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## Creating a Case-Based Exam to Assess Student Progress in a Health Professional Program

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## Creating a Case-Based Exam to Assess Student Progress in a Health Professional Program

### Abstract

Student-centered education requires timely identification of professional students not progressing appropriately in their chosen discipline. However, many institutions in the United States have been slow to develop “progress” exams designed to assess to test individual student progress towards graduation. Literature review found scant evidence of schools reporting design and implementation of such assessments. This paper shares the process piloted at one U.S. dental school to develop a case-based written exam, map test items to concepts/knowledge expected of students and evaluate the validity and effectiveness of the exam as a useful measure of learning progress. It also analyzes the correlation between other existing student performance measures and scores on this assessment. Regression analysis revealed that student performance measures such as undergraduate grade point average (GPA), academic standing in the program, class rank, and first-time success or failure on the National Board Dental Exam (NBDE) Part II all had significant positive correlation with student scores on this assessment examination. This assessment was found to have a strong reliability score as well. Although piloted in a dental school, the methodology employed in this exam creation may provide a pedagogical model for building comprehensive assessments in other professional or vocational training programs providing valuable early identification of students not progressing towards competency in time for remedial action to be taken.

### Keywords

assessment, competency, exam mapping, progress exams, student performance data

## Introduction

Institutions are seeking to create innovative learner-centered methods to assess students' knowledge, skills, and application of problem-solving skills. Multiple choice questions that are well written and integrating multiple disciplines can test a higher level of learning in students.<sup>1,2</sup> Although no studies were found on designing suitable comprehensive assessments for graduating dental students, the use of a validated multiple choice exam written assessment mapped to expected competencies in Optometry was found in the medical literature.<sup>3</sup> That study described an assessment that was followed over several years for certifying competency in Optometry students in Australia. Multiple choice and short answer questions were mapped to key competencies and skill sets. The students' performance and psychometrics of the assessment revealed that all the required competencies were assessed successfully and the exam had high validity and reliability.

The University of the Pacific, Arthur A. Dugoni School of Dentistry in San Francisco, California, U.S. offers a three-year accelerated Doctor of Dental Surgery (DDS) program and a two-year International Dental Studies (IDS) program. The IDS program is for students who have obtained a dental degree in a foreign country but want to practice dentistry in the U.S. Each year the DDS program admits 140-145 students and the IDS program admits about 20-25 students. The school's integrated curriculum emphasizes students' ability to integrate basic science and clinical science knowledge.

In the spring of 2020, with the COVID19 interruption to patient care, students were left without a valid and reliable evaluation of their academic progress. In an effort to provide this crucial feedback, a small task force was assembled to create and pilot a multidisciplinary written

assessment that could supply this important data point in each student's overall progress towards competency. The exam's purpose would be to assess students' ability to apply basic information, use reasoning and critical thinking skills, and integrate material from multiple areas within the curriculum.

Other educators have written about finding tools that may be predictors of professional school performance. One study found a positive correlation between dental performance and rigorous pre-dental education.<sup>4</sup> Another study found the Dental Admission Test (DAT) score, [The DAT is the standardized exam taken by dental school applicants in the U.S and Canada], to be a poor predictor of performance on a school's competency exam.<sup>5</sup> Further research found mixed results using the DAT as a predictor of strong performance on comprehensive exams.<sup>6</sup> In light of those findings, we were particularly interested in how students' performance on these measures (undergraduate GPA, DAT scores) as well as other benchmarks such as dental school academic ranking and national board performance correlated with their scores on our written exam.

## **Methods**

### **Assessment design and development**

The assessment task force selected 26 concepts/knowledge areas in the curriculum that could be tested in a written format. 250 multiple choice questions were assembled from throughout the school's three year curriculum from department chairs, course directors, content experts, and other faculty familiar with what our students are taught. These test items contained many quality radiographs, clinical photos, diagrams, charts, and case scenarios. A small editing team was established, all with extensive test writing/editing experience and eventually 120 questions were included in the exam, a number that was felt students could handle in three hours. Three to seven

questions were allotted to each of the 26 concept/knowledge areas based roughly on time devoted to that content in the curriculum. The best practices style used in the National Board Dental Exam (NBDE) for test item construction was employed—a stem that asks a question followed by four possible answer choices with only a single correct answer was chosen out of clarity for exam-takers and consistency in scoring.

Following editing and formatting, the exam was entered into ExamSoft and tagged to content (see details below) by a faculty and administrative team. This exam with the case scenarios and images in word doc form is very large (141 MB and 55 pages). The exam was administered to 162 senior students in the graduating class of DDS 2020 and IDS 2020 in mid-May 2020. Students took the assessment remotely (a COVID-19 restriction) using the electronic proctoring software “Exam Monitor”.<sup>7</sup>

### **Assessment question mapping**

Test items were mapped in two different systems within ExamSoft to assure coverage of school curricular content. These two mapping schemas had been established early in the academic year by department chairs for use in all school examinations. This ExamSoft mapping tagged<sup>8</sup> test items as follows: first, each test item was tagged to a discipline or sub-discipline; this linking to department (or discipline) maps the distribution of exam questions throughout the school departments delivering the curriculum; second, since many test questions assessing a particular concept cannot be effectively handled by students without knowledge from other disciplines or competencies, test items were additionally mapped to “overlapping” competencies. An example would be radiographic interpretation skills being necessary to answer many questions from other concept areas.

Table 1 shows the number of questions per concept tested, number of disciplines and subspecialties tagged to a concept as well as school competencies tagged to that same concept. This tagging demonstrates the integration of content in many questions.

**Table 1:** Tagging of Questions with Disciplines and School Competencies

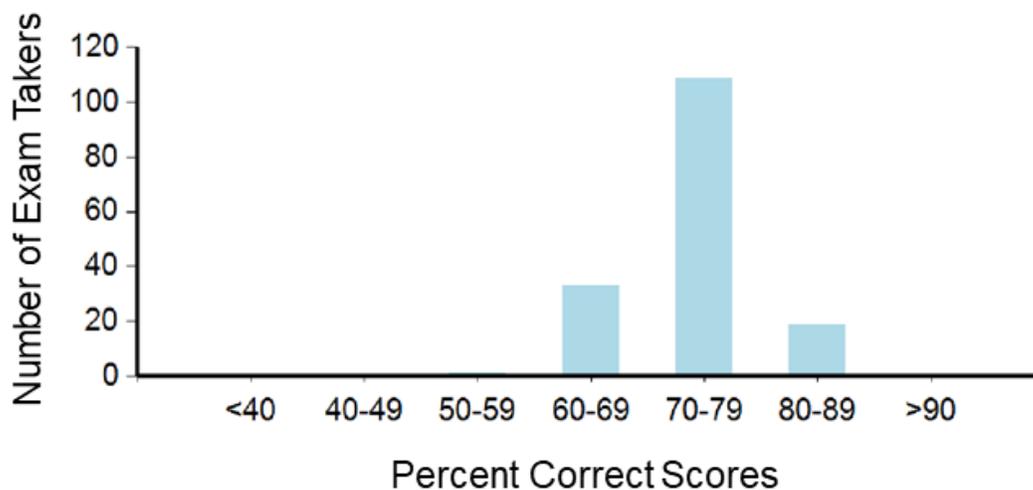
Competency	Number of questions per competency	Number of separate disciplines/sub disciplines tagged from these questions	Number of other school competencies tagged from these questions
Cariology/Risk Assessment	6	6	7
Community/Public Health	5	6	7
Dental Emergencies	5	5	6
Dental Materials	6	3	2
Digital Dentistry	6	3	3
Evidence Based Dentistry/ Applied Research methodology	3	4	5
Endodontics	7	1	3
Ethics/ Professionalism	5	3	4
Fixed Prosthodontics	3 Also Embedded in multiple questions	2	2
General Pathology	4	8	6
Oral Pathology	5	3	3
Implants	4	3	4
Local Anesthesia/Pain Management	3	6	3

Medical Dentistry	7	5	5
Occlusion	5	5	3
Oral Diagnosis and Treatment Planning	Embedded in multiple questions	3	2
Operative Dentistry	7	3	3
Oral Facial Pain/TMD	5	3	3
Oral Surgery	5	6	5
Orthodontics/Space Management	4	5	3
Pediatric Dentistry	7	6	6
Periodontics	5	3	3
Pharmacology	Embedded in multiple questions	-	-
Physiology	6	5	3
Radiology	Embedded in multiple questions	-	-
Removable Prosthodontics	7	5	4
Total	120		

### Exam results

All students were able to complete the exam comfortably in under three hours. The class performance was as follows: class average (74%; 89 out of 120 points); highest (88%; 106 points), and lowest (59%; 71 points). 19 students scored above 80%, 109 students scored between 70-79%, 33 students scored between 60-69%, and one student scored below 60% (see Figure 2). Since this was a pilot exam, the students were not given an exam grade nor was their score used in determination of readiness for graduation.

**Figure 2:** Exam results



### Exam reliability score

The reliability score (KR-20) of the exam generated from ExamSoft was 0.55. The general accepted convention is that a reliability score of 0.6-0.7 is acceptable. Therefore, our reliability score was considered respectable, especially considering the short time allotted for test construction. The reliability score we believe reflects the quality of the exam and the objective of the task force to accurately measure student knowledge of specific content. We were pleased

with the coverage of our school's disciplines and competencies as demonstrated by our test item mapping described earlier.

### **Data analysis**

The study used two main data sources to track individual student exam performance. The first was the student exam score generated from ExamSoft. The second data source was each student's other school performance measures provided by the school's Office of Academic Affairs. A total of six school performance parameters were selected for comparison with student scores on this exam:

- Undergraduate GPA
- Total science score on the DAT
- Academic standing at beginning of last quarter of dental school
- Class rank in the program
- NBDE Part I first time performance
- NBDE Part II first time performance

Coding of these parameters was numerical: for class rank, "1" indicating the top-ranked student followed by students in order of rank (2, 3, 4, etc.); for academic standing, students who were on contract were coded as "0", and those who were not on contract were coded as "1"; similarly, failing the NBDE Part I and Part II was coded as "0", and passing was coded as "1". A series of single regression analyses were performed on this numerical coding to see if these coded data points or parameters correlated with a students' performance on this competency assessment.

### **Exam results correlation with other student performance measures**

The series of simple regression analysis revealed that four of the six examined student performance parameters had a statistically significant positive correlation with their scores on this written assessment. The results were as follows:

- Undergraduate GPA,  $b=5.80$ ,  $t(136)=2.78$ ,  $p=.01$ ,  $r\text{ square}=.05$
- Academic standing (on contract or not),  $b=3.81$ ,  $t(135)=2.79$ ,  $p=.00$ ,  $r\text{ square}=.05$
- Class rank in program,  $b= -.07$ ,  $t(136)= -5.70$ ,  $p=.00$ ,  $r\text{ square}=0.19$
- NBDE Part II first time performance,  $b=5.84$ ,  $t(135)=2.11$ ,  $p=.04$ ,  $r\text{ square}=.03$ .

A student's total science score in the DAT and NBDE Part I failure didn't have a statistically significant correlation with their comprehensive exam performance. The positive correlation between undergraduate or pre-dental grades and the lack of correlation of DAT scores with our students' performance on our comprehensive assessment is consistent with findings of authors mentioned earlier.

## Discussion

Assimilating test items for this multidisciplinary exam was not a difficult hurdle. Faculty exam contributors were clear on the knowledge, application, and critical thinking skills expected of our students. Many contributors were quite adept as well at creating test items requiring knowledge from multiple areas to answer, which is supported by our question mapping. Examssoft's question mapping feature already discussed, along with the ability to create customizable reports for students was an important factor in our selection of this testing tool. One such report is the "Student Strength and Improvement Opportunities Report"<sup>9</sup> (see Figure 3) which provides an individual student specific information of concept or discipline areas of strengths and improvement opportunities.

**Figure 3:** Strength and Improvement Opportunities Report categorizes a student's performance in various disciplines and subdisciplines in this assessment by assigning either a green triangle ▲ : doing well, or a yellow circle ● : needs review or a red inverted triangle ▼: needs improvement.



Student X

## Strengths and Improvement Opportunities

## Comprehensive OSCE Exam - Spring 2020 (5-14-2020)

Course: DDS2020-IDS2020 • Instructor: Dr. T Hoover • 05/14/2020 • Questions: 120  
 StdDev = 5.96 • Mean = 88.74 • Median = 89 • Rank = 90/163 • Percentile Rank = 42.3313

73.33%

My Score  
(88/120)

73.95%

Average Score  
(88.73/120)

Overall, you scored near the class average. Please take note of the areas, noted in yellow or red, where you may have opportunities for improvement.

CATEGORY	SCORE RANGE			MY SCORE	AVERAGE	CORRECT	
	★ MY SCORE	◆ AVERAGE/MEAN	0 50 100				
<b>*D1-Biomedical sciences</b>			0 50 100	71.43%	64.77%	10/14	▲
<b>*D2-Diagnostic Sciences</b>			0 50 100	72.97%	75.38%	27/37	●
<b>*D3-Endodontics</b>			0 50 100	44.44%	58.35%	4/9	▼
<b>*D4-Orthodontics</b>			0 50 100	100.00%	84.97%	4/4	▲
<b>*D5-Oral surgery</b>			0 50 100	100.00%	73.82%	3/3	▲
<b>*D6-Pediatrics</b>			0 50 100	75.00%	80.06%	9/12	●
<b>*D7-Periodontics</b>			0 50 100	60.00%	63.07%	3/5	▼
<b>*D8-Restorative dentistry</b>			0 50 100	74.47%	76.71%	35/47	●
<b>*D9-Behavioral skills</b>			0 50 100	75.00%	87.73%	3/4	●
<b>D10-EBD/Epidemiology/Applied research methodology</b>			0 50 100	100.00%	64.01%	3/3	▲
<b>D12-Community Health</b>			0 50 100	83.33%	76.69%	10/12	▲
<b>D13-Preventive Medicine and Dentistry</b>			0 50 100	100.00%	95.09%	1/1	▲
<b>D8a- Cariology/Caries risk assessment</b>			0 50 100	83.33%	71.98%	5/6	▲

An exam such as this is just a sampling of the knowledge and critical thinking students should have acquired by the date of said exam administration. The KR-20 for any such exam could be improved with editing, re-writing, or elimination of poor performing questions as is done in perfecting national board exams which have strong reliability scores.

Confidence in a reliable exam can be a valuable tool informing students of their learning progress and could help an institution's teaching practices and curriculum design and efforts. The statistical positive correlation between low student scores on this exam with other performance data points where a student's performance was also weak, suggests that progress exams could help early identification of students not progressing adequately even before other indicators of weak performance are evident. Distinguishing struggling students early would provide for remediation or additional training time prior to completion of their professional program. The previously mentioned Student Strength and Improvement Opportunities Report would be valuable for identifying specific content areas on which these students need to focus.<sup>10,11</sup> Additionally, a well-done assessment exam with credible item tagging and a strong reliability score could confirm for faculty what students have learned; inform curricular designers of weaknesses such as content sequence, timing, or gaps in curriculum; and finally provide an additional measure of outcomes of curricular changes. Intention to use progress exams, of course, must be communicated to students at the matriculation into the program as a matter of transparency and fairness.

We hope that this framework would help other institutions design and implement similar assessments of student progress before graduation. Implementing a similar exam question

tagging system to help track and monitor students' learning outcomes based on concept/knowledge areas is worth consideration as well.

### **Limitations**

This study has a few limitations. A written examination cannot assess technical skills required of students. Thought also must be given ahead of exam administration as to how the exam results would be shared with the students and faculty so that an effective remediation plan can be created but at the same time protect the integrity of the exam test items. Future studies on effective design of progress examinations, barriers to implementation, validity and reliability are needed in educational programs.

As this assessment was piloted in one dental school, the results might not be readily generalized to other vocational programs. This exam was administered during the unprecedented times of the COVID-19 pandemic. Outcomes of similar exams administered during non-pandemic times would be valuable as well. The pandemic might have elevated anxiety in some dental students due to concerns about exam results affecting graduation, financial situation, or employment opportunities. Finally, this was a comprehensive exam administered near the end of students' completion of DDS training. Progress exams between years would have different goals than "readiness for graduation". They could help identify individual student challenges in particular areas needing remediation so that students could be mentored to reach competency by the end of the program. Strategy in the preparation of these yearly progress exams must carefully match the pace of instruction and student learning levels expected each year as they build over time in the students.

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