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AN EXPERIMENTAL STUDY ON THE TEACHING METHODS FOR PROSPECTIVE FIREMEN

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Synopsis:

This study is an experimental design with two types of teaching methods for prospective firefighters, which explores and assesses the teaching effectiveness with a self-constructed test that drew on practices of current firefighters. The study concludes: lecture with group discussion method is better than direct teaching method, and the self-constructed test is a sound instrument in terms of its reliability and validity for assessing teaching effectiveness.

An Experimental Study on the Teaching Methods for Prospective Firefighters

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Abstract

A graduate of senior high school passing a national exam of firefighter is a prospective firefighter in Taiwan. After finishing an extra one-year vocational training and six months of internship, he/she becomes a full-time firefighter. The major duties of firefighters are fire prevention, emergency response and first aid. Fire prevention management (FPM), a circle of fire prevention, plays a very important role because the owners of public places are required to devise and perform fire plans. When the firefighters enforce fire safety inspection, they will check the execution of fire plans. A survey of Ministry of Interior revealed overall satisfaction of fire services was 98.94%, while fire safety inspection was only 67.54%. It more or less reflects the practical inspection had something to be improved. Therefore, it deserves to explore what the prospective firefighters have learned during the training session since the course on FPM is only four hours. Because few studies focused on FPM training for prospective firefighters, the first aim of this research is to devise self-constructed questions on FPM to guide prospective firefighters. The second purpose is to compare the teaching effectiveness between direct teaching method and lecture with group discussion through an experimental design. The target research population consisted of 49 current and 110 prospective firefighters. The current firefighters came from local fire departments and the prospective firefighters were sampled form 2 classes out of the total 11 classes randomly distributed in turns by their results of national exam. The tool for assessing teaching effectiveness was a self-constructed FPM test that utilized practical scenarios of FPM around Taiwan. For data analysis, descriptive analysis and ANCOVA utilized R language as well as Microsoft Excel 2013 for calculation. The conclusions are as follows: First, the self-constructed FPM test is a sound instrument in terms of its reliability and validity for assessing teaching effectiveness. Second, the lecture with group discussion is better than the direct teaching method.

Keywords: firefighters, self-constructed questions, teaching methods

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1. Introduction

1.1 Motivation

A “prospective firefighter” is a graduate of senior high school who has passed a national firefighter exam. After an extra year of vocational training and six months of internship, he/she becomes a full-time firefighter. According to the Fire Services Act in Taiwan, the major duties of firefighters are fire prevention, emergency response, and providing first aid. The prevention of fires is very important because it requires owners of public places to establish self-defense systems to protect their property.

Fire prevention management (FPM) is a circle of fire prevention, which requires the owner to devise and perform fire plans that include, for example, education and training of employees, the practice of fire drills, arson countermeasures and self-checks of fire safety equipment. These jobs are essential and complicated, and the owners sometimes feel confused and need the assistance of firefighters. The firefighters, especially newly recruited ones, should be able to answer the frequently asked questions about FPM. When firefighters check the execution of FPM in public places, firefighters are law enforcers: if the properties do not pass a fire safety inspection, the owners will get a warning to correct the shortcomings by a deadline or face a fine.

A survey by the Ministry of Interior revealed overall satisfaction of fire services was 98.94% while that of fire safety inspections was only 67.54%. This shows that it is essential for these prospective firefighters to recognize the common problems the owners face. If firefighters could have reminded the owners of frequently asked questions in advance, the dissatisfaction rate might be lower.

1.2 Purpose

Although previous researchers, such as Tovar (2008) and Baskas (2011), focused their studies on firefighters, little attention has been paid to the learning effectiveness of firefighters. In addition, it is important to ascertain what the trainees have learned, and to develop a better teaching method to understand their learning effectiveness.

In light of this, it deserves to explore the teaching effectiveness and practical knowledge of FPM that prospective firefighters need during their training, which has to be completed in a short time (four hours). The first purpose of this study is to devise self-constructed questions on FPM by current firefighters to guide the prospective firefighters to deal with future practical questions. The second aim is to compare learning effectiveness between two different teaching methods through an experimental design.

2. Literature Review

2.1 Adult learning of firefighters

Lalley and Miller (2007) divided teaching methods into lecture or direct instruction, reading, audio-visual, demonstration, cooperative learning and discussion group, practice by doing and teaching others. They concluded that these seven teaching methods should be viewed as continuum instead of hierarchy. Students should have different learning experiences, and direct instruction should be combined with various methods to know what students had learnt.

Further, Tovar (2008) focused his study on police officers and firefighters. In the study, the adult students, thought of as non-traditional adult students, went back to school to earn their bachelor or master diplomas. He summarized that firefighters favored group learning than leaning alone due to the reason of teamwork in firefighting. Additionally, Baskas (2011) argued if firefighters had possessed necessary knowledge, they would be trained as self-directed learners to solve problems by using available resources around them.

2.2 Learning assessment

Bloom (1956) divided the educational activities or learning into three domains: cognitive, affective and psychomotor. According to the classification, FPM belongs to the cognitive domain and object test is the most common and easier to grade (Walker, 2006). To develop the object test, the test instrument involves specifications, test construction, validation, try-out, analysis and revision (CoPox, 2015). About the quality of items, Matlock-Hetzel (1997) argued item analysis practices could use item difficulty, item discrimination and item distractors as tools. Among them, the item difficulty index was simply the percentage of correct answer. Item discrimination can determine which item is good or bad in the test. A negative discrimination index means that the item is bad and should be deleted. Item distractors are the selection of incorrect answers and suitable for multiple-choice items.

Takashi Sato (cited from Yu, 2011) created S-P table (S is student and P is problem) to help instructor diagnose the learning problems of students in the 1970s. This table is suitable for forty to fifty students and twenty to thirty question items. It also can diagnose the learning types of students. These types are stable (A), negligent (A’), common (B), insufficient (B’), deficient (C) and anomaly (C').

Training was conducted during the day and night. Hence, the prospective firefighters were so busy that they had no time to study FPM and other advanced techniques, which emphasize the concepts of law, before the course began. It is

knowledge-oriented and difficult to practice by performing or other operative methods. For these reasons, this study will use experimental design with two of the seven teaching methods (Lalley & Miller, 2007): the direct teaching method, in other words, lecture or direct instruction; and lecture with group discussion, combining lecture with cooperative learning and discussion groups. The assessment tool of learning effectiveness is the object test of self-constructed FPM combined with practical experience of current firefighters.

3. Method

3.1 Sampling

3.1.1 The current firefighters for self-constructed questions

The National Fire Agency holds a safety inspection class for one month, once a year. It offers active duty firefighters from different local fire departments the chance to strengthen their knowledge. Their primary work is fire safety inspection. Because they have far more working experience than prospective firefighters, these current firefighters were good candidates to construct self-constructed questions to guide the teaching and act as a tool for assessing learning effectiveness. In 2015, all fifty current firefighters attending the class were sampled.

3.1.2 The prospective firefighters for experimental design

There were eleven classes, called special exam classes, for the prospective firefighters in 2015. They graduated from senior high schools or higher and were distributed to different classes according to their results in the national exam. Each class had about fifty trainees. These two classes were sampled at random. One served as experimental group (group E), and the other served as control group (group C).

3.2 Research design

3.2.1 Self-constructed questions

Because the teaching time is only four hours, there were two types of self-constructed questions. One was an object test, which played the role of a tool for assessing learning effectiveness. The items of the object test were true–false and multiple-choice questions. For the convenience of counting, the perfect score is 100 points. These items took subjects and time into consideration by two-way specification table. Table 1 lists all the 50 items.

Table 1 The items of two-way specification table for object test

Cognitive level / Subject (minutes)	Knowledge	Comprehension	Application & Analysis	Total (percent)
Fire law (65)	3	2	16	21(42%)
Fire safety Inspection (25)	1	1	7	9(18%)
Fire drill (35)	1	6	4	11(22%)
Fire plan (25)	0	4	5	9(18%)
Total (150)	5	13	32	50(100%)

The other type of self-constructed questions were 10 essay items designed to review the focus of the course near the end of class.

3.2.2 Experimental design

The experimental treatment was 10 essay items, listed in Table 2. These were discussed by the trainees from group E, but in group C the items were only presented by the instructor in lecture format.

Table 2 Experimental design table

Category / Group	Pretest	Teaching Method	Posttest
Group E	O_1	X_1	O_3
Group C	O_2	X_2	O_4

Note：O1 ~O4 = the same items; X1 ~ X2 = the different teaching methods

3.3 Process

The first stage was to exchange opinions with firefighters responsible for FPM and draft self-framed questions. Firefighters in the safety inspection class then discussed the 10 essay items, and took and discussed the 50 items of object test. After that, the self-constructed questions were completed.

The next stage was the experimental treatment. At the beginning of group E's session, they took a pretest for about 20 minutes. Then, the instructor delivered the study subjects for about 65 minutes, before a 10-minute break. During the break, the participants were divided into 10 teams and each team discussed one of the 10 essay items. After that, a representative of each team presented their points of view and the instructor summarized the items. This took around 30 minutes. At the end of class, a posttest was administered, which took approximately 20 minutes.

Group C followed a similar procedure, but did not discuss the essay questions. Instead, the instructor presented the subjects one by one.

3.4 Data analysis

3.4.1 Analysis of self-constructed questions

This study omitted item distractors as they were up to fifty and included true-and-false items. Items difficulty and discrimination were major consideration. The validity of these questions were planned through a specification table and discussed by current firefighters. After that, the software of Tester for Windows 3.0 developed by Yu (2011) would analyze these fifty items of object test and diagnose these current firefighters at the same time.

The estimate of reliability for internal consistency was the calculation of Cronbach's Alpha (Cronbach, 1951) that would use Microsoft Excel 2013. Gaffney (1997) listed acceptable Alpha value of various scholars whose range could be from 0.8 to 0.6 or lower.

3.4.2 Descriptive analysis

This study summarized common statistics, such as mean and standard deviation, and used graphical tools including boxplots to display preliminary conclusion.

3.4.3 Analysis of covariance

The teaching methods were organized in different groups, and the learning effectiveness levels of all groups were compared by examining the posttest scores. More than one of the variables were possibly correlated. Thus, analysis of covariance (ANCOVA), computed with R language, was used to avoid the inferential error engendered by different aptitudes between groups.

4. Result

4.1 The validity and reliability of self-constructed questions

There were fifty firefighters in the safety inspection class. Because one had forgotten to answer the items on the back page, his score was deleted. Table 3 indicated the total scores. It revealed these items seemed to be very easy. The score of means was 81.5, standard error was 7.9 and extreme values were 96.0 and 62.0.

On the other hand, there were only four learning types of the current firefighters after the diagnosis of software. Most of them, 27 of 49 firefighters, were “stable (A)”. It meant these current firefighters were good tool of content validity after discussion with them

Table 3 Score and learning types in the safety inspection class

Stem	Leaf	Diagnosis of learning type
9	6,4,2,2,2,0,0,0,0,0	There were four learning types after the diagnosis. Stable (A) was twenty-seven, negligent (A') was ten, common (B) was eleven and insufficient (B') was one.
8	8,8,8,6,6,6,6,6,6,6,4,4,4,2,2,2,2,0,0,0	
7	8,8,8,8,6,6,6,4,4,4,4,4,2,2,2,2	
6	8,4,2	

From Table 4, the index of items difficulty (P) reflected most of the items were easy because their values were high. It was also difficult to judge whether the items were good or bad by the index of item discrimination (D).

The outcomes were not surprised at all since the test was taken by professional firefighters. However, questions 2, 31 and 32 were negative values. They were revised because of possible discrepancies on expression of meanings. Finally, these items were sorted by ascending order of item discrimination and descending order of item difficulty.

Table 4 Index of item difficulty and discrimination in the safety inspection class

No.	P	D	**No.**	P	D	**No.**	P	D	**No.**	P	D
1	0.96	0.08	**14**	0.46	0.31	**27**	0.92	0.15	**40**	0.96	0.08
2	0.85	-0.31	**15**	0.92	0.15	**28**	0.23	0.46	**41**	0.81	0.23
3	0.84	0.17	**16**	0.81	0.38	**29**	0.62	0.46	**42**	0.77	0.46
4	0.83	0.33	**17**	0.85	0.31	**30**	0.88	0.08	**43**	0.96	0.08
5	0.39	0.61	**18**	0.73	0.54	**31**	0.81	-0.08	**44**	1.00	0.00
6	0.84	0.17	**19**	0.85	0.31	**32**	0.96	-0.08	**45**	0.81	0.38
7	0.81	0.08	**20**	0.54	0.62	**33**	1.00	0.00	**46**	0.81	0.08
8	1.00	0.00	**21**	0.73	0.38	**34**	0.69	0.15	**47**	0.88	0.08
9	1.00	0.00	**22**	0.88	0.23	**35**	0.73	0.23	**48**	0.77	0.46
10	0.81	0.38	**23**	0.85	0.31	**36**	0.92	0.15	**49**	0.85	0.15
11	0.88	0.23	**24**	0.46	0.46	**37**	0.96	0.08	**50**	0.69	0.15
12	0.85	0.31	**25**	0.85	0.15	**38**	1.00	0.00			
13	0.92	0.15	**26**	0.19	0.23	**39**	0.92	0.15			

The reliability of Cronbach's Alpha was 0.7, located in the acceptable range of 0.8 to 0.6.

From these results mentioned above, they showed the self-constructed questions had good validity and reliability. They can act as an assessing tool of learning effectiveness for prospective firefighters.

4.2 Descriptive analysis

There were 42 firefighters in group E and 46 in group C. Both group E and group C had the same number of students when the classes began. However, later, the former had more dropouts than the latter. From their basic data in Table 5, the properties of these two groups were almost the same by direct observation.

Table 5 Basic data summary of special exam classes

Category \ Group		Group E		Group C		Total
Sex		Male	Female	Male	Female	
Educational background	Senior high school	5	0	5	0	10
	College or University	33	4	36	4	77
	Missing value	0	0	0	1	1
Total		38	4	41	5	88

The score of group E and group C in a stem-and-leaf display was given in Table 6. It could be observed the scores of pretest made no apparent difference and centered on fifties. However, the score of posttest of group E seemed better than that of group C in every aspect.

Table 6 Pretest and posttest of special exam classes

Group / Score	Pretest of group E	Pretest of group C
Stem	Leaf	Leaf
7	2	8,
6	8,8,6,4,0,0,0,0,0	4,4,4,0,0,0
5	8,8,8,6,6,6,6,6,6,6,6,4,4,4,4,4,4,2, 2,2,2,0,0,0	8,8,8,8,8,8,8,6,6,6,6,6,6,6,6,6,6,4, 4,4,4,4,2,2,0,0,0,0,0,0
4	8,8,8,4,4,4,2,2	8,8,8,8,6,4,4,4,0
Group / Score	Posttest of group E	**Posttest of g**roup C
Stem	Leaf	Leaf
9	8,6	
8	8,8,6,6,6,4,2,2,2,2,0,0,0	6,4,4,2,2,0
7	8,6,6,6,4,4,4,4,4,4,4,4,2,2,2,2,0,0	8,8,8,6,6,6,4,0,0,0,0,0
6	8,8,6,6,2	8,8,8,8,8,8,8,6,6,4,4,4,4,4,2,2,0,0,
5	8,8,6,4	8,6,6,4,4,2,
4		6

Further, from the data of Table 7, the statistics of posttest of group E were apparently better than that of group C, which meant learning effectiveness was different after various teaching methods.

Table 7 Statistics of special exam classes

Statistics	Experiment group (42 trainees)		Control group (46 trainees)	
	Pretest	**Posttest**	Pretest	**Posttest**
Minimum	42.0	**54.0**	40.0	**46.0**
First quantile	50.5	**70.5**	50.0	**60.5**
Median	55.0	**74.0**	56.0	**68.0**
Mean	54.8	**75.3**	54.4	**67.7**
Standard deviation	6.9	**9.8**	6.6	**9.3**
Third quantile	58.0	**82.0**	58.0	**75.5**
Maximum	72.0	**98.0**	78.0	**86.0**
Mode	56.0	**74.0**	56.0	**68.0**

Boxplot in Figure 1 could show prominent feature of these two groups. It included center, spread, outlier and so forth.

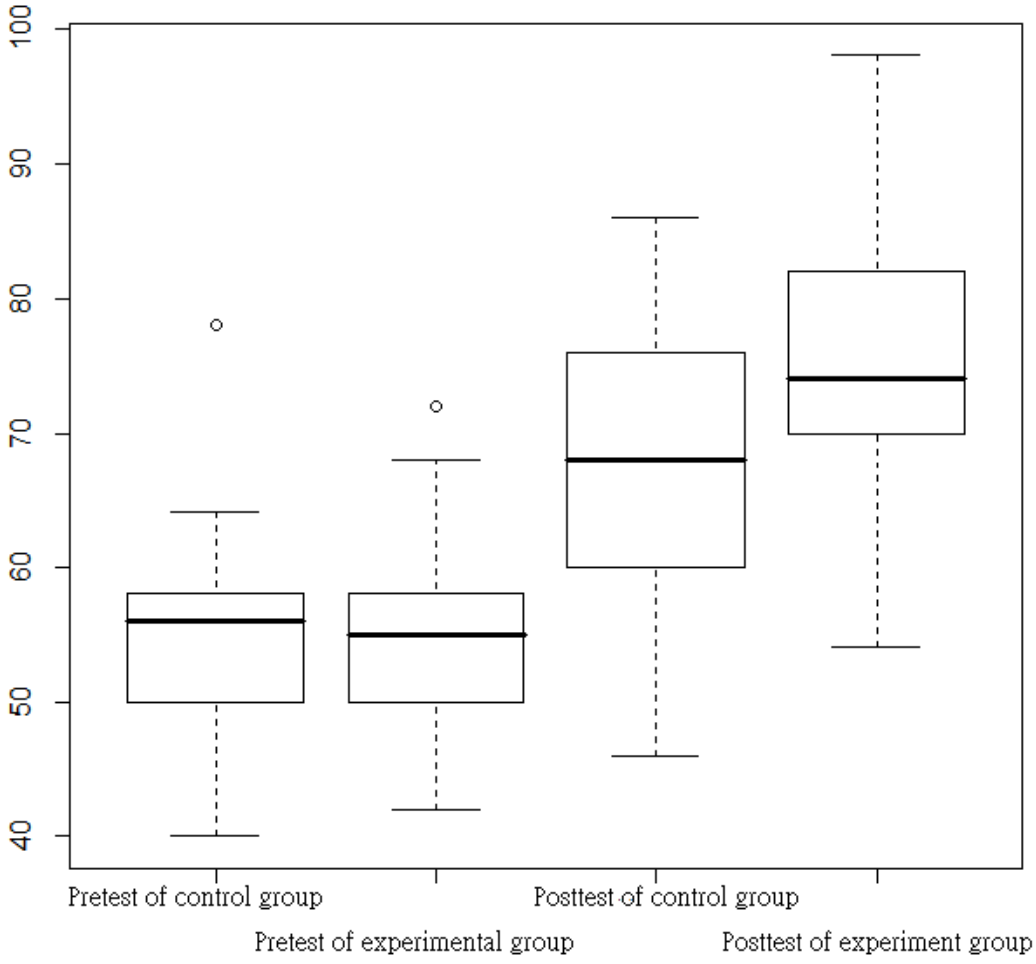

Figure 1 Boxplot of scores in special exam class

In the pretest, the outlier was 72 in group E and 78 in group C. These were close and did not drastically affect the statistics between groups. From the

comparison between pretest and posttest, it was clear that the teaching method of group E (lecture with group discussion) was superior to that of group C (the direct teaching method).

4.3 ANCOVA

First, significant differences and interaction between groups E and C in the pretest were identified. The R output is given below. The results showed that the interaction between groups in the pretest did not differ significantly ($p = 0.19 > 0.05$). Therefore, in the pretest, the variances of the groups were the same.

Coefficients	Estimate	Std. Error	t value	Pr (> |t|)
(Intercept)	57.01	11.90	4.79	6.99e-06
Pretest	0.33	0.22	1.54	0.13
Factor(group)2	14.45	16.80	0.86	0.39
Pretest:	-0.40	0.31	-1.32	**0.19**

After the interaction of variables was excluded, ANCOVA was conducted to determine whether teaching methods affected the posttest scores. The R output is given below. The results revealed significant difference ($p = 0.00 < 0.05$), and they confirmed that the score of group E was higher than that of group C.

	df	Sum Sq	Mean Sq	F value	Pr(>F)
Pretest	1	89	88.5	1.10	0.30
Factor(group)	1	2199	1257.6	27.32	**1.21e-06**
Residuals	85	6841	80.5		

5. Discussion

The results of this study show that self-constructed questions have good reliability and validity as tool for assessing teaching effectiveness, and lecture with group discussion is better than a direct teaching method.

5.1 Self-constructed questions

In this study, self-constructed questions have good reliability and validity to become a tool of assessment for teaching effectiveness in FPM. When this study considered the teaching hours and focus of courses, the practice of current firefighters was a good basis for the self-constructed questions. By the diagnosis of learning types,

most of the firefighters were “stable”, and were very suitable candidates for constructing a measurement tool. The basic requirement of self-constructed questions is that they are practice-oriented and the items of object are not of negative item discrimination index. Thus, these items with a minus index were revised. The content of self-constructed questions is valid because they combine practical experience of current firefighters with assistance of items analysis and two-way specification table.

These questions require more intervention from experts in terms of their depth and range. The opinions of scholars, educators, and from the bottom-up are good references. However, since the questions require expert intervention, it is easier to attempt and reduce the number of questions in both the pretest and the posttest as a short-term initiative. If there were up to 50 questions these would be time-consuming to answer or review and this is far more than the suggested number of items by S-P table. Twenty questions may be optimal, which would allow more time for interaction between the instructor and trainees.

In future, the pretest should focus on introducing the concept of law, attracting the trainees’ attention and hinting at inferential questions. Difficult questions that would hit the confidence of trainees are not appropriate at this stage. At the end of class, the posttest plays the role of summative assessment.

5.2 Teaching methods

From the pretest, the aptitudes of these two groups are the same statistically. The trainees from group C (the direct teaching method) seemed to be a little passive or absent-minded. If their learning motivation is not strong, it is difficult to attract their attention. Conversely, the trainees in group E (the lecture with group discussion method) had better learning effectiveness, perhaps due to peer pressure and active participation. This type of teaching method should be encouraged because it can stimulate brainstorming despite possible exhaustion from long-term training.

In the future, the teaching methods could be refined by experts from different fields. In addition, it can increase the sample classes and adopt various teaching methods between different groups in order to explore fully the learning traits of prospective firefighters and search for more proper teaching methods.

Finally, teaching methods can be roughly summarized as seven types. Every type has its practical function and depends on expenditure, time and profession, etc. It is the duty of the instructor, a wise decision-maker, to lead the trainees to learn actively and to select the best method or mixed methods.

References

Baskas, R. S. (2011). Adult Learning Theories Closure. Retrieved form http://files.eric.ed.gov/fulltext/ED520902.pdf.

Bloom, B.S. (1956) Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain. New York: David McKay Co. Inc., http://www.nwlink.com/~donclark/hrd/bloom.html.

CoPo, Antonio Roland I. (2015). Students' Initial Knowledge State and Test Design: Towards a Valid and Reliable Test Instrument. *Journal of College Teaching & Learning*. Vol.12 N.3 p.189-194. Retrieved form http://files.eric.ed.gov/fulltext/EJ1067277.pdf.

Cronbach, L .J. (1951). Coefficient alpha and the internal structure of tests. Psychometrika, 16(3), 297-334

Gaffney, P.V.A (1997). Test Reliability Analysis of an Abbreviated Version of the Pupil Control Ideology Form. Retrieved form http://eric.ed.gov/?q=cronbach%27s%2c+1951&ft=on&id=ED407422.

Lalley, J. P.& Miller, R. H. (2007). The Learning Pyramid: Does It Point Teachers in the Right Direction. Retrieved form http://eric.ed.gov/?id=EJ790160.

Matlock-Hetzel, S. (1997). Basic Concepts in Item and Test Analysis. Retrieved form http://eric.ed.gov/?id=ED406441.

Tovar, L. A. (2008). Learning How to Learn: Implications for Non Traditional Adult Students. Retrieved form http://files.eric.ed.gov/fulltext/ED501597.pdf.

Walker, K. (2006). Teacher Made Exam Designs. Retrieved form http://eric.ed.gov/?id=ED537929.

Yu, M. N. (2011). Educational Testing and Assessment. Taipei: Psychological Publishing Co.