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The Role of Online Learning in Radiographic Diagnosis in Dental Education

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Abstract

The purpose of the pilot study was to investigate whether an interactive online module improved third-year dental students' radiographic caries diagnosis abilities and conceptual understanding.

Third year dental students were given online tutoring modules and assessed afterward to determine whether their diagnostic skills improved, whether they perceived and improvement in their diagnostic skills, and whether following the modules with interactive group discussions was a more effective teaching method. The choice to use the module was left to each individual. Thirty-one students completed an assessment consisting of three full-mouth series (FMX) radiographs of varying number and severity of carious lesions first individually and then in teams.

Performance was evaluated quantitatively and qualitatively. A T-test analysis revealed that the students who accessed the module did not perform significantly better than students who did not access the module; however, a χ^2-test showed that students who accessed the module correctly diagnosed yet over- and under-diagnosed more frequently. Survey responses showed that students believed the module helped clarify lecture topics.

The online radiographic caries diagnosis module has introduced a promising and beneficial adjunctive resource for dental students.

Keywords: Online learning, caries diagnosis, blended learning, predoctoral education

1. Introduction

The recent U.S. Department of Education report documents that instruction combining online and face-to-face elements had a larger advantage relative to purely face-to-face instruction than did purely online instruction (US Department of Education Office of Planning, Evaluation and Policy Development, 2010). Blended learning is pedagogically planned integration of online and face-to face class activities that is driven by an institutionally defined portion of face-to-face time that is replaced by online activity (Picciano, 2011) for the improvement of student learning (Garrison & Vaughan, 2008).

A proliferation of blended education, which is a combination of traditional face-to-face and online instructional method, has emerged in recent years. One study reports that 69.1 % of chief academic leaders believe online learning is critical to long-term strategy, which is the highest it has been for 10 years (Allen & Seaman, 2013).

Teaching caries detection and diagnosis and subsequent decision for preventive and invasive caries treatment remains as a core topic in dental education. With the increasing availability of e-learning and virtual classroom software, lectures have the potential to become more interactive and effective.

In a 2014 study, El-Damanhoury *et al.* demonstrated that the International Caries Detection and Assessment System (ICDAS II) lectures and corresponding e-learning program significantly improved the ability of both first year dental students and dental graduates with two years of experience to detect clinical caries. (El-Damanhoury, Fakhruddin, & Awad, 2014)

There has yet to be a study on the effect of e-learning programs on radiographic caries diagnosis. Currently, commercial options are not available and the scope is very limited. The current Harvard School of Dental Medicine (HSDM)

curriculum presents the students with an oral radiology course in the second year, and then they begin to interpret radiographs in a clinical setting as part of the preclinical course.

The authors proposed to study whether use of an interactive digital teaching tool, or Online Tutor, in the preclinical dental courses will help the students learn basic diagnostic skills and facilitate embedding these teaching tools in other courses. A new model for an expanded use of technology leading to new innovations that incorporate a digital teaching tool into educational pedagogy was introduced for the pre-doctoral students at HSDM. The purpose of the study was to describe the development and implementation of a pilot online e-learning program about radiographic caries diagnosis.

2. Materials and Methods

The study protocol was reviewed by the Harvard Medical School/Harvard School of Dental Medicine Institutional Review Board. Performance data was collected from the Class of 2016 (n = 31) via a caries diagnosis assessment consisting of three de-identified patient full-mouth series (FMX) radiographs.

2.1 Creation of the Online Modules

A pilot five-module online learning program was created for frank caries, incipient caries, recurrent caries, false caries, and application to patient cases. The interactive lessons included matching and multiple-choice questions as shown in Figure 1.

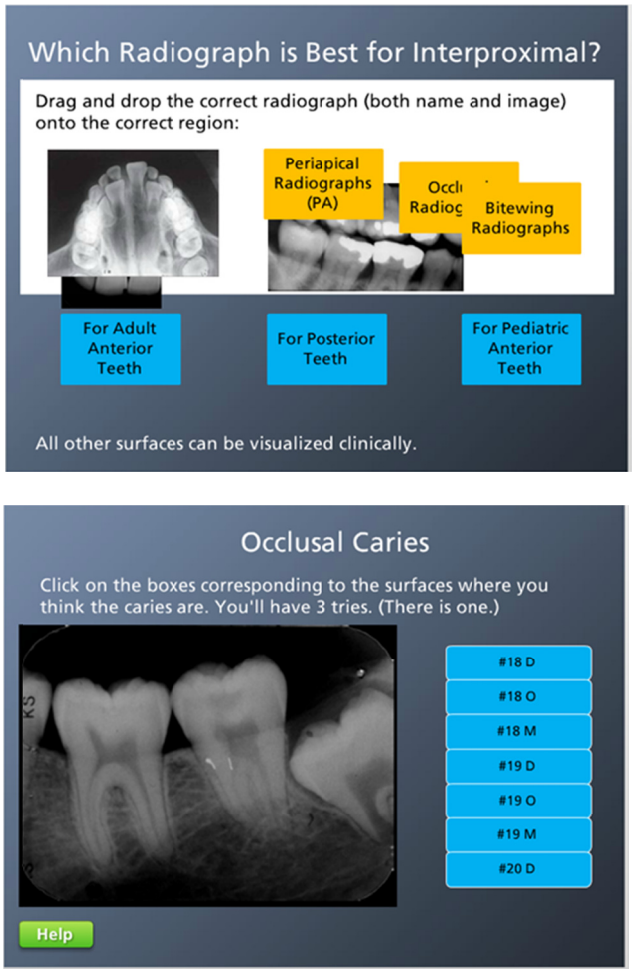

Figure 1. Screenshots of the online module

Any concepts presented in the modules were taken from learning objectives of lectures given by HSDM faculty and all carious lesions were confirmed by faculty.

2.2 Implementation of Online Modules

This resource was made available to the Class of 2016 for practice two months prior to their entrance into clinic. The modules were uploaded to cloud storage that could be accessed by students at any point in time with their computers or tablets. Reminders were sent out periodically, especially as the assessment date drew closer.

2.3 Assessment of Module

Students were given three clinical cases labeled David, Katherine and Michael. They varied in severity and number of carious lesions. Students were asked to focus only on interproximal caries and tasked with recording their answers individually and in groups. Responses were categorized into five classes, as shown in Table 1.

Table 1. Five possible response classes and their interpretations.

Response Classes	Description
Very Over-Diagnosed = OO	Indicate active caries, but in fact is sound tooth
Over-diagnosed = O	Indicate active caries, but in fact is incipient caries. Indicate incipient caries, but in fact is sound tooth.
Correct = R	Indicate accurate severity of lesion or lack thereof
Under-diagnosed = U	Indicate sound tooth, but in fact is incipient caries Indicate incipient caries, but in fact is active caries
Very Under-diagnosed = UU	Indicate sound tooth, but in fact is active caries

2.4 Quantitative Analysis

Both χ^2-test and T-test analyses were used to determine the significance the modules have on performance. Total responses of each answer class were counted in order to determine expected frequencies for the χ^2-test . This method allows the maintenance of directionality in responses. In order to use the t-test, the categorical responses were assigned a numerical value based on degree of accuracy: OO and UU = 0, O and U = 0.5, and R = 1. Then a percentage was determined per student.

2.5 Qualitative Analysis

Students were required to answer a survey about the caries diagnosis module. Survey responses were de-identified and paired with the respective student's answers in order to track performance differences. The questions focused on evaluating students' perception of module's usefulness and on determining future improvements for the module.

3. Results

The χ^2-test analysis revealed a statistically significant difference in the frequencies of responses between the test and control group (p=0.0053). As shown in Table 2, the test group had higher frequency of R responses; however, they tended to answer both extremes (OO and UU) more often and middle responses (O and U) less often than the control group.

Table 2. Observed frequencies of each response per group.

Group	OO (%)	O (%)	R (%)	U (%)	UU (%)
Test	5.0	2.8	78.2	7.8	6.2
Control	4.0	4.4	77.2	8.4	5.9

Table 3. The calculated T-test p-values per combination

P-values	Test vs Control	Completers vs Non-completers	Completers vs Control
Overall Responses	0.45	0.47	0.43
Incipient Caries	0.49	-	-

As shown in Table 3, one-tailed t-tests were performed to compare percentage of overall correct responses for all three cases between the following: test and control groups, module completers and non-completers within the test group, module completers and control group, and test and control groups specifically for incipient caries. There is no statistically significant difference in accuracy between any of the aforementioned combinations.

Students who did not use the online module did not answer the survey questions. The 16 students who used the module completed surveys. Their responses were tallied and the percentages calculated.

Table 4. Breakdown of survey responses by question.

Survey Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Did you feel that this module has improved your radiographic caries diagnosis skills?	-	25.0%	37.5%	12.5%	12.5%
Should this module be instituted as part of the curriculum?	25.0%	43.8%	18.8%	12.5%	-
Did you feel that this module was more effective than reviewing lecture slides?	6.3%	56.2%	18.8%	12.5%	6.3%

As shown in Table 4, in general, students reported a positive perception of the module and support its implementation with modifications in the curriculum.

4. Discussion

This project was developed from a need to give the dental students the essential skills they need, and to remind them of skills they have already acquired, but require higher complex application exercises. Park *et al.* previously conducted a study evaluating a team-based learning (TBL) method for detecting radiographic caries among dental students in caries detection and activity assessment. (Park, Kim, & Anderson, 2014) The teams had a significantly larger percentage of accurate anterior caries evaluations than the individual students, but also saw significantly more carious lesions when there was no lesion compared to the students working singly. The individual students, however, were significantly more likely to incorrectly call incipient caries active than the teams.

The χ^2-test revealed that the test group exhibited a higher frequency of correct responses (R) but also tended to answer the extremes (OO and UU) more often than the control group. This could be the result of overconfidence in their diagnostic abilities resulting in the tendency to make quicker decisions.

Despite the results of the χ^2-test, the overall percent correct of the test and control groups were not significantly different when analyzed with the T-test. It was expected that the test group would perform better than the control group and that the subgroup of students who completed the entire module would in turn perform even better. In addition, the test group did not identify incipient caries any more accurately than the control group.

For various reasons, it is difficult to conclude the effectiveness of using online modules. By arbitrarily assigning point values to the answer categories in a palindromic fashion, we have inadvertently averaged out the difference in frequency of correct responses between the two groups. The test group responded both more correctly (R) but also more inaccurately (UU, OO) which were assigned point values of 1 and 0 respectively. When the T-test analysis was performed, these point values were added and converted into a percentage for each FMX. These percentages were compared across the two groups. Since the control group responded more frequently with U and O which was assigned the point value of 0.5, both groups effectively received an average of 0.5 points per interproximal surface.

This leads us to the issue of whether the point values can be assigned in a fashion that maintains directionality and severity of erroneous diagnosis. For example, it can be argued that missing an active carious lesion (UU) leads to worse consequences than erroneously filling a tooth with no carious lesion (OO). Possible infection of the pulp can lead to more extensive and expensive treatment with the ultimate consequence being extraction of the tooth due to non-restorability. Thus UU should be assigned a lower score than OO.

Additionally, due to the nature of an observational study, selection bias is a confounding factor. Perhaps students who felt most underprepared to diagnose caries were more inclined to access the module. Regardless, it is difficult to determine whether this biased the results positively or negatively.

On a more positive note, students felt this pilot online module clarified lecture topics. 62.5% of the students who used the module reported reviewing the module prior to entering clinic. Student feedback also made it clear that this pilot module could be improved by including more test questions along with answer keys and explanations. Other suggestions included improving navigation through the module in order to increase usage.

Interpreting radiographic carious lesions requires extensive training before pre-doctoral students become competent in making accurate diagnosis. (Brocklehurst, Ashley, Walsh, & Tickle, 2012; Lussi, 1993) If they can practice through an online tutoring module before entering clinic, they can reinforce their foundational knowledge through repetitive application of these skills on complex case exercises.

The new online e-learning software programs can introduce students to complex clinical topics in patient care during

their preclinical courses. These software programs are also capable of presenting students with clinical exercises such as visually identifying the symptoms of dental problems and diagnoses in areas of radiographic identification of dental caries, periodontitis, or even hard tissue pathology. With these new tools and their capabilities, students can be given exercises to complete in an interactive online module before actual class time and then discuss the results in a small group format to develop more thorough understanding of the basic diagnostic and clinical skills every oral health care provider needs.

5. Conclusion

Adding an online component may increase course effectiveness and student skill levels. The online radiographic caries diagnosis module introduced could be a promising and beneficial adjunctive resource for dental students and has potential to be implemented in the overall curriculum. This additional resource can be applied for other topics and forums, such as areas of health sciences and for the purpose of continuing education.

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