

Item Equivalence Verification according to Test Information Media of the Optician National Licensing Examination: Focused on the Smart Device Based and Paper Based Tests Including Multimedia Items

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Abstract

This study conducts the validity of the pen-and-paper and smart-device-based tests on optician's examination. The developed questions for each media were based on the national optician's simulation test. The subjects of this study were 60 students enrolled in E University. The data analysis was performed to verify the equivalence of the two evaluation methods, specifically, through split-plot factorial design of the evaluation method as a partition variable. As a result of the statistical significance test for the difference in achievement for each type of test information medium, indicating that there was no difference in achievement according to the type of test information medium at the significance level of .05. Although the validity of the smart device-based test and the paper-and-pencil test was verified through this study. To develop and set multimedia items in the optician national licensing examination, it is necessary to establish guidelines for how to develop the items.

Keywords: paper-pencil test, computer-based test, multimedia question, test information media

1. Introduction

The national examination for healthcare workers is a test conducted to grant licenses or qualifications for relevant healthcare occupation. The national examination for each occupation should be evaluated to include problem-solving skills in the actual job situation. The optional test questions currently used in the paper test mainly evaluate whether the relevant knowledge necessary to perform a job is remembered or understood rather than their problem-solving ability, so a lot of effort is still required to become an authentic test reflecting the reality of the job. Questions for national examinations are intended to evaluate the examinee's problem-solving ability by presenting common or important cases or job situations on the question stem in text form. However, it is known that the test questions that present the well-structured problem well-defined problem differ from the real-world problem, and there is a limit to predicting the examinee's ability in the actual job situation. To overcome this and evaluate the U.S. problem-solving ability of the real world, The National Board of Medical Examiners (NBME) began using multimedia questions that reinforced the authenticity of the case in the computer-based test in 2007.

In Korea, all the national licensing examinations for health and medical service personnel, except for the licensing examination of emergency medical technician, are paper-and-pen-based tests. There is much research on national examinations that are based on pen-and-paper and smart devices (Andersson, Kaldo Sandström, Ström, & Strömgren, 2003, Carlbring et al., 2005). According to previous study, who researched the equivalence of Paper and Pencil-Based Test (PBT) and Computer-Based Test (CBT), emphasized that it is required to verify test equivalence of Smart Device Based Test (SBT) and the PBT as evaluation media (Si Ghi-ja, 2003). No matter how reliable, convenient, and useful the SBT is, if it fails to secure the same equivalence as the PBT, it is impossible to become a good test evaluation method (Haney, 1991). Depending on the test information media, a test taker's ability level can

be overestimated or underestimated; a particular group can have an advantage or disadvantage. Therefore, which test information medium is selected is important. The unique medium characteristics of items can make a difference when a test taker's ability level is measured (Park, Kim, & Yang, 2002; Boo, 1997). Test information media to deliver items are classified into print media and electronic media according to information delivery types. In terms of knowledge measurement, the test takers' linguistic abilities and the error of measurement for test takers' answers to evaluation items were evaluated in the PBT, under the print media category (Lim & Seong, 2001, Thorndike, 1949). The advanced countries already adopted computer-based national licensing examinations for medical practitioners and nurses, or other licensing examinations organized by academic groups. Accordingly, researchers try to verify the validity of the items set according to Item Response Theory (IRT) which is the basis of the CBT. Even if the SBT provide better evaluation conditions than the PBT, it is important to verify the item equivalence of the SBT and the PBT to replace the PBT with the SBT. In short, it is required to review whether there is any difference in result interpretation, no matter which test, either smart device or paper and pencil-based test, is conducted. This study developed test items for the PBT and SBT for the optician national licensing examination and verified the test equivalence of the two test types to check the validity of the set items.

2. Method

2.1 Study Subjects

As trial tests for the optician national licensing examination, the PBT and the SBT including the multimedia items developed were conducted. Sixty students majoring in optical science of the four-year at E university situated in Seongnam, Gyeonggi-do took the trial tests. The method of sampling the study subjects was simple random sampling. In addition, to comply with research ethics standards such as protection of personal information and prior consent in experimental study, consent forms from research participants were collected and submitted in electronic file format. Students who will take the national examination are required to complete their major subjects and must have major skills. Therefore, this study was conducted among the third-year students who completed all the essentials major subjects and were considered to have sufficient major skills. Furthermore, only those who agreed to participate after understanding the study purpose and process and acquiring their personal information consent participated. Those who did not agree were excluded from the study subjects.

2.2 Research Procedure

To develop mock national test questions, the development of paper-based test questions and smart device-based test questions were requested centering on professors in the relevant department. In addition, after recruiting subjects for the research progress, mock national tests and smart device-based tests were conducted on subjects wishing to participate in this study. The national test date for the simulation was determined on the day when all the subjects could conduct the simulation test.

2.3 Taxonomy Table of the Two-Dimensional Objectives for Item Development

The total number of items is 100, which were developed for the test trials for the optician national licensing examination. The taxonomy table of the two-dimensional objectives includes the number of items in each category, item classification, and item type. The items were developed under the leadership of the professors of relevant departments. The paper and pencil-based test items and the smart device-based test items were developed like the PBT test items. The SBT included five percent multimedia items. The binary taxonomy is a table that intersects the two dimensions of the learning content system to be taught to students and the expected behavior. The steps for creating a binary taxonomy are as follows.

Step 1: State your learning goals

Step 2: Confirmation of the learning content system

Step 3: Selection (or creation) of a behavior classification system

Step 4: Preparation of binary classification table and selection of evaluation ratio

Step 5: Selection and preparation of evaluation method

2.4 Trial Tests

Through random sampling, 60 test takers were equally divided into group A and group B. For psychological adaptation of test takers, they followed the provided instructions and answered practice test items in the smart-device based evaluation. For evaluation, each one of the two groups had two tests: the PBT and the SBT, each consisting

of 100 items. In the first evaluation, group A took the PBT and group B took the SBT. In the second evaluation, group B had the SBT, and group A had the PBT. (Table 1) The trial test subjects and test instructions are presented in Table 2 Each item is given one point, summing the number of points to 100 for the 100-item test. (Table 2)

Table 1. Design of Trial Tests

Group Test	1 st test	2 nd test
Group A	PBT	SBT
Group B	SBT	PBT

Table 2. Trial Test Subjects and Test Instructions

Type of occupation	Class	Subject name (No. of items)	No. of items	Test item	Item type
Optician	First Class	Eye disorders (10)	50	14:00-14:45	1. Multiple choice items with five options 2. Multimedia items (14 items, 80 seconds per item) 3. Text items (36 items, 45 seconds per item)
		Ocular anatomy (10)			
		Ocular physiology (10)			
		Contact lens (20)			
Optician	Second Class	Refraction test (20)	50	15:00-13:45	1. Multiple choice items with five options 2. Multimedia items (14 items, 80 seconds per item) 3. Text items (36 items, 45 seconds per item)
		Something about product knowledge (contact lens) (10)			
		Binocular visual function test (20)			

3. Data Analysis

Frequency and percentage were calculated to understand the general characteristics of the study subjects.

Split-Plot Factorial Design was applied to verify the equivalence of the two test types. The split-plot factorial design is a mixture design in which the factors between or in test takers are integrated. It is repeated design in which one or more plot factors are included in independent variables. In this case, a model of Analysis of Variance (ANOVA) is presented as follows:

$$Y_{ijk} = \mu + a_j + r_{jk} + \beta_k + S_{(i)k} + \epsilon_{ijk}$$

a_j : The effect of factor A

r_{jk} : The interaction effect of factors A and B

β_k : The effect of factor B

$S_{(i)k}$: The effect of test taker

ϵ_{ijk} : Error

ϵ_{ijk}

4. Results

4.1 General Characteristics of Study Subjects

According to the analysis of the general characteristics of the study subjects, there were 26 (43.3%) men and 34 (56.7%) women, thus, the distribution of women was larger; regarding their CPA in the previous semester, the largest distribution was found in the group of students whose GPA was between 2.1 and 3.5 (40 persons, 66.7%).

Table 3. General Characteristics of the Study Subjects (N=60)

Observed variable		Frequency (person)	Percentage (%)
Gender	Male	26	43.3
	Female	34	56.7
GPA in previous semester	Less than 2.0	0	.0
	Between 2.1 and 3.5	40	66.7
	Between 3.6 and 4.0	13	21.7
	Between 4.1 and 4.5	7	11.7

4.2 Taxonomy Table of the Two-Dimensional Objectives for Item Development

The multimedia items for the optician national licensing examination were developed based on ‘other problems and solutions’ (physical stimulation, immune response, solution toxicity) in the contact lens section of the subject ‘Application of vision optics’. The question items on the causes of inconvenient senses should be answered after the test takers watched the videos and pictures of the symptoms. Three items (no. 89 and no.97) were developed for the smart-device based trial test. Although item numbers 89 and 97 have the same pictures and solutions, they have different scenarios. The purpose of these items was to find a test taker’s response when the same content is applied in a different scenario.

Table 4. Taxonomy Table of the Two-Dimensional Objectives

Subject name	Content (No. of items)	Item classification			Item type*
		Memory item	Analysis item	Solution item	
Theory of vision optics	Eye disorders (10)	20%	80%	0%	T. 80% I. 20%
	Ocular anatomy (10)	80%	20%	0%	T. 70% I. 30%
	Ocular physiology (10)	50%	30%	20%	T. 80% I. 20%
Application of vision optics	Contact lens (20)	20%	30%	50%	T. 60% I. 30% M. 10%
	Refraction test (20)	0%	60	40	T. 75% I. 20% M. 5%
Practical skill test	Something about product knowledge (contact lens) (10)	40%	20%	40%	T. 50% I. 30% M. 20%
	Binocular visual function test (20)	0%	50%	50%	T. 80% I. 20%

* Note) T: text, I: image, M: video

4.3 Multimedia Questions Based on PBT and SBT

4.3.1 Item Number 89 Was Developed as a Multimedia Item Describing as Follows:

The eye disorder is often found in men whose eyelid tension is strong. In this case, wearing contact lenses continuously cause corneal injuries and corneal inflammation. Therefore, it is necessary to change a contact lens material rightly. In the PBT, the item can be answered somewhat easily since it is a knowledge-memory type item solved with the memory of symptoms and solutions. In the SBT, it was developed as a problem-solving multimedia item to find if a test taker can judge corneal injuries and solve the problem. When it is additionally developed in the field ‘application of vision optics (refraction test and binocular visual function test) and the field ‘practical skills’ (contact lens and ophthalmic dispensing), it is possible to evaluate a test taker’s ability to solve the problem in a clinical setting [Fig.1].

PBT QUESTIONS NO. 89

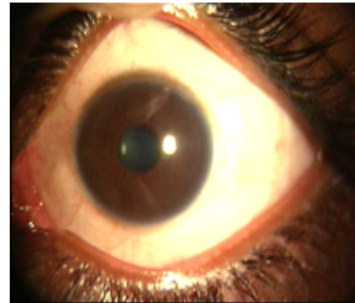
A 23-year-old woman who wears soft contact lenses on a continuous wear schedule visited the site because she felt pain and glare from the day before and had poor eyesight. As a result of the interview, he said that he wore contact lenses at night and slept. There were no medical or allergic diseases. A slit lamp examination revealed a dent in the upper part of the cornea. What to consider when choosing contact lenses again after the wound has healed?

- 1) Choose disposable contact lenses.
- 2) Choose a material with a low modulus.
- 3) Adjust the power by performing the refraction test again.
- 4) Adjust the base curve to make a flat fitting.
- 5) Adjust the base curve for a tight fit.

SUBJECT	FIELD	DIFFICULTY	ESTIMATE CORRECT ANSWER RATE
Visual Optics Applications	CONTACT LENS	MIDDLE	60%

SBT QUESTIONS NO.89

A 23-year-old man who wears silicone hydrogel contact lenses on a continuous schedule visited the site because he had pain and glare in his right eye from the day before and had poor vision. What should be considered when choosing contact lenses again after the wound is healed by looking at the test results of the video data?



- 1) Choose disposable contact lenses.
- 2) Choose a material with a low modulus.
- 3) Adjust the power by performing the refraction test again.
- 4) Adjust the base curve to make a flat fitting.
- 5) Adjust the base curve for a tight fit.

Figure 1. Item Number 89 in the PBT and in the SBT (multimedia item)

4.3.2 Item Number 97 Was Developed as a Multimedia Item Describing as Follows:

The cause of allergic conjunctivitis, which often occurs in persons wearing soft contact lenses, that is their negligence of cleaning contact lenses. In short, the eye disorder occurs when protein deposits are accumulated in contact lenses and are combined with a preservative of contact lens cleaner. In this case, it is required to instruct a relevant person to stop wearing contact lenses immediately. To prevent recurrence, it is important to select contact lenses rightly. If this item is set in the type of knowledge memory, it is easy to answer the item correctly when a test taker memorizes the symptoms. The item was developed to evaluate if a test taker can find abnormal movement of contact lenses, understand that its cause is protein deposits, and thereby select a material that prevents protein attachment in a real setting. Using a multimedia item, the field 'application of vision optics (refraction test and binocular visual function test) and the field 'practical skills' (contact lens and ophthalmic dispensing), it is possible to evaluate a test taker's ability to solve the problem in a clinical setting.

PBT QUESTIONS No. 97

A 25-year-old man who wears soft contact lenses continuously visited recently with symptoms such as a feeling of foreign body more than before and his visual acuity not as good as before. There were no medical or allergic diseases. Visual acuity was OD 6/9-1, OS: 6/6. As a result of the slit lamp examination, the lens moved a lot and a nipple was observed in the right upper eyelid. What should I do when refitting my contact lenses?

- 1) Make the base curve tight.
- 2) Replace with non-ionic contact lenses.
- 3) Change the design to a thicker perimeter.
- 4) Change to contact lenses with high oxygen permeability (Dk)
- 5) Replace with low modulus contact lenses.

SUBJECT	FIELD	DIFFICULTY	ESTIMATE CORRECT ANSWER RATE
Visual Optics Applications	CONTACT LENS	HIGH	50%

SBT QUESTIONS NO. 97

A 25-year-old man who continuously wears soft contact lenses recently visited a visit where he had more foreign body sensation than before and his eyesight was not as good as before. There were no medical or allergic diseases. The test results are the same as video data. What action to take?



- 1) Make the base curve tight.
- 2) Replace with non-ionic contact lenses.
- 3) Change the design to a thicker perimeter.
- 4) Change to contact lenses with high oxygen permeability (Dk)
- 5) Replace with low modulus contact lenses.

Figure 2. Item Number 97 in the PBT and in the SBT (multimedia item)

4.4 Result of Item Equivalence Verification According to Test Information Media

Table 5 presents the descriptive statistics of the achievements of the trial tests for the optician national licensing examination according to the test information media based on PBT and SBT. The mean value (standard deviation) of the points of the 60 students who took the PBT and SBT was 42.81(9.16), and the mean value (standard deviation) of the points of 60 SBT takers was 42.90(7.55).

Table 5. Descriptive Statistics for Test Score According to Test Information Media (N=60)

Type of occupation	PBT	SBT
	M(SD)	M(SD)
Optician	42.81(9.16)	42.90(7.55)

4.5 Repeated Measures ANOVA According to Test Information Media

A repeated measure ANOVA was conducted to find any achievement difference depending on the types of test information media. The results are shown in Table 6. Statistical significance for any difference of achievement was analyzed according to test information media. As a result, at 0.006 of F-value, 0.941 of significance probability, and 0.05 of significance level, there was no difference in achievement according to test information media. The result proves the PBT and SBT achievement test equivalence.

Table 6. Result of Repeated Measures ANOVA According to Test Information Media

Deviance element	Sum of squares	Degree of freedom	Mean square	F	p
Inter-entity	6093.092	59	103.273		
Intra-entity	2,231.5	60			
Evaluation type	.208	1	.208	.006	.941
Error	2231.292	59	37.819		
All	8,324.592	119			

5. Discussion

The biggest characteristic of computerized tests is that visualization and audio data can be used, and there is a technology that can measure social interpersonal relationships. These characteristics are essential for medical technicians who need to read, diagnose, and communicate with patients. In the case of social interpersonal relationships, the responses of students solving related questions are recorded so that they can be scored afterwards, or computers follow up according to the responses of students in various situations.

Measures can be presented, and the computer records the student's response related to this, so that the student's interpersonal relationship can be measured later. The use of computers has opened the possibility of measuring social interpersonal skills that are essential for medical personnel. In addition, it can provide quick feedback through immediate scoring. The test results can be given to the student at the end of the test by scoring the student's questions at the same time as the student's answer. The method of conducting a computerized test is conducted at a test center that conducts a computer test. The advantage of a computer test center is that unlike large-scale paper-written tests, students can go to the test center when they can, not at a fixed test time and place. However, computer testing centers for computerized testing can accommodate only a small number of people. Accordingly, there is a security problem in which the student who took the test exposes the test to the prospective examinee. In the case of SBT, visual and auditory data, which are characteristics of computerized tests, are used, and fast scoring is performed, while high-burden tests, where security is important, can be conducted on a largescale (Huh, 2012).

The SBT system construction process has been embodied in the SBT system in which the ubiquitous based test promoted by the National Assembly has been changed to a smart device since 2012 and problems are directly entered. The SBT system does not use an offline-based wireless network, so there are no security vulnerabilities, and the size of equipment input is reduced, so the possibility of errors is low, and the system can be simplified. Based on these advantages, the test management efficiency was maximized by modularizing the system to enable equipment management by individual laboratory units, and the completeness of the system was improved by additionally developing candidate denial prevention and other convenience functions (Lim, Kim, Jung, & Kim, 2015). As video implementation is possible, the SBT can evaluate test takers' problem-solving ability by developing various case-oriented multimedia test questions, as well as compensate for the shortcomings of computer-based tests such as answer review and power outage (Lim, 2014). The National Examination for Health Care Workers is a test conducted to grant licenses or qualifications for the relevant occupation, and the national examination for each occupation shall evaluate the ability to solve problems in the actual job situation.

Currently, paper-based tests mainly evaluate whether the relevant knowledge necessary for job performance is remembered or understood rather than problem-solving ability, and many changes are needed to become an authentic test. As a result of the statistical significance test for the difference in achievement of the inspection information medium type that can be used for SBT, the F statistic value is .006 and the significance probability is .941, indicating that there is no difference in achievement according to the inspection information medium type.

Another study on the effectiveness of multimedia questions reported that Taekwondo Knowledge Test obtained higher correct answer rates and average scores when using multimedia test information media than paper-written tests (Choi, Park, Lee, Lee, & Kim, 2012).

Multimedia questions that can be implemented in the SBT system can not only overcome the limitations of paper writing tests to evaluate the problem-solving ability of the field, but also contribute to strengthening field-oriented problem-solving skills in school education. In occupations that evaluate practical tests as data presentation types, it can be an opportunity to evaluate the clinical field performance required by each occupation while unifying the evaluation stage by replacing separate practical tests with multimedia test questions. Problem-solving questions are essential for qualification tests due to the nature of the job of health care professionals who are practical-oriented

(Lim, Yim, & Huh, 2017). According to Bloom's hierarchy of knowledge, knowledge can be classified according to its level from memorization, understanding, analysis, synthesis, and problem solving, and it means higher mental ability as it goes toward problem-solving skills rather than fragmentary knowledge memorization skills (Gierl & Lai, 2012). Therefore, in the qualifying test, it is not possible to evaluate the problem-solving ability of the clinical field simply by measuring the understanding of knowledge and memorization ability.

According to other study said through a question development study for evaluating nurses' problem-solving skills, nurses' independent decision-making is important as an accident, not as an actor, and nursing education needs the ability to apply, analyze, synthesize, and make decisions (Kwak et al., 2012). This is not limited to specific occupations. The evaluation of these problem-solving skills is of paramount importance in verifying job qualifications due to the nature of healthcare workers who should be able to properly take necessary measures for patients at the scene of an accident, diagnose diseases or test results. Due to the nature of computers, the rapidity of various data collection and processing processes, and the freedom to use multimedia devices can maximize educational and administrative effects. Various advantages in question production and management and educational aspects of this computer-based problem-solving ability evaluation are well presented (Kim, 2017). The biggest effect is that it is possible to create questions beyond the limit of writing. Unlike paper-based tests, which have limitations in delivering evaluation contents in text, it is effective to present a problem situation close to the actual situation in computer-based evaluation, and if used in the evaluation questions, more realistic questions can be created. This advantage is in line with efficient question production, and questions can be efficiently produced by utilizing multimedia elements such as video, voice, 3D, and animation. In terms of management, automatic scoring, immediate feedback, and extensive data collection power are mentioned. Comprehensive monitoring, and further multifaceted evaluation is possible because of the collection of information related to the test-taking behavior and attitude of the subject in the problem-solving process as well as the results of the question (Moon et al., 2020, Nam et al., 2020).

Through the results of this study, since the information delivery of smart device-based multimedia questions has relatively clear characteristics, it can be used as a valid multimedia question by reducing the difficulty of information delivery according to text expression in the national health exam.

Also, given the study results, it was assured that the SBT secured test equivalence with the PBT. Therefore, first, it will be necessary to apply active improvements in smart devices to the smart-device based optician national licensing examination. Some persons are still unfamiliar with table computer type smart devices. Moreover, test takers' ability and assurance of using smart devices can work as interference factors of test performance. In the follow-up research, it will be necessary to analyze any performance difference depending on the smart device function improvements and function factors.

For example, to prevent any omission of answers, it will be necessary to improve the function of going to an omitted item and the function of correcting an answer easily. In terms of the research on performance difference depending on functional factors, it is possible to analyze a performance difference between the function of showing one item per display and the function of looking over all items through scrolling down in a smart device. By discussing improvements in smart functions with technical staff, it is possible to expect more advanced smart-device based test.

Second, it will be necessary to change university education to smart-device based education and assessment system. With the expansion of smart phones and tablet computers to various fields, smart devices are highly related to people's life. Given the sharp rise in the use of new smart devices, it is natural to be interested in why and how the devices are utilized.

Students access a variety of educational content using diverse smart devices, such as smart phones, iPads, and tablet computer, and they produce, reproduce, and process new information with the uses of diverse functions in such devices (Kim, 2013). According to Kim Young-rok et al. study revealed that 87.7% of schoolteachers utilized smart devices in their everyday life, but only 25.4% applied smart devices to their class or evaluation. Despite high penetration and application rates of smart devices, smart devices fail to be applied to class and evaluation in school. In the smart era, smart devices are tried to be applied to National Health Personnel Licensing Examinations. In this circumstance, universities respond to the change at a snail's pace. To achieve smart device based smart education effectively in school, it is necessary to investigate the overall conditions of smart device use and education. In addition, it is necessary to survey and analyze the problem of low intention of applying smart devices to class, and to conduct a follow-up study to help professors utilize smart devices in universities.

Third, it will be necessary to develop multimedia items with high validity. Given the results of this study, applying multimedia items to the optician national licensing examination seems to be part of the effort to diversify test types

and evaluate test takers' ability in a more valid and reliable way. Aside from that, entities who design and develop multimedia items will be interested in such aspects of measurement, as 'is it necessary to make all items as multimedia items?'. or 'what kinds of items are needed to be made as multimedia items?'. Therefore, to develop and set multimedia items in the optician national licensing examination, it is necessary to establish guidelines for how to develop the items. In a follow-up study, it will be necessary to investigate the absence of theoretical guidelines for the development of multimedia items and to conduct more analysis to secure the validity of developed items. In other words, it is required to establish systematic and theoretical guidelines through the research on the development of multimedia items and to define a variety of characteristics of multimedia items in terms of measurement. Since multimedia items show relatively more clear information delivery than paper-based test items, it is expected to reduce difficulty in understanding text-based information in the optician national licensing examination. Moreover, multimedia items will be used as items with high validity.

6. Conclusion

Given the study results, it was assured that the SBT secured test equivalence with the PBT. It will be necessary to apply actively improvements in smart devices to the smart device-based optician national licensing examination. Some persons are still unfamiliar with table PC type smart devices. Moreover, test takers' ability and assurance of using smart devices can work as interference factors of test performance. Therefore, in the follow-up research, it will be necessary to analyze any performance difference depending on smart device function improvements and function factors.

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