

Integrating digital resources and laboratory-based learning in undergraduate physiotherapy education: a repeated cross-sectional study.

Integración de recursos digitales y aprendizaje basado en el laboratorio en la formación universitaria en fisioterapia: un estudio transversal repetido.

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Abstract.

Background: Physiotherapy education combines theoretical instruction with practical training, and evidence supports the integration of digital learning and laboratory-based experiences. The flipped classroom has gained prominence in health professions education, demonstrating positive effects on student engagement and academic outcomes. However, little is known about the integration of this methodology within motion analysis laboratories in physiotherapy curricula. **Objective:** To evaluate the implementation of an educational innovation project integrating digital resources, flipped classroom methodology, and laboratory-based gait analysis sessions within a fourth-year physiotherapy course. **Methods:** A longitudinal observational study was conducted with physiotherapy students at Rey Juan Carlos University (Spain) between 2020–2021 and 2024–2025. The intervention included digital learning resources (podcasts and videos), flipped classroom seminars, and a gait analysis workshop using a motion capture system. Academic performance was assessed through multiple-choice examinations. Student satisfaction with digital resources, methodology, and practical seminars was evaluated using Likert-type questionnaires. Welch's ANOVA was used to compare cohorts. **Results:** A total of 549 students were included in the performance analysis and 188 in the satisfaction survey. Academic outcomes improved during the years in which the project was implemented, with increased rates of distinction and outstanding grades and reduced fail rates. The year without the intervention showed the poorest performance. Student satisfaction was high, with strong ratings for methodology, teaching staff, facilities, and seminar usefulness. Podcasts and the laboratory seminar received excellent evaluations. **Conclusions:** The integration of digital tools,

flipped classroom strategies, and laboratory-based learning enhances student satisfaction and academic performance in physiotherapy education, strengthening the link between theory and clinical practice.

Keywords: active learning, flipped classroom, gait analysis, physiotherapy education.

Resumen.

Antecedentes: La formación en fisioterapia combina la instrucción teórica con la práctica, y la evidencia respalda la integración del aprendizaje digital y las experiencias de laboratorio. El aula invertida ha ganado prominencia en la educación de las profesiones de la salud, demostrando efectos positivos en la participación estudiantil y los resultados académicos. Sin embargo, se sabe poco sobre la integración de esta metodología en los laboratorios de análisis de movimiento en los planes de estudio de fisioterapia. **Objetivo:** Evaluar la implementación de un proyecto de innovación educativa que integra recursos digitales, metodología de aula invertida y sesiones de análisis de la marcha en laboratorio dentro de un curso de fisioterapia de cuarto año. **Métodos:** Se realizó un estudio observacional longitudinal con estudiantes de fisioterapia de la Universidad Rey Juan Carlos (España) entre 2020-2021 y 2024-2025. La intervención incluyó recursos de aprendizaje digital (podcasts y videos), seminarios de aula invertida y un taller de análisis de la marcha utilizando un sistema de captura de movimiento. El rendimiento académico se evaluó mediante exámenes de opción múltiple. La satisfacción de los estudiantes con los recursos digitales, la metodología y los seminarios prácticos se evaluó mediante cuestionarios tipo Likert. Se utilizó el ANOVA de Welch para comparar las cohortes. **Resultados:** Se incluyeron 549 estudiantes en el análisis de rendimiento y 188 en la encuesta de satisfacción. Los resultados académicos mejoraron durante los años en que se implementó el proyecto, con mayores tasas de calificaciones sobresalientes y una menor tasa de reprobación. El año sin la intervención mostró el peor desempeño. La satisfacción estudiantil fue alta, con excelentes calificaciones para la metodología, el personal docente, las instalaciones y la utilidad de los seminarios. Los podcasts y el seminario de laboratorio recibieron evaluaciones excelentes. **Conclusiones:** La integración de herramientas digitales, estrategias de aula invertida y aprendizaje basado en laboratorio mejora la satisfacción estudiantil y el rendimiento académico en la formación en fisioterapia, fortaleciendo el vínculo entre la teoría y la práctica clínica.

Palabras clave: aprendizaje activo, aula invertida, análisis de la marcha, educación en fisioterapia.

1. Introduction

The curriculum of a physiotherapy degree typically combines theoretical instruction—delivered at universities and in laboratory settings—with practical training, which usually takes place in hospitals and healthcare centers (1). For physiotherapists to be effectively integrated into healthcare systems, their clinical education must be grounded in evidence-based practice (EBP) and include hands-on experience in real, not simulated, clinical environments. These environments may include not only hospitals and health centers but also research laboratories and scientific facilities. Fostering scientific curiosity among physiotherapy students is essential to instill a lifelong commitment to learning and continuous knowledge updating.

In this context, educational strategies that integrate active learning methodologies—such as the flipped classroom—with student engagement in research laboratories may offer significant benefits (1-2). This pedagogical approach was inspired by previous implementations in physiotherapy education, such as the work by Røe et al. (1), which demonstrated improved student performance and engagement through a flipped classroom model that combined 12 hours of video lectures and digital learning resources with seven full-day group seminars, compared with conventional teaching methods. These findings support the use of digital content for pre-class preparation and

collaborative, problem-based learning during in-class activities, fostering higher-order cognitive skills and student autonomy. The review by Ramnanan et al. (3) on learner perceptions of flipped classrooms in health professions education reported an overwhelmingly positive student response, with high levels of satisfaction regarding pre-class video lectures. However, although a favorable student perception of this methodology has been described, early evidence suggested that positive perceptions alone did not necessarily translate into significant improvements in learning outcomes (4-5). Addressing this gap, Hew et al. (6) conducted a meta-analysis of 28 comparative studies and demonstrated a significant overall effect in favor of flipped classrooms compared with traditional teaching approaches in health professions education.

Despite the potential of such approaches, educational interventions that combine digital tools, active learning methodologies, and demonstrations in research laboratories remain underexplored in physiotherapy education. Most existing studies have focused on experimental demonstrations within simulated clinical scenarios or traditional clinical settings. For instance, De la Casa Almeida, et al. (7) implemented an innovative teaching experience in mesotherapy practice classes at the University of Sevilla (Spain), employing active learning strategies such as concept maps, guided questions, multimedia resources, and technology-supported collaborative activities. The effectiveness of this intervention was assessed using a pretest–posttest design. In parallel, other authors (8) emphasized that clinical education in physiotherapy constitutes a multidimensional learning environment shaped by workplace dynamics, professional engagement, supervisor guidance, and students' dispositions. Furthermore, other studies (9-10) examined the integration of EBP into physiotherapy curricula, highlighting its positive influence on students' knowledge, skills, and clinical behaviors from entry-level training through graduation. From a theoretical perspective, this educational approach can be framed within constructivist learning theories, which emphasize the active role of learners in constructing knowledge through experience and interaction. In particular, the flipped classroom model aligns with principles of self-regulated learning, as it encourages students to engage with content independently prior to class and to take responsibility for their learning process. Furthermore, the incorporation of laboratory-based activities reflects the principles of situated learning, whereby knowledge is developed through participation in authentic contexts that resemble real professional environments. Together, these perspectives support the integration of active, student-centered, and context-based learning strategies in physiotherapy education (2, 8, 11-12).

Taken together, these studies underscore the importance of innovative, evidence-based, and student-centered approaches in physiotherapy education. However, further research is needed to evaluate the effectiveness of combining digital learning, active methodologies, and real-world laboratory experiences in fostering clinical and scientific competencies among physiotherapy students. In response to this gap, the present study aimed to evaluate an educational intervention consisting of a course on gait disorders in individuals with neurological conditions and older adults. The course integrated digital learning resources within a flipped classroom approach theory-practice seminars conducted in a motion analysis laboratory, and theoretical classes grounded in EBP principles.

2. Methods

2.1 Study Design and context

A longitudinal observational study was conducted to evaluate the impact of a teaching innovation project on students' academic performance and satisfaction across multiple academic years. The analysis covered five consecutive academic years (2020–2021 to 2024–2025), enabling comparisons between the periods in which the innovation project was actively implemented and the academic year in which it was not applied (2022–2023). The study population consisted of fourth-year Physiotherapy students at Rey Juan Carlos University (Spain) enrolled in the compulsory subject Physiotherapy in Clinical Specialties: Neurological, Cardiorespiratory, and Vascular. This subject is

taught during the second semester of the final year of the Physiotherapy degree and comprises 6 European Credit Transfer and Accumulation System (ECTS) credits, including 4 theoretical and 2 practical credits. All students enrolled in the subject during the study period were included in the analysis; therefore, no exclusion criteria were applied, and no participants were excluded. The curriculum includes several seminars covering diverse clinical areas; however, the seminar analyzed in this study is the only one delivered within the framework of a teaching innovation project. Ethical approval was obtained from the local research ethics committee (internal registration number: 271220250212026).

2.2 Educational Intervention

The intervention consisted of a seminar on gait disorders in older adults and individuals with neurological conditions. It was designed following a flipped classroom model, combining digital learning resources, theoretical-practical seminars, and evidence-based theoretical instruction.

The intervention was structured according to a flipped classroom model and implemented in two sequential phases. Initially, students engaged in pre-class preparation through digital learning resources, which introduced key theoretical concepts. This was followed by in-class theoretical-practical sessions, where students worked collaboratively to discuss and apply the previously acquired knowledge under instructor guidance.

Subsequently, a practical workshop seminar was conducted in a motion analysis laboratory, allowing students to apply theoretical concepts in a real-world context. This progression from individual preparation to collaborative learning and, finally, to practical application was designed to promote active learning, critical thinking, and the integration of theoretical and clinical knowledge.

2.3 Flipped Classroom Approach

Students accessed digital content prior to in-class activities, including six podcast episodes covering key topics. The course was delivered in April and included:

1. Theoretical-Practical Sessions (6 hours): conducted over one week in three 50-minute sessions. Students worked in small groups (7–8 participants) to discuss preloaded materials (PowerPoint slides and podcasts from the MOVEDUCA channel on Spotify®). The instructor guided discussions, facilitating critical reflection and reinforcing key concepts.
2. Practical Workshop-Seminar (2 hours): held at the Laboratory of Movement Analysis, Biomechanics, Ergonomics, and Motor Control (LAMBECOM), Faculty of Health Sciences, URJC. Students applied reflective markers to a peer, recorded gait trials, and analyzed biomechanical data using the Vicon® Vero 2.2® motion capture system (8 cameras, 330 Hz) synchronized with three AMTI® force platforms (1000 Hz) via Vicon Nexus® 2.15 software. The Lower-Body Plug-in Gait model was used for data processing and interpretation.

This hands-on experience allowed students to observe gait abnormalities and link them to theoretical content, enhancing clinical reasoning and application.

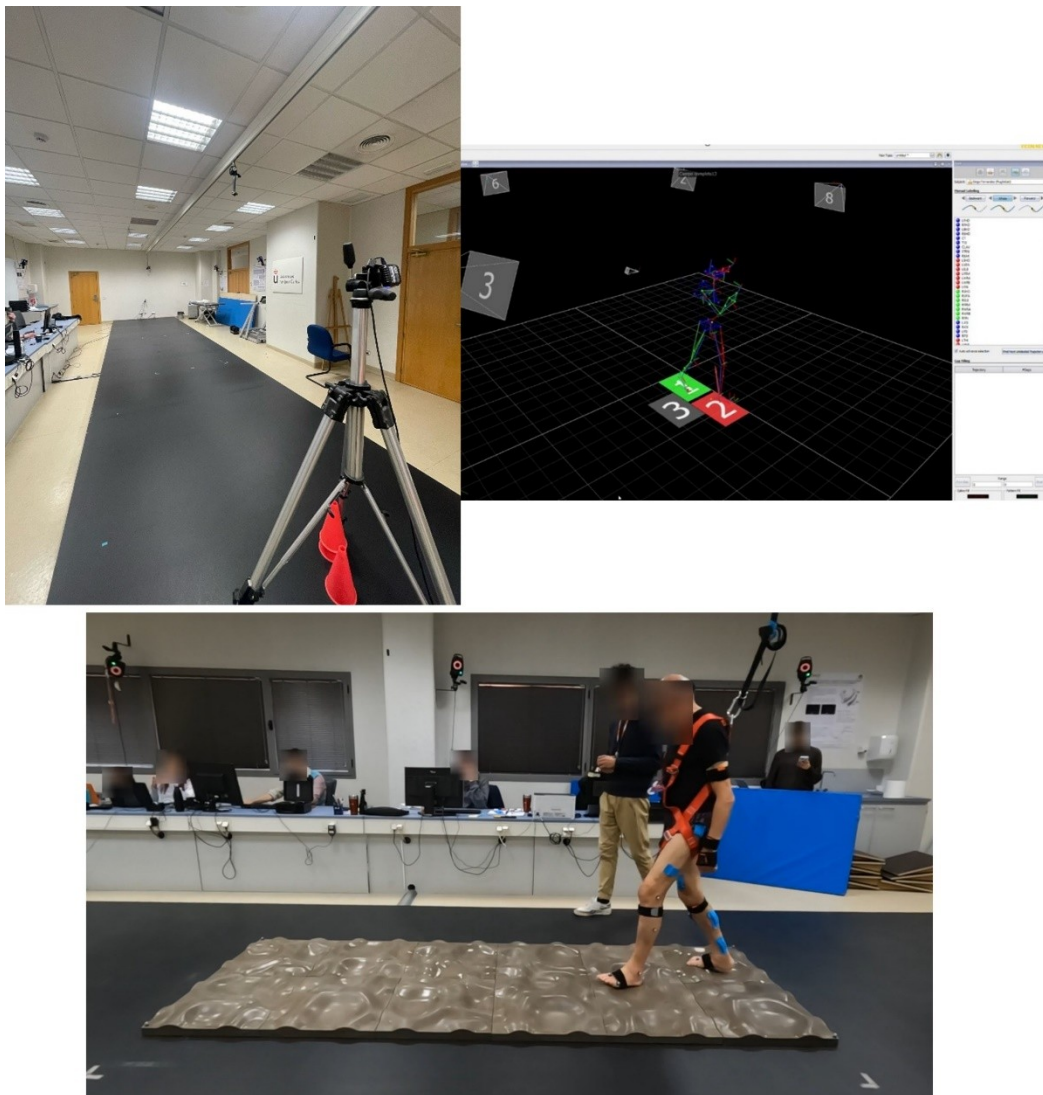


Figure 1. LAMBECOM setup, Vicon Nexus interface, and subject walking on uneven terrain. These tests allow students to observe a motion analysis assessment and examine, through the system's interface, the parameters and clinical findings obtained.

2.4 Content and Structure

Course content focuses on gait analysis in neurological and elderly populations. All assessments and therapeutic strategies were evidence-based. Podcast topics included: Gait in Parkinson's disease; Gait in aquatic environments; Gait in multiple sclerosis; Exercise in stroke; Gait in children with hypotonia; and Gait in older adults (all podcast materials are accessible as detailed in Availability of data and materials). An overview of PowerPoint content is provided in table 1.

Table 1. Overview of course content and structure.

Main Topic	Description
Gait Cycle Phases	Detailed breakdown of stance and swing phases, highlighting their functional and muscular roles.
Gait Biomechanics	Analysis of stability, progression, propulsion, and energy efficiency; identification of key muscle groups involved.
3D Motion Analysis Systems	Use of infrared cameras, force platforms, and surface EMG to assess biomechanical variables (spatiotemporal, kinematic, kinetic, and muscular).
Clinical Gait Patterns	Characterization of gait in neurological conditions: hemiparetic, ataxic, parkinsonian, apraxic, cerebral palsy, multiple sclerosis, hypotonia.
Functional Gait Assessments	Evidence-based tests: TUG, L-Test, 6MWT, 10MWT, 25-Foot Walk Test, Narrow Path Test, Figure of Eight Walk Test; use of Borg scales and gait speed.
Therapeutic Interventions	Motor learning strategies (repetition, instruction, reinforcement, sensorimotor calibration); aquatic therapy, obstacle training, strength programs.
Evidence-Based Practice	All assessments and interventions are grounded in scientific evidence within the field of physiotherapy.

Abbreviations: 6MWT, 6-Minute Walk Test; 10MWT, 10-Meter Walk Test; 25-Foot Walk Test; EMG, electromyography; L-Test, L-shaped walk test; TUG, Timed Up and Go.

2.5 Evaluation and data analysis

Learning outcomes were evaluated by calculating the percentage of students who successfully completed the subject assessment, which consisted of a multiple-choice examination administered at the end of the semester in May. The exam included specific questions related to the teaching innovation seminar analyzed in this study but also incorporated items covering the remaining seminars and theoretical content of the subject, as it served as a global assessment of the entire course. The exam included questions covering both the theoretical and practical components of the teaching innovation project. In addition, attendance and active participation in the practical laboratory seminar were recorded and considered. These aspects were documented using a checklist completed by the teaching staff. Active participation was defined as students' involvement in the movement analysis process and their ability to provide appropriate responses to oral questions posed by the instructors, aimed at linking theoretical concepts with practical activities.

Students' perceptions related to digital resources, methodology and practical seminars were assessed via an anonymous Microsoft Forms® questionnaire. For the satisfaction assessment, participation was voluntary. Responses were collected anonymously, and no incentives were provided. The survey included Likert-type items (0 = not satisfied to 5 = very satisfied) evaluating: methodology and teaching approach, instructor performance, interest in content, facilities and time distribution, clarity of explanations, knowledge acquisition and clinical relevance, and overall organization. In 2025, three additional items were added: evaluation of the podcasts, willingness to retain the seminar in future editions, and overall seminar rating. The questionnaire design was based on previous studies in physiotherapy education (13-15).

Students' responses were summarized as mean (SD) by cohort, with item-specific sample sizes reported in table 2. Between-cohort differences across the four editions (corresponding to four independent student cohorts assessed in different academic years) were tested using Welch's one-way ANOVA (robust to unequal variances), with a two-sided $\alpha = 0.05$. Satisfaction scores were derived from Likert-type items and treated as continuous variables due to their aggregated nature.

Model assumptions were evaluated, and residuals showed an approximately normal distribution. Therefore, the use of Welch’s ANOVA was considered appropriate given its robustness to heteroscedasticity and moderate deviations from normality.

3. Results

All enrolled students were included in the academic performance analysis, resulting in a total sample of 549 students. Table 2 summarizes the total number of students per academic year and the percentage distribution of grades. The academic year 2022–2023, in which the innovation project was not implemented, presented the least favorable performance profile, characterized by: 1) The absence of outstanding grades (0%); 2) The highest combined percentage of fail and non-attendance (15.5%); 3) A shift from higher grades (distinction) towards lower passing grades. Following the reintroduction of the project, academic outcomes improved again in 2023–2024 and reached their best overall values in 2024–2025, with: 1) The highest proportion of distinction grades (64.6%); The lowest percentage of failing grades (5.2%); and 3) The highest overall pass rate (94.8%).

Table 2. Number of students and grade distribution by academic year.

Year	N	Honors %	Outstanding %	Merit %	Pass %	Fail %	Non-attendance (NP) %	Fail and non-attendance %	Survey respondents %*
20–21	117	0.0	4.3	54.7	30.8	9.4	0.9	10.3	18.8
21–22	126	0.8	4.8	47.6	19.0	12.7	1.6	14.3	40.5
22–23*	97	1.0	0.0	54.6	27.8	13.4	2.1	15.5	—
23–24	113	0.9	1.8	54.9	26.5	13.3	0.9	14.2	50.4
24–25	96	1.0	2.1	64.6	26.0	5.2	3.1	8.3	60.4

*Percentage of students who voluntarily completed the satisfaction questionnaire.+, no project.

In addition to academic performance, students’ satisfaction with the teaching innovation project was assessed through a voluntary questionnaire administered across several academic years. A total of 188 students from four cohorts completed the survey: 2021 (n = 22), 2022 (n = 51), 2024 (n = 57), and 2025 (n = 58). Participation in the satisfaction survey increased progressively over time, representing a growing proportion of enrolled students. This increase may reflect greater student engagement and interest in providing feedback as the innovation project became more established. Overall, the results indicate a positive evolution in students’ perceptions of the teaching methodology across the years. Descriptively (table 3), methodology improved over time, from a mean of 4.52 in 2021 to 4.91 in 2025.

Teaching staff ratings were consistently very high and rose from 4.71 (2021) to 4.97 (2025). Interest in content remained high, peaking at 4.82 in 2024 and stabilizing at 4.79 in 2025. Facilities dipped in 2022 (4.47) but recovered to 4.84 in 2024 and 4.86 in 2025. Time distribution showed the largest descriptive gain, from 4.14 (2021) to 4.66 (2025). Clarity of explanations increased from 4.57 (2021) to 4.95 (2025), consistent with the significant omnibus test. Knowledge acquired and clinical usefulness showed modest increases across cohorts (from 4.40 in 2021 to 4.62 in 2025). Finally, Organization remained high throughout, rising from 4.71 (2021) to 4.86 (2025) (figure 2).

Across all cohorts and items, mean ratings were high (all items mean ≥ 4.1). Welch’s ANOVA detected a significant difference among cohorts only for Clarity of explanations ($F = 2.768, p = 0.049$). Facilities approached significance ($F = 2.636, p = 0.056$), whereas no significant difference between cohort differences were observed for methodology, teaching staff, interest in content, time distribution, knowledge acquired and clinical usefulness, or organization (all $p > 0.05$; see table 4). The new questions introduced in 2025 reflected a high acceptance of the digital resources and

practical seminar: the podcast was rated 4.79 (0.64), the question on whether to keep the seminar scored 4.96 (0.20), and the overall seminar rating was 4.82 (0.39).

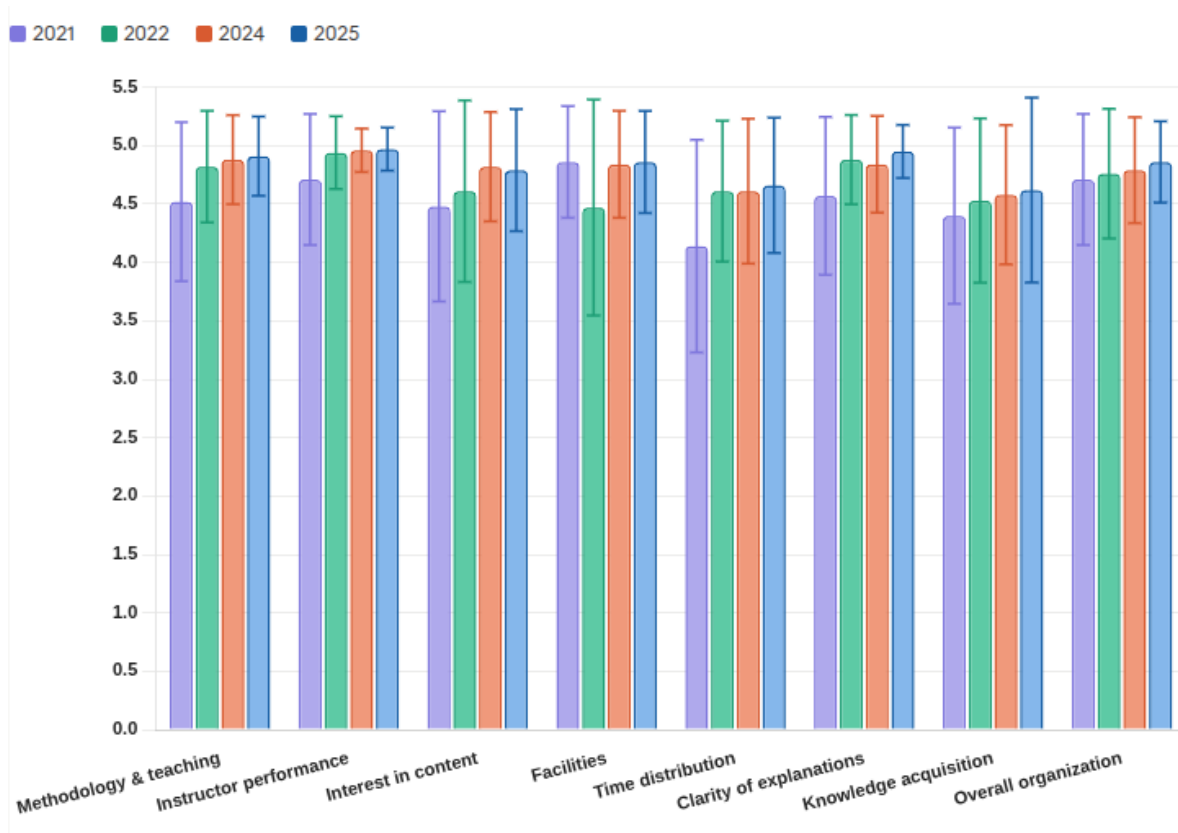


Figure 2. Mean (95% CI) ratings of course evaluation items across editions (2021–2025).

Table 3. Descriptive statistics and item-specific sample sizes for students’ ratings by cohort.

Items	Edition	Mean	SD
Methodology and teaching approach	2021	4.52	0.680
	2022	4.82	0.478
	2024	4.88	0.381
	2025	4.91	0.339
Instructor performance	2021	4.71	0.561
	2022	4.94	0.311
	2024	4.96	0.186
	2025	4.97	0.184
Interest in content	2021	4.48	0.814
	2022	4.61	0.777
	2024	4.82	0.468
	2025	4.79	0.522
Facilities	2021	4.86	0.478
	2022	4.47	0.924
	2024	4.84	0.458
	2025	4.86	0.437
Time distribution	2021	4.14	0.910
	2022	4.61	0.603
	2024	4.61	0.620
	2025	4.66	0.579

Clarity of explanations	2021	4.57	0.676
	2022	4.88	0.382
	2024	4.84	0.414
	2025	4.95	0.227
Knowledge acquisition and clinical relevance	2021	4.40	0.754
	2022	4.53	0.703
	2024	4.58	0.596
	2025	4.62	0.791
Overall organization	2021	4.71	0.561
	2022	4.76	0.555
	2024	4.79	0.453
	2025	4.86	0.348

Table 4. One-Factor ANOVA (Welch).

Items	F	p
Methodology and teaching approach	2.261	0.089
Instructor performance	1.403	0.250
Interest in content	1.905	0.137
Facilities	2.636	0.056
Time distribution	1.917	0.135
Clarity of explanations	2.768	0.049
Knowledge acquisition and clinical relevance	0.457	0.713
Overall organization	0.789	0.504

4. Discussion

Overall, academic performance shows an improvement in years with active implementation of the innovation project, particularly after its consolidation over time. The proportion of students achieving high grades (merit/very good, outstanding and honors) increased progressively while the percentage of failing grades and non-attendance decreased.

These results suggest a positive and cumulative effect of the teaching innovation project on students' academic performance. The temporary decline observed during the year without the project reinforces the hypothesis that the innovation strategy contributes meaningfully to improved learning outcomes. Also, the results of this educational innovation project show a progressive improvement in students' perceptions across the editions of the course. The steady increase in ratings for methodology, teaching staff, and clarity of explanations reflects both the refinement of the educational design and the growing familiarity of students with blended and technology-enhanced learning environments. In addition, all students who participated in the teaching innovation project showed active participation during the practical workshop seminar.

Similar to the experiences described by Røe et al. (1) and De la Casa Almeida, et al. (7) our intervention confirms that combining digital materials within a flipped classroom approach with face-to-face, problem-oriented activities enhances engagement and perceived learning quality. The use of podcasts appears to facilitate self-paced learning and allows students to revisit complex content before practical sessions, which may explain the improvement observed in clarity and time distribution scores. This finding is consistent with the theory of self-regulated learning (16) which posits that students who actively manage their learning—by setting goals, monitoring their understanding, and reflecting on their performance—develop greater control over their learning processes and strategies that optimize their performance in hybrid learning environments. This is

supported by recent research in allied health education showing that podcasts provide appreciated flexibility, enhance engagement, and, when integrated into blended or flipped learning models, allow students to control their own learning pace (17-18). When students are asked about positive perception of using digital learning resources over traditional classrooms, their explication is having unrestricted access to them before class what enables students to learn anywhere and at any time, at their own pace (6). These findings can be interpreted within a broader constructivist framework, in which students actively construct knowledge through engagement with both digital and experiential learning environments.

The enhancements introduced in 2024–2025, such as reducing group size and improving access to laboratory sessions, likely promoted more individualized feedback and active participation, key elements in student-centered learning (2, 11). The high ratings for facilities and seminar usefulness highlight the value of exposing students to real research environments. Practicing in a motion analysis laboratory provides students with authentic research-oriented experience, in contrast to simulated clinical settings, fostering scientific curiosity and early engagement with evidence-based research. From the perspective of situated learning (19), this type of experience promotes knowledge construction through participation in real professional contexts, where students progressively integrate into a community of practice and develop competencies linked to their future professional identity. This aligns with the literature on research-based learning, which suggests that involving students in authentic investigative contexts enhances conceptual understanding, analytical skills, and motivation (20-21). Clinical practice is a fundamental component of undergraduate physiotherapy education, enabling students to acquire critical clinical skills, physiotherapy knowledge, and interpersonal communication abilities serving as an indispensable stage for bridging theoretical knowledge with real-world healthcare settings.

From an international perspective, this educational model may be transferable to other higher education settings, particularly using flipped classroom strategies, digital resources, and laboratory-based learning. However, its implementation requires consideration of institutional factors such as curriculum structure, technological infrastructure, and faculty training. In particular, the incorporation of laboratory-based sessions, such as gait analysis, may depend on access to specialized equipment, technical support, and dedicated facilities, which may not be available in all institutions. In such contexts, alternative approaches, such as simulation-based activities or simplified motion analysis tools, could be considered to achieve similar educational objectives. Furthermore, the development of digital materials requires an initial investment of time and institutional support, although these resources can be reused and adapted across academic years.

Although perceived clinical applicability improved more modestly, this points to the need for stronger integration between biomechanical concepts and clinical decision-making. Overall, the results support that integrating digital tools and active methodologies within authentic learning contexts enhances student satisfaction and engagement, while promoting competencies aligned with EBP. Finally, these considerations highlight the importance of institutional support to ensure the effective implementation of digitally enhanced and active learning methodologies, particularly in terms of economic, organizational, and technological resources (5).

Limitations

This study presents several limitations that should be considered when interpreting the findings. First, the absence of a robust control group prevents establishing a causal relationship between the educational intervention and the improvements observed in academic performance. Although comparisons were made with an academic year in which the project was not implemented, these comparisons should be interpreted with caution, as differences may be influenced by other curricular or contextual factors. The subject includes multiple seminars and theoretical contents delivered

throughout the semester, and the gait-related seminar presented here is the only one formally embedded within a teaching innovation project. Consequently, the improvements attributed to the intervention should be interpreted as indirect and potentially influenced by the broader educational context.

Second, the evaluation of student satisfaction relied on self-reported Likert-type questionnaires, which may be subject to response bias. While these measures provide valuable insights into students' perceptions of the methodology, they do not constitute a direct indicator of learning outcomes, skill acquisition, or clinical competence.

Additionally, the study was conducted within a single subject, degree program, and institution, focusing on a specific seminar within the broader curriculum. This context-specific design may limit the transferability of the findings to other educational settings, particularly in the absence of institutional and curricular conditions.

Finally, although the intervention was grounded in evidence-based physiotherapy and informed by previous research (e.g., Røe et al. (1)), its long-term impact on students' clinical reasoning, autonomy, or professional practice remains unknown. Future research should incorporate objective performance measures, longitudinal follow-up, and comparisons with conventional teaching formats to strengthen the evidence base and clarify the specific contribution of each component of the course.

5. Conclusions

- This teaching innovation experience, implemented within an undergraduate physiotherapy program, suggests that the integration of accessible digital learning resources, flipped classroom strategies, and active student participation in a motion analysis laboratory may support the learning of course-specific content closely related to professional practice.
- Although the impact of the intervention was assessed through indirect and subjective measures, primarily based on student satisfaction instruments, the sustained implementation of the teaching innovation project coincided with an improvement in academic performance over consecutive academic years. It should be noted, however, that this improvement may also be influenced by other complementary teaching activities conducted within the subject.
- The findings indicate that the combination of digital learning resources (including podcasts), flipped classroom methodologies, and hands-on laboratory-based gait analysis is associated with high levels of student satisfaction. However, due to the multifactorial nature of the intervention, the specific contribution of each component cannot be isolated or quantified.

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Declaration of conflict of interest: The authors declare that they have no conflict of interest.

Availability of data and materials: The datasets used and analysed during the current study are available from the corresponding author on reasonable request. The podcast episode used in this study can be listened at <https://open.spotify.com/show/66CjXI6PFAHWAbvc4gPw8?si=962bb86c653f4880>. Collaboration can be accessed by contacting francisco.molina@urjc.es

Ethical approval: This study was approved by the Research Ethics Committee of Rey Juan Carlos University (internal registration number: 271220250212026).

Author contributions: FMR: Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. ACG: Methodology, Resources, Writing – review & editing. ÁAR: Data curation, Writing – review & editing. DFV: Methodology, Resources, Writing – review & editing. DPC: Data curation, Writing – review & editing. IMAD: Methodology, Resources, Writing – review & editing. JGR: Methodology, Resources, Writing – review & editing. MCT: Methodology, Resources, Writing – review &

editing. MMMC: Methodology, Writing – review & editing. PFG: Methodology, Resources, Writing – review & editing. RCdIC: Methodology, Resources, Writing – review & editing. VNL: Methodology, Data curation, Formal analysis, Resources, Writing – review & editing.

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