Impact of Learning-Style-Based Education on Student Performance and Perception in Preclinical Endodontics: Part II

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IMPACT OF LEARNING-STYLE-BASED EDUCATION ON STUDENT PERFORMANCE AND PERCEPTION IN PRECLINICAL ENDODONTICS: PART II

By
Rebecca N. Flaugher, D.M.D.

A Thesis Submitted to the Faculty of the Graduate School,
Marquette University,
in Partial Fulfillment of the Requirements for
the Degree of Master of Science

Milwaukee, Wisconsin
May 2024
ABSTRACT

Impact of Learning-Style-Based Education on Student Performance and Perception in Preclinical Endodontics: Part II

Rebecca N. Flaugher, D.M.D.

Marquette University, 2024

Objectives: This study aimed to investigate if providing supplemental learning materials aligned to students’ learning modes is equally beneficial among all modes both subjectively and objectively.

Methods: IRB approval was obtained (Approval #HR-3746). Second-year dental students (n=92) enrolled in Preclinical Endodontics took Kolb Experiential Learning Profile (KELP) questionnaire to determine their learning mode: Abstract Conceptualization (AC), Active Experimentation (AE), Reflective Observation (RO), or Concrete Experience (CE). Students were assigned into groups corresponding to their learning mode. Students performed non-surgical root canal treatment (NSRCT) on a #9 typodont tooth and were graded to determine baseline performance (Project 1). Students were then given their learning mode and provided aligned supplemental material. Next, students performed NSRCT on a second #9 typodont tooth (Project 2) and were graded. Students completed a satisfaction survey at the completion of Project 2. Grades from the two projects were evaluated to determine if the provided supplemental material objectively improved student performance, while responses from the survey were quantified to determine subjective perception.

Results: The distribution of learning modes was 41% AE, 37% RO 11% AC, and 11% CE. While mean score improvements were observed in the AE, RO, and AC groups, they did not reach statistical significance with no notable differences between groups (P > 0.05). Subjectively, 78.3% of students agreed that the materials enhanced their educational experience, 75.0% affirmed they increased their understanding of concepts, and 68.9% reported greater success as result. These perceptions were uniform across all learning modes. Age and gender had no significant influence on objective or subjective outcomes.

Conclusion: Providing supplemental learning material aligned with students’ learning modes improved subjective perception for all modes without significant impact on objective performance. Incorporating learning-style-based education may improve student satisfaction in a preclinical dental school setting.
ACKNOWLEDGEMENTS

Rebecca N. Flaugher, D.M.D.

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INTRODUCTION

Dental educators face the challenge of delivering engaging and effective educational material to adult learners who often enter programs with established learning styles. (1,2) Traditional teaching methods have been based heavily on lectures and note taking, encouraging learning through rote memorization. Student frustration and dissatisfaction can arise when teaching methodology does not align with their learning preference. (1,3) Furthermore, it is difficult to incorporate clinical sciences into traditional lecture-based teaching and can be challenging for students to apply knowledge taught in this manner. (4)

Alternative teaching styles have been proposed to address the shortcomings of conventional teaching such as problem-based learning, case-based learning, team-based learning, and learning-style-based education. (5–7) Learning-style-based education is rooted in adapting the method of instruction according to students’ preferred learning style (7) and has shown positive outcomes in previous studies among medical and dental students. (8) Studies that provided education materials tailored to students’ learning style preference have shown not only an increase in academic performance and student understanding of concepts, but improved student satisfaction and attitudes towards learning.

Using Kolb’s Learning Style Inventory (LSI), Tsatalis et al. (9) found that providing dental students with supplemental material aligned with the reflective observation learning mode significantly improved students’ learning experience both subjectively and objectively when compared to control groups provided with either misaligned materials or no materials at all. While Part I of this study showed promising
results in support of learning-style-based education, one of its major limitations was that no customized learning materials were provided to students that preferred the other three learning modes (concrete experience, abstract conceptualization, and active experimentation). Thus, the objectives of the present study were to investigate the effect of providing supplemental learning materials aligned with all four of Kolb’s learning modes, evaluate the impact of these materials on student performance and perception, and determine whether there is a possible relationship between learning mode, age, and gender.
LITERATURE REVIEW

Traditional Teaching Methodology

Dental students are adult learners often coming into their programs with established learning styles as well as preferences for how they acquire and process new information. (2) Despite this, traditional dental pedology is heavily reliant on the lecture format as the sole form of instruction, encouraging learning through passive note taking and rote memorization. In the United States, predoctoral dental school curriculum is typically condensed into four years with an emphasis placed on didactic courses in the first two years, followed by a transition into clinical practice in the final two years. (1) Applying knowledge learned from didactic courses to patient care can be challenging when students are taught in this manner. Furthermore, student frustration and dissatisfaction can arise when teaching methodology does not align with their learning preference. (1,3)

Alternative Teaching Styles

Several alternative teaching styles have been proposed in an attempt to address the shortcomings of conventional teaching such as problem-based learning, case-based learning, team-based learning, and learning-style-based education. Problem-based learning is a student-driven process whereby students work together to solve a problem while the teacher acts as the facilitator. (5,6) Case-based learning requires the application of existing knowledge to solve a case involving a realistic clinical scenario. (5,6) Team-based learning is an interactive form of learning where students work in small groups to apply their knowledge to solve problems. (10)
Learning-style refers to how individuals “perceive, interact with, and respond to the learning environment”. (7) Learning-style-based education is rooted in adapting the method of instruction according to students’ preferred learning style. (11) Proponents of learning-style-based education encourage dental educators to be aware of different learning styles among students and consider accommodating different preferences to increase teaching effectiveness and enhance students’ educational experience. (1,12)

Support for Learning-Style-Based Education

The benefits of learning style-based-education implementation have been demonstrated in several studies among both medical and dental students. (9,13–15) A study among medical students found that providing educational materials tailored to students’ preferred learning style increased their academic performance, understanding of the subject matter, and subject retrieval when compared with traditional didactic teaching. (14) Meta-analysis revealed that matching instruction to learning-style preference resulted in improved academic achievement and attitude toward learning among dental students. (13) Further, a study among Chilean dental students found that providing a variety of learning methodologies to accommodate multiple learning styles increased exam scores and was rated as highly effective by students. (15) Most recently, Tsatalis et al. (9) found that learning-style-based education provided both objective and subjective improvement among predoctoral dental students.

Critique of Learning-Style-Based Education

While many studies highlight the benefits of learning-style-based education, others argue that it is not useful in enhancing the educational experience. (16–19) Pashler et al. (16) questioned the validity of studies on learning-style-based research, asserted that there is a lack of evidence to justify incorporating this type of education. Using the Kolb
Learning Style Inventory, Wang and Liu (17) found that learning style had no effect on students’ satisfaction with traditional and inverted classroom model learning in a medical school setting. In a cross-sectional study among Iranian dental students, Hosseini et al. found no significant relationship between academic achievement and students’ dominant learning style. (19) A recent systematic review by Childs-Kean et al. (18) reviewed multiple learning style frameworks in the context of health science education including the Kolb Learning Style Inventory and found the association between learning style and learning outcomes to be weak.

**Learning Style Inventories**

Several learning style inventories have been reported in the literature including the Visual, Aural, Read/Write, and Kinesthetic model (VARK), Kolb Learning Style Inventory (LSI), and Honey and Mumford Learning Style Questionnaire. (18,20)

**VARK**

The VARK model was developed by Neil Fleming in 1998. This learning style inventory is based on the senses and focuses on how information is obtained by the learner. (21) It includes four types of learners: visual, aural, read/write, and kinesthetic. Visual learners benefit most from the use of diagrams, pictures, and charts while read/write learners prefer written information in the form of lists, essays, and handouts. Aural learners like to learn by listening and benefit most from lectures, discussions, and recordings. Lastly, kinesthetic learners tend to learn most by new experiences, engaging in simulations, and practicing what they have learned.
Kolb Learning Style Inventory

Kolb LSI was proposed by David Kolb in 1984 is one of the most well-known and most cited learning style assessments. (9,15,17,20,22–25) It is based on the Experiential Learning Theory which focuses on learning as a dynamic process that results from synergistic interactions between an individual and their environment. (26) This questionnaire helps identify individuals’ preference for the four different learning modes: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE).

The four learning modes represent stages of learning cycle with CE representing the first experience, followed by a reflection based on that experience. Next, the individual transforms these reflections into abstract concepts which can be applied to new situations. The final stage of the learning cycle is when the learner actively tests these new concepts creating a new experience. Differences in personality, education, career, current job role, culture, and adaptiveness can all affect the way an individual uses the learning cycle, and most people will gravitate towards some modes of learning more than others. Learning is most effective when individuals are able to successfully utilize all four learning modes. (26)

Honey and Mumford Learning Style Questionnaire

The Honey and Mumford Learning Style Questionnaire was developed by Peter Honey and Alan Mumford in 1986 is based Kolb’s Experiential Learning Theory. Similar to Kolb LSI, it focuses on how learners perceive information and includes four types of learners: the activist (action-oriented), reflector (prefers thinking before acting), theorist (logically oriented), and the pragmatist (enjoy experimenting). Rather than asking
individuals how they learn, this learning style assessment focuses on one’s behaviors and
tendencies and is popular in business environments. (20)

**Part I Study**

Part I of this investigation by Tsatalis et al. (9) found that there was a statistically
significant difference in the distribution of learning modes among a population of second
year dental students with RO being the most prevalent learning mode. Customized
“reflection-based” supplemental learning material was provided only to students in the
RO group while students in CE, AC, and AE groups served as controls. The authors
found that providing dental students with supplemental material aligned with the RO
dominant learning mode significantly improved their learning experience both
subjectively and objectively when compared to the groups that either received materials
misaligned with their dominant learning mode or no materials at all. (9) The current study
seeks to expand upon this research by providing supplemental learning materials aligned
with all four learning modes to determine if all learning modes will benefit equally.
MATERIALS AND METHODS

Participation and Ethics

Ninety-seven second-year dental students enrolled in Preclinical Endodontics at Marquette University School of Dentistry were invited to participate in this part II study. Informed consent was obtained from all participants with appropriate IRB parameters (Approval #HR-3746). The decision to participate in the study had no effect on students’ grades in the course.

KELP and Group Assignment

Students took the Kolb Experiential Learning Profile (KELP) questionnaire to determine their dominant learning mode. Like Kolb LSI 4.0, KELP is based on the Experiential Learning Theory and is an updated version of the Kolb LSI 4.0 that was utilized in part I. According to Kolb and Kolb (26), this update includes “new norms that are based on a larger, more diverse and representative sample of 26,356 users.” Kolb LSI 4.0 was no longer available at the time of this part II study; thus, KELP was used to derive dominant learning modes. Students were then informed of their dominant learning mode. Results were analyzed to determine the distribution of learning modes among participants and if there were any associations between preferred learning mode, age, or gender.

In a laboratory session, all students completed non-surgical root canal treatment (NSRCT) on a #9 typodont tooth (Acadental, Overland Park, KS, USA). Teeth were collected and graded by two calibrated, blinded endodontic faculty members. Student performance was determined by using a grading rubric on a scale from 0-10 to determine baseline performance (Project 1). The grading rubric utilized is shown in Table 1.
Following Project 1, students were provided with corresponding supplemental material designed specifically for each learning mode (CE, RO, AC, or AE).

**CE Supplemental Material**

Students with the CE learning mode were divided into groups of three and given three radiographs of an obturated #9 typodont tooth. As a group, students discussed each case and collectively graded them based on a grading rubric. Following the activity, endodontic faculty provided feedback on the cases and students were given the opportunity to discuss their findings and compare them with faculty findings.

**RO Supplemental Material**

Students with the RO learning mode were asked to reflect on their performance, including any errors made and consider how they would avoid, improve, or manage these errors next time. After submitting this reflection, students were provided with written feedback from the two calibrated endodontic faculty members on their performance. Students were asked to read and reflect on faculty comments and suggestions prior to participation in the second attempt at NSRCT on a new #9 typodont tooth (Project 2).

**AC Supplemental Material**

Students with the AC learning mode were provided with a PowerPoint presentation on endodontic procedural errors which they were asked to review on their own time and at their own pace. To determine participation in the assignment, students were asked to complete a one-question quiz in D2L after reviewing the material prior to Project 2.
AE Supplemental Material

Lastly, students with the AE learning mode were provided with an additional #9 typodont tooth and asked to complete NSRCT and submit it prior to Project 2. Students completed this activity without faculty supervision.

All students completed NSRCT on a new #9 typodont tooth after completion of supplemental materials. Teeth were collected and graded by the same two calibrated, blinded endodontic faculty members using the same rubric as before. Only students who successfully completed and submitted supplemental material prior to Project 2 were included in the study. Grades from the two projects were evaluated to determine if the provided aligned supplemental material objectively improved student performance.

Student Satisfaction Survey

All students were asked to complete a seven-question satisfaction survey at the conclusion of the study to subjectively determine the effect of the supplemental learning material on students’ performance. Questions 1 and 2 pertained to students’ awareness of learning styles/modes and were coded on a Likert scale of 1 to 5 with 1 = very unaware, 2= somewhat unaware, 3 = neutral, 4 = somewhat aware, and 5 = very aware. Questions 3-5 asked students to reflect on the impact the supplemental materials had on their learning experience. Lastly, questions 6 and 7 asked students about the time burden of these materials and if they would recommend them to future classes, respectively. Responses to questions 3 through 7 were coded on a Likert scale of 1 to 5 with 1 = strongly disagree, 2= somewhat disagree, 3 = neither agree or disagree, 4 = somewhat agree, and 5 = strongly agree (Likert). (27)
Statistical Analysis

A comprehensive analysis of the variables was achieved using relevant descriptive statistical methods. Categorical variables were represented through their frequencies and corresponding percentages. In contrast, continuous variables were presented as means and standard deviations. To evaluate the effect of the supplemental intervention, total scores were compared before and after their application across the four learning styles using rigorous statistical techniques. The means of the four groups were compared using one-way ANOVA for Projects 1 and 2 separately. Survey questions were analyzed using chi-square and/or fisher exact tests. Consistent with standard practices, alpha level was set at 0.05 to determine statistical significance in all tests. All statistical analyses were conducted using SAS version 9.4, a software developed by the SAS Institute in Cary, NC.
RESULTS

Learning Mode Distribution

Of the original ninety-seven students, ninety-two successfully submitted all required surveys and assessments for a participation rate of 94.8%. There was a total of ninety-two participants in the study, 38 male and 54 female (Figure 1). The mean age was 23.9 years with a standard deviation of 1.12 years. The most prevalent learning mode was Active Experimentation (n = 38, 41%), followed by Reflective Observation (n= 34, 37%), Abstract Conceptualization (n = 10, 11%), and Concrete Experience (n = 10, 11%) as shown in Figure 2. The mean age was similar for all learning modes with no significant correlation found between age and learning mode. Similarly, there was no significant difference found between gender and learning mode.

Student Objective Performance

In the baseline assessment (Project 1), mean scores were comparable across all groups, showing no statistically significant differences. The scores were as follows: Concrete Experience (CE) scored 6.40 ± 1.07, Reflective Observation (RO) 5.56 ± 1.73, Abstract Conceptualization (AC) 6.90 ± 1.29, and Active Experimentation (AE) 5.95 ± 1.75 (Figure 3). Similarly, for Project 2, mean scores across the groups were consistent, with no significant differences observed: CE achieved 6.10 ± 1.37, RO 6.29 ± 1.90, AC 7.20 ± 1.81, and AE 6.58 ± 1.78 (Figure 3).

Notably, the RO, AE, and AC groups exhibited an increase in mean scores from Project 1 to Project 2; however, this difference among the four learning modes was not statistically significant, as depicted in Figure 4. Furthermore, analysis revealed no
significant correlation between age and the mean scores for either project. Additionally, gender did not significantly affect the mean scores in Project 1 and Project 2.

**Student Subjective Perception of Performance**

The post-project 2 survey response rate was 100%. All survey questions and responses are depicted in Table 2. There was no correlation between preferred learning mode and survey response to any question (P > 0.05). In question 1, 85.9% of participants responded that they were aware that different learning styles/modes existed prior to the study. In response to question 2, 76.1% of participants indicated that they were familiar with their own learning style/mode prior to the study. In response to question 3, 68.9% of participants agreed they achieved greater success on Project 2 than they otherwise would have as a result of receiving the supplemental material. In response to question 4, 75.0% of participants agreed that the supplemental material enhanced their understanding of concepts delivered in class. In response to question 5, 78.3% of participants agreed that the supplemental material enhanced their preclinical lab experience and performance. In response to question 6, 69.6% of participants agreed that the supplemental material was worth the extra time needed to complete these tasks. In response to question 7, 56.5% of participants agreed that these supplemental materials should be provided to students in future classes. There were no correlations between age and learning mode among the survey responses and no correlations between gender and learning mode observed.
**Table 1: Grading Rubric**

<table>
<thead>
<tr>
<th></th>
<th>Score: 0</th>
<th>Score: 1</th>
<th>Score: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Access</strong></td>
<td>Significant coronal gauging; access perforation</td>
<td>Minimal coronal gauging</td>
<td>No coronal gauging</td>
</tr>
<tr>
<td><strong>Voids</strong></td>
<td>&gt;1 void</td>
<td>Single void</td>
<td>No voids</td>
</tr>
<tr>
<td></td>
<td>&gt;0.5 mm void</td>
<td>0.5 mm void</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Void in apical 1/3</td>
<td>Space between cones visible</td>
<td></td>
</tr>
<tr>
<td><strong>Location from Apex</strong></td>
<td>&gt;2 mm from apex Over-extruded GP</td>
<td>Flush</td>
<td>0.5-1 mm from apex</td>
</tr>
<tr>
<td><strong>CEJ Location</strong></td>
<td>&gt;1 mm from CEJ</td>
<td>+ or - 1 mm from CEJ</td>
<td>At CEJ</td>
</tr>
<tr>
<td><strong>Shape</strong></td>
<td>Single cone</td>
<td>Single cone</td>
<td>Well-tapered with coronal flare</td>
</tr>
<tr>
<td></td>
<td>No or minimal taper</td>
<td>Few accessory cones</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Separated file affecting length</td>
<td>Minimal taper</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Separated file not affecting length</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Final score was based on the cumulative results from each section of the rubric for a maximum possible score of 10.*
Table 2: Survey Questions and Results

<table>
<thead>
<tr>
<th>Survey questions</th>
<th>RO</th>
<th>CE</th>
<th>AE</th>
<th>AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question #1: Prior to this study, were you aware that different learning styles/modes exist?</td>
<td>4.03</td>
<td>4.40</td>
<td>4.24</td>
<td>4.10</td>
</tr>
<tr>
<td>Question #2: Prior to this study, were you aware of your own learning style/mode?</td>
<td>3.62</td>
<td>3.70</td>
<td>4.05</td>
<td>3.80</td>
</tr>
<tr>
<td>Question #3: I believe I achieved greater success on the second attempt at obturation of tooth #9 than I otherwise would have because of having received the supplemental material.</td>
<td>3.91</td>
<td>3.44</td>
<td>3.95</td>
<td>3.60</td>
</tr>
<tr>
<td>Question #4: The provided supplemental material enhanced my understanding of concepts regarding obturation delivered in class.</td>
<td>3.94</td>
<td>3.40</td>
<td>3.92</td>
<td>3.70</td>
</tr>
<tr>
<td>Question #5: The provided supplemental material enhanced my preclinical lab experience and lab activity performance.</td>
<td>3.94</td>
<td>3.80</td>
<td>4.08</td>
<td>3.90</td>
</tr>
<tr>
<td>Question #6: The provided supplemental material was worth the extra time needed to complete these tasks.</td>
<td>3.79</td>
<td>3.20</td>
<td>3.66</td>
<td>3.90</td>
</tr>
<tr>
<td>Question #7: I think these supplemental materials should be provided to students in future classes.</td>
<td>3.94</td>
<td>3.60</td>
<td>4.00</td>
<td>3.40</td>
</tr>
</tbody>
</table>

Note: Responses to questions were assessed using a Likert scale ranging from 5 to 1 (Questions #1 and #2: 5 = very aware, 1 = very unaware; Questions #3-7: 5 = strongly agree, 1 = strongly disagree). RO = Reflective Observation, CE = Concrete Experience, AE = Active Experimentation, AC = Abstract Conceptualization
**Figure 1: Gender Distribution**

![Gender Distribution Graph]

**Participant Gender Distribution**

- Male: 54 participants (37%)
- Female: 38 participants (23%)

**Figure 2: Learning Mode Distribution**

![Learning Mode Distribution Graph]

**Learning Mode Distribution**

- Reflective Observation: 41% (11 participants)
- Concrete Experience: 37% (11 participants)
- Active Experimentation: 11% (11 participants)
- Abstract Conceptualization: 11% (11 participants)

*Figure 2: Learning Mode Distribution*
**Figure 3:** Projects 1 and 2 Score Distribution.

Note: Error bars indicate standard error of the mean.

**Figure 4:** Mean Score Changes Between Projects 1 and 2.

Note: Error bars indicate standard error of the mean.
DISCUSSION

Part I of this study (9) demonstrated that providing learning-style-based education improved RO-dominant students’ performance both subjectively and objectively when compared to groups with no supplemental material or groups with misaligned material. The current part II study aimed to evaluate whether students in all four learning modes (CE, RO, AE, and AC), as determined by the KELP assessment, benefitted equally from receiving learning-mode-specific materials, both objectively and subjectively.

The two most prevalent learning modes in the current study were AE (41%) and RO (37%), followed by CE (11%), and AC (11%). Part I found RO (40%) to be the most prevalent followed by CE (29%), AE (27%), and AC (5%). These differences in learning style distribution may have been attributed to using KELP in this study rather than Kolb LSI (utilized in Part I) in addition to inherent differences between the two classes. Despite these differences, the high preference for the RO learning mode and lower preference for AC were a common finding among both studies. The AC learner is best engaged when they can think through testable concepts or theories while RO learners benefit most from receiving feedback on their work and being able to connect their feelings with their experience (26).

Dental students at the preclinical stage of their education are accustomed to performing a laboratory activity, such as a restoration on a plastic tooth, and receiving customized feedback from faculty based on their performance. Students typically have the opportunity to perform the procedure several times to apply what they learned and experiment with different techniques before completing the procedure in a clinical setting, a style of learning that is preferred by the AE learner. Based on this typical style
of education at the preclinical level, it is understandable that RO and AE learning modes would be preferred by the majority of students as opposed to AC at this stage since learning preference is a dynamic process shaped by experiences. (26)

There were no significant differences between gender and learning mode found in this study, agreeing with the findings from Part I (9) and ALQahtani and Al-Gahtani (22) on Kolb’s learning-style based research in a dental setting. Additionally, there were no significant associations between age and learning mode found, agreeing with the findings from Part I (9) and Adesunloye et al. (28)

There were no significant differences in the mean scores for Project 1 among all groups indicating that each group began the study at the same skill level, and there were no correlations between baseline score and learning mode. Mean score changes between projects did not differ significantly for any of the four learning modes demonstrating that supplemental materials were equally impactful among all learning modes.

The RO group showed the highest mean improvement between project 1 and project 2 and was the closest to achieving statistical significance among all groups (P = 0.07). This finding, although statistically insignificant, is analogous to the findings of part I (9) of this study that found that students in the RO group benefited most from receiving supplemental learning materials, both objectively and subjectively (P < 0.05). This finding was also demonstrated by Tsingos et al. (29) who also found that reflective learners achieved higher academic success compared to non-reflective learners in a pharmacy school setting.

The AC and CE groups showed the lowest increase in mean improvement at a difference of 0.30 and -0.30, respectively. These two groups had the smallest sample size
with only 10 students per group. The low sample sizes in these groups compared to the AE (n = 38) and RO (n = 34) groups may have contributed to the relative lack of change observed. These results are consistent with other studies among dental and medical students reporting a little to no correlations between learning style and academic assessment. (25,30) Furthermore, a recent systemic review also found a weak association between learning styles and learning outcomes in a health science setting. (18)

Part I (9) of this study found a statistically significant difference in the objective assessment as result of the supplemental materials in the RO group (the only group provided with aligned learning materials), while this part II study did not demonstrate a significant mean score change from Project 1 to Project 2 for any of the four groups. The different design of this study, including having four unequal groups where all students received supplemental materials, no control groups, using KELP rather than Kolb LSI to derive learning modes, and having a different class of participants could have impacted and accounted for these differences in results. It would be interesting to conduct a future study with a control group not provided supplemental materials in addition to the four groups from the present study to better determine the impact of the supplemental learning materials.

Responses to survey questions 1 and 2 indicated that 85.9% of students were aware that different learning styles/modes existed while 76.1% were already familiar with their own style/mode. This high awareness for one’s learning style is not a surprising finding as dental students are adult learners that have already had many years of education to develop and refine their own style of learning. (2)
The survey responses indicated that most students had a positive experience with the provided supplemental material. 68.9% of students believed the supplemental material helped them achieve greater success on Project 2, 75.0% felt that it improved their understanding of concepts, 78.3% agreed it enhanced their experience, 69.6% felt it was worth the extra time, and 56.5% believed that these materials should be provided to students in future classes. Responses to the survey were similar among all learning modes. These results agree with Part I (9) that found statistically significant differences in survey responses from RO students provided with aligned supplemental material compared with groups with unaligned supplemental material or no supplemental material. Students in the RO group believed that, as a result of the provided material, they achieved greater success and had an enhanced understanding of concepts. (9)

The findings of the present study are similar to a study by Gurpinar et al. (25) who explored learning-style-based education in a medical school setting. While high student satisfaction scores were reported in all learning style groups, exam scores did not significantly differ among groups. (25) Knoll et al. (31) also found that learning style was related to the subjective aspects of learning but did not affect learning objectively. Positive perceptions from students were reported in a study among dental students where 76% of students found the learning-style-based activities effective in their education, and 82% believed they helped clarify concepts and content from courses. (15) The survey results of the present study affirm that providing supplemental learning material aligned with students’ dominant learning mode subjectively improves their learning experience equally across all four learning modes.
The limitations of this study include its limited sample size, participant variability, and time elapsed between Project 1 and Project 2. Having larger groups of equal sample sizes would not have been possible based on the design of this study since groups were based on the learning mode derived from the KELP questionnaire. This study was conducted in conjunction with the Preclinical endodontics course taken by all second-year dental students. As result, the timing of Projects 1 and 2 was subject to the schedule of the course’s lab activities with Project 2 being scheduled roughly 2 months after Project 1. Additionally, since all groups were provided with supplemental material, additional time was given to ensure all students were able to complete them, particularly those students in the AE group who were asked to complete NRSCT on an additional tooth #9 on their own time.

While measures were taken to ensure completion of supplemental material such as collecting the practice teeth from the AE group and having the AC group complete a one-question quiz after reviewing the provided PowerPoint lecture, most supplemental activities required students to complete the material without supervision. Furthermore, there was no way to control how much students practiced between projects or how much effort they put into completing the supplemental activities.

Conducting future research with larger sample sizes, perhaps by enlisting students across several classes, is indicated. According to experiential learning theory, an individual’s learning preference is dynamic and evolves over time based on one’s interactions with their environment. (26) It would be interesting to design a future study that tracks student’s learning preference over the course of their dental education as they transition from a heavily didactic-based curriculum to clinical experiences in their final
years. Further research is needed to determine the impact of learning-style-based education on learning outcomes as well as finding the appropriate balance between added effort to the educator and benefit to the learner.
CONCLUSION

The two most prevalent learning modes in this study were AE and RO. There were no associations found between gender or age and preferred learning mode. Providing supplemental learning material aligned with students' learning modes improved subjective performance equally among all learning modes but did not produce statistically different results among the four learning modes objectively. Receiving supplemental material corresponding to one's dominant learning mode was equally impactful among all four learning modes. Incorporating learning-style-based education may improve student satisfaction in a preclinical dental school setting.


