

Article

Impact of Peer-Assisted Learning in Histology and Embryology of a Medical Course: A Mixed-Methods Study

Rita Abreu Russo ¹, Bruno Daniel Carneiro ^{1,2} and Isaura Tavares ^{1,3,*}

¹ Unit of Experimental Biology, Department of Biomedicine, Faculty of Medicine, University of Porto, 4200-319 Porto, Portugal; up202007395@up.pt (R.A.R.); bcarneiro@med.up.pt (B.D.C.)

² Rheumatology Service, Unidade Local de Saúde do Alto Minho, Hospital Conde de Bertiandos, 4990-078 Ponte de Lima, Portugal

³ Institute for Research and Innovation in Health and IBMC (i3S), University of Porto, 4200-135 Porto, Portugal

* Correspondence: isatav@med.up.pt

Abstract

Background: Peer-assisted learning (PAL) is used in medical education. Its impact in basic medical sciences remains unexplored, namely considering the perspectives of all the populations involved: students, undergraduate teaching assistants (UTAs), and faculty members. We evaluated the educational impact of a PAL programme in Histology and Embryology in a medical course at the Faculty of Medicine of the University of Porto (FMUP). **Methods:** A cross-sectional convergent mixed-methods study was conducted in the Histology and Embryology course. Tailored online questionnaires comprising Likert-type items and open-ended questions were replied to by students attending theoretical–practical classes with UTAs, the UTAs, and the professors. Internal consistency was assessed using Cronbach’s alpha. Students’ theoretical–practical examination scores were compared between classes with and without UTAs using the Mann–Whitney U test, and effect size (r) was calculated to estimate the magnitude of differences observed. **Results:** Students ($n = 190$) reported highly positive perceptions regarding the creation of a more approachable learning environment, clarification of doubts, and identification of histological structures and strongly recommended the extension of UTAs to other courses of the medical school. UTAs ($n = 17$) described gains in disciplinary understanding, broader perspectives on the medical curriculum, communication and public-speaking skills, teamwork, leadership, self-confidence, and interest in academic careers. Professors ($n = 6$) valued PAL for improving individual support, facilitating time management, and contributing to UTA training, while highlighting the need for structured pedagogical preparation. Students attending classes with UTAs achieved significantly higher theoretical–practical examination scores ($p = 0.04$; effect size $r = 0.12$). **Conclusions:** PAL was perceived as highly beneficial by all groups involved in the project, enhancing the learning environment, supporting knowledge consolidation, and developing pedagogical and interpersonal skills. A grade analysis indicated that PAL was associated with improved academic performance. These findings reinforce the value of integrating PAL initiatives into preclinical medical education while highlighting the importance of sustained tutor preparation and supervision.

Keywords: peer-assisted learning; undergraduate teaching assistant; histology; embryology; medical education; academic performance; microscope



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1. Introduction

The teaching environment is important for human experiences. Bringing diversity to the class in a medical school may provide multiple perspectives and enrich the academic environment. Peer-assisted learning (PAL), an important tool in medical education (Shenoy & Petersen, 2020), was first defined in 1996 by Topping (Topping, 1996) as a method that promotes the acquisition of knowledge and skills through active helping and support among status equals or matched companions. PAL involves “people from similar social groupings who are not professional teachers” that “help each other to learn and learn themselves by teaching” (Topping, 1996). PAL fosters a collaborative and student-centred learning environment, reinforcing participants’ self-confidence, communication, and teaching skills, while allowing the construction of a diverse educational environment (Feng et al., 2024; Hamarash et al., 2025; Hernandez Colinir et al., 2022; Z. Li et al., 2025).

Several studies documented the benefits of PAL in various domains of medical education (Shenoy & Petersen, 2020) including basic sciences (P. L. Li et al., 2025; Petersen et al., 2021; Yang et al., 2022) and clinical training (Burke et al., 2007; Nunnink et al., 2021; Saleh et al., 2013; Shah, 2022). There are some suggestions of beneficial effects for both students being tutored (Menezes et al., 2016) and the students that play a role as tutors (Bowyer & Shaw, 2021). The latter type of students received several designations, including ‘peer tutors’, ‘near-peer tutors’, and ‘student teachers’. In a manner similar to other studies, the term ‘undergraduate teaching assistant’ (UTA) was adopted in the present study to reflect the formal pedagogical role assumed by the tutor students (Schalk et al., 2009). In this context, UTAs were former medical students who were formally integrated into theoretical–practical classes under faculty supervision, actively supporting students’ learning and providing practical guidance (Cate & Durning, 2007a; Jabker & Rives, 1976).

From the students’ perspective, PAL has been shown to foster a more approachable and less intimidating learning environment, which encourages clarification of doubts and active participation during theoretical–practical sessions (Menezes et al., 2016). Several studies have indicated that PAL may also enhance conceptual understanding, motivation, and satisfaction among students (Feng et al., 2024; Khapre et al., 2021; Tamachi et al., 2018). These educational benefits have been theoretically associated with the concepts of cognitive and social congruence, which help explain the effectiveness of peer-assisted learning in medical education. Cognitive congruence refers to the sharing of a similar knowledge base and language between tutors and learners, enabling near-peer tutors to provide explanations that are more accessible, comprehensible, and adapted to students’ level of understanding. Social congruence, in turn, reflects the sharing of similar social roles and experiences between tutors and learners, promoting a more empathetic, supportive, and psychologically safe learning environment that encourages students to ask questions and participate more actively (Lockspeiser et al., 2008; Loda et al., 2019).

Regarding the personal benefits for UTAs, improvements in academic performance, critical thinking, self-confidence, and pedagogical skills have been reported (Feng et al., 2024; Tanveer et al., 2023; Zhang et al., 2022). UTAs perceive PAL as beneficial across several domains, namely the consolidation of disciplinary knowledge (Tanveer et al., 2023), the fostering of communication (Cate & Durning, 2007b), public-speaking and leadership skills (Hernandez Colinir et al., 2022), the strengthening of teamwork (Evans & Cuffe, 2009), the enhancement of self-confidence (Evans & Cuffe, 2009), and the contribution to the development of a professional educator identity (Herrmann-Werner et al., 2017).

Despite the literature supporting PAL in medical education (Bloodgood, 2012; de Oliveira et al., 2015), several important gaps remain, namely the simultaneous analysis of the perspectives of all the groups involved in the process. Besides the importance of analysing the diverse perspectives, the professors’ and institutional perspectives on PAL

have been neglected in the literature, namely regarding how faculty members perceive the educational impact and integration of PAL programmes within the medical curricula (Tanveer et al., 2023). In faculty-supervised or hybrid PAL models, professors have reported that their involvement may mitigate some limitations of peer-assisted learning, namely by improving tutor supervision and content consistency (Evans & Cuffe, 2009). However, there are concerns regarding the heterogeneity of PAL models, standardisation, and quality maintenance across educational settings, training of UTAs, and evaluation of outcomes (Feng et al., 2024), and generalizability of findings across different educational contexts remains a challenge (Herrmann-Werner et al., 2017). Furthermore, evidence regarding the impact of PAL on students' performance in formal examinations remains inconsistent, with variable findings across educational contexts and disciplines (Zhang et al., 2022). In addition, important challenges and limitations of PAL models have been insufficiently explored, including the risk of inaccurate information transmission in the absence of adequate supervision, variability in tutor preparedness and integration with faculty, and the increased workload and stress occasionally reported by UTAs (Bowyer & Shaw, 2021; Cate & Durning, 2007b; Zhang et al., 2022).

PAL may be particularly valuable in Histology and Embryology courses due to the practical and microscopy-based nature of these disciplines, which require active observation, interpretation of histological structures, and collaborative discussion among learners (Bloodgood, 2012; de Oliveira et al., 2015; Petersen et al., 2021). Histology learning relies on the recognition and interpretation of microscopic patterns, whereas Embryology often involves understanding dynamic three-dimensional developmental processes that students frequently perceive as abstract and conceptually challenging (Guilherme Guedert et al., 2022). In this context, near-peer support may facilitate knowledge construction by allowing students to discuss observations, clarify misconceptions, and receive explanations adapted to their level of understanding (Cambrón-Carmona et al., 2016). Furthermore, classes of Anatomy, Histology, and Embryology were considered "relevant socially networked learning environments" with significant interactions between professors and students and also between students, due to the active discussion of images observed in the microscope (Hafferty et al., 2013). Nevertheless, studies of the PAL method and all the personal interactions provided by this method in the classes of Histology and Embryology remain limited.

This study aims to address the gaps in the evaluation of PAL programmes by providing an in-depth and contextualised analysis of the impact of the PAL model on preclinical teaching in Histology and Embryology at the second largest Portuguese medical school, the Faculty of Medicine of the University of Porto (FMUP). We adopted a faculty-supervised near-peer teaching approach, in which tutors and UTAs are at least one academic year apart, in a manner similar to other studies (Olaussen et al., 2016). In this context, the UTAs were third-year Integrated Master's Degree in Medicine (MIMED) students who attended the Histology and Embryology curricular units in the previous academic year and achieved above-average academic performance. During theoretical–practical classes, UTAs worked alongside faculty members, guiding students in the observation and interpretation of histological and embryological preparations, assisting in the identification of relevant microscopic structures, and clarifying student's questions. For the purposes of this study, the term "students" refers to second-year MIMED participants in the Histology and Embryology classes who had the presence of a UTA in the classes, and "professors" refers to the academic staff who were responsible for teaching these classes.

Our work aims to simultaneously examine the impact of PAL in the three key groups (students, UTAs, and professors), following a mixed-methods approach, combining the administration of questionnaires with an analysis of students' performance in the theoretical–

practical assessments of Histology and Embryology, to achieve a complete understanding of the model.

2. Materials and Methods

2.1. Study Design and Participants

The present study was a cross-sectional observational study, conducted using a convergent mixed-methods design (Kajamaa et al., 2020). Data were collected concurrently through questionnaires administered to students, UTAs, and professors, together with the analysis of students' academic performance in theoretical–practical assessments. Quantitative findings from Likert-scale responses and examination results were analysed alongside qualitative data obtained from open-ended questions. Both datasets were subsequently integrated during interpretation of the results within the convergent mixed-methods framework to provide a comprehensive understanding of the educational impact of the PAL model. It was conducted in the Department of Biomedicine, at FMUP, during the second semester of the 2023/2024 academic year and the first semester of the 2024/2025 academic year. This study was approved by the Ethics Committee of the FMUP (rapport number 296/CEFMUP/2024).

This study included three participant groups with the following inclusion criteria:

- A. Students who attended the Histology and Embryology courses, namely “Histology I” and “Histology II. Embryology” in the second year of the MIMED at FMUP and who were aged 18 years or older. Participants were required to attend weekly theoretical–practical classes with the presence of a UTA. Students were allocated to theoretical–practical class groups according to the standard class allocation procedures routinely adopted by the Faculty of Medicine of the University of Porto. The authors had no influence on this allocation process, and these procedures are independent of the present study. Then, the UTAs were randomly allocated to the theoretical–practical classes with no criteria besides the ability to conciliate the Histology and Embryology classes with their schedules as medical students. Due to this random allocation, at the end, there were classes with UTAs and other classes without UTAs. For the purposes of the analysis, the grades obtained by the students were subsequently divided according to whether they were allocated in a class with or without a UTA.
- B. Students enrolled in the UTA programme, specifically third-year students of the MIMED at FMUP, who had successfully completed the Histology and Embryology courses in the preceding academic year, with above-average academic performance.
- C. Lecturers of the Histology and Embryology classes, including both invited professors (part-time) and full-time professors, who had delivered at least one theoretical–practical class in conjunction with a UTA.

All participants were presented with written information regarding the objectives of this study and were assured of the confidentiality of the collected information and that they were free to decline to participate in this study, before accessing the online questionnaire.

2.2. Data Collection Questionnaires

The data acquisition process involved three self-administered questionnaires, each tailored to one of the three distinct populations (students, UTAs, and professors), with the corresponding questionnaire being sent to each participant via institutional email. The questionnaires were created by the research team based on adaptations of questions previously used by other authors and questions previously used in the authors' own work, as well as through the creation of new questions considering the line of research and the intended objectives. The questions adapted from previous works by other authors were the questions numbered 4, 6, 7, 9, 13, 30, 34, 50, and 53 (Yang et al., 2022). Also, the questions

numbered 18, 19, 22, 23, 25, 26–29, 35–37, and 41–50 were adapted from previous works by other authors (Nunnink et al., 2021). The questions 21 and 24 were constructed based on the authors' previous studies (Carneiro et al., 2023).

Participants completed structured and anonymous Google Forms questionnaires specifically developed for each group (students, UTAs, and professors). All questionnaires included closed-ended items assessed using a 5-point Likert scale (1 = "strongly disagree"; 2 = "disagree"; 3 = "neutral"; 4 = "agree"; and 5 = "strongly agree"), as well as optional open-ended questions. Only fully completed questionnaires were included in the analysis. To minimise the risk of duplicate responses, access to the questionnaires was restricted to institutional accounts and limited to a single submission per participant. The complete questionnaires are available in the Supplementary Materials.

The three questionnaires shared a common introductory structure, including information regarding the objectives of this study; the voluntary, anonymous, and confidential nature of participation; estimated completion time; data protection; and informed consent procedures in accordance with the General Data Protection Regulation (European Union Regulation 2016/679), as well as clarification of concepts and abbreviations used throughout the questionnaires to ensure consistent interpretation across participants.

2.2.1. Description of the Questionnaire Applied to Students

The questionnaire administered to students (Supplementary Materials) included items assessing sociodemographic characteristics and confirmation of attendance in theoretical–practical classes with UTAs. Questions 1 to 9 explored students' perceptions regarding the contribution of UTAs to the learning environment, while questions 10 to 17 focused on the perceived impact of UTAs on academic performance and personal development. Open-ended questions invited students to describe the characteristics of a good UTA, suggest ways of improving the role of UTAs in classes, and provide additional comments regarding the PAL programme.

2.2.2. Description of the Questionnaire Applied to UTAs

The questionnaire administered to UTAs (Supplementary Materials) included items assessing sociodemographic characteristics and confirmation of participation in the UTA programme. Questions 18 to 24 explored the perceived educational impact of the UTA role and its influence on knowledge consolidation and academic performance. Questions 25 to 29 focused on the development of soft skills, whereas questions 30 to 37 addressed workload, emotional implications, and communication-related aspects associated with UTA responsibilities. Questions 38 to 44 assessed preparation, pedagogical training, and integration with faculty, while questions 45 to 47 explored perceptions regarding acceptance and recognition of the UTA role. Finally, questions 48 to 53 focused on academic perspectives, professional development, and future career interests. Open-ended questions explored participants' perceptions regarding the educational impact of the programme.

2.2.3. Description of the Questionnaire Applied to Professors

The questionnaire administered to professors (Supplementary Materials) included items evaluating the pedagogical impact of PAL and the integration of UTAs within theoretical–practical classes. Questions 54 to 56 assessed professors' perceptions regarding the educational contribution of PAL, whereas questions 57 to 61 focused on the performance, preparation, and scientific rigour of UTAs. Open-ended questions explored professors' perspectives regarding the educational impact of PAL, characteristics of effective UTAs, and suggestions for improving the role of UTAs within classes.

2.3. Students' Academic Performance

In addition to the questionnaires, students' academic performance was assessed through the theoretical–practical examination of the Histology and Embryology classes, which accounted for one third of the final course grade. The examination consisted of two main components:

- (1) A practical test requiring the identification of 4 histological structures using the classical optical microscope; this component represented 25% of the overall grade of the theoretical–practical examination.
- (2) A mixed-format assessment comprising (i) the identification of three structures using Histolab (a digital microscopy platform that allows interactive visualisation of histological preparations), and (ii) seven questions delivered through the Moodle platform, requiring the identification and labelling of histological material from both light and electron microscopy. This component represented 75% of the grade.

2.4. Data Analysis and Statistical Evaluation

Quantitative data analysis was conducted using IBM SPSS Statistics (version 29.0.2.0).

To ascertain the adequacy of the students' questionnaire for the target population, a pre-test was conducted on a sample of 16 s-year FMUP students, who were excluded from the final sample. The internal consistency was assessed using Cronbach's alpha for full item set of the questionnaire directed to students. An alpha value of 0.81 was obtained, indicating good internal consistency (George & Mallery, 2024). No modifications were required following the pre-test phase. Regarding the questionnaires directed to UTAs and professors, given the small sample size of the populations involved, the alpha value was not calculated since formal reliability testing is limited.

Descriptive statistics were employed to summarise the responses provided by the participants. For items assessed on a Likert scale, mean values and standard deviations were calculated to provide measures of central tendency and variability. Results were reported with corresponding confidence intervals, and a significance level of 0.05 was adopted for all analyses. In addition, absolute and relative frequencies were reported for each response category to capture the distribution of answers across the scale. This combined approach enabled both a global overview of students' perceptions and a detailed description of response patterns.

A comparative analysis of students' grades obtained in the practical component of Histology and Embryology was also conducted. The comparison focused on the mean grades of students who attended theoretical–practical classes with the presence of a UTA and those who did not, across the second semester of the 2023/2024 academic year. Prior to conducting the comparative analysis, the distribution of the data was analysed using the Shapiro–Wilk test. Considering the data did not meet the assumption of normality, the Mann–Whitney U test was applied for group comparisons. Effect size (r) was additionally calculated to estimate the magnitude of the observed differences. A significance level of 0.05 was adopted.

Qualitative data were analysed using reflexive thematic analysis, following the six-phase approach described by Braun and Clarke (Braun & Clarke, 2006), a methodology widely applied in health and medical education research due to its flexibility and suitability for exploring participants' experiences and perceptions (Kiger & Varpio, 2020). Open-ended responses were independently reviewed by two authors to ensure familiarisation with the data. An initial manual coding process was subsequently performed, with meaningful units of text being identified and labelled according to their conceptual relevance. This process was performed independently by both authors. The resulting codes were then iteratively grouped into broader recurring themes and subthemes reflecting shared patterns across

participants’ responses. Any discrepancies in coding or interpretation were discussed and resolved through consensus. The emerging themes were discussed and refined through consensus between the two authors to enhance interpretative coherence and analytical rigour. This approach allowed a systematic and contextualised exploration of participants’ perspectives regarding the PAL programme while remaining appropriate for the relatively small qualitative dataset analysed in the present study.

3. Results

3.1. Questionnaires

The questionnaires were completed by 190 students, 17 UTAs, and 6 professors. These numbers are highly representative of each population, which is composed by about 300 students, 17 UTAs, and 8 professors. The sociodemographic characteristics of these groups are presented in Table 1.

Table 1. Sociodemographic characteristics of the samples.

Characteristics	23/24 Student Sample	24/25 Student Sample	Total Student Sample	UTA Sample	Professor Sample
Total <i>n</i>	87	103	190	17	6
Age (years) *	19.8 [19.5–20.1]	19.5 [19.1–20.1]	19.6 [19.4–20.0]	20.2 [19.9–20.7]	
Sex, <i>n</i> (%)					
Female	69 (79.3%)	73 (70.9%)	142 (74.7%)	7 (41.2%)	
Male	18 (20.7%)	29 (28.2%)	47 (24.7%)	10 (58.8%)	
Other	0 (0.0%)	1 (1.0%)	1 (0.5%)	0 (0.0%)	

* Arithmetic mean (95% confidence interval). *n*, number; UTAs, undergraduate teaching assistants.

The two samples of students from the 2023/2024 and 2024/2025 academic years were found to be highly comparable, both in terms of mean age and the corresponding 95% confidence interval (Petersen et al., 2021), as well as in the proportion of female and male participants. Given the observed high homogeneity, the two student samples will hereafter be regarded as a single combined sample for the purpose of subsequent analyses. Regarding the professor sample, information on age and gender was not collected due to the small group size, to protect participants’ anonymity and avoid potential bias.

3.1.1. Description of the Questionnaire Results Applied to Students

A descriptive analysis of the answers to the 17 questions, divided in 2 main sections (learning environment, and academic performance and development), was performed for the total student sample. The results are summarised in Table 2.

In the learning environment dimension (questions 1 to 9), students reported a highly favourable perception of the contribution of PAL to theoretical–practical classes. Most respondents recognised that the presence of UTAs facilitated the identification and interpretation of histological structures and contributed to clarification of doubts during practical activities, with particularly elevated levels of agreement observed in Q2 and Q5 (means: 4.64 and 4.68, respectively). Students also perceived UTAs as approachable and supportive, with 75.2% reporting reduced fear of questioning or making mistakes in the presence of UTAs (Q4). Furthermore, most participants considered that UTAs were able to better understand students’ difficulties than professors and demonstrated strong commitment and availability in supporting learning. Confidence in the scientific rigour of UTAs was also high, with most students trusting the accuracy of their explanations and rejecting the perception that they had received incorrect information. However, perceptions were more heterogeneous regarding whether UTAs’ explanations were more intuitive than

those provided by professors and whether students trusted UTAs to the same extent as faculty members.

Table 2. Student sample frequency (absolute and relative in percentage) of answers to the questions (1 = “strongly disagree”; 2 = “disagree”; 3 = “neutral”; 4 = “agree”; and 5 = “strongly agree”).

Questions	Total Student Sample Answers					Mean *
	1	2	3	4	5	
Learning environment						
Q1: The presence of a UTA helps me to correctly label and identify structures in histological preparations.	1 (0.5%)	1 (0.5%)	16 (8.4%)	63 (33.2%)	109 (57.4%)	4.46 [4.36–4.55]
Q2: The presence of a UTA allows me to clarify doubts when identifying structures in histological preparations.	1 (0.5%)	1 (0.5%)	7 (3.7%)	48 (25.3%)	133 (70.0%)	4.64 [4.54–4.72]
Q3: The UTA’s explanation is more intuitive for my understanding of histological preparations than that of the professor.	2 (1.1%)	9 (4.7%)	69 (36.3%)	59 (31.1%)	51 (26.8%)	3.78 [3.65–3.93]
Q4: I am less afraid of questioning and/or making mistakes with the UTA than with the professor.	11 (5.8%)	12 (6.3%)	24 (12.6%)	58 (30.5%)	85 (44.7%)	4.02 [3.85–4.20]
Q5: The UTA shows concern and commitment to fully clarifying the doubts raised by the students.	0 (0.0%)	1 (0.5%)	11 (5.8%)	36 (18.9%)	142 (74.7%)	4.68 [4.58–4.76]
Q6: The UTA understands the position and difficulties of the student attending H&E better than the professor.	1 (0.5%)	9 (4.7%)	27 (14.2%)	63 (33.2%)	90 (47.4%)	4.22 [4.09–4.35]
Q7: I trust the correctness and scientific rigour of the UTA’s explanations.	0 (0.0%)	4 (2.1%)	22 (11.6%)	97 (51.1%)	67 (35.3%)	4.19 [4.08–4.29]
Q8: I have already received information from the UTA that contains errors or inaccuracies.	118 (62.1%)	41 (21.6%)	17 (8.9%)	6 (3.2%)	8 (4.2%)	1.66 [1.52–1.82]
Q9: I have as much confidence in the explanations given by the UTA as in those given by the professor.	2 (1.1%)	27 (14.2%)	37 (19.5%)	69 (36.3%)	55 (28.9%)	3.78 [3.64–3.92]
Academic performance and development						
Q10: I believe that the UTA has provided advice that will be useful in the positive performance in the practical and theoretical-practical assessment of H&E.	0 (0.0%)	0 (0.0%)	13 (6.8%)	69 (36.3%)	108 (56.8%)	4.50 [4.42–4.58]
Q11: The fact that the UTA had recently attended the CUs H&E and obtained a high grade served to clarify doubts about the most effective study strategies for it.	0 (0.0%)	3 (1.6%)	26 (13.7%)	68 (35.8%)	93 (48.9%)	4.32 [4.21–4.43]
Q12: The UTA provided me with useful advice for my performance in other CUs.	9 (4.7%)	22 (11.6%)	36 (18.9%)	55 (28.9%)	68 (35.8%)	3.79 [3.63–3.97]
Q13: I had a positive relationship with the UTA(s).	0 (0.0%)	1 (0.5%)	10 (5.3%)	49 (25.8%)	130 (68.4%)	4.62 [4.53–4.71]
Q14: The UTA(s) were consistently available to provide me assistance and clarify matters.	0 (0.0%)	3 (1.6%)	3 (1.6%)	38 (20.0%)	146 (76.8%)	4.72 [4.64–4.80]

Table 2. *Cont.*

Questions	Total Student Sample Answers					Mean *
	1	2	3	4	5	
Academic performance and development						
Q15: I would recommend the existence of UTA in all weekly theoretical-practical classes for all H&E classes in future academic years.	3 (1.6%)	3 (1.6%)	8 (4.2%)	45 (23.7%)	131 (68.9%)	4.57 [4.45–4.68]
Q16: I would recommend the existence of UTA in practical/theoretical-practical classes of other CUs of the Integrated Master’s Degree in Medicine.	4 (2.1%)	4 (2.1%)	19 (10.0%)	42 (22.1%)	121 (63.7%)	4.43 [4.29–4.56]
Q17: Having a UTA in theoretical-practical classes has aroused my interest in working as a UTA in the future.	23 (12.1%)	33 (17.4%)	43 (22.6%)	41 (21.6%)	50 (26.3%)	3.33 [3.13–3.51]

* Arithmetic mean (95% confidence interval). CUs, curricular units; H&E, Histology and Embryology; Q, question; UTA, undergraduate teaching assistant; UTAs, undergraduate teaching assistants.

Regarding academic performance and development (questions 10 to 17), students also reported a favourable perception of the impact of UTAs on academic performance and personal development. Most responses considered that UTAs provided useful advice for theoretical–practical assessments and contributed to the identification of effective study strategies. Perceived benefits were less evident regarding the applicability of this support to other curricular units. Students consistently highlighted the positive relationship established with UTAs and their high level of availability and commitment. Overall acceptance of the PAL model was high, with most students recommending the inclusion of UTAs in Histology and Embryology classes and extending this approach to other courses in the medical school. In contrast, students showed more heterogeneous perceptions regarding their own future interest in assuming a UTA role.

Two open-ended questions allowed students to freely express their perceptions concerning the role of UTAs. Reflexive thematic analysis of the responses revealed several recurring themes regarding the characteristics of a “good UTA”. Among the 99 responses obtained, three major themes consistently emerged: (1) scientific competence; (2) availability and accessibility; and (3) interpersonal qualities. Students frequently highlighted the importance of a solid command of the scientific content and the ability to explain concepts clearly, simply, and in a manner adapted to the student's level of understanding. Availability to answer questions and an empathetic attitude of UTAs were repeatedly identified as essential for promoting a comfortable and collaborative learning environment. In addition, friendliness, good communication skills, proactivity, and enthusiasm for teaching were commonly described as characteristics that make UTAs more approachable and motivating for students. Regarding the second open-ended question, students were invited to suggest ways of enhancing the role of UTAs in theoretical–practical classes. Of the 54 responses obtained, a consensus emerged regarding the desire for greater intervention by UTAs, namely with greater direct participation in theoretical presentations and in conducting practical activities. Many students argued that UTAs should teach certain classes under faculty supervision. Another recurrent recommendation was the encouragement of interactive moments, such as quizzes or collective reviews of histological preparations using Histolab. Concurrently, numerous responses emphasised the significance of guaranteeing enhanced autonomy for intervention for UTAs within classes, empowering them to proactively direct the observation of histological preparations through preliminary elucidation of key histological structures.

3.1.2. Description of the Questionnaire Results Applied to UTAs

A descriptive analysis of the answers to the 36 questions, divided in 6 main sections (learning environment, soft skills, other implications of performing UTA duties, preparation/training, acceptance as a UTA, and academic perspective), was performed for the UTA sample. The results are summarised in Table 3.

Table 3. UTA sample frequency (absolute and relative in percentage) of answers to the questions (1 = “strongly disagree”; 2 = “disagree”; 3 = “neutral”; 4 = “agree”; and 5 = “strongly agree”).

Questions	UTAs' Answers					Mean *
	1	2	3	4	5	
Learning environment						
My UTA experience in theoretical and practical Histology and Embryology classes enabled me to:						
Q18: increase my understanding of the contents and consolidate knowledge taught in H&E.	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (11.8%)	15 (88.2%)	4.88 [4.71–5.00]
Q19: improve the analysis and interpretation of histological preparations.	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (29.4%)	12 (70.6%)	4.71 [4.47–4.88]
Q20: to increase my interest in H&E.	0 (0.0%)	0 (0.0%)	1 (5.9%)	3 (17.6%)	13 (76.5%)	4.71 [4.41–4.94]
Q21: Being a UTA has increased my awareness of the importance of H&E in other curricular units, namely Biopathology.	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (23.5%)	13 (76.5%)	4.76 [4.53–4.94]
Q22: The doubts raised by the students changed my perception of the H&E content.	0 (0.0%)	1 (5.9%)	3 (17.6%)	8 (47.1%)	5 (29.4%)	4.00 [3.59–4.35]
Q23: When a student asks me a question I don't know how to answer, I ask the professor for help.	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (5.9%)	16 (94.1%)	4.94 [4.82–5.00]
Q24: Being a H&E UTA has had a positive impact on my performance as a student in other CUs.	0 (0.0%)	0 (0.0%)	3 (17.6%)	9 (52.9%)	5 (29.4%)	4.12 [3.76–4.47]
Soft skills						
My UTA experience in Histology and Embryology theoretical and practical classes allowed me to:						
Q25: develop communication skills.	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (35.3%)	11 (64.7%)	4.65 [4.41–4.88]
Q26: increase my ability to communicate in public.	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (23.5%)	13 (76.5%)	4.76 [4.53–4.94]
Q27: develop a spirit of leadership.	0 (0.0%)	0 (0.0%)	2 (11.8%)	7 (41.2%)	8 (47.1%)	4.35 [4.00–4.70]
Q28: improve teamwork skills.	0 (0.0%)	0 (0.0%)	3 (17.6%)	6 (35.3%)	8 (47.1%)	4.29 [3.94–4.65]
Q29: strengthen my self-esteem and self-confidence.	0 (0.0%)	0 (0.0%)	2 (11.8%)	5 (29.4%)	10 (58.8%)	4.47 [4.12–4.76]

Table 3. Cont.

Questions	UTAs' Answers					Mean *
	1	2	3	4	5	
Other implications of performing UTA duties						
Q30: Being a H&E UTA is stressful.	2 (11.8%)	10 (58.8%)	4 (23.5%)	1 (5.9%)	0 (0.0%)	2.24 [1.88–2.59]
Q31: On the day I attend class as a UTA, I feel more anxious than on other days.	4 (23.5%)	6 (35.3%)	3 (17.6%)	4 (23.5%)	0 (0.0%)	2.41 [1.88–2.94]
Q32: Being a H&E UTA takes time away from the CUs I'm taking.	8 (47.1%)	4 (23.5%)	3 (17.6%)	2 (11.8%)	0 (0.0%)	1.94 [1.47–2.41]
Q33: Being a H&E UTA takes time away to take part in non-teaching activities organised by the faculty and/or associations.	8 (47.1%)	5 (29.4%)	3 (17.6%)	1 (5.9%)	0 (0.0%)	1.82 [1.35–2.29]
Q34: Being a Histology and Embryology UTA takes time away from personal and leisure activities	8 (47.1%)	1 (5.9%)	3 (17.6%)	5 (29.4%)	0 (0.0%)	2.29 [1.65–2.88]
Q35: I cope well when I recognise a mistake I may have made and then correct it in front of the class.	0 (0.0%)	0 (0.0%)	1 (5.9%)	8 (47.1%)	8 (47.1%)	4.41 [4.12–4.71]
Q36: I feel uncomfortable when I need to communicate to the whole class.	9 (52.9%)	6 (35.3%)	2 (11.8%)	0 (0.0%)	0 (0.0%)	1.59 [1.24–1.88]
Q37: I feel uncomfortable with the need to communicate closely and individually with each student.	15 (88.2%)	2 (11.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1.12 [1.00–1.29]
Preparation/training						
Q38: I have received sufficient preparation and training to fulfil the duties of a UTA.	0 (0.0%)	0 (0.0%)	4 (23.5%)	7 (41.2%)	6 (35.3%)	4.12 [3.76–4.53]
Q39: I feel that my knowledge of Histology and Embryology is sufficient for the duties of a UTA.	0 (0.0%)	0 (0.0%)	1 (5.9%)	9 (52.9%)	7 (41.2%)	4.35 [4.06–4.65]
Q40: I feel sufficiently integrated with the other UTAs and the H&E professors.	0 (0.0%)	2 (11.8%)	3 (17.6%)	6 (35.3%)	6 (35.3%)	3.94 [3.47–4.41]
Q41: I have a positive relationship with my professor.	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (11.8%)	15 (88.2%)	4.88 [4.71–5.00]
Q42: I am satisfied with the help and explanations provided by the professor.	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (11.8%)	15 (88.2%)	4.88 [4.71–5.00]
Q43: I learnt theoretical and practical knowledge of H&E from the professor.	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (11.8%)	15 (88.2%)	4.88 [4.71–5.00]
Q44: I acquired pedagogical skills from the professor.	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (5.9%)	16 (94.1%)	4.94 [4.82–5.00]
Acceptance as UTA						
Q45: I feel that the students in the class prefer to be clarified by the professor.	2 (11.8%)	4 (23.5%)	8 (47.1%)	3 (17.6%)	0 (0.0%)	2.71 [2.29–3.12]
Q46: When there is significant demand for my help from the class, I feel that I am doing a good job as a UTA and it helps to improve my motivation and self-confidence.	0 (0.0%)	0 (0.0%)	1 (5.9%)	7 (41.2%)	9 (52.9%)	4.47 [4.18–4.76]
Q47: I feel that my duties as a UTA are positively encouraged by the professor.	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (23.5%)	13 (76.5%)	4.76 [4.53–4.94]

Table 3. Cont.

Questions	UTAs' Answers					Mean *
	1	2	3	4	5	
Academic perspective						
My experience as a UTA in the Theoretical and Practical Histology and Embryology classes allowed me to:						
Q48: feel gratification in helping colleagues.	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (11.8%)	15 (88.2%)	4.88 [4.71–5.00]
Q49: increase my sense of personal responsibility.	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (11.8%)	15 (88.2%)	4.88 [4.71–5.00]
Q50: be interested in a future academic career (as a teacher and/or researcher).	0 (0.0%)	0 (0.0%)	1 (5.9%)	5 (29.4%)	11 (64.7%)	4.59 [4.29–4.82]
I believe that my experience as a UTA in the Theoretical and Practical Histology and Embryology classes will have a significant impact in the future:						
Q51: on the future development of a better curriculum that can be more valued by other medical and academic institutions.	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (29.4%)	12 (70.6%)	4.71 [4.53–4.88]
Q52: on the development of my professional identity.	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (23.5%)	13 (76.5%)	4.76 [4.59–4.94]
Q53: on my future role as a doctor, particularly in terms of guiding and educating my patients.	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (17.6%)	14 (82.4%)	4.82 [4.65–5.00]

* Arithmetic mean (95% confidence interval). CUs, curricular units; H&E, Histology and Embryology; Q, question; UTA, undergraduate teaching assistant; UTAs, undergraduate teaching assistants.

In the learning environment dimension (questions 18 to 24), UTAs reported a strongly positive overall perception regarding the impact of their experience in teaching Histology and Embryology. In Q18, most participants reported that performing UTA duties contributed to improved comprehension and consolidation of knowledge, with 88.2% of respondents awarding the maximum score (mean: 4.88; 95% CI: 4.71–5.00). In Q19, all UTAs agreed that their experience enhanced their capacity to analyse and interpret histological preparations. Q20 demonstrated that 94.1% of UTAs reported an increase in their interest in Histology and Embryology. All UTAs recognised that their role increased awareness of the relevance of Histology and Embryology for other curricular units, particularly Biopathology (Q21). Q22 revealed greater heterogeneity: 76.5% of respondents agreed that the questions posed by students altered their perception of the content, while 23.5% adopted a neutral or dissenting perspective (mean 4.00; 95% CI: 3.59–4.35). All UTAs reported consulting professors when faced with unanswered student questions, reflecting a collaborative and supervised educational environment (Q23). Finally, Q24 indicated that 82.3% recognised that their UTA experience had a positive impact on their performance in other curricular units. UTAs who answered four or five were invited to respond to an additional open-ended question to describe how that occurred. Of the 14 responses obtained, most participants highlighted the contribution of the UTA role to knowledge consolidation and improved performance in other curricular units. Participants particularly emphasised that deeper understanding of normal histology facilitated interpretation of pathological alterations. The Biopathology course was identified most frequently as the primary beneficiary of this educational approach. UTAs also reported greater ease in correlating normal and pathological tissues and interpreting microscopic preparations. Other disciplines mentioned were Medical and Surgical Propaedeutics, Pharmacology

and Clinical Immunology, due to the integration between morphology and pathophysiology. Furthermore, participants described perceived improvements in self-confidence, and communication and time management skills.

In the soft skills section (questions 25 to 29), UTAs reported broadly favourable perceptions regarding the development of interpersonal competencies. All UTAs reported perceived improvements in communication and public speaking skills (Q25 and Q26). Questions 27 and 28 demonstrated that UTAs recognised progress in leadership and teamwork, respectively, although with lower agreement and slightly lower means (4.35, 95% CI: 4.00–4.70; 4.29, 95% CI: 3.94–4.65). Finally, 88.2% of UTAs reported an increase in self-esteem and self-confidence (Q29).

Within the section exploring other implications of the UTA role, 70.6% of UTAs disagreed with the statement describing their tasks as stressful. However, 23.5% of respondents reported feelings of anxiety on the day of teaching (Q31; mean 2.41, 95% CI: 1.88–2.94). Regarding time management, there was a broad consensus that UTA duties do not interfere with curricular units or non-academic activities (Q32, mean 1.94, 95% CI: 1.47–2.41; Q33, mean 1.82, 95% CI: 1.35–2.29). Perceptions were more heterogeneous regarding leisure time: 29.4% of respondents agreed that the role affects leisure time. Regarding communication and error management, 94.2% of respondents report that they can deal effectively with public errors and their correction in class (Q35). UTAs generally did not report communication-related discomfort. This absence of discomfort was more pronounced in individual communication (Q37: 100% disagreement) than in classroom communication (Q36: 88.2% disagreement).

Regarding preparation/training, the overall perception was highly positive. In Q38 and Q39, UTAs considered that they had sufficient preparation and knowledge to perform their duties (means: 4.12 and 4.35, respectively; 95% CI: 3.76–4.53 and 4.06–4.65, respectively). Integration with peers and faculty members (Q40) was positively rated, although agreement was more moderate (mean 3.94, 95% CI: 3.47–4.41). The excellent relationship with the mentor professor stands out: in Q41 to Q44, most UTAs gave the maximum score to statements about their relationship, support, and learning with their mentor (means between 4.88 and 4.94), reflecting effective pedagogical support.

Furthermore, UTAs also reported favourable perceptions regarding acceptance and recognition of their role. Only 17.6% of respondents expressed that students prefer to be taught by professors, and almost half of the respondents stated that they remained neutral, suggesting an absence of rejection of their role. Most participants (94.1%) reported elevated levels of motivation and confidence when their explanations were solicited. Additionally, all UTAs indicated positive encouragement from their teachers, suggesting a supportive environment and recognition.

In the final section, academic perspective, all UTAs reported high satisfaction in helping colleagues (Q48) and recognised an increased sense of personal responsibility (Q49). In Q50, 94.1% of respondents expressed an interest in pursuing a future academic career (mean 4.59, 95% CI: 4.29–4.82). Finally, questions 51 to 53 reinforced the perception of the future relevance of this experience, with means ranging from 4.71 to 4.82.

3.1.3. Description of the Questionnaires Results Applied to Professors

A descriptive analysis of the answers to the eight questions, divided in two main sections (pedagogical implications of the PAL model and performance of UTAs) was performed for the professor sample. The results are summarised in Table 4.

Table 4. Professor sample frequency (absolute and relative in percentage) of answers to the questions (1 = “strongly disagree”; 2 = “disagree”; 3 = “neutral”; 4 = “agree”; and 5 = “strongly agree”).

Questions	Professors' Answers					Mean *
	1	2	3	4	5	
Pedagogical implications of the pal model						
Q54: The PAL teaching model is effective in clarifying students' doubts.	0 (0.0%)	0 (0.0%)	1 (16.7%)	3 (50.0%)	2 (33.3%)	4.17 [3.67–4.67]
Q55: The presence of a UTA allows each student to receive greater and more individualized support during the class practical component (viewing histological preparations).	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (33.3%)	4 (66.7%)	4.67 [4.33–5.00]
Q56: The PAL teaching model is an important addition to the academic training of UTAs.	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (33.3%)	4 (66.7%)	4.67 [4.33–5.00]
Performance of UTAs						
Q57: UTAs have sufficient knowledge to fulfil their duties.	0 (0.0%)	0 (0.0%)	2 (33.3%)	2 (33.3%)	2 (33.3%)	4.00 [3.33–4.67]
Q58: UTAs should be better trained for their role through short pedagogical trainings.	0 (0.0%)	0 (0.0%)	1 (16,7%)	2 (33.3%)	3 (50.0%)	4.33 [3.67–4.83]
Q59: I have full confidence in the scientific rigor of the information provided by the UTA to students.	0 (0.0%)	0 (0.0%)	2 (33.3%)	2 (33.3%)	2 (33.3%)	4.00 [3.33–4.67]
Q60: I've had to correct the UTA in theoretical and practical lessons.	2 (33.3%)	0 (0.0%)	1 (16,7%)	3 (50.0%)	0 (0.0%)	2.83 [1.67–3.83]
Q61: I learn new teaching approaches by observing the examples and explanations given by the UTA to the students.	0 (0.0%)	1 (16.7%)	2 (33.3%)	3 (50.0%)	0 (0.0%)	3.33 [2.67–3.83]

* Arithmetic mean (95% confidence interval). Q, question; UTA, undergraduate teaching assistant; UTAs, undergraduate teaching assistants.

The first section explored professors' perceptions regarding the pedagogical implications of the PAL model (questions 54 to 56). Overall, professors reported a highly positive evaluation of PAL, particularly regarding its contribution to clarification of students' doubts, provision of more individualised support during practical activities, and educational value for UTAs themselves. More than 80% of respondents expressed agreement across all items in this section, with elevated mean scores ranging from 4.17 to 4.67.

Regarding the performance of UTAs, professors generally reported favourable perceptions of their scientific knowledge, rigour, and integration within theoretical–practical classes. Nevertheless, some respondents highlighted the need for additional pedagogical training for UTAs. Although teachers reported occasionally correcting UTAs during classes, these situations were perceived as infrequent. Professors also acknowledged that observation of UTAs occasionally contributed to the acquisition of new pedagogical approaches and teaching strategies, although this perception was not uniformly reported across participants.

In response to the first open-ended question “Overall, how does the presence of UTAs influence the learning process of students?”, reflexive thematic analysis revealed a strong consensus regarding the positive contribution of UTAs and the PAL model to the teaching–learning process. All teachers emphasised that the presence of UTAs promotes closeness, interaction, and trust among students, creating a “more welcoming and less intimidating” environment because it “reduces hierarchical barriers” and facilitates the

clarification of doubts. The responses further emphasised that UTAs facilitate more effective integration of content with other curricular units, both concurrently and in subsequent years, and that they serve as role models for their peers, as they “have already confronted similar challenges”.

The second open-ended question inquired about the impact of the PAL method on the academic and personal development of UTAs. Reflexive thematic analysis identified recurring themes related to knowledge consolidation, multidisciplinary integration, and personal development among UTAs. Teachers described the PAL method as “an enormous asset in the training of UTAs”, highlighting that the need to teach their colleagues leads them to “consolidate the acquired knowledge” and achieve a “deeper and more lasting” understanding of the content. It was also emphasised that this experience promotes multidisciplinary integration of knowledge, thereby enhancing the connection between distinct areas of medicine. In both the personal and professional domains, the development of communication skills, empathy, confidence, and responsibility was highlighted, with one teacher mentioning that PAL is “an excellent way to grow from a social and ethical point of view”. Furthermore, its pertinence within the medical context was underlined, as it enhances effective communication with patients and the elucidation of complex concepts.

Regarding the third open-ended question “How does the presence of UTAs change the way you perform your duties as a teacher?”, thematic analysis revealed heterogeneous perceptions regarding the impact of UTAs on teaching practices. Half of the teachers stated that the presence of UTAs “does not change” the way they perform their duties. Nevertheless, it was acknowledged that UTAs “add value and dynamism to classes”, making them “more interactive” and promoting an environment of greater proximity to students. The perception that UTAs “facilitate time management” and “optimise individual support for each student in the microscope” was particularly salient, allowing teachers to “respond more easily to everyone’s questions in the practical component”. Furthermore, it was emphasised that, due to their proximity to the learning experience, UTAs provide “interesting insights that improve the dynamics of the teaching approach”, thus contributing to a more collaborative and efficient pedagogical process.

In the fourth open-ended question “What are the characteristics that define a good UTA?”, reflexive thematic analysis identified two major recurring themes: scientific competence and interpersonal skills. The competencies emphasised encompassed comprehensive subject mastery in Histology and Embryology, effective communication, empathy, and the capacity to adapt to students’ diverse needs. Responsibility, diligence, prior preparation, and the ability to balance the role of colleague and teaching collaborator were also valued.

Regarding the last open-ended question, “What suggestions do you have for UTAs to play a more active and relevant role in theoretical–practical classes?”, thematic analysis revealed a recurrent desire for greater autonomy and active participation of UTAs within classes. Recurring suggestions included allowing UTAs to give “mini presentations/summaries at the beginning or end of classes”, conduct “brief presentations on topics related to the class content”, or participate in presenting classes under the supervision of the professor. The integration of digital tools and interactive quizzes, involvement in planning and suggesting dynamics or practical examples, and individualised monitoring of students during the practical component, with reporting of difficulties to the teacher, were also emphasised.

3.2. Comparative Analysis of Academic Performance

Students were divided into two subgroups according to the presence or absence of a UTA in their theoretical–practical classes ($n = 99$ and $n = 219$, respectively). The

grades obtained in the theoretical–practical examination of Histology and Embryology were subsequently analysed, and the descriptive statistics are displayed in Table 5.

Table 5. Descriptive and comparative analysis of the practical exam results.

Variable	With UTA	Without UTA
<i>n</i>	99	219
Mean (95% CI) of practical exam results	15.58 [14.96–16.21]	14.99 [14.62–15.37]
Mann–Whitney U test (<i>p</i> value; <i>r</i>)	12.399 (0.04 [#] ; 0.12)	

[#] Statistically significant difference. CI, confidence interval; *n*, number; UTA, undergraduate teaching assistant.

Students attending classes with UTAs achieved significantly higher grades in the practical examination compared with students without UTAs (15.58 ± 0.31 vs. 14.99 ± 0.19 ; $p = 0.04$), although the observed effect size was small ($r = 0.12$).

4. Discussion

The present study evaluated the impact of implementing the PAL model in Histology and Embryology teaching within a medical course. To achieve a comprehensive understanding, this study gathered perspectives from all stakeholders: students, UTAs, and professors. The students’ responses indicate a favourable perception of the contribution of UTAs to their learning experience in the Histology and Embryology classes and demonstrated a high level of satisfaction with the PAL programme. The students particularly valued the contribution of UTAs to clarification of doubts, identification of histological structures, and promotion of a more approachable learning environment. The students also reported that UTAs fostered a more comfortable and approachable learning environment—reducing the fear of asking questions or making mistakes—and perceived them as committed, empathetic facilitators. These findings are consistent with the previous literature, highlighting PAL as an effective strategy to enhance engagement, motivation, and conceptual understanding while promoting a supportive classroom climate (Cate & Durning, 2007b; Feng et al., 2024; Herrmann-Werner et al., 2017; Z. Li et al., 2025). Expanding the integration of PAL into the medical curriculum could strengthen student engagement, promote collaborative learning, and enhance the overall quality of teaching in preclinical education.

A comparison of the grades in the Histology and Embryology assessments showed a significantly higher mean score in classes with UTAs versus those without, suggesting a positive association between exposure to PAL and students’ academic performance. Given the observational nature of the analysis and the complexity of educational environments, these findings should not be interpreted as evidence of a direct causal effect but rather as an observed association between exposure to PAL and students’ academic performance under routine curricular conditions. Although the observed effect size was small, modest effect sizes are common and expected in educational interventions implemented in authentic curricular settings, where learning outcomes are influenced by multiple factors (Kraft, 2020). Nonetheless, a major strength of these findings lies in its ecological validity as the data were obtained from routine curricular activities and formal assessments within the medical programme (Andrade, 2018). In contrast to studies conducted under more controlled educational interventions (Nunnink et al., 2021; Stephens et al., 2016; Yang et al., 2022), the present study captures the real-world impact of PAL embedded in the medical curriculum. This may reinforce the potential of PAL to enhance learning outcomes in authentic educational environments.

The analysis of the UTAs’ responses revealed a consistently positive evaluation of their participation in the PAL programme, suggesting that this role contributes significantly to the consolidation of knowledge and the development of pedagogical and interpersonal

competencies. These results are in agreement with previous studies (Bene & Bergus, 2014). UTAs reported that their participation reinforced their understanding of and interest in histology and embryology, while also sharpening their interpretation of histological preparations. These findings align with previous studies demonstrating that acting as a peer tutor promotes deeper cognitive processing and more enduring knowledge retention through the 'learning by teaching' mechanism (Fiorella & Mayer, 2013).

UTAs also acknowledged the significance of Histology and Embryology in relation to other medical school courses, most notably Biopathology (Histopathology), emphasising that participating in a PAL programme can facilitate both horizontal and vertical curricular integration. This finding corroborates previous results (Carneiro et al., 2023) showing that more advanced medical students—such as these UTAs—attribute great relevance to Histology and Embryology for understanding pathological mechanisms in Biopathology, as well as other biomedical and clinical disciplines. The potential development of soft skills was also addressed in the UTA questionnaires. UTAs reported considerable gains in communication and public speaking skills along with development of competences for leadership and teamwork and strengthened self-confidence. These findings corroborate the previous literature identifying PAL as a promoter of skills deemed essential to medical professionalism and as a reinforcer of medical students' professional identity as future physicians (Cate & Durning, 2007b).

Overall, UTAs did not perceive their role as stressful. However, a subset reported situational anxiety on teaching days. This finding is consistent with a previous study (Hundertmark et al., 2019) that demonstrated that near-peer tutors in medical education experience moderate psychophysiological stress responses during teaching, primarily linked to performance expectations and social evaluation, yet do not report harmful stress levels that compromise well-being or performance. With regard to workload, the majority of UTAs indicated that their responsibilities did not interfere with their academic or extracurricular commitments, which aligns with prior research suggesting that peer-tutoring activities are perceived as manageable and even beneficial for time management and organisational skills (Al Kharusi, 2016). However, since a modest proportion of participants reported reduced leisure time, institutional frameworks should ensure structured workload distribution along with a formal recognition of their role as UTAs in the final diploma as a medical doctor. Concerning preparation and mentorship, UTAs recognised that they had received adequate preparation. The mentoring relationship with the professors was positively evaluated, as reflected in the maximum ratings for guidance, learning, and pedagogical training. This underscores the significance of structured faculty supervision in maintaining PAL quality and is consistent with prior recommendations that effective PAL requires both pedagogical preparation and continuous feedback from faculty supervision (Herrmann-Werner et al., 2017). Acceptance and self-perception as tutors were also positive. Only a few perceived students preferred the professor's clarification and nearly all participants reported feeling motivated and confident when solicited by peers. This aligns with evidence that PAL increases motivation and academic self-concept (Cate & Durning, 2007b; Herrmann-Werner et al., 2017) as well as fostering professional socialisation among UTAs, evidenced by their strong sense of fulfilment and responsibility.

UTAs also demonstrated an increased interest in pursuing academic careers, perceiving the experience as valuable for their curriculum. They further recognised its relevance in enhancing their professional identity and in shaping their future role as physicians, particularly in educating and guiding patients. These findings reinforce that PAL not only cultivates future educators and researchers but also contributes to the formation of reflective, pedagogically aware medical professionals (Herrmann-Werner et al., 2017). The UTA

experience proved highly enriching, reinforcing disciplinary knowledge, enhancing communication and teamwork skills, and fostering professional and academic development.

From the professors' perspective, the findings demonstrate a broadly positive perception of PAL as a pedagogical methodology that enriches teaching and learning in Histology and Embryology classes. In agreement with other studies (Stephens et al., 2016), the group of professors notes that the presence of UTAs facilitates the clarification of doubts and increases support during practical sessions, aligning with previous evidence that PAL promotes student engagement and reduces the hierarchical distance between teachers and learners. Furthermore, professors also acknowledged that PAL benefits UTAs themselves by reinforcing knowledge retention, consolidating pedagogical understanding, and stimulating motivation towards teaching or academic careers (Herrmann-Werner et al., 2017). Despite this overall positive evaluation, the professor highlighted the importance of structured pedagogical training of UTAs, highlighting that the sustainability and educational validity of PAL depend on organised UTA preparation, faculty supervision, and clear alignment with curricular objectives. These challenges in generalised PAL implementation have been discussed by other studies (Feng et al., 2024).

The qualitative findings further revealed that professors perceived PAL to be adding dynamism, interactivity, and efficiency to classes; improving time management; and promoting more individualised student support, suggesting that near-peer tutors can enhance classroom fluidity and the distribution of attention, particularly within practical settings, which is very relevant in Histology and Embryology (Herrmann-Werner et al., 2017). Nevertheless, most respondents stated that the presence of UTAs “does not change” the way they perform their teaching duties. Professors acknowledged positive contributions of the UTAs, including better time management and improvement of individual support during the practical microscopy component. Finally, professors' suggestions to increase UTAs' autonomy illustrate a perceived willingness to expand PAL's scope under appropriate supervision, thereby enhancing the importance of structured institutional support of PAL methodologies.

The convergent mixed-methods methodology used in this study is of particular pertinence within educational research, as it facilitates the integration of numerical data with participants' personal experiences and perceptions, thereby yielding a more profound interpretation of the findings (Creswell & Clark, 2018). Quantitative data—comprising Likert-type responses and scores from the Histology and Embryology theoretical–practical examination—served as measurable outcomes. Concurrently, open-ended questions captured qualitative insights into participants' reflections, suggestions, and subjective experiences, thereby ensuring thematic exploration and contextual depth (Shorten & Smith, 2017). The qualitative findings did not merely illustrate the quantitative results but provided explanations for several of the observed response patterns, thereby contributing to a more comprehensive interpretation of the educational impact of PAL. Open-ended questions were of particular value in the professors' questionnaire, as the small sample size ($n = 6$) limited quantitative analysis (O'Cathain et al., 2010). Therefore, this design enabled triangulation of evidence across data sources and participant groups, reinforcing the validity and interpretative coherence of the results, thereby enhancing the overall credibility of the study outcomes (Creswell & Clark, 2018).

Nevertheless, our study inevitably faces limitations and potential biases that may affect the validity of some results. Firstly, it is important to acknowledge the limitations related to sampling and participant recruitment. Despite our interest in producing meaningful data regarding professors' perspectives and role in PAL methodology, the size of professor sample was limited ($n = 6$) because the number of staff dedicated to teaching Histology and Embryology in our medical school is small ($n = 8$). This limited our ability to perform

formal validation of the questionnaires, in a manner like what was performed for the large group of students ($n = 190$) and may have reduced the statistical power. Consequently, the overall positive findings from this subgroup should be interpreted as indicative rather than definitive. Self-selection and response bias also constitute limitations. The final inclusion depended on voluntary consent, which can favour participants with stronger views or higher motivation, potentially inflating positive or negative perceptions (Goos & Salomons, 2016). To reduce this bias, invitations were disseminated via the institutional mailing list to all eligible students. Another methodological limitation concerns the design and validation of the questionnaires, since no previously validated instruments in Portuguese were available. Although it is generally preferable to use existing questionnaires whose validity and reliability have been demonstrated, validated Portuguese-language instruments in the medical education field remain scarce (Story & Tait, 2019; Sullivan, 2011). We mitigated this limitation by carefully adapting questions previously used in published studies on the PAL model and in our own previous research in medical education (Carneiro et al., 2023). Additionally, a pilot analysis was conducted with a small sample of second-year students not included in the final sample to assess the clarity, consistency, and applicability of the items. The questionnaire's internal consistency was analysed and demonstrated good internal validity (Cronbach's alpha value > 0.8 is generally desirable, with our questionnaire obtained an alpha of 0.81) (Downing, 2004). Therefore, our study presented an adequate level of consistency between items. The use of the Likert-type items is common in educational and medical education research (Sullivan & Artino, 2013) due to its simplicity, accessibility, and suitability for capturing structured perceptions across large groups of respondents (Artino et al., 2014). Likert-type items were selected due to their suitability for assessing perceptions in large participant groups, a factor which has been demonstrated to promote data completeness and response consistency across items (Sullivan & Artino, 2013). However, variability in the interpretation of response options and difficulties associated with neutral responses represent recognised limitations of this methodology (Kankaraš & Capecchi, 2024). In our study, such limitations were likely minimised given the relative homogeneity of the participant group in terms of cognitive skills and literacy. Likert-type instruments are also susceptible to response biases, such as social desirability and acquiescence, which may compromise the validity of self-reported data, especially in small or socially cohesive groups (Kreitchmann et al., 2019), a factor especially relevant in UTAs and professors groups. Besides the relative homogeneity of the participant pool in terms of cognitive and linguistic abilities, the anonymous nature of data collection mitigated these biases. Although the questionnaires comprised several independent Likert-type items, each with five ordered response options ranging from "strongly disagree" to "strongly agree", corresponding to the original Likert response structure, the items were analysed individually rather than as part of a composite validated scale (Koo & Yang, 2025). Regarding the qualitative component, the open-ended responses provided by students, UTAs, and professors were manually reviewed by two of the authors and systematically coded (O'Cathain et al., 2010). While qualitative interpretation inherently involves subjectivity, this risk was mitigated by focusing on recurring key themes and conceptually relevant patterns that emerged consistently across participant groups (Ramanadhan et al., 2021). The integration of these qualitative findings with quantitative results through a triangulation approach allowed a more comprehensive understanding of the data and strengthened the interpretative coherence and credibility of the study's conclusions (O'Cathain et al., 2010). Although the comparison of examination results was conducted under routine curricular conditions and therefore reflects the ecological validity of PAL implementation in a real educational setting, potential influences related to class composition, teaching dynamics, and faculty-related factors were not controlled. Such sources of variability are

inherent to authentic educational environments, where learning outcomes emerge from the interaction of multiple student-, teacher- and context-related factors. Consequently, the observed differences should be interpreted as associations rather than full evidence of a causal effect of PAL on academic performance; however, they provide valuable insight into the implementation of PAL under real-world curricular conditions. Lastly, external validity may be challenging to establish. This study was conducted within a single institutional and curricular context, which constrains the generalizability of its findings to other medical schools.

These findings may contribute to the ongoing discussion regarding the formal implementation of PAL methodologies in medical education, both in Portugal and internationally. Students' feedback strongly supports the presence of UTAs in all Histology and Embryology classes and beyond these curricular units, highlighting the possibility of extending the PAL model to other curricular units within the medical curriculum. Structured peer involvement may significantly complement and enrich the medical curriculum, as PAL is an effective and distinctive approach that simultaneously enhances medical knowledge, autonomy, and personality growth among medical students. Subsequent implementations should incorporate formal tutor training and continuous monitoring to ensure pedagogical coherence and sustainability.

It would be relevant to evaluate the long-term academic and professional impact of PAL participation, both in PAL tutors and tutees. Within the Portuguese medical education context, this investigation is a pioneering effort to systematically evaluate the PAL model in preclinical medical education. By integrating quantitative and qualitative methodologies and encompassing the perspectives of students, UTAs, and professors, this study provides additional evidence regarding PAL implementation in specific courses such as Histology and Embryology and may contribute to future pedagogical innovation and sustainable enhancement of medical education in Portugal and other countries.

5. Conclusions

By collecting the collective perspective of all the groups involved in a PAL programme within a medical curriculum, this study indicates global positive perceptions, with improved learning experiences, increased student engagement, enhanced knowledge consolidation, and development of interpersonal and pedagogical skills. Diversity in a classroom of a medical school, with active participation of tutor students (UTAs) may improve both the experience of being a student in a demanding course such as a medical degree, but also of being a professor.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/educsci16071093/s1>.

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Informed Consent Statement: Study participation was voluntary. All students were adequately informed about this study's purpose and were granted anonymity and confidentiality regarding their data. We obtained written informed consent from all the participants in this study prior to participation.

Data Availability Statement: Anonymised raw data are available from the corresponding author upon request. All new data generated by this study are available within this article.

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Abbreviations

The following abbreviations are used in this manuscript:

CI	confidence interval
CIs	confidence intervals
CUs	curricular units
FMUP	Faculty of Medicine of the University of Porto
H&E	Histology and Embryology
IBM	International Business Machines
MIMED	Integrated Master's Degree in Medicine
NA	not applicable
<i>n</i>	number
PAL	peer-assisted learning
Q	question
SPSS	Statistical Package for the Social Sciences
UTA	undergraduate teaching assistant
UTAs	undergraduate teaching assistants

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