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The Impact of Teaching Methodologies on Dental Students' Confidence and Perceived Preparedness for Clinical Practice

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Highlights

What are the main findings?

- Student confidence increased following asynchronous learning (AL) and flipped classroom (FC) activities.
- The greatest improvements in confidence were observed after clinical exposure.
- No significant differences in absolute confidence scores were identified between groups.
- Domain-specific differences in confidence gains were observed between AL+FC and FC groups.
- Increased confidence should not be interpreted as a direct measure of clinical competence.

What are the implications of the main findings?

- AL and FC may enhance students' self-reported confidence and perceived readiness during the transition to clinical practice.
- Future studies should include objective measures of clinical competence to determine whether these approaches improve clinical performance.

Abstract

Background: This study investigated the association between different teaching modalities and undergraduate dental students' confidence during the transition from simulation-based training to clinical practice, as well as perceived preparedness for clinical practice. Objectives: The aims were two-fold: (1) To evaluate the impact of different teaching modalities on the students' confidence during this transition, and (2) to explore differences in supervisor and peer assessments following the implementation of different teaching modalities. Methods: A quasi-experimental design was employed, involving 33 students allocated to three groups: Group A (flipped classroom (FC) and asynchronous learning (AL), $n = 11$), Group B (FC only, $n = 12$) and a Control group (access to online e-learning modules only, $n = 10$). Confidence levels were measured longitudinally at baseline, after their allocated interventions, and pre- and post-clinical stages, alongside supervisor and peer assessments. Data were analysed longitudinally within each group throughout the observation period and between groups at similar timepoints. These analyses were based on self-confidence survey measurements collected throughout the study. Results: A statistically significant overall increase in confidence was observed across all groups over the study period ($p < 0.05$), with the greatest improvement observed after the clinical session. Students in AL and FC groups demonstrated a general rise in confidence from baseline to post-FC. However, both groups exhibited a consistent, modest decline in confidence at the preclinical stage. This decline may be attributed to the prolonged interval between FC sessions and

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clinical exposure, and heightened anxiety in an unfamiliar clinical setting. No statistically significant differences in confidence were found between groups, likely due to the limited sample size. Conclusions: Within the limitations of this study, FC and AL methodologies demonstrate potential in enhancing self-directed learning and boosting confidence by supporting the progressive development of competence and safe, holistic patient-centered practice. These approaches may better prepare students for the challenges of clinical dental practice and the rapidly changing professional landscape.

Keywords: flipped classroom; asynchronous learning; teaching modalities; confidence; perceived preparedness; simulation

1. Introduction

Developing clinical competence is a key challenge in dental education, particularly for junior undergraduate students starting clinical training [1]. Periodontal therapy requires not only technical proficiency but also the ability to navigate complex clinical scenarios that cannot be fully replicated in preclinical simulation-based training. While simulators are instrumental in developing technical skills, they fail to reproduce critical patient-related factors such as soft-tissue anatomy, saliva presence, and inter-individual anatomical variations. Moreover, students must acquire essential non-technical competencies, including communication skills, professionalism, clinical decision-making, and teamwork, which are fundamental to holistic patient care. These components highlight the need for a competence-based educational approach [2], in which learning outcomes are defined not solely by the completion of procedures but by the demonstrable integration of knowledge, technical skills, and professional behaviours in authentic clinical contexts. Such a framework emphasises progressive development of competence (holistic clinical practice) to the level of a safe, independent practitioner supported by ongoing formative assessment, structured self-assessment, and the cultivation of learner autonomy.

To support the progressive development of clinical competence, contemporary pedagogical approaches such as Asynchronous Learning (AL) and the Flipped Classroom (FC) have been introduced in dental education [3]. Within a competence-based framework, these instructional strategies foster greater learner autonomy and have been associated with increased intrinsic motivation [4]. AL has been shown to enhance student engagement with educational content [5], enabling learners to regulate their own study pace [6] and optimise working memory capacity. The e-learning revision module on Periodontology provides essential preparatory material to help ease the students' transition from phantom head to person-centred practice. However, there is evidence suggesting that 'time management' is one of the main drawbacks for students actively engaging in AL material. To support equitable learning and address time-management challenges, timetabled AL sessions were implemented to provide additional structure [7]. Thereby ensuring that students enter the in-person teaching sessions with foundational practice knowledge and maximise the effectiveness of face-to-face interaction.

The Flipped Classroom (FC) is a pedagogical approach designed to enhance active learning by shifting traditional lecture-based content outside of the classroom and utilising in-class time for interactive, student-centred learning activities. This model is characterised by three core principles: (1) relocating the transmission of foundational practice knowledge to pre-class activities, (2) utilising classroom time for higher-order cognitive tasks and collaborative learning, and (3) requiring students to engage in structured pre- and post-class activities to consolidate practice knowledge [8,9]. An additional advantage of FC is

that instructors can assess student engagement with pre-class materials and tailor in-class teaching to address specific learning needs. For example, students may review a pre-recorded lecture or multimedia resource on a clinical topic before class, allowing in-class time for case-based discussion or problem-solving exercises that apply this knowledge.

Recent evidence supports the efficacy of FC in enhancing clinical reasoning and self-directed learning skills. A systematic review by Baig & Yadegaridehkordi (2023) examined FC implementations across four medical education courses, incorporating class debates, problem-solving tasks, quizzes, and explanatory discussions [10]. Their findings suggested that structured clinical case discussions improved students' ability to provide person-centred care by focusing on individualised patient needs and risk factors. Based on this evidence, the present study incorporates case-based discussions in FC sessions, using guided prompts to facilitate student-led exploration of key periodontal considerations, including diabetes mellitus and smoking, as evidence-based risk factors.

Previous studies have also demonstrated positive outcomes of FC in dental education [11,12]. A study investigating FC in preclinical fixed prosthodontics training reported significant improvements in students' perceptions of teaching quality and self-reported understanding of the subject [13]. Additionally, a three-year randomised controlled trial by Wang et al. (2021) concluded that FC enhanced self-directed learning skills and facilitated knowledge consolidation during in-class sessions [14]. However, most FC studies in dental education have been conducted in preclinical settings, with limited research on the associations between FC and student confidence in initial clinical experiences. It is essential to note that Periodontology serves as students' first transition into clinical practice before they progress to restorative clinic, as it emphasises the prevention of dental diseases.

The present study is the first to conduct a longitudinal assessment of the effects of FC on dental students' confidence as they transition from simulation-based training to clinical periodontal practice.

Study Aims

This study aims to:

1. Evaluate the association of different teaching modalities on the self-assessment of dental students' confidence during their early transition from simulated clinical practice to clinical periodontal therapy.
2. Explore differences in supervisor and peer assessments after the students' first periodontal clinical experience.

The null hypotheses for this study are:

1. There is no significant difference in the self assessment of the dental students' confidence during the transition from simulated clinical practice to clinical periodontal therapy across different teaching modalities.
2. There is no significant difference between supervisor and peer assessment following the student's first periodontal clinical experience.

2. Methods

2.1. Participants

Participants were second-year undergraduate dental students enrolled in the Foundation of Clinical Skills course during the 2024–2025 academic year of the Bachelor of Dental Surgery (BDS) programme. At this stage of the curriculum, students had completed foundational coursework in dental anatomy, oral biology and preventive dentistry, providing the scientific basis for subsequent periodontal education and clinical training. The cohort included students from both standard-entry and graduate entry pathways, with the

latter comprising individuals who had previously completed an undergraduate degree in medicine of biology-related background.

Within the Foundation of Clinical Skills course, periodontology teaching focused on developing students' understanding of periodontal health and disease, periodontal assessment and diagnosis, treatment planning, and the principles of professional mechanical plaque removal. As second-year students in the early stages of their professional development, participants had not yet undertaken supervised periodontal patient management. Consequently, their learning was primarily centred on acquiring foundational knowledge and developing essential clinical competencies under close supervision.

2.2. Recruitment and Consent

All participants received a comprehensive information sheet detailing the study objectives, their role in the research, the procedures involved, and potential benefits. Participation was entirely voluntary, and students were explicitly informed that their decision to participate or withdraw would not impact their academic standing or educational rights. Written informed consent was obtained prior to enrolment in the study. Ethics was approved by King's College London (Ethical Clearance Reference Number: LRS/DP-23/24-36416).

2.3. Study Design and Participant Allocation

This study employed a quasi-experimental design in which pre-existing student groups were randomly assigned to one of three study groups (Figure 1) by the course consultant (EL). The three intervention groups (Groups A and B) received different combinations of AL and FC sessions:

- Group A (AL+FC): students completed the online e-learning during the timetabled AL session, prior to participation in the FC session.
- Group B (FC): students participated in FC session exclusively, without a timetabled AL session. Although the online e-learning remained accessible, completion of the module prior to the FC session was not monitored.
- Control Group: students had access to online e-learning modules, but received no timetabled AL or FC sessions.

Therefore, although all students were provided with access to the online e-learning modules, only Group A completed the study material during a dedicated, timetabled AL session prior to the FC activity.

The study was conducted between January and May 2024. Baseline confidence questionnaires were completed in January 2024 prior to any educational intervention. Students allocated to Group A participated in a timetabled AL session in March 2024, immediately followed by a post-AL confidence questionnaire. FC sessions for students in Groups A and B were conducted in April 2024, with a post-FC confidence questionnaire administered immediately afterwards. Students subsequently attended their first periodontal clinical session between 1 and 4 weeks after the FC session. Pre-clinical confidence questionnaires were completed prior to clinical exposure, and post-clinical questionnaires were administered immediately following the clinical session. Supervisor and peer assessments were also undertaken immediately after the clinical encounter (Figure 1).

2.4. Online Periodontology Revision Course

All participants had access to an online Periodontology Revision Course hosted on KEATS. The course comprised four structured modules, each estimated to last 10–15 min. The content was designed to reinforce key competencies, including history-taking, clinical and periodontal assessment, interpretation of clinical and radiographic information and case presentation to a supervisor.

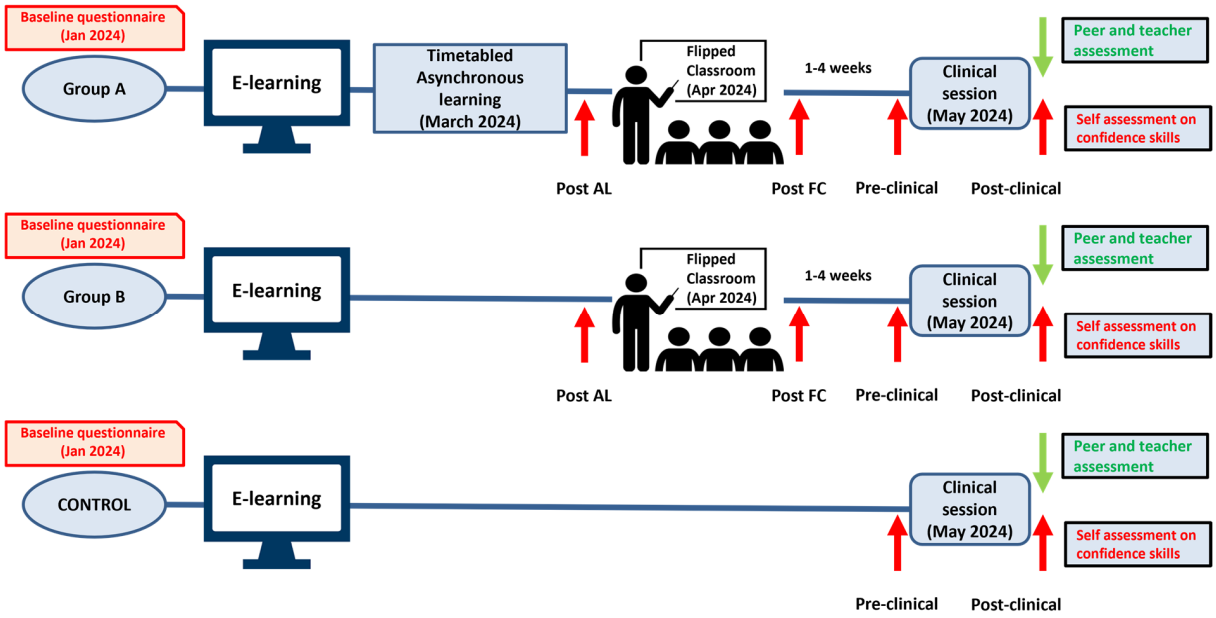

Figure 1. The intervention received by the different groups and the various timepoints for data collection. Students completed self-assessment questionnaires after each intervention, and immediately before and after patient care (red arrow). Peer and supervisor assessments were carried out immediately after patient care (green arrow).

2.5. Data Collection

Data collection was conducted at multiple timepoints, as outlined in Figure 1. Three primary assessment methods were utilised:

1. Validated Self-Assessment Questionnaires (Figure 2)

A 13-item questionnaire, adapted from Thilakumara et al., 2020 [15], was piloted on a group of students to assess clarity and comprehension. During the pilot phase, students' confidence levels were assessed on a Likert scale ranging from "Not confident at all" to "Very confident". Following confirmation of its understandability, the questionnaire was then administered to the study participants. The questionnaires were carefully selected to ensure relevance for BDS Year 2 during their first clinical session, aligning with the content covered in the AL and FC sessions.

Student self-assessment confidence questionnaires

1. Take presenting complaint and pain history.
2. Take a history from the patient (including medical, social, dental, diet history).
3. Interpret the medical history obtained from the patient (including identifying specific symptoms and important aetiological factors (systemic and local factors) to periodontal disease.
4. Positioning of the operator and patient for an oral examination.
5. Carry out an Extra-oral examination.
6. Carry out an Intra-oral examination.
7. Carry out clinical assessment including Basic Periodontal Examination (BPE).
8. Obtain the patient's Plaque Score.
9. Know when to carry out a 6-point pocket chart based on BPE score.
10. Complete a radiographic report and presentation.
11. Using the information collected to stage and grade the periodontal diagnosis.
12. Presenting the case to your clinical demonstrator.
13. Communicating effectively with your patient chair-side.

1=not confident at all, 5=very confident

Figure 2. 13-item questionnaire on the student's confidence adapted from Thilakumara et al. 2020 [15].

Group A completed the questionnaire at baseline, after AL, after FC, and pre- and post-clinical sessions. Group B completed the questionnaire at baseline, after FC, and before and after patient care. The control group completed the questionnaire at baseline, and pre- and post-clinical sessions.

2. Peer and Supervisor Assessments (Figure 3)

Peer and supervisor assessments were conducted immediately post-patient care. Validated assessment criteria were provided to ensure standardisation and reliability.

Both the assessment domains and rubrics were those used in the existing Periodontology module.

To ensure educational equity, all students, including those not enrolled in the study, were provided access to both AL and FC sessions upon study completion.

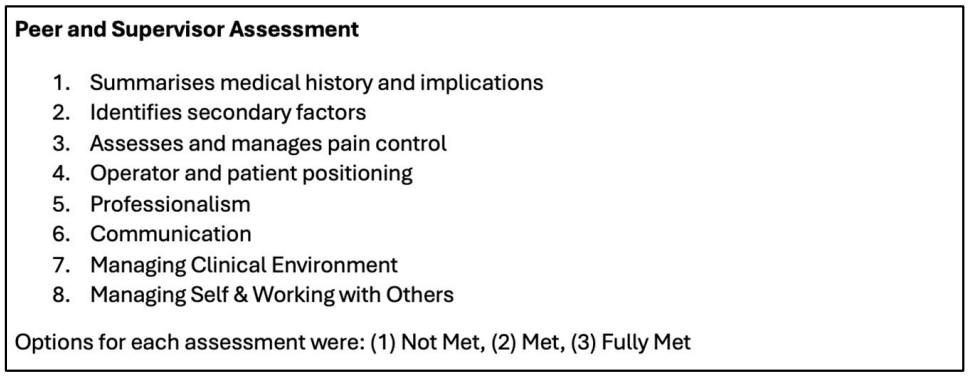

Figure 3. 8-item peer and supervisor assessment.

2.6. Statistical Analysis

All data were analysed using SPSS for statistical analysis (IBM® SPSS® Statistics Premium 29). Missing questionnaire responses were addressed using the multiple imputation method to minimise potential bias associated with incomplete datasets. Statistical analyses were conducted on both original and inputted datasets, and the findings were consistent (Supplementary Table S2); therefore, the results from the imputed dataset are presented in the main text document. Questionnaire responses were categorised into the following domains: (a) History-taking and communication (Q1, Q2, Q3, Q13), (b) Intra- and extra-oral examination (Q4, Q5, Q6), (c) Periodontal examination (Q7, Q8, Q9), (d) Periodontal diagnosis (Q11), (e) Radiographic and clinical presentation (Q10, Q12). Within each domain, the scores for each question were summed, and statistical analysis was conducted at the domain level.

Non-parametric approaches were employed to analyse confidence scores derived from Likert-scale responses, as these data were assumed not to follow a normal distribution. Descriptive statistics were used to summarise baseline confidence levels across groups. Baseline between-group differences were assessed using Kruskal–Wallis test. Changes in confidence scores across repeated assessment timepoints within each group were analysed using the Friedman test, followed by Bonferroni-adjusted pairwise comparisons when significant differences were identified. Between-group differences at equivalent timepoints were analysed using the Kruskal–Wallis test with Bonferroni correction for multiple comparisons. Statistical significance was set at $p < 0.05$, and all tests were two-sided. The reported p-values represent either within-group comparisons across timepoints (Friedman test) or between-group comparisons at equivalent assessment timepoints.

3. Results

3.1. Participant Characteristics

Participant characteristics are summarised in Table 1. A total of 33 students participated in the study, distributed across the groups as follows: Group A (AL+FC) (n = 11), Group B (FC) (n = 12), and the Control group (n = 10). These were opt-in students who voluntarily agreed to participate. All participants were BDS Year 2 students, comprising either standard-entry or graduate-entry students (Table 1). Graduate students held degrees in medicine or biology-related disciplines.

Table 1. Participant characteristics.

Characteristic	Group A (n = 11)	Group B (n = 12)	Control (n = 10)	Total (n = 33)
BDS Year 2 students, n (%)	11 (100)	12 (100)	10 (100)	33 (100)
First periodontal clinical session, n (%)	11 (100)	12 (100)	10 (100)	33 (100)
Standard-entry students, n (%)	9 (81.8)	4 (33.3)	7 (70.0)	20 (60.6)
Graduate-entry students, n (%)	2 (18.2)	8 (66.7)	3 (30.0)	13 (39.4)
Previous medical/biology-related degree *, n (%)	2 (18.2)	8 (66.7)	3 (30.0)	13 (39.4)

* Previous medical/biology-related degrees include Medicine, Biomedical Sciences, Pharmacy or other related life science disciplines.

The proportion of graduate students was highest in group B, with 8 out of 12 participants (66.7%) having a prior degree. By contrast, Group A and the Control group consisted mainly of standard-entry students (Table 1). This disparity could be responsible for the higher baseline confidence scores observed in Group B across multiple domains, although this did not reach statistical significance.

3.2. Baseline Comparison of Confidence Levels Between Groups

At baseline, the self-reported confidence levels across all categories were comparable between groups. However, students in Group B (FC) exhibited slightly higher baseline confidence levels relative to Groups A (AL+FC) and the Control group, though this difference was not statistically significant ($p > 0.05$) (Figure 4).

3.3. Within-Group Comparison of Self-Confidence Levels at Different Timepoints

In Group A (AL+FC), confidence levels increased across all categories from baseline to post-AL and post-FC, with a statistically significant increase from baseline to post-clinical ($p < 0.05$). However, confidence levels declined slightly before the clinical session and then increased again afterwards (Figure 5).

A similar trend was observed in Group B (FC), where confidence levels steadily increased from baseline to post-FC ($p < 0.05$) (Figure 6). However, unlike Group A (AL+FC), Group B (FC) did not undergo post-AL assessments.

In contrast, the Control group exhibited variable changes in confidence levels across different categories between baseline and the pre-clinical session. Confidence levels in history-taking and communication, as well as radiographic and clinical examination, remained relatively stable. However, self-confidence in periodontal examination and diagnosis increased, whereas it decreased in intra- and extra-oral examination. Similar to Groups A (AL+FC) and B (FC), confidence levels significantly increased across all categories following the clinical session ($p < 0.05$).

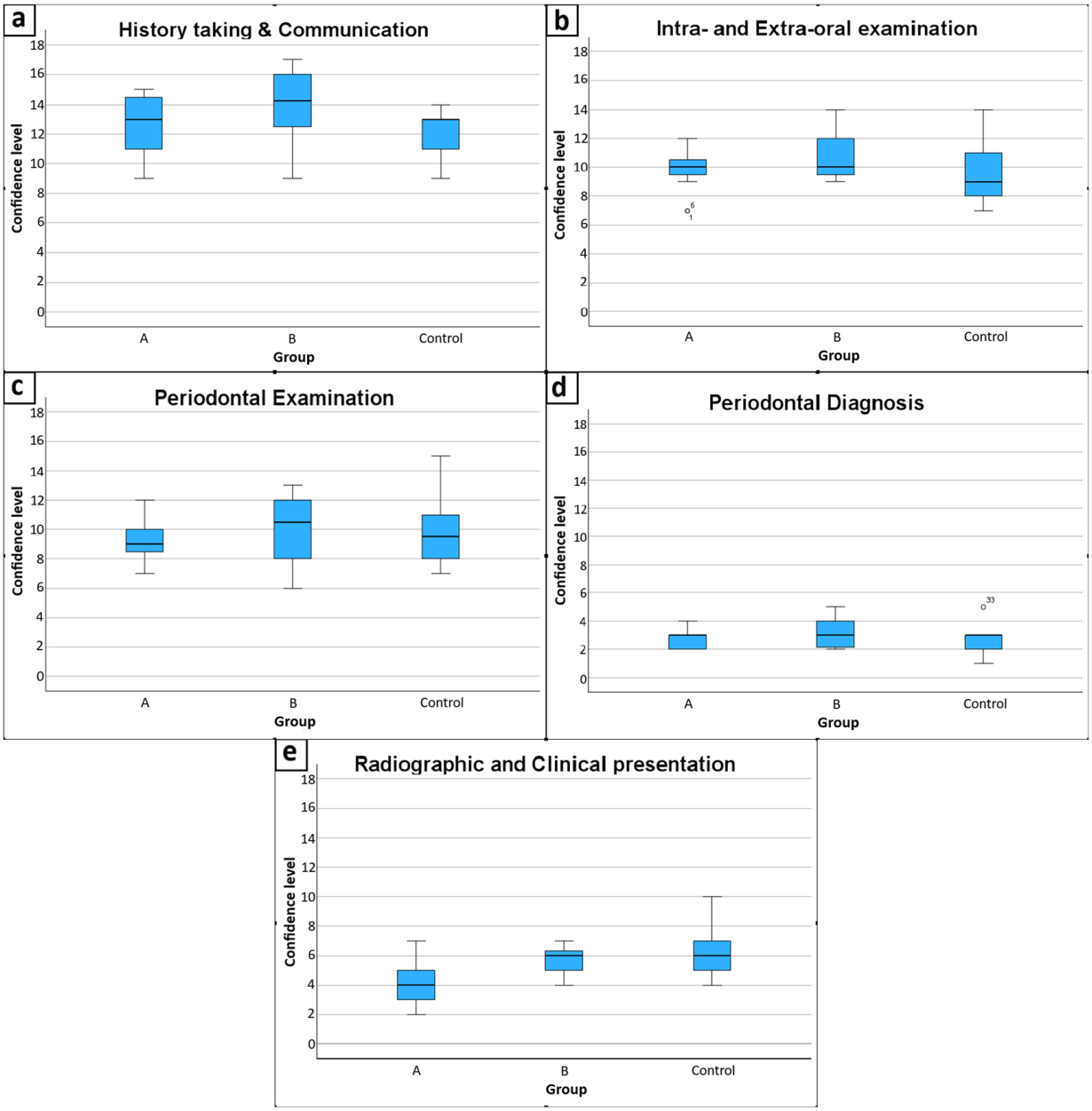

Figure 4. Box whisker plot for Groups A (AL+FC), B (FC) and Control at baseline according to each category: (**a**) History taking and communication, (**b**) Intra- and Extra-oral examination, (**c**) Periodontal examination, (**d**) Periodontal diagnosis, (**e**) Radiographic and clinical presentation. There were no statistically significant differences in confidence levels between the groups and categories at baseline ($p > 0.05$). Data are presented as box-and-whisker plots, where the horizontal line within each box represents the median, the box represents the interquartile range, the whiskers represents the minimum and maximum values, and the dots represents outliers.

3.4. Between-Group Comparison of Confidence Gains Following Educational Interventions

Between-group comparisons were conducted at baseline, pre-clinical, and post-clinical timepoints. Overall, a similar trend was observed across all groups, with the most substantial increase in self-confidence levels occurring after the clinical session. However, no statistically significant differences in absolute confidence scores were identified between the groups at equivalent assessment timepoints ($p > 0.05$) (Figure 7).

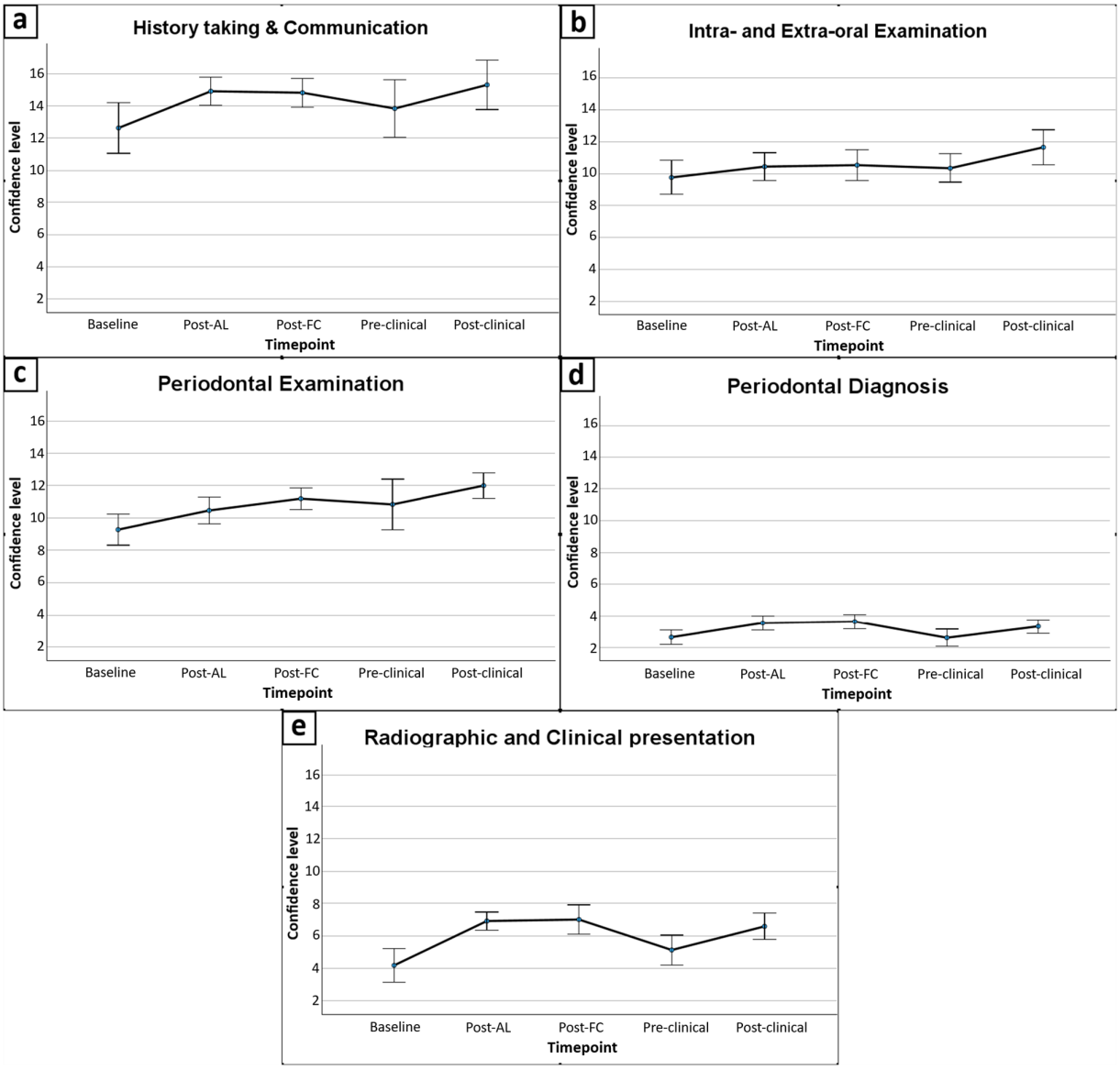

Figure 5. Comparison of self-confidence in Group A (AL+FC) at baseline, post-AL, post-FC, pre- and post-clinical according to each category: (**a**) History taking and communication ($p = 0.012$), (**b**) Intra- and Extra-oral examination ($p = 0.055$), (**c**) Periodontal examination ($p < 0.001$), (**d**) Periodontal diagnosis ($p < 0.001$), (**e**) Radiographic and clinical presentation ($p < 0.001$). Overall, confidence shows an upward trajectory across the different timepoints ($p < 0.05$). Data are presented as estimated marginal mean (blue dot), with the error bars (line) representing the 95% confidence intervals (95% CI).

Across all groups, the category that exhibited the greatest improvement following the clinical session was history-taking and communication. To further explore the association of the educational interventions, changes in confidence from baseline to post-FC were compared between Groups A (AL+FC) and B (FC). Overall, confidence gains were comparable across most domains (Figure 8). However, significant between-group differences were observed in several areas. In radiographic interpretation and clinical presentation, Group A (AL+FC) demonstrated a significantly greater increase in confidence compared with Group B (FC) ($p = 0.030$) (Figure 8e). Conversely, Group B (FC) demonstrated significantly greater improvements in history-taking and communication ($p = 0.032$) and intra- and extra-oral examination ($p = 0.022$) compared with Group A (AL+FC) (Figure 8a,b).

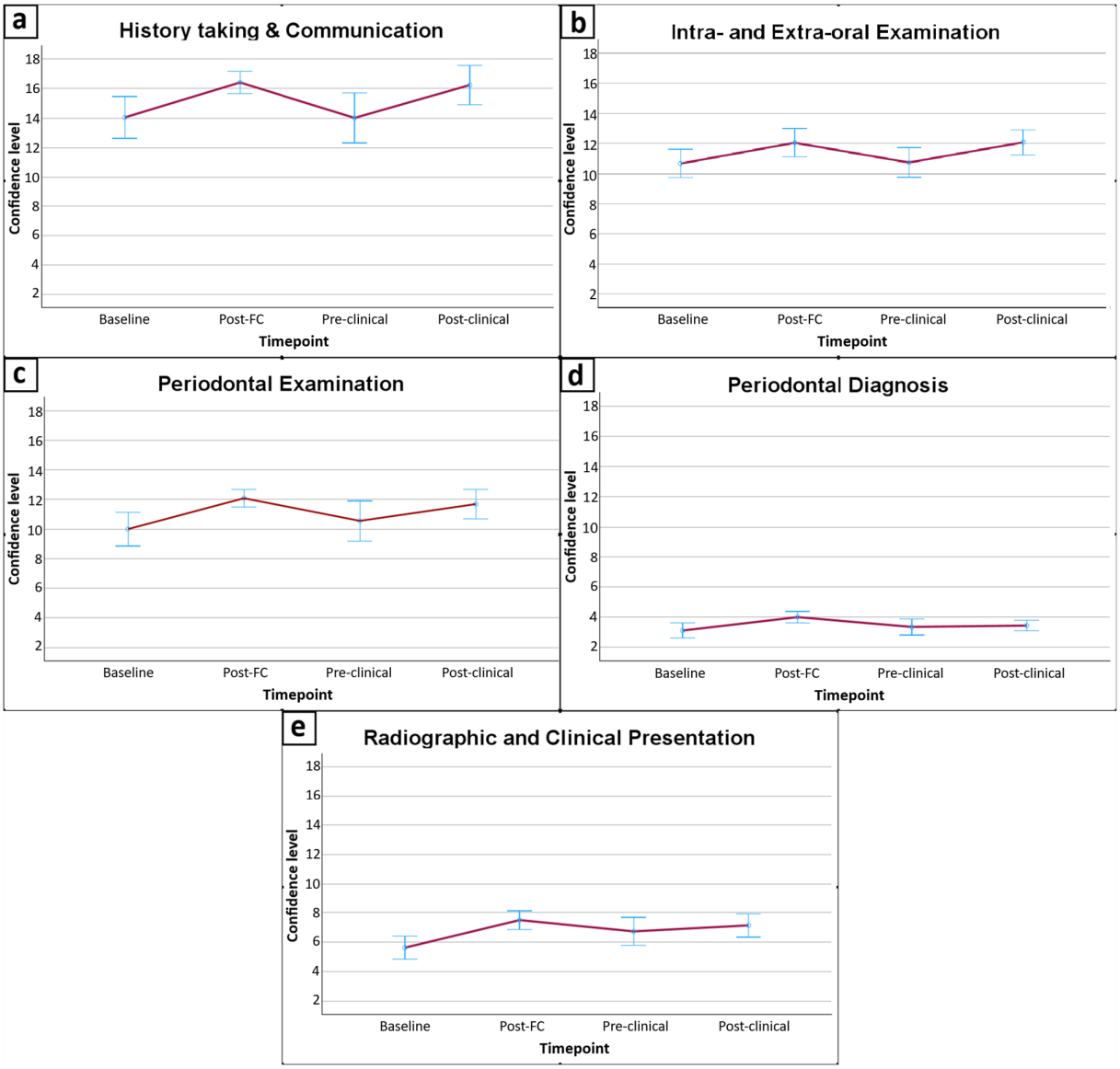

Figure 6. Comparison of self-confidence in Group B (FC) at baseline, post-FC, pre- and post-clinical according to each category: (**a**) History taking and communication ($p < 0.001$), (**b**) Intra- and Extra-oral examination ($p < 0.001$), (**c**) Periodontal examination ($p < 0.001$), (**d**) Periodontal diagnosis ($p = 0.002$), (**e**) Radiographic and clinical presentation ($p < 0.001$). Overall, confidence increased from baseline to post-clinical session ($p < 0.05$). Data are presented as estimated marginal mean (blue dot), with the error bars (line) representing the 95% confidence intervals (95% CI).

3.5. Descriptive Analysis of Supervisor and Peer Assessments

Due to the small sample size and the limited grading options on the clinical assessment forms, most students received passing scores on both supervisor and peer assessments. As a result, a direct statistical comparison between supervisor and peer evaluations was deemed inappropriate. Instead, we identified students who did not meet the required competence levels, along with the reasons provided.

- One student in Group A (AL+FC) did not meet the required standard in both supervisor and peer assessments due to inaccuracies in identifying calculus on teeth and failure to explore family medical history, respectively.
- One student in Group B (FC) received a failing grade in peer assessment, with feedback indicating the need for further improvement in identifying calculus on teeth.

- One student in the Control group did not meet the supervisor's assessment criteria in clinical environment management, specifically in relation to ineffective disinfection of the spittoon. However, as clinical environment management was not explicitly covered in the AL and FC learning sessions, this criterion falls outside the scope of the intervention and should not be considered in evaluating the impact of the study.

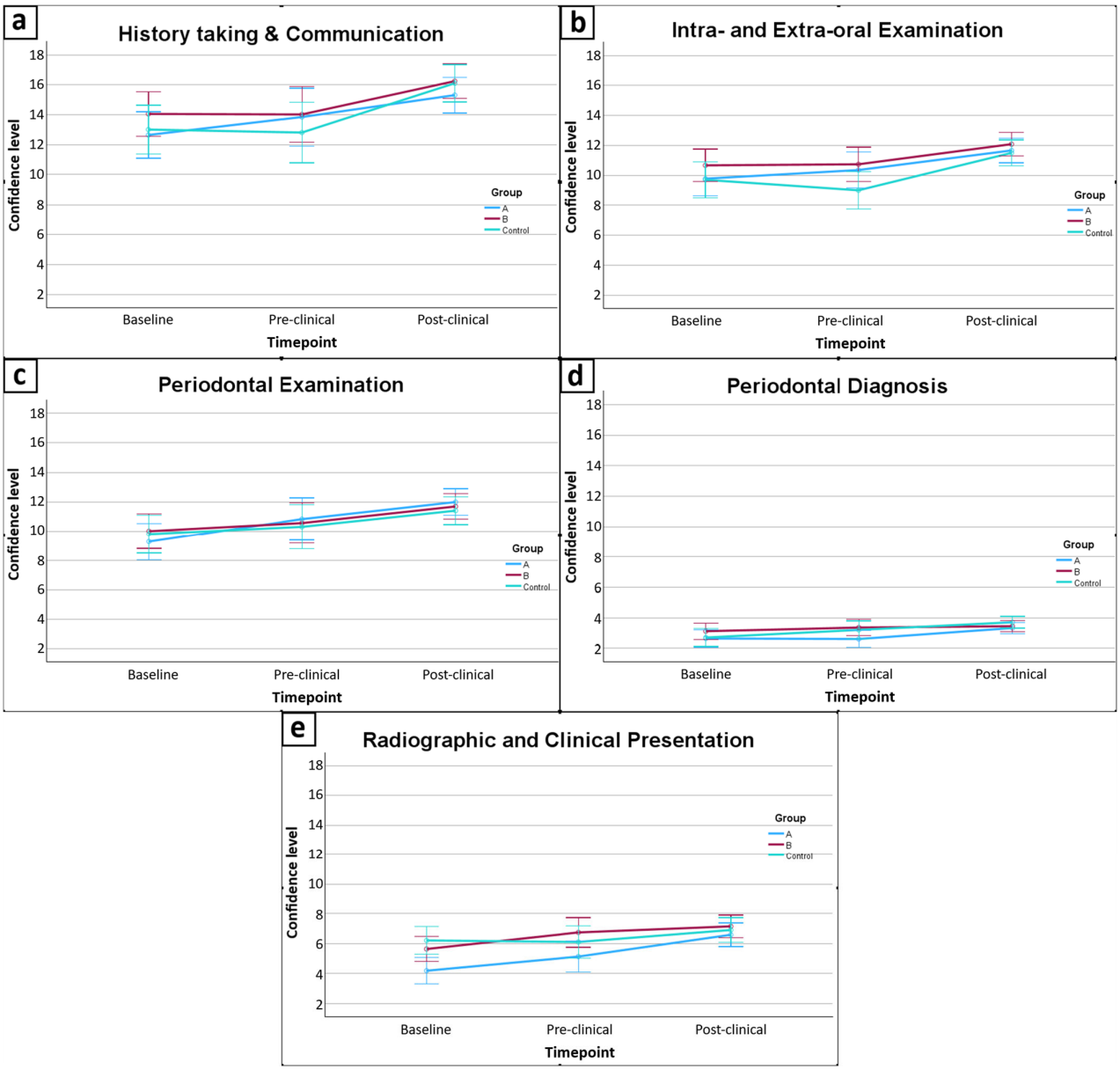

Figure 7. Comparison of self-confidence in Group A (blue line), B (red line) and Control (green line) at baseline, pre- and post-clinical according to each category: (**a**) History taking and communication, (**b**) Intra- and Extra-oral examination, (**c**) Periodontal examination, (**d**) Periodontal diagnosis, (**e**) Radiographic and clinical presentation. In general, confidence increases progressively across the various timepoints within each group and category. However, there were no statistically significant differences between the groups and categories ($p > 0.05$). Data are presented as estimated marginal mean (blue, red and green dots), with the error bars (line) representing the 95% confidence intervals (95% CI).

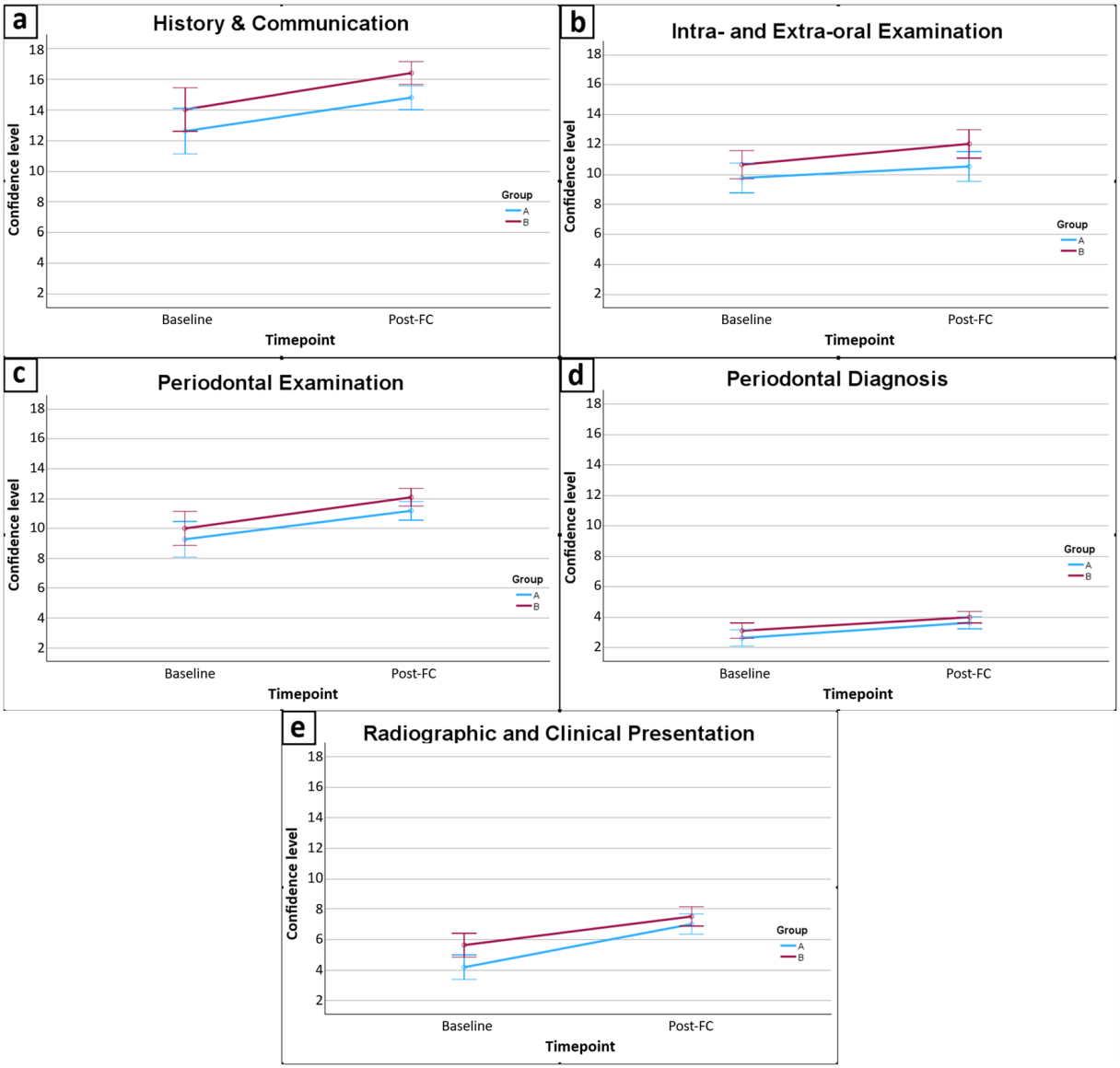

Figure 8. Comparison of self-confidence in Group A (blue line) and B (red line) at baseline and post-FC according to each category: (**a**) History taking and communication ($p = 0.032$), (**b**) Intra- and Extra-oral examination ($p = 0.022$), (**c**) Periodontal examination ($p = 0.134$), (**d**) Periodontal diagnosis ($p = 0.148$), (**e**) Radiographic and clinical presentation ($p = 0.030$). There was a statistically significant difference between the groups in only the categories of history-taking and communication, intra- and extra-oral examination, and radiographic and clinical presentation ($p < 0.05$). Data are presented as estimated marginal mean (blue and red dots), with the error bars (line) representing the 95% confidence intervals (95% CI).

4. Discussion

This study assessed the different teaching methodologies on student confidence during the transition from simulation-based learning to clinical practice. Overall, students across all groups demonstrated comparable baseline confidence levels, with no statistically significant difference observed. Within-group analyses showed a consistent increase in self-confidence over time, with the most substantial gains occurring after the clinical session, suggesting that clinical exposure played a key role in the development of confidence. While no significant differences in absolute confidence scores were identified between groups at equivalent assessment timepoints, significant domain-specific differences were observed in the magnitude of confidence gains between Group A (AL+FC) and Group B (FC).

Supervisor and peer assessments were largely consistent, with most students achieving passing scores and only a small number of isolated competency concerns identified.

The transition from theoretical learning to clinical practice poses a significant challenge for students, particularly those with limited prior practical experience. This study aimed to evaluate the effectiveness of timetabled AL and the FC approach in fostering self-directed learning and enhancing student confidence during their initial clinical sessions. An online revision module was developed to reinforce fundamental theoretical concepts covered in the second year of the BDS curriculum. These included essential, authentic clinical tasks such as eliciting a patient's presenting complaint, ensuring appropriate patient positioning for a procedure, conducting extra- and intra-oral examinations, performing a basic periodontal assessment, calculating the percentage of bone loss on radiographs, interpreting findings, and presenting them to a supervisor. Reinforcing these skills was intended to facilitate a smoother transition into clinical practice.

The distinctive feature of Group A was the provision of the timetabled AL session prior to FC activity. By contrast, students in Group B attended FC without the timetabled AL session beforehand, although the e-learning modules remained accessible online. This aspect of the study design enabled the assessment of whether structured, protected AL conferred additional benefits beyond participation in the FC session alone.

Previous research on FC in medical and dental education has primarily focused on comparing its effectiveness to traditional teaching modalities, with knowledge retention—measured through examination results—being a primary outcome. While many studies have reported improved academic performance among students exposed to FC interventions, the approach has also been well received by students [16–18]. However, some studies have found no statistically significant differences in examination scores between FC and traditional methods, despite higher levels of satisfaction among both students and instructors with the FC learning experience [19,20]. The differences in outcome measures used to assess the impact of FC make direct comparisons with our study challenging.

A distinguishing feature of this study was its longitudinal design, which enabled tracking of student confidence across multiple timepoints, from baseline to post-clinical sessions. This approach enabled the assessment of both intra-group confidence changes and inter-group comparisons. The Clinical Assessment Framework (CAF) was used for post-clinical evaluation, focusing on key clinical tasks in basic periodontal assessment. The CAF was selected for its validity as an assessment tool, with students evaluated by calibrated supervisors to ensure consistency in student evaluation. Additionally, peer assessment was incorporated to enhance students' assessment literacy, ability to self-assess, and learner autonomy, as engaging in peer evaluation using standardised criteria could facilitate a more critical and reflective approach to patient assessment.

This study explored the influence of AL and FC on student confidence during the transition from theoretical learning to clinical application. Statistical analyses were conducted twice: first using raw data and subsequently with multiple imputation to address missing data. The results remained consistent across both analyses, as presented in the Supplementary Materials.

The findings suggest that the AL and FC methodologies contributed to an overall increase in student confidence from baseline to post-FC in Groups A (AL+FC) and B (FC). This aligns with prior research among third-year Harvard dental students, in which 84–90% of students who participated in FC agreed or strongly agreed that FC was effective for learning and understanding periodontal diagnosis and treatment planning [3]. Moreover, a study by Farah-Franco et al., which aligns with our research, implemented FC for content reinforcement (CR) following a period of asynchronous learning. Their study utilised student surveys to evaluate the influence of FC on various aspects of learning. Interest-

ingly, "Clinical Practice" and "Learning" were two aspects the student groups found most beneficial through the FC session. Notably, the reported mean scores for self-confidence improvement were 2.37 and 2.04 in the respective groups, which were categorised as "Very Helpful" in their rating system [21]. These findings are consistent with our study's results, which also indicate that FC contributes to increased student confidence and perceived learning benefits.

Despite the beneficial trend observed after the FC session, confidence declined at the pre-clinical stage in this study. This may be attributed to the prolonged interval between the FC session and the students' first clinical exposure, which may impair knowledge retention and increase anxiety, thereby negatively impacting confidence. Furthermore, working in an unfamiliar clinical environment may increase cognitive load and self-doubt, particularly regarding work quality and peer perception, which are known stressors for novice learners [22]. As anticipated, the most substantial increase in confidence was observed between the pre- and post-clinical sessions across all groups, as hands-on experience enables students to apply theoretical knowledge in a real-world setting.

In Group A (AL+FC), the increase in confidence between post-AL and post-FC was minimal. This may be explained by the relatively short duration between AL and FC, as the latter was conducted approximately one hour after the former, potentially limiting the time available for students to internalise the AL material before engaging in FC discussions. Nevertheless, when comparing the overall increase in confidence from baseline to post-FC across both Groups A (AL+FC) and B (FC), the observed improvements were similar, suggesting that FC positively influenced student confidence. A key concern in the FC model is student compliance with pre-class e-learning materials, as highlighted by Vanka et al., 2020 [12]. To mitigate this, they encouraged the use of readiness-assurance quizzes to enhance student engagement with pre-class content. Although such quizzes were not used in this study, the novelty of the FC model alone could have encouraged students to interact further with the online material, thereby accounting for the comparable confidence gains observed in both groups. This finding is supported by a randomised controlled trial by Wang et al. (2021), which demonstrated that engagement in online learning sessions was significantly higher in the FC model than in traditional lectures, resulting in improved individual assessment scores at the end of the course [14].

At baseline, eight of twelve students in Group B (FC) were graduate-entry pathway students with a medical or biology-related background. This demographic composition is likely to have influenced the results, as their prior experience could explain the consistently higher self-confidence scores observed across all categories and timepoints.

Confidence levels in the Control group exhibited variable changes across different domains between baseline and pre-clinical assessment. These variations may be attributed to independent engagement with the AL module, as students in this group had the option to access the material at their discretion. However, due to the study design, it was not possible to track individual engagement with the e-learning module prior to the designated timepoints, which may have influenced the observed trends.

When directly comparing confidence gains from baseline to post-FC between Groups A (AL+FC) and B (FC), significant between-group differences were observed in several domains. Group A (AL+FC) exhibited a greater increase in confidence in radiographic and clinical presentation. Interpretation of radiographic images requires students to analyse two-dimensional images and identify dental pathologies or abnormalities, skills that may benefit from the flexibility facilitated by AL, including the ability to pause, rewind, and revisit educational content at an individualised pace. Similarly, clinical case presentation requires students to extract and synthesise key information, a process that was emphasised in the e-learning module, potentially contributing to the greater gains in confidence observed

in Group A (AL+FC). In contrast, the domains of history-taking and communication, as well as intra- and extra-oral examination, demonstrated a significantly greater increase in confidence in Group B (FC). One possible explanation is the demographic composition of Group B, which consisted of a substantially higher proportion of graduate-entry students with previous medical or biology-related degrees. Prior clinical, academic and communication experience may have contributed to higher baseline confidence scores and influenced subsequent confidence gains within these domains. Therefore, the observed differences between Groups A and B should be interpreted with caution, as disparities in educational background may have confounded the study findings. The reasons for students failing to meet competency criteria in peer and supervisor assessments provide additional insights into areas for improvement. Two students received feedback on inaccuracies in their detection of calculus, highlighting a challenge in teaching this skill in a theoretical setting. Since the identification of calculus relies not only on visual assessment but also on tactile feedback, this competency can only be fully developed in a clinical environment. Therefore, different theoretical teaching methods will not affect this technical domain. Taken together, these findings highlight the broader educational implications of incorporating active learning approaches into early clinical training. While this study demonstrated that AL and FC are associated with increased student confidence, these findings should be interpreted within a wider educational context. Within a competence-based educational framework, these approaches align closely with the emphasis on active engagement, progressive skill development, and reflective practice. By encouraging learners to take greater ownership of their preparation, apply knowledge in meaningful contexts, and evaluate their own confidence, AL and FC may support the development of observable competencies rather than passive acquisition of content. The FC model allocates in-person teaching time to higher-order cognitive activities, including clinical reasoning, discussion and application of knowledge. While the increased confidence reported by students may indicate greater familiarity with clinical concepts and a perceived readiness for practice, further studies that incorporate objective measures of clinical competence are required to determine whether these educational approaches translate into measurable improvements in clinical performance.

5. Limitations

Several limitations of this study should be acknowledged. First, the small sample size may limit the generalisability of the findings, and no statistically significant differences were detected between groups at baseline, pre-, or post-clinical sessions. This is likely attributable to the study's voluntary nature, as students were not required to attend these sessions beyond their core curriculum. Second, despite initial plans to recruit students across four intervention groups, recruitment challenges prevented the inclusion of the group with only AL, as students were reluctant to attend supervised online sessions in-person. Third, despite the materials and guidance provided for the FC workshops, differences likely existed among the instructors' teaching styles. Fourth, additional complications arose when students deviated from their assigned clinical groups, leading to difficulties with data collection and missing questionnaire responses. Fifth, a major logistical challenge was the prolonged delay in obtaining pre-clinical timepoint data due to a lack of patient allocation to BDS 2 students over several weeks, contrary to the initial expectation of a one-week interval. In some cases, students had to engage in peer-to-peer clinical exercises instead of patient-based assessments, which may have distorted their true clinical confidence and assessment skills. Moreover, the extended interval between the FC session and the students' first patient assessment may have contributed to the observed decline in pre-clinical confidence, possibly due to insufficient recent reinforcement of the material.

Sixth, though the CAF questions were carefully selected to reflect what was covered in the e-learning session, a mismatch between the students' confidence survey items and the CAF assessment criteria complicated direct comparisons between self-reported confidence and their perceived preparedness as assessed by peers and supervisors. Also, the improvements in confidence observed in this study may have resulted from increased exposure to learning materials rather than the specific teaching modalities (AL or FC). Finally, we acknowledge that variation in baseline knowledge and prior educational experience may have influenced both self-assessment and perceived preparedness outcomes, particularly among students entering through graduate-entry pathways, who have more advanced academic backgrounds. This indicates that variability in students' backgrounds across groups may have affected comparability, and this was acknowledged when interpreting the results.

Future studies should consider several strategies to enhance student engagement and the effectiveness of the Flipped Classroom model. To improve preparation, instructors could include a short formal presentation outlining expectations before the session, along with pre-class assignments, such as worksheets, to encourage active preparation and targeted learning. Improvements to the teaching format within the sessions are also recommended; organising group activities around multiple distinct clinical cases, rather than a single scenario, may prevent fatigue and maintain interest. Facilitators must also remain mindful of group dynamics, particularly regarding dominant participants; asking active students to nominate quieter peers to contribute could encourage more equitable participation. Future research should implement strategies to increase participation, such as providing incentives (such as vouchers, gift cards), and expanding recruitment to multiple cohorts to enhance the generalisability of the findings. To minimise delays between FC sessions and clinical exposure, researchers must collaborate with program administrators to ensure adequate patient allocation. Finally, future designs should include both a distinct feedback section for students immediately after the session and a dedicated section within the research questionnaire to capture their qualitative experiences, enabling comparisons with traditional didactic sessions.

6. Conclusions

This study suggests that AL and FC approaches may support students' confidence during the transition from theoretical learning to clinical practice. Confidence levels increased over time across all study groups, with the greatest gains observed following clinical exposure. No statistically significant differences in absolute confidence scores were identified between groups at equivalent assessment timepoints, although domain-specific differences in confidence gains were observed between students who participated in both AL and FC and those who were allocated to the FC group only. Although supervisor and peer assessments indicated generally satisfactory performance across all groups, the study was not designed or powered to detect differences in objective clinical competence. Further research incorporating robust and standardised measures of clinical performance is required to determine whether improvements in confidence translate into measurable improvements in clinical competence.

Appendix A (questionnaires adapted from Thilakumara et al., 2020 [15]) and Appendix B (assessment domains and rubics based on the validated assessment criteria used in the existing BDS2 Periodontology module at Kings College London).

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/oral6040095/s1, Figure S1: Comparison of the differences in self-reported confidence level in Group A (AL+FC), B (FC) and Control from baseline to pre-clinical session according to each category: (a) History taking and communication, (b) Intra- and Extra-oral

examination, (c) Periodontal examination, (d) Periodontal diagnosis, Radiographic and Clinical presentation. Based on the Kruskal–Wallis analysis, there were no statistically significant difference between the groups in each category ($p > 0.05$). Table S1: Kruskal–Wallis analysis of the differences in self-reported confidence level in Group A (AL+FC), B (FC) and Control from baseline to pre-clinical session for each category. Based on the Kruskal–Wallis analysis, there were no statistically significant difference between the groups in each category ($p > 0.05$). Table S2: Comparison of Statistical Analyses Performed Using Original and Multiple-Imputed Datasets.

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Data Availability Statement: The data supporting this manuscript can be made available upon reasonable to the corresponding author. Identifying information has been removed.

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Appendix A

Student questionnaire: Confidence skills

1. Take presenting complaint and pain history.
2. Take a history from the patient (including medical, social, dental, diet history).
3. Interpret the medical history obtained from the patient (including identifying specific symptoms and important aetiological factors (systemic and local factors) to periodontal disease.
4. Positioning of the operator and patient for an oral examination.
5. Carry out an Extra-oral examination.
6. Carry out an Intra-oral examination.
7. Carry out clinical assessment including Basic Periodontal Examination (BPE).
8. Obtain the patient's Plaque Score.
9. Know when to carry out a 6-point pocket chart based on BPE score.
10. Complete a radiographic report and presentation.
11. Using the information collected to stage and grade the periodontal diagnosis.
12. Presenting the case to your clinical demonstrator.
13. Communicating effectively with your patient chair-side.

1 = uncertain, 5 = very confident

Appendix B

Peer and Teacher Assessment

1. Summarises medical history and implications
2. Identifies secondary factors
3. Assesses and manages pain control
4. Operator and patient positioning
5. Professionalism
6. Communication
7. Managing Clinical Environment
8. Managing Self and Working with Others

Options for each assessment were: (1) Not Met, (2) Met, (3) Fully Met.

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