After applying the Bonferroni correction, some initially significant differences were attenuated. Specifically, no significant variation was observed in clinical interview skills, whereas setting physiotherapy goals showed a marginally significant difference between first- and second-year students ($p=0.044$). Planning and treatment skills were significantly higher among second- and third-year students compared to first-year students ($p=0.023$ and $p=0.014$). Research skills were more highly rated by third-year students compared to first- and second-year peers ($p=0.047$ and $p=0.015$). Diagnostic skills showed significant increases in second-versus first-year students ($p=0.010$), fourth-versus second-year students ($p<0.001$), and fourth-versus third-year students ($p=0.036$).

Table 2. Students' perspectives on the application of games in higher education and physiotherapy training

Item	Statement	1st year (mean±SD)	2nd year (mean±SD)	3rd year (mean±SD)	4th year (mean±SD)	Total (mean±SD)	p-value
1	Analog games should be used in higher education teaching–learning contexts.	4.89±1.59	5.08±1.54	5.50±1.50	4.76±1.62	5.05±1.58	0.693
2	Digital games should be used in higher education teaching–learning contexts.	5.00±1.53	5.09±1.69	5.30±1.47	4.78±1.61	5.03±1.58	0.682
3	Performative/role-play games should be used in higher education teaching–learning contexts.	4.17±2.04	4.73±1.97	4.61±1.82	4.24±1.88	4.42±1.94	0.149
4	The current use of games in teaching–learning contexts is sufficient.	3.24±1.59	3.84±1.75	4.13±1.66	2.96±1.73	3.51±1.73	0.063
5	I would like to have more opportunities to use games in theoretical classes.	5.31±1.42	5.52±1.53	5.50±1.49	5.00±1.65	5.32±1.54	0.327
6	I would like to have more opportunities to use games in practical classes.	5.21±1.61	5.56±1.54	5.61±1.57	5.15±1.65	5.37±1.60	0.210
7	The use of games is important in health-related courses.	4.96±1.39	5.38±1.59	5.11±1.48	4.51±1.81	5.09±1.58	0.090
8	The use of games is important in the physiotherapy degree.	4.90±1.42	5.31±1.64	5.09±1.52	4.85±1.84	5.03±1.61	0.264
9	The use of games in physiotherapy training should start in the first year of the course.	4.86±1.57	5.17±1.68	5.27±1.63	4.24±1.88	4.87±1.73	0.264
10	The use of games in physiotherapy training should be implemented in discipline-specific courses.	4.76±1.45	5.09±1.62	4.75±1.56	4.61±1.83	4.80±1.62	0.193

Table 3. Perspectives of students on the application of games for training transversal and technical skills in physiotherapy classes

Domain	Item	Statement	1st year (mean±SD)	2nd year (mean±SD)	3rd year (mean±SD)	4th year (mean±SD)	Total	p-value
Transversal competencies	1	Generate ideas and foster innovation	5.59±1.43	5.87±1.51	6.02±1.23	5.80±1.48	5.80±1.42	0.122
	2	Emerge or reinforce leadership	5.14±1.63	5.17±1.61	5.50±1.47	5.24±1.73	5.25±1.61	0.912
	3	Make decisions	5.28±1.40	5.63±1.52	5.73±1.34	5.48±1.55	5.51±1.46	0.083
	4	Develop empathy	5.67±1.32	5.85±1.33	5.59±1.50	5.63±1.42	5.69±1.38	0.422
	5	Improve communication	5.90±1.21	5.79±1.47	5.77±1.43	6.02±1.27	5.88±1.33	0.972
	6	Enhance collaboration	5.93±1.14	5.98±1.34	5.95±1.20	5.98±1.32	5.96±1.24	0.512
	7	Promote motivation and enjoyment	6.16±1.06	6.27±1.17	6.14±1.25	6.00±1.73	6.14±1.21	0.292
Technical competencies for the rehabilitation cycle	8	Train assessment skills in physiotherapy	5.36±1.36	5.69±1.42	5.73±1.52	5.22±1.73	5.49±1.52	0.144
	9	Train clinical interview skills	5.02±1.72	5.65±1.47	5.66±1.36	5.07±1.56	5.33±1.57	0.044*
	10	Train skills in setting physiotherapy goals	4.87±1.55	6.04±1.39	5.70±1.42	5.13±1.65	5.24±1.58	0.023*
	11	Train planning and treatment skills	5.36±1.21	6.04±1.39	5.70±1.42	5.13±1.65	5.54±1.45	0.000**
	12	Train research skills in physiotherapy	4.62±1.62	5.63±1.58	5.27±1.62	4.79±1.93	5.06±1.73	0.000**
	13	Train diagnostic skills in physiotherapy	5.12±1.50	5.81±1.52	5.45±1.55	4.65±1.90	5.24±1.67	0.005**

Note: *p<0.05; **p<0.01

These patterns suggest that while the educational value of GBL for transversal skills is universally acknowledged, technical competencies are appreciated differentially across the curriculum, likely reflecting students' stage-specific clinical exposure and competence development. Previous quasi-experimental research with physiotherapy students in Portugal has similarly highlighted the relevance of GBL in fostering transversal competencies such as communication, collaboration, and motivation [22], [23]. It is also natural that the perceived impact of GBL on technical competencies evolves over the course of training, as students encounter different stages of clinical practice. For example, planning, treatment, and diagnostic skills were rated higher among second- and third-year students, corresponding to their initial exposure to practical clinical settings in Portuguese higher education institutions [23]. This early practical experience may also help explain why, in later years, students perceive a growing need for innovative approaches such as GBL, as they increasingly recognize a lack of an evidence-based practice culture in clinical placements—a contrast that can foster openness to novel learning strategies [24]. Collectively, these findings indicate that GBL may serve as a flexible

pedagogical tool. Students consistently value its role in developing transversal competencies throughout the curriculum, while its impact on technical skills evolves in alignment with experiential learning opportunities, emerging most strongly in intermediate stages (e.g., planning and treatment skills) and consolidating in later years (e.g., diagnostic and research skills).

3.3. Individual and educational factors shaping acceptance of GBL in physiotherapy education

Analysis of associations between students' characteristics and their perceptions of GBL revealed several relevant patterns. As summarized in Table 4, no significant correlations were found between age and students' views on the application of games in higher education or physiotherapy training, either for transversal or technical competencies (all $p > 0.05$). Gender-related differences were observed, with female students reporting significantly higher agreement regarding the early introduction of games in physiotherapy training ($p = 0.026$) and greater perceived benefits for assessment ($p = 0.027$), clinical interview ($p = 0.020$), research ($p = 0.014$), and diagnostic skills ($p = 0.044$). Specifically, the study by Padilla-Meléndez *et al.* [25] demonstrated that female students' attitudes toward playful strategies are independent of other factors, whereas in male students, the effect of playfulness is mediated by perceived usefulness. Applied to our context, this suggests that female physiotherapy students may more readily embrace GBL due to its inherent engagement and interactivity, while male students may require a clearer understanding of the pedagogical value and utility to fully appreciate its benefits. Therefore, to ensure equitable acceptance of GBL among both male and female students, it is important to explicitly communicate both the principles and the practical relevance of these strategies within physiotherapy curricula.

Students who had previously attended other higher education programs were less favorable toward performative or role-play games ($p = 0.025$) and more likely to consider current game use sufficient ($p = 0.005$), compared with those without such experience. Interestingly, research in other areas of GBL, such as language education, has shown that male students with higher prior knowledge tend to achieve better outcomes in GBL interventions [26], [27]. However, resistance among physiotherapy students may reflect the cultural and professional context of health education, where the delivery of care is perceived as a highly serious domain. Our findings mirror a paradox already described in other studies, where play and the serious act of learning coexist, yet their value and meaning are strongly context-dependent for students [28], [29].

Table 4. Individual and educational factors associated with variations in students' perspectives on GBL

Item	Group 1 (mean±SD)	Group 2 (mean±SD)	p-value
Gender	Male (n=71)	Female (n=137)	
Games should start in the first year	4.49±1.78	5.05±1.67	0.026
Train assessment skills	5.20±1.54	5.64±1.49	0.027
Train clinical interview skills	5.03±1.50	5.48±1.58	0.020
Train research skills	4.70±1.63	5.24±1.76	0.014
Train diagnostic skills	4.93±1.73	5.40±1.63	0.044
Previous higher education course	Yes (n=19)	No (n=189)	
Performative/role-play games should be used	3.47±1.95	4.52±1.91	0.025
Current use of games is sufficient	2.47±1.50	3.61±1.72	0.005
Previous health-related training	Yes (n=23)	No (n=185)	
Games are important in a physiotherapy degree	5.52±1.93	4.97±1.56	0.043

Additionally, students with prior health-related training rated the importance of games within the physiotherapy curriculum significantly higher than peers without similar backgrounds ($p = 0.043$). These observations suggest that, in health-related programs, the introduction of GBL may benefit from carefully selecting game types with lower playful or performative intensity, such as collaborative or competitive formats, while avoiding complex role-play or simulation games that may not align with students' professional expectations [30]. When teaching health content with games, two objectives must be clearly communicated: the rules or gameplay, which define how the player interacts with the game, and the challenges, which reward successful actions and create obstacles that prevent immediate success. Achieving clarity on both components is particularly challenging in performative or role-playing games, potentially limiting their perceived educational value in serious professional training contexts.

This study presents some limitations that should be considered in light of their implications for educational practice. First, its cross-sectional design does not allow causal inferences between student characteristics and perceptions of GBL; however, it provided a valuable snapshot of associations across a broad and diverse physiotherapy student population, offering insights that can inform curriculum development and pedagogical planning. Second, data were collected via self-administered questionnaires, which may be influenced by social desirability bias or variable interpretations; nonetheless, this method facilitated the inclusion of a larger and more representative sample across multiple regions of Portugal, supporting the identification of trends relevant for higher education strategies.

Future research could build on these findings to guide the design and implementation of more effective GBL strategies in physiotherapy education. Longitudinal or mixed-method studies would allow for an understanding of how students' perceptions evolve throughout their training and early professional practice, informing the timing and sequencing of GBL interventions. Observational or experimental studies could evaluate how GBL directly impacts the development of transversal and technical competencies, including clinical reasoning and patient-centered skills, thereby providing evidence to refine curricular integration. Comparative studies across health professions and international contexts could illuminate how educational structures and cultural factors influence the effectiveness of game-based pedagogies. Furthermore, qualitative investigations of educator perspectives and implementation processes could identify practical enablers and barriers, offering actionable insights for sustainable adoption and optimization of GBL approaches in higher education curricula.

3.4. The SPINE framework: a student-informed model for integrating GBL in physiotherapy education

Drawing on the empirical findings of this study, the student-perceived integration for novel education (SPINE) framework is proposed as a decision-making model to guide the pedagogically grounded and context-sensitive integration of GBL within physiotherapy curricula, as shown in Figure 1. This framework acknowledges that the effective implementation of GBL depends not only on pedagogical design but also on learner perceptions, contextual constraints, and institutional readiness. The model is structured around five interrelated dimensions:

- Student needs and perceptions (S)—supported by students' strong agreement on the value of increasing GBL opportunities in both theoretical and practical classes ($M=5.32$ and $M=5.37$, respectively), highlighting motivation and perceived relevance as key drivers.
- Pedagogical alignment and playfulness (P)—informed by findings that collaborative and competitive games were more acceptable than performative or role-play formats, suggesting that game typology must align with professional authenticity and course objectives.
- Individual factors (I)—derived from gender-related differences and prior educational experience; for instance, female students rated GBL higher for assessment and diagnostic skills, while students with prior higher education showed less interest in role-play games.
- Negotiation and iteration (N)—reflected in students' neutral views on the adequacy of current GBL use ($M=3.51$), which emphasize the need for ongoing dialogue between educators and learners to iteratively refine GBL implementation and ensure responsiveness to feedback.
- Environmental and institutional support (E)—emerging from the recognition of underutilization of games in current curricula, pointing to the importance of faculty training, infrastructure, and curricular alignment for sustainable integration.

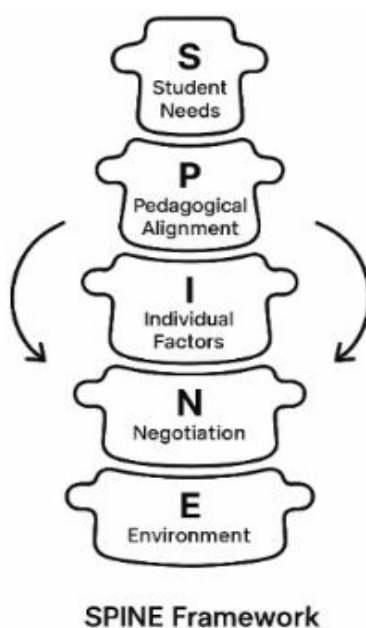


Figure 1. Conceptual representation of the SPINE framework

Collectively, the SPINE framework provides a theoretically grounded yet empirically informed structure to guide educators and curriculum designers in embedding GBL in physiotherapy education, fostering meaningful learning experiences that integrate cognitive, affective, and professional dimensions of competence. The framework in Figure 1 is visually depicted as a spinal column, where each vertebra represents one of the five interdependent dimensions: student needs (S), pedagogical alignment (P), individual factors (I), negotiation (N), and environment (E). The structure conveys the idea of alignment, support, and adaptive feedback essential for sustainable GBL integration in physiotherapy curricula.

4. CONCLUSION

This study confirmed that, as anticipated in the introduction, physiotherapy students recognize the educational value of GBL for both transversal and technical competencies. Students consistently valued GBL for enhancing transversal skills across all years, while perceived benefits for technical competencies evolved with clinical exposure, particularly in intermediate stages of training. Gender and prior educational or health-related experience were also shown to influence students' perceptions, highlighting the need for tailored strategies to ensure equitable acceptance and effective integration. These findings support the deliberate incorporation of GBL into physiotherapy curricula, with careful consideration of game types, learning objectives, and practical relevance. Drawing on these empirical insights, the SPINE framework was developed as a student-informed model to guide the pedagogically grounded and context-sensitive integration of GBL within physiotherapy curricula. The framework synthesizes key factors, including student needs, pedagogical alignment, individual differences, iterative feedback, and environmental support, providing actionable guidance for educators and curriculum designers. These findings demonstrate that GBL can be a flexible and effective pedagogical tool, with the SPINE framework offering a structured approach to optimize curriculum design and learning experiences. Future research should explore longitudinal impacts of GBL on competence acquisition, investigate educator perspectives, and examine cross-cultural applications to further refine the framework.

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M : **M**ethodology

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Vi : **V**isualization

Su : **S**upervision

P : **P**roject administration

Fu : **F**unding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known financial or personal conflicts of interest that could have influenced the work reported in this paper.

INFORMED CONSENT

All participants were informed about the objectives and procedures of the study and provided written informed consent prior to participation.

ETHICAL APPROVAL

The study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of the Polytechnic Institute of Leiria-CE/IPLEIRIA/53/2025.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [MCNR], upon reasonable request. Restrictions apply to protect the privacy of research participants.

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