Quantitative and Qualitative Analysis of Student Feedback on ePortfolio Learning

Karen M. Gardner, D.M.D., M.Ed.; Jolanta Aleksejuniene, Ph.D.

Abstract: At the University of British Columbia, we introduced an ePortfolio assignment in the operative dentistry clinical simulation module and conducted a pilot study to explore the usefulness of ePortfolios as a learning tool for dental students. Qualitative assessments included student self-reflections on the ePortfolio experience. In the quantitative evaluation, ePortfolio learning was hypothesized as a multidimensional experience with four dimensions: 1) an ePortfolio experience is valuable for learning operative dentistry; 2) an ePortfolio is time-consuming, but overall a useful experience; 3) ePortfolio learning requires technical skills that are manageable; and 4) ePortfolio experience may be beneficial for lifelong learning. Overall, both quantitative and qualitative assessments demonstrated that students valued ePortfolio learning as a positive experience. In multivariate analyses (confirmatory factor analysis), the four-dimensional model of ePortfolio learning was confirmed. Future studies are needed to validate or revise the four-factor model of ePortfolio learning in different student cohorts.

Dr. Gardner is Assistant Clinical Professor, and Dr. Aleksejuniene is Assistant Professor—both at the University of British Columbia Faculty of Dentistry. Direct correspondence and requests for reprints to Dr. Karen Gardner, University of British Columbia Faculty of Dentistry, 254–2199 Wesbrook Mall, Vancouver, British Columbia, Canada V6T 1Z4; 604-822-3566 phone; 604-822-3562 fax; drkg@interchange.ubc.ca.

In higher education, professors are oftentimes caught up in the excitement of their research, resulting in the presentation of this information in a form that may be difficult for some students to comprehend. In short, sometimes professors forget that their students don't know the subject to the depth their instructors do and thus the students need to be taught rather than told the information. Carl Wieman in his article "Why Not Try a Scientific Approach to Scientific Education?" says we must "apply to science teaching the practices that are essential components of scientific research . . . based on objective data rather than anecdotal or tradition. This includes using the results of prior research, such as work on how people learn."[1] So from there it would be a logical leap to apply the results of pedagogical research to pedagogy. Therefore, assignments should be based on proven educational principles that address individual learning styles and sound pedagogical ideals. Our research evaluated a dental education assignment that used the pedagogical tool of reflection, drawing on Kolb's experiential learning theory, with the aim of making learning easier for dental students.

Reflection was established as a powerful learning tool in the early 1900s by Dewey,[2] with support from sociological and educational research and subsequent implementation in medical and dental curricula.[3-7] Kolb's work on individual learning styles[8] has led to the hypothesis that people learn through various means that can be categorized into four types: concrete, reflective, abstract, and active. Therefore, in designing our assignment we tried to incorporate reflection with learning styles. This was approached by designing didactic assignments for an operative dentistry module that would appeal to students with various learning styles and then allowing the students to select an assignment that would appeal to their own learning style. In so doing, it was hoped the students would opt for an assignment that would make their learning easier.

To accomplish this, two options were offered to the students: one option was a traditional research essay, and the other was a reflective ePortfolio. The concept of allowing students to make choices in their method of learning in order to address various learning styles is presented throughout the educational literature,[10] but it is usually mandatory for the whole class to complete the same assignments, with various assignments required throughout the course. Educators try to accommodate various learning styles by asking the entire class to complete a variety of assignments encompassing a variety of learning styles. Thus, each student completes at least one assignment that suits his or her learning style. Our approach allowed students to select the one assignment that they felt would suit them best. As the students were offered options that theoretically would appeal to their learning style, the learning outcome of grades

was not measured as all students would hopefully be completing an assignment that suited their learning strength. Thus, the comparison of grades would be meaningless.

Although commonplace in British dental schools,[11] which have established a joint website specifically for ePortfolio learning in higher education,[12] ePortfolios are just now coming into the realm of student-centered learning in North American dental schools. Through personal communications, it was discovered that ePortfolio projects at our university and others had been cancelled either because they were labor-intensive for both the student and the educator[13,14] or because of a lack of student technical support.[15] Following upon this, it would seem the ePortfolio could be an effective learning tool if it was an option for reflective learners, for although it is more time-consuming, they enjoy this type of learning and are willing to put in the extra time. Perhaps one reason ePortfolios had been cancelled in other institutions was that they were assigned to all students and thus became a chore to students who learn primarily through other styles. Another reason for cancellation was educators' time requirements. If the ePortfolio was completed only by reflective learners, rather than all students, the workload for the educators would be reduced significantly. Another strategy to reduce educators' workload is to set up the individual assignment submissions for formative feedback throughout the term with a summative grade at the end. This reduces the workload for students and educators because it requires only a small amount of the educators' time for the formative feedback and it allows the students more time to produce a quality document based on feedback throughout the term. A final key requirement would be strong technical support to get the assignments up and running. Fortunately, the University of British Columbia Faculty of Dentistry has a well-developed technical support team.

As the basis for designing the ePortfolio assignment, two pedagogical fundamentals were implemented into the ePortfolio design. The first was using reflection as a learning strategy, and the other was to consider individual learning styles. Therefore, our ePortfolio was designed to target reflective students, allowing them to develop their clinical skills, research ability, critical thinking, reflection, and creativity while working closely with our technical support team. In addition, it was important that the assignment be stimulating and empowering as well as increasing students' professional knowledge. The objectives of our pilot study did not attempt to vali-date the ePortfolio as the best method of learning; therefore, randomized selection was not sought. The objective was to determine if an ePortfolio would assist learning for those students who choose to use reflection.

Materials and Methods

The study was conducted in the Faculty of Dentistry at the University of British Columbia (UBC). When given the option of completing either two research essays or the ePortfolio, sixteen of the forty-eight students in the operative dentistry module opted for the ePortfolio. The ePortfolios consist of reflective compilations on an individual's accomplishments, opinions, and thoughts, which are stored electronically on a website. The entries may be in the form of text (Word document or a pdf), pictures, photographs, multimedia, and hyperlinks. The ePortfolio entries are dynamic (allowing editing) and may be open to the public, completely private, or open to selected communities.[9] The research essay topics were on current issues in operative dentistry such as bonded amalgams, approaches in other parts of the world to teaching Class II composites, and implications of the psychology of the smile in esthetic dentistry. In addition, the essays were to be written in American Psychological Association (APA) format and to be of five to seven pages in length.

The ePortfolio assignment was conducted in a blog (web log) format, which is a personal website maintained and supplemented through commentary, photos, videos, etc. that is compiled by an individual in reverse chronological order.[16] Blogs are being used more and more in dental and medical education as they are an ideal format for collaboration with students from other schools as well as their own and for lifelong learning.[17-19] In addition, they are a form of socialization for students who may at times feel isolated.[20] The web offers several free sites for blogging such as Facebook.com, MySpace.com, and Blogger.com, but the UBC Faculty of Dentistry purchased its own web space and blog software to form a blog site especially for UBC dental students and alumni. (The blog site's URL is www.blog.dentistry.ubc.ca.)

The ePortfolio assignment's critical requirements consisted of the analysis of seven operative procedures spaced evenly throughout the module (see Table 1). The students were to photograph their work and critically reflect on it using the critical requirements guidelines as outlined in the module.

Table 1. The ePortfolio assignment's critical requirements

Procedure	Critical Requirements
Class II Amalgam	Preparation: contacts just open, cavosurfaces smooth, occlusal along central grove, reverse S, rounded axiopulpal line angle, no iatrogenic flaws, just into dentin, axiopulpal wall parallel to gingival cavosurface, walls slightly convergent.
	Restoration: closed contact, cusps/central groove in proper arch alignment, true anatomy, pits in proper location, properly formed marginal ridge, in occlusion, proximal surface is flush, no marginal voids, smooth (no scratches).
Class II Composite	Preparation: shallow (1 mm), narrow outline form, minimal proximal box, proximal wall bevels, walls slightly divergent.
	Restoration: closed contact, no flash, smooth interproximal (no overhang), true anatomy, central groove improper location, properly shaped marginal ridge, no voids, smooth (no scratches).
Class III	Preparation: 90° to cavosurface, incisal extension to mid-contact, gingival extension just past contact, axiolingual wall parallel to the labial cavosurface, incisal/gingival floors are parallel, rounded internal form.
	Restoration: properly cured, cuspal alignment, smooth, proper contours, closed contact, no iatrogenic flaws, esthetic results.
Direct Bond Veneer (esthetics option)	Preparation: .3 gingival reduction, .5 mid-body reduction, incisal chamber, dog leg embrasure, smooth labial surface, proper line angle location, exactly to gingival crest, no gingival trauma.
	Restoration: natural tooth shading, has surface texture, proper line angle location, correct incisal length, smooth contact, no gingival trauma, proper contour, correct emergence profile.
Complex Amalgam Preparation	All Class II amalgam requirements plus proximal trough that butts axial wall, 1 mm in depth, accommodates small condenser, .5 mm into dentin (from cavosurface), pin parallel to the gingival cavosurface, just into dentin, retention groove accommodates the smallest condenser.
Complex Amalgam Restoration	All Class II amalgam requirements plus height of contour in proper location, correct cusp and central groove location, true anatomy, properly shaped marginal ridge, in occlusion, correct individual cusp height.
Ergonomics Video	Running fifteen-minute commentary on ergonomic positioning during a restorative procedure.

The ePortfolio grading rubric is presented in Table 2. In addition, all assignments were handed in for formative feedback, with a summative grade assigned at the end of each term. The marks ranged between 11/15 and 15/15 with an average of 14/15 (see Tables 1 and 2).

The focus of our pilot study was not to evaluate the research essay, so this learning tool will not be discussed. Nor was this study designed to assess whether the ePortfolio was the best learning tool; thus, randomized selection was not sought. Rather, the study investigated the experience of ePortfolio learning, employing qualitative and quantitative methods. Once the school year was over, a survey was designed to conduct qualitative and quantitative analyses, both based on self-reports, of the ePortfolio's effectiveness as a learning tool. For this survey, the informed consent of students was sought, and all students agreed to share their experience about ePortfolio learning. The quantitative assessment was designed to test the multidimensional structure

of the ePortfolio learning experience using factor analysis (FA). The theoretical rationale of FA is to identify or confirm patterns of interrelated indicators (in this study, statements about different aspects of ePortfolio learning), which are defined in FA as effect indicators. In general, the higher the level of interrelationship between indicators, the easier it is to identify the pattern of their commonality. In FA, each of these commonalities represents a factor that might be interpreted as a dimension comprising interrelated indicators. Consequently, any factor should be viewed as having a broader meaning than any of its indicators.

In our pilot study, ePortfolio learning was hypothesized to have a four-dimensional structure: The first dimension, "The ePortfolio experience is a good learning tool for operative dentistry," specifically related to the module content. The second dimension, "Although time-consuming, the ePortfolio learning is a useful experience," was chosen because there are known time constraints related to ePortfolio learning,

to the point that in some universities ePortfolio learning was discontinued due to extensive time demands. Therefore, prior to commitment to the ePortfolio, students were informed about the time-consuming aspect of this type of learning. In this way, they could make an informed decision prior to the start of the study. The third dimension, "The ePortfolio experience requires technical skills that are manageable," was chosen because some technical aspects have to be managed in ePortfolio learning. The fourth dimension, "The ePortfolio experience is a tool useful for future learning," was chosen to assess students' perceptions about ePortfolio as a possible tool for lifelong learning. For the quantitative evaluation of ePortfolio learning, we chose at least two interrelated statements (indicators) to represent each dimension. The dimensions with their corresponding indicators are shown in Table 3.

Qualitative Assessment of the ePortfolio Learning

The qualitative assessment, consisting of a few open-ended questions, aimed to explore students' self-reflections about ePortfolio learning. Thus, information related to students' perspectives might be captured that may have been unknown to researchers at the time this study was conducted. Consequently, the qualitative findings were considered useful for

Table 2. The ePortfolio grading rubric

15 marks, fall term

Organization of the blog site	2 marks
Critical analysis of	10 marks
1. Class II ag preparation/restoration	
2. Class III preparation/restoration	
3. Class II comp preparation/restoration	
Quality of word document	3 marks
1. APA format (UBC library example)	
2. amount and quality of references	
3. grammar and spelling	

15 marks, winter term

Critical analysis of ergonomics video	2 marks
Critical analysis of	10 marks
1. an esthetics procedure	
2. a complex amalgam (prep/resto)	
Quality of word document	3 marks
1. APA format (UBC library example)	
2. amount and quality of references	
3. grammar and spelling	

Table 3. Psychometric analyses of the four-dimensional model of ePortfolio learning*

Indicators (St. 1–St. 17)	Loadings†
1st dimension: The ePortfolio experience is a good learning tool for operative dentistry.	
St. 1. The ePortfolio assignment allowed me to learn the material to a deep level of understanding.	.867
St. 7. I believe I achieved a higher mark in the module because of completing the ePortfolio assignment.	.829
St. 13. All in all, I'm glad I opted for the ePortfolio assignment.	.799
St. 14. I don't think the assignment could be improved.	.790
St. 3. I found the assignment to be very relevant to operative dentistry.	.706
2nd dimension: Although time-consuming, the ePortfolio learning is a useful experience.	
St. 2. I found the time spent on the assignment was worthwhile.	.844
St. 9. Given the workload in the third year, I feel the time spent on the ePortfolio was too onerous.	-.844
St. 15. I found I was spending too much time on the assignment	-.536
3rd dimension: The ePortfolio experience requires technical skills that are manageable.	
St. 16. I found learning the technical aspects required a lot of time.	-.838
St. 4. I found the technical aspect of the assignment was user-friendly.	.838
4th dimension: The ePortfolio experience is a tool useful for future learning.	
St. 17. I think learning how to build a professional ePortfolio will help me in other aspects of my life.	.815
St. 6. I believe it is important to document my achievements throughout my dental career, including dental school.	.757
St. 5. I feel this is a type of learning I can continue throughout my life.	.693
St. 8. I would like to have an ePortfolio option in other modules throughout dental school.	.664
St. 10. I do consider lifelong learning necessary in my dental career.	.568

*Confirmatory factor analysis
†Loadings indicate the relative weight of an indicator (max=1.0). The higher loading indicates higher contributions to a common dimension.

such purposes as providing a deeper exploration of students' views, suggesting new hypotheses, and possibly cross-validating quantitative findings. In the qualitative domain, the following aspects were considered: did the assignment help students improve their clinical and research skills; did it stimulate reflection, creativity, and critical thinking; and did it help them become more knowledgeable about their profession and thus feel stimulated and empowered? Students were asked to self-reflect on these topics as their assignment in the ePortfolio via their blog site. The questions are presented in Table 4.

Quantitative Assessment of the ePortfolio Learning

The quantitative assessment was based upon the hypothesis that ePortfolio learning is a multidimensional experience in which a few conceptually different experiences coexist. The quantitative assessment of ePortfolio learning was performed in three steps. In step one, the ePortfolio learning was hypothesized as a four-dimensional experience. The first dimension was related to specific operative dentistry learning, the second related to time constraints, the third related to technical aspects inherent in this learning modality, and the fourth related to a more general learning possibility. Subsequently, all dimensions were arbitrarily defined by the authors. In step two, a few interrelated indicators (statements about ePortfolio learning) were selected to measure each dimension. Table 3 presents fifteen statements used to assess the ePortfolio learning. The agreement with each statement was measured on an interval scale from 0 (complete disagreement) to 10 (complete agreement).

The first dimension addressed the ePortfolio as a good learning tool for operative dentistry. To represent this dimension, five effect indicators or statements were chosen: "The ePortfolio assignment allowed me to learn the material to a deep level of understanding"; "I believe I achieved a higher mark in the module because of completing the ePortfolio assignment"; "All in all, I'm glad I opted for the ePortfolio assignment"; "I don't think the assignment for operative dentistry could be improved"; and "I found the assignment to be very relevant to operative dentistry."

The second dimension addressed whether the ePortfolio, although time-consuming, was a useful experience, as indicated by three statements: "I found the time spent on the assignment was worthwhile"; "Given the workload in the third year, I feel the time spent on the ePortfolio was too onerous"; and "I found I was spending too much time on the assignment." The third dimension addressed whether learning the technical skills needed for ePortfolio was manageable. This factor consisted of two indicators: "I found learning the technical aspects required a lot of time" and "I found the technical aspect of the assignment was user-friendly." Finally, the fourth dimension explored whether the ePortfolio was a useful tool for lifelong learning. Five indicators were chosen to represent this factor: "I think learning how to build a professional ePortfolio will help me in other aspects of my life"; "I believe it is important to document my achievements throughout my dental career, including dental school"; "I feel this is a type of learning I can continue throughout my life"; "I would like to have an ePortfolio option in other modules throughout dental school"; and "I do consider lifelong learning necessary in my dental career."

In step three of the quantitative analysis, the four-dimensional model of the ePortfolio experience was statistically tested.

SPSS program (version 16.0) was used for all statistical analyses with the threshold for significance at P value <0.05. The reliability testing was

Table 4. Brief guidelines for ePortfolio learning assignment

Objectives	Consider	Need to Know
What are the critical requirements?	Why are these requirements critical?	What new skill was gained? What constituted your breakthrough moment?
Does your product meet these requirements?	How did you achieve these results? Where did you have the most problems? How did you solve these problems?	What evidence in the literature supports these critical requirements?
Lifelong learning	How will this help you define yourself as a dentist?	

assessed by Cronbach's alpha. This method tests the internal consistency, referring to the degree to which parts of an instrument are all measuring the same dimension. In our context, the similar statements were expected to be internally consistent. The higher the alpha score, the more reliable the interrelated indicators. The coefficient of 0.7 or higher has been suggested as an acceptable level of reliability among the interrelated levels, but lower thresholds are sometimes used in the literature.[17] In our study, given the wording in similar statements was different, an acceptable level of reliability was lowered, and measurements (statements) were considered reliable when Cronbach's alpha exceeded 0.65. Univariate statistics was used to explore the frequency distributions in regards to different statements about ePortfolio learning.

In the multivariate statistics, the confirmatory factor analysis (CFA) was used to test the four-dimensional model of ePortfolio learning. The CFA statistical method was used to determine if the number of factors and the loadings of measured indicators confirm what was expected on the basis of the pre-established four factor hypothesis. The principal component analysis was chosen as a method, and the Eigen value beyond unity was set as the threshold for extracting a factor, i.e., confirming a dimension.

Results

The reliability statistics revealed an acceptable level of agreement for interrelated items (Cronbach's alpha from 0.67 to 0.77). Then, the ePortfolio experience was assessed both qualitatively and quantitatively.

Qualitative Assessments of ePortfolio Learning

Examples of students' comments on the subject of reflection, critical thinking, and creativity are the following: "The ePortfolio has allowed me to see where my mistakes were and to think of ways to overcome obstacles"; and "We will only continue to learn from our mistakes and gain more experience in perfecting our clinical skills." Some examples of comments on the subject of becoming more knowledgeable about one's profession are the following: "This allows me to have a profound understanding behind restorative dentistry"; "The levels of detail explored during the research enabled me to actu-

ally learn the material rather than memorize"; I "wouldn't have gained as much knowledge in the same way as from doing the ePortfolio assignment"; and "By doing the research it also helps to reinforce what we learned during our lectures." Two examples of comments on whether it was a stimulating and empowering experience are as follows: it "definitely allowed me to operate on my patients with more confidence and a better understanding"; "I feel that the ePortfolio assignment has allowed me to critically assess my own work and also compare what we are being taught in operative dentistry with current literature findings." One participant in the survey did tend to be more negative. The following comment indicates this student did not consider there was any benefit to doing the ePortfolio: "I guess it is a good tool to force some people to reflect on their work, but for those that already self-criticize everything they do, it just [takes] a couple of years off your life trying to take the perfect picture." Some disadvantages reported by two students included comments on the ePortfolio being time-consuming, finding it difficult to acquire the camera at the time it was needed (too few available), and having some difficulties with the technical aspects, such as the following: "The elgg.net site . . . did not allow for formatting of text."

One statement we considered important is the following: "I think all dental students will benefit from this assignment and it will help them grow as future practitioners." This is considered important as the statement may have implications regarding introduction of the ePortfolio throughout the curriculum and for lifelong learning. As this is only one student's comment, we will investigate this possibility further in future studies.

Quantitative Analyses of ePortfolio Learning

The response to statements about ePortfolio learning is presented in Figure 1. In general, students had a positive experience with the ePortfolio: a high level of agreement was observed regarding the ePortfolio assignment because it allowed students to learn the material to a deeper level of understanding, and there was almost unanimous agreement that lifelong learning is necessary in a dental career. Similar to the qualitative assessment, the quantitative analyses confirmed that some students were concerned about technical difficulties and time management related to ePortfolio learning.
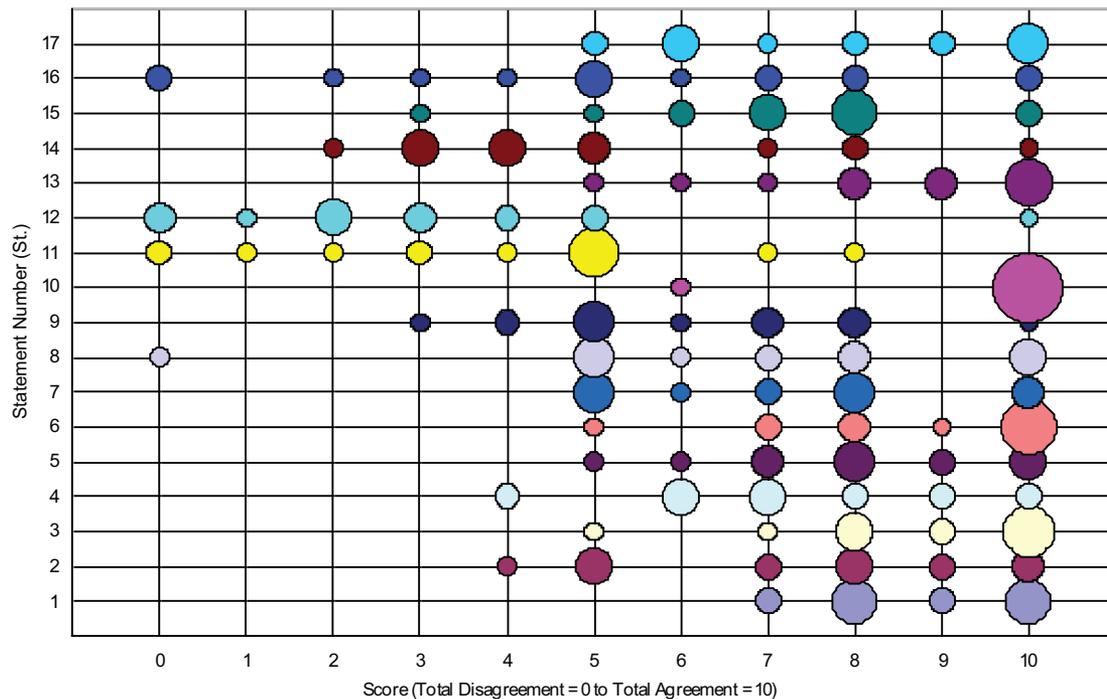
Figure 1. Relative percentage distribution* of scores for statements† about learning (N=16)

*Area of circles represents percentage of scores assigned to each statement, ranging from 6.4 percent (e.g., St. 10:Score 6) to 93.8 percent (St. 10:Score 10). Color of circles indicates statement number.

†Statements are identified in Table 3.

In the multivariate testing, the four-dimensional model of the ePortfolio experience was confirmed. All dimensions with their corresponding indicators and their loadings are presented in Table 3. The first dimension ("The ePortfolio experience is a good learning tool for operative dentistry") was reflected by five indicators. The second dimension ("Although time-consuming, the ePortfolio learning is a useful experience") generated information from three indicators related to the time aspect. The third dimension ("The ePortfolio experience requires technical skills that are manageable") consisted of two indicators. The fourth dimension ("The ePortfolio experience is a tool useful for lifelong learning") included information from five indicators. All indicators contributed substantially and significantly to their corresponding dimensions.

Discussion

Both the qualitative and quantitative assessments found that the ePortfolio was a very positive experience for the majority of participating students. This may seem a bit one-sided, but it is crucial to remember that the ePortfolio assignment was presented as an option for those students who like to work on their assignments at a steady pace (as opposed to cramming) and to reflect on their work. It is assumed therefore that reflective learners opted for this assignment, but this assumption needs to be confirmed. In the next phase of the study, we will ask these students to take the Kolb learning style inventory (KLSI) to determine if they are indeed reflective learners. In addition, we will ask this year's cohort of students to take the KLSI prior to making their assignment selection, giving us a means to establish their learning

style and to determine if they select an assignment that suits that style.

The ePortfolio appears to have been an effective learning tool for those students who opted for this type of learning. Overall, only one (out of sixteen) students gave negative feedback, but it is important to note that this individual perceived him- or herself to already possess self-critiquing skills and thus not require the ePortfolio to learn; this response implies the student did not see other benefits of ePortfolio learning. However, the majority of the students reported a positive experience that helped them to grow professionally. One student stated, "This experience allowed me to have a profound understanding of the concepts behind restorative dentistry, its requirements, and criteria and definitely allowed me to operate on my patients with more confidence and a better understanding." Another important finding was that many students understood the benefit of combining science and clinical experience and that this type of assignment leads to deeper understanding and learning. This point of view is supported by two comments: "Actually, I learned the material, not memorized it," and this technology "helps to reinforce what we learned during our lectures." Other positive aspects of ePortfolio learning may be illustrated with these student statements: we "learned from our mistakes and gained more experience," and this experience "allowed me to study operative dentistry throughout the year at a steady pace."

However, it is important to consider that despite the overall positive and useful experience, there are limitations that are an unavoidable part of this type of learning, such as being time-consuming or having technical difficulties. In addition, students have various learning styles, so the ePortfolio will not appeal to all students. Indeed, ePortfolios are labor-intensive, and some students who signed up for this option may have eventually felt it was too time-consuming. But despite these limitations, some students recommended this experience for all students.

A four-dimensional model of ePortfolio learning experience was found, in which two dimensions related to the learning experience for both the present and the future. The other two dimensions were not related to learning but rather to time management and technical aspects. This means that all four aspects of ePortfolio learning should be considered. Given this was a pilot study and the sample size was relatively small, its findings should not be generalized. Future studies are needed to validate, revise, or discard the four-factor model of ePortfolio learning in various cohorts. To ensure that acquired factors were not simply effects of sampling error, a bigger sample size is also recommended. In addition, we need to assess the effectiveness of the ePortfolio on learning skills in a quantifiable manner. The learning skills profile developed by Kolb will be investigated as a possible tool for this aspect of the ePortfolio as a learning tool. We plan to assess students' learning styles inventory and leaning skills profile prior to commencement of the ePortfolio in the future and then to perform the learning skills profile at its completion to determine if reflective learners did select the ePortfolio and if the ePortfolio had an effect on the students' learning skills. Future work will be to validate a four-dimensional model of ePortfolio learning in a new cohort, to measure the ePortfolio's effectiveness in improving learning skills through Kolb's learning skills profile, and to consider the effectiveness of offering choices in a course to appeal to various learning styles.

Conclusion

The ePortfolio learning experience was valued by the majority of participating students with the feeling that it was time-consuming but worthwhile and a positive experience. They felt it helped them grow professionally as well as to integrate scientific understanding into their clinical performance of operative dentistry. In general, the evaluation of the students' feedback to this experience indicates that ePortfolio learning may be considered a useful addition to students' learning for those who choose it as an option. At the same time, it is important to emphasize that the project respected various types of learners and the ePortfolio may not be as effective for all learners. Therefore, it is recommended the ePortfolio be offered as an option with other choices such as a research essay or a group project.

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