

Student Responses to Smart Device–Based Test on Competency Evaluation in Dental Education

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Purpose: This study was aimed to investigate the possibility of utilizing smart device-based test (SBT) for competency evaluation in dental education and to analyze the student responses on overall competency evaluation using SBT method, in comparison to ubiquitous-based test (UBT).

Materials and Methods: Questionnaire surveys have been conducted at Yonsei University College of Dentistry from 2015 to 2018 to obtain students' feedback on the application of SBT to competency evaluation. In addition, in order to supplement the competency evaluation procedure, considerations were explored by comparing the expected and actual difficulty of each item when preparing items for competency evaluation with SBT.

Result: According to the survey results, student responses between the initial two years (2015 and 2016) differed from those in next two years (2017 and 2018). Students in 2017 and 2018 had more positive responses on competency evaluation with SBT. To determine the test validity, criterion-referenced evaluation was adopted to compare the data in 2017 and 2018 and slight differences in test difficulty in 2018 between the expected and actual difficulty of items were found.

Conclusion: The results indicated that SBT was more appropriate for competency evaluation than UBT, based on four-year period of competency evaluation. The SBT was not affected by either the file size or the number of test-takers. Interestingly, students were not sensitive to test version of competency evaluation (paper-based test and SBT). This study suggests that the quality of the test items should be measured by continuous monitoring of the expected and actual difficulty of items for determining test validity. More detailed results and discussions of the findings are given for the development of test procedure and further potential research directions in dental education.

Key Words: Competency evaluation; Scenario-based test; Smart device based test; Ubiquitous based test

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Introduction

To date, proper contents and methods of competency evaluation have been much investigated and debated in the field of dental education. Regarding the official announcement on the inclusion of the practical hands-on examination part in the National Dental Licensing Examination starting from 2022, the development of a newer test items and methods than conventional National Dental Licensing Examination has been actively discussed. The National Dental Licensing Examination, conducted as paper-based test (PBT), covers 13 subjects, which consists of 364 multiple choice questions in which only one is chosen as correct answer among five candidate answers. Since the National Dental Licensing Examination is divided into subdomains, it tends to be relatively difficult to prepare test items that measure higher mental abilities. Related to this, there have been limitations in evaluating the problem-solving skills and comprehensive critical thinking skills that are required for a dentist after obtaining a dental license. In order to overcome this, many studies on criteria for test item development standards, domains to be included in National Dental Licensing Examination, and test validity have been published since 2000¹⁻³⁾.

A study on how to improve the subjects in National Dental Licensing Examination (2005) emphasized not only the need to assess competency not only to examine maxillofacial and oral diseases, but also to link and apply a large amount of basic science knowledge related to diseases for diagnosis and treatment to clinical performance. In addition, according to the study on the improvement of National Dental Licensing Examination system for the evaluation of dentists' competency in 2015, the general dentists' competency was defined as the ability to integrate knowledge, treatment, and attitudes of dentists in the actual problems of real patients in the practical situation. Furthermore, this same study

concluded that changes in National Dental Licensing Examination are essential for the evaluation of the competency which should be acquired and maintained by dentists⁴⁾.

The competency should be evaluated in the same way as in actual job performance. However, the current paper-based test (PBT) with limited information has a limitation when evaluating some competency in clinical reasoning and integrated critical thinking skills. In order to evaluate competency in diagnosing the patients in the context similar to the actual situation, testing methods should be revised. The adoption of computer-based test (CBT) for written examination of National Medical Licensing Examination has been discussed and reviewed in medical education⁵⁻⁷⁾. Moreover, the written examination of the 23rd National Emergency Medical Technician Examination (Level-1) conducted in 2017, was carried out by switching from PBT to smart device-based test (SBT)⁸⁾.

A conventional version of computer test may be the PBT, performed by the computer using analysis with the optical mark reader. The PBT has been widely used in many standard tests including National Dental Licensing Examination. According to the development of new technologies for effective learning, testing methods for smart education using various devices are also emerging in the order of CBT and ubiquitous-based test (UBT). The CBT is performed by viewing a computer screen. If a test-taker submits the answers to the questions provided by the computer connected to an internet server, it is called internet-based test⁹⁾.

The tests using smart devices can be divided into UBT and SBT methods depending on how test items are provided to smart devices. The UBT is a testing method that transmits all test items to test-taker's smart device at the testing site by wireless local area network (LAN) system. In contrast, the SBT is performed in the smart device distributed to each test-taker, in which all test items are stored in advance.

Depending on the testing environment of the test-takers, it can be divided into the CBT and UBT. The CBT may limit the number of test-takers depending on the total number of computers available at the testing site. In contrast, the UBT, regardless of the environment of the testing site, allows a relatively larger number of test-takers to take the test than the CBT. In addition, the UBT and SBT are distinguished according to the way of transmitting test items. In case of the UBT, transmitting test items at the test site is affected by the file size or the number of test-takers.

The purpose of this study was to examine the possibility of applying SBT for competency evaluation as a method of testing in dental education. Yonsei University College of Dentistry (YUCD) has conducted competency evaluation for graduation based on SBT since 2015. In this regard, student responses on overall competency evaluation using newly adopted SBT were also analyzed based on the previous data of YUCD.

Materials and Methods

1. Participants

Competency evaluation for graduation based on SBT has been carried out since 2015 to evaluate competency in problem-solving skills and comprehensive critical thinking skills required when performing duties as a dentist. In addition, an annual questionnaire was administered to all YUCD students participating in competency evaluation in order to examine their responses on the use of the SBT, a newly introduced test method. The number of students who completed the competency evaluation each year is as follows: 68 in 2015, 58 in 2016, 67 in 2017, and 64 in 2018.

2. Student Questionnaire on the Use of Smart Device-Based Test

After completing competency evaluation for

graduation, all students responded to the questionnaire to provide comments on the SBT. Items were concerning convenience of using smart devices, appropriateness of tablet PC screen composition and structure for problem solving, preference between PBT and SBT, and competency evaluation based on SBT. Items include two kinds of scoring system. The first type of scoring used a Likert scale from 1 to 5, with 1 representing “strongly disagree” and 5 representing “strongly agree”. The second type of scoring was to reflect whether students agreed with each of the questionnaire items.

3. Data Analysis Procedure

To discover any significant quantitative differences, IBM SPSS Statistics 25.0 for Windows (IBM Corp., Armonk, NY, USA) was used for statistical analysis. First, the descriptive statistics was conducted to analyze the students’ overall satisfaction measured by the questionnaire. Second, the Cronbach’s α coefficient was used to determine the questionnaire reliability.

4. Review of Competency Evaluation Procedure

The YUCD has developed scenario-based test through a series of discussions and meetings in order to evaluate students’ competency in problem-solving and comprehensive critical thinking skills required when performing duties as a dentist. Table

Table 1. Content of competency evaluation

Construct	Competency (domain)
1	Application of biomedical knowledge to clinical care of patients Critical thinking and problem solving Treatment needs of patients with special needs (complex medical problems)
2	Treatment plans for the emergency patients
3	Behavioral sciences in dentistry Communications ability for the disabled patients
4	Evidence based decision-making
5	Ethics (ethical decision making)

Table 2. Number of clinical cases and items selected for competency evaluation from 2015 to 2018

Construct	2015		2016		2017		2018	
	Case	Item	Case	Item	Case	Item	Case	Item
1	6	53	9	66	11	58	7	81
2	3	15	1	8	2	12	1	5
3	3	7	3	12	4	10	4	8
4	1	4	2	19	2	9	1	11
5	-	-	3	10	3	9	3	6
Total	13	79	18	115	22	98	16	111

Values are presented as number only.

1 describes the content of competency evaluation for graduation.

Competency evaluation comprised triple jump exercises in selected clinical cases. Table 2 shows not only the number of selected clinical cases, but also the number of items, developed in each year from 2015 to 2018 according to construct. Ethics (ethical decision making), construct #4, has been included in competency evaluation since 2016.

The item development procedure and potential considerations when preparing items were reviewed carefully based on the students' responses on overall competency evaluation using SBT as well as 4-year experience of competency evaluation with SBT.

Result

1. Students' Responses on Overall Competency Evaluation Using Smart Device-Based Test

In order to identify to what extent and in what way the SBT affected the participants' satisfaction on competency evaluation, the results of student questionnaire conducted from 2015 to 2018 are presented (Table 3).

Firstly, the reliability of each questionnaire was calculated using Cronbach's α coefficient. As a result, the Cronbach's α coefficient of the entire factors were over the recommended threshold of 0.70, ensuring adequate internal consistency of the scales (2015: 0.896; 2016: 0.886; 2017: 0.930; and 2018: 0.889). The results were presented using mean score for items

categorized by using smart devices, screen composition and structure, and competency evaluation while preference were processed by percent calculation. Based on the results of the students' responses, the YUCD has been striving to improve the SBT every year.

1) Use of smart devices

The results of the student's questionnaire on the use of smart devices in 2017 showed much increase, compared to 2015 and 2016 (Table 3). The UBT was applied for the first time in 2015, however, it took a long time to transmit all test items to individual smart devices so that not every student took the test at the same time. Although smart devices had improved transmitting performance of all test items, they did not yet appear to be use-friendly in 2016. It can be claimed that finally the SBT has been adopted for competency evaluation and worked successfully.

2) Screen composition and structure

As seen in Table 3, most students did not struggle with screen composition and structure overall in 2017 and 2018, because they were already very accustomed to using it. In contrast, they were facing the inconvenience of returning to the previous screen to see clinical photographs and radiographs. In particular, smart devices have been fixed on the desks since 2018 to prevent cheating on tests and exams. However, the students mentioned that the tablet PC screen was reflected by the light of the ceiling, mak-

Table 3. Students responses on smart device-based test

Content	Item	2015 (n=68)	2016 (n=58)	2017 (n=67)	2018 (n=64)	
Using smart devices	1. Was it convenient to use smart devices?	3.03	3.00	3.91	3.55	
	2. Were you generally satisfied with the test based on smart devices?	3.10	2.86	3.66	3.42	
	3. Was the system stable when taking the test?	3.46	2.97	4.16	3.80	
Screen composition and structure	4. Was it easy to understand the manual of a smart device?	3.67	3.64	4.00	3.89	
	5. Was the layout of the items and answers appropriate?	3.17	3.31	3.72	3.48	
	6. Was the font size of the items well managed?	3.42	3.93	3.90	3.67	
	7. Was the font style of the items well managed?	3.58	3.91	3.97	3.78	
	8. Was overall composition of the screen easily recognizable?	2.93	3.26	3.60	3.38	
Preference (%)	9. Was the quality of photos appropriate to recognize?	3.20	2.72	3.60	3.09	
	10. Do you think that you need more time for yourself when taking the test with a smart device than printed paper? (Suppose both tests includes test items)					
		Necessary	55.9	56.9	50.7	51.6
		Unnecessary	44.1	43.1	49.3	48.4
	11. Which test version do you prefer?					
	Smart device	32.4	50.1	76.1	56.3	
	Paper	67.6	50.0	23.9	43.7	
	12. Was the scenario-based test helpful to measure your competency?	2.68	3.40	3.40	3.25	
	13. Do you think that the scenario-based test can evaluate competency required to be acquired and maintained by dentists?	2.82	3.17	3.39	3.23	

ing it difficult to take the test.

3) Preference

The students who took the test in 2017 and 2018 showed their overall preference for taking a test with SBT rather than PBT. The reason was that students did not experience any difficulties or technical issues during the competency evaluation based on SBT. Some students responded that typing answers on the keyboard was much more convenient than writing the answers by hand when completing essay type questions. Moreover, they also explained that they prefer the SBT because it can be misinterpreted due to the unclear or ambiguous handwriting when grading essay answers. On the other hand, some students in 2016 had negative opinions towards testing, UBT. The reason was that (a) certain students needed more time to answer the questions, and (b) they were not allowed to return to the previous questions to change the answers, once they have left a question. It can be assumed that students' opinions on test time

are related to the level of difficulty of the questions presented each year.

Most students who took the test in 2015 complained that it was extremely difficult because they had never experienced such competency evaluation before. For this reason, YUCD decided to offer students the opportunity to practice this kind of simulated test in February 2016 before taking an actual test in October 2016. Starting from 2017, Third year predoctoral students were able to practice the shortened version of competency evaluation with SBT. Overall, students responded positively to competency evaluation with SBT as they were accustomed to the test procedure and test items.

2. Procedure for Item Development for Competency Evaluation

The YUCD has prepared procedure for item development based on the analysis of 4-year experience of competency evaluation with SBT and students' responses. Competency evaluation committee mem-

bers discussed many times the item difficulties and item types in order to develop items for competency evaluation with SBT. The developed items were based on competency in clinical reasoning and integrated critical thinking skills that students must have for graduation in order to meet test purpose. The test items were developed as the scenario-based items, and were accompanied by clinical photographs and radiographs of clinical cases and patient's present illness. Scenario-based test consists of multiple-choice and essay type items based on given scenarios. Fig. 1 shows a detailed procedure for conducting scenario-based test.

1) Selection criteria for clinical cases

Clinical cases were selected from the YUCD curriculum. Clinical cases were common cases that can be seen in predoctoral student clinic. Clinical cases had to include situations in which students can identify important concepts and content that they must know.

2) Guidelines for scenario and item development

Scenarios should be written so that they can be understood by students. Items for scenario-based test requires integrated critical thinking skills, including analysis, interpretation, and problem solving, rather than memorization.

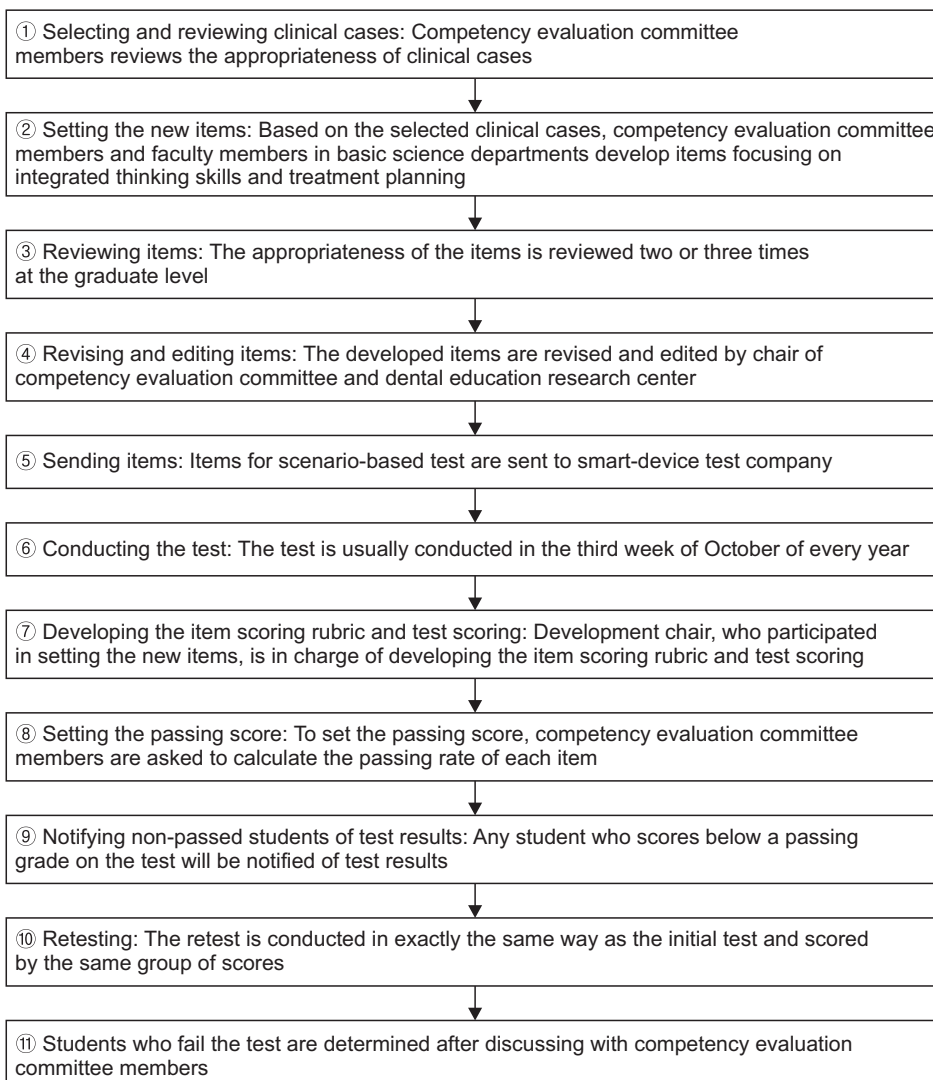


Fig. 1. The flowchart of developing scenario-based test.

Table 4. Ratio of the difference between the actual and the expected item difficulty (2017~2018)

Year	Number of items (difference \pm 0.3)/Total number of items	Proportion of total number of items (%)
2017	15/58	25.9
2018	8/81	9.9

3. Considerations When Preparing Items for Competency Evaluation

The YUCD has been exploring ways to review the quality of the test items in order to ensure the validity of competency evaluation. Thirteen professors who have been participating in setting items since 2017 were asked about the probability that the minimum competent person (MCP) could answer each item. The average of the results predicted by each professor that the MCP would be able to answer each item is called the expected item difficulty of the professors. The quality of the items can be analyzed quantitatively by the difference among the actual item difficulty, the probability that students answered in the actual item, and the expected item difficulty by the professors.

Of the five domains of competency evaluation with SBT, the difference between the actual item difficulty and the expected item difficulty of 58 items in 2017 and 81 items in 2018 in the first domain was calculated. Table 4 shows the ratio of items above and below (plus-minus) 0.3 to total items by comparing the difference between expected and actual difficulty of items. Although the number of items in 2018 was higher than in 2017, the proportion of items with difficulty \pm 0.3 was lower. It can be assumed that the proportion of items that are appropriate to the level of students has increased.

Discussion

The following results and implication could be drawn based on the analysis of 4-year experience of competency evaluation with SBT.

First, although there were slightly more clinical cases in competency evaluation with SBT than one with

UBT, the test was conducted smoothly without any technical glitches. The reason may be that the SBT was not affected by either the file size or the number of test-takers. However, it is necessary to consider not only securing sufficient smart devices for testing, but also security issues related to storing test items in advance on smart devices.

Second, students were not significantly affected by the test version of competency evaluation (PBT and SBT). In addition, students gave positive feedback on (a) avoiding misinterpretation of the unclear or ambiguous handwriting when grading essay answers and (b) convenience of complete and correct the answers. On the other hand, several students expressed that they faced the inconvenience of returning to the previous screen to see clinical photos and radiographs like real photos. This may depend on the number of items included in each clinical case. Therefore, continuous monitoring is required for the use of smart devices, and screen composition and structure.

Third, the way of ensuring the validity of competency evaluation should be considered carefully. In order to determine the test validity, the quality of the test items should be measured by continuous monitoring of the expected and actual difficulty of items. As seen in Fig. 1, it takes a long time when setting new items for competency evaluation. The quality of the items was reviewed by analyzing the difference between the actual item difficulty and expected item difficulty. This finding may help to ensure the test validity by preparing items that meet the purpose of the competency evaluation.

While this study showed the effectiveness of competency evaluation with SBT, it also identified some limitations, which stem from the limited scope of the

participants and their setting. Regarding the scope of the participants, the limited number of certain Korean fourth year predoctoral students in one of the universities in Seoul participated in this study. Therefore, the results may not be applicable to students of other predoctoral students or other level of dental students. Also, because this study was conducted in Seoul, the capital of South Korea, dental students in other regions/setting might not show the similar results.

Despite the limitations, this study examines the first competency evaluation based on SBT in dental education. The SBT, which has advantages such as convenience, satisfaction, and usefulness as an evaluation tool, can be used as an effective evaluation tool for competency evaluation in dental education.

Conclusion

The results indicated that SBT was more appropriate for competency evaluation than UBT based on four-year period of competency evaluation. The SBT was not affected by either the file size or the number of test-takers. Interestingly, students were not sensitive to test version of competency evaluation (PBT and SBT). This study suggests that the quality of the test items should be measured by continuous monitoring of the expected and actual difficulty of items for determining test validity. More detailed results and discussions of the findings are given for development of test procedure and further potential research directions in dental education.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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