Research on Evaluating the Instructional Design Ability of Pre-service Mathematics Teachers

Abstract: Normal universities can obtain important cultivating references by evaluating the instructional design ability of pre-service mathematics teachers. However, there isn't research on how to test and evaluate the instructional design ability of pre-service mathematics teachers. Analyzing the relevant definition, the speed, and quality of completing instructional design can be used to evaluate instructional design ability, and the key point of evaluating the quality of instructional design is whether instructional design can achieve the teaching objectives or not. Based on the above analysis, we proposed how to test the instructional design ability of pre-service mathematics teachers, how to compile test questions, and how to select raters, and provided reasonable scoring criteria. This research can provide a reference for further in-depth studies.
Keywords: Pre-service Mathematics Teacher, Instructional Design Ability, Evaluation

1. Introduction

The instructional design ability of pre-service mathematics teachers will impact their teaching level and reflect the professional level of normal universities [1-2]. Therefore, the evaluation of the instructional design ability of pre-service mathematics teachers can meet the needs of improving teaching quality for normal universities, and provide a reference for pre-service mathematics teachers to learn their instructional design ability [1]. However, the current problem is that few scholars have researched how to evaluate the instructional design ability of pre-service mathematics teachers. Therefore, this paper intends to study how to test and evaluate the instructional design ability of pre-service mathematics teachers. We hope to provide a reference for the further study of instructional design ability in the future.

2. Concept Analysis

2.1 Pre-service Mathematics Teachers

Some scholars defined pre-service teachers as college students who will soon be teachers after graduation [3]. On this basis, some scholars define the pre-service mathematics teacher as normal college students majoring in mathematics [4], and other scholars define them as the senior students majoring in mathematics and applied mathematics [5]. Referring to the above definition and the definition in other disciplines [6-7]. We define pre-service mathematics teachers as normal college students who have professional mathematics knowledge, are about to experience or have experienced practice, and will be mathematics teachers within 1 to 3 years after graduation.

2.2 Instructional Design

At present, scholars have different definitions of instructional design. They focus on

two views with the definition of instructional design. One is that instructional design is deemed as a process of solving teaching and learning problems. For example, Professor Pi thought instructional design is the process of analyzing the teaching problems, designing the solution, implementing and evaluating the scheme, and further optimizing the scheme. This process is based on teaching theory, learning theory, communication studies, and psychology [8]. The other view is that instructional design is deemed as a process of planning teaching. For example, Wu believes that the purpose of instructional design is to optimize the teaching effect. This is a process of setting teaching objectives, analyzing teaching problems and formulating a program, evaluating and modifying the program [9]. Because the second view is easier to implement, it has been recognized by many scholars in China. The second view was adopted by this paper. This research defines the instructional design as follows: Instructional design is the activity of designing a reasonable teaching program to achieve the teaching objectives, which are based on the teaching theme, the students' characteristics, and the instructional theories

2.3 Ability

Ability is defined slightly differently in each field. In the workplace, some scholars call ability "competence", which is regarded as the characteristic of completing a job [10] . In psychology, many scholars define ability as the psychological characteristics affecting activity efficiency in activities [10-12]. The definition of ability in psychology has been used by many scholars in China. This paper adopts the definition of ability in the field of psychology.

2.4 Instructional Design Ability

Instructional design ability is a special ability shown in instructional design [13]. But there is no unified definition of instructional design ability at present. In this paper, according to the above definition of "Instructional Design" and "Ability", we define the instructional design ability as follows: Instructional design ability is the ability to design reasonable instructional programs that can achieve the certain teaching objectives, which are based on professional knowledge and teaching skills, referring to the content theme and student characteristics, and using the theories of teaching and learning.

3. Tests and Evaluation of Instructional Design Ability

3.1 Evaluation Methodology

The instructional design ability is a special ability shown in the instructional design activities. We can consider how to evaluate the ability firstly, and then consider how to evaluate the instructional design ability, finally analyze how to test the instructional design ability of pre-service mathematics teachers.

3.1.1 How to Evaluate the Ability

According to the above definition of ability, it can be seen that the ability is expressed as a person's efficiency in the activities. The two indicators of efficiency are speed and quality of activities. Therefore, The speed and quality of an activity can be used to

evaluate the ability.

3.1.2 How to Evaluate the Instructional Design Ability

Based on the evaluation method of ability, the evaluation of the instructional design ability should pay attention to the speed and quality of completing the instructional design. Time duration can measure speed. Achieving the teaching objectives is the ultimate goal of the instructional design. Therefore, the situation of whether the instructional design can achieve the teaching goals or not can be used to evaluate the quality of instructional design.

3.1.3 The Testing Method of the Instructional Design Ability

Based on the above analysis, there are two methods to test the instructional design ability of the pre-service mathematics teachers.

The first method that designers need to complete is the instructional design by referring to content themes, learning situations of students, and teaching objectives. The requirement is that instructional design must be able to achieve teaching objectives. If the designer spends less time completing it and achieving requirements, the better the instructional design ability is.

The second method is that designers need to complete the instructional design in a limited time by referring to content themes, the learning situation of students, and teaching objectives. The main purpose focus on observing the quality of the instructional design. If this instructional design can achieve teaching objectives, which represents the good quality of the instructional design and means that the instructional design ability of the pre-service mathematics teacher is strong.

The respondents are pre-service mathematics teachers, and their schools and spare time are scattered. So, recording the time and receiving the answers are the difficulties. Therefore, the second method is more convenient and the best choice.

3.2 Tests and Scoring Criteria

3.2.1 Testing Content Analysis

According to the definition of instructional design ability, content theme and learner situation are the basis of completing the instructional design, achieving teaching objectives is the ultimate goal of instructional design. Therefore, content themes, learner situations, and teaching objectives should be set in the tests.

Firstly, the content theme of instructional design should include textbooks and chapters. For example, the content theme is *Explore the Pythagorean theorem*, which was selected from a mathematics textbook published by Beijing Normal University Press.

Secondly, the characteristics of learners should include the mathematics achievement in a class and other basic information. The mathematics achievement of a class can be expressed as follows: students with excellent math scores account for 50%, students with middle math scores account for 40%, and students with poor math grades account for 10%.

Thirdly, the teaching objectives should be specific and operational. For example, the

teaching objective is that students can understand the proof method of the Pythagorean Theorem, master the theorem, and use the theorem to solve related mathematical problems and practical problems.

3.2.2 Tests

According to the second investigation method, two questions can be compiled in the test paper. The one is about junior high school content, the other about senior high school content. The full score of the test paper is 100 points, each question accounts for 50 points, and the test time is 60 minutes. Two kinds of math learning situations, two content themes, and different teaching objectives are involved in this test paper.

(a) Question 1

Question 1 is about geometry in the mathematics textbook of the junior middle school, and the math performance of the students is good. The question is as follows:

"Please refer to the students' mathematics achievement, teaching objectives, and content theme about *Exploration of the Pythagorean Theorem* tocomplete an instructional design. This part is selected from the textbook of junior middle school mathematics published by Beijing Normal University Press. Teaching objectives are that students understand the proof method of the Pythagorean Theorem, master the Pythagorean Theorem, and use the theorem to solve related mathematical problems and practical problems. Besides, students with excellent math scores account for 50%, students with middle math scores account for 40%, and students with poor math grades account for 10%. Note: the teaching process is written in as much detail as possible."

(b) The Question 2

Question 2 is about geometry in the mathematics textbook of the high school, and the math performance of students is normal. The question is as follows:

"Please refer to the students' mathematics achievement, teaching objectives, and content theme about *Summation of Arithmetic Sequences* tocomplete an instructional design. The content is selected from the textbook of junior middle school mathematics published by People's Education Press. Teaching objectives are that students understand the properties of an arithmetic sequence, master the sum formula of an arithmetic sequence, and apply the formula to solve practical problems. Besides, students with excellent math scores account for 20%, students with middle math scores account for 40%, and students with poor math grades account for 20%. Note: the teaching process is written in as much detail as possible."

3.2.3 Scoring Criteria

Each question is 50 points and involves 3 instructional objectives. 50 points can be assigned equally to three teaching objectives, and each objective will be scored separately.

When scoring the actual score, different scores should be given according to the specific situation of their design. For example, the teaching objective is that understand the proof method of the Pythagorean Theorem in question 1. Raters will give a full score of 16 if students can understand the proof method of the Pythagorean

Theorem through this instructional design; Raters will give 0 points if the students cannot understand the proof method of the Pythagorean Theorem through this instructional design; if the instructional design can achieve objectives but the process is not perfect or not specific, the score of this situation will be 40% -70% of the total score of 16, which is 6 to 12 points. Other parts are scored on similar criteria. Detailed scoring criteria are shown below in Table 1:

Table 1:Scoring Criteria

Content Theme	Teaching Objective	The Core Point of Scoring	Scoring Criteria
Question 1: Exploring the Pythagorean Theorem" (50 Points)	Students can understand the proof method of the Pythagorean Theorem (16 points)	Whether can students understand the proof method of the Pythagorean Theorem or not?	(a) Students can understand the proof method (16 points); (b) Students can understand it but the design is not perfect or specific (6-12 points); (c)Students can't understand it (0 points)
	Students can master the Pythagorean Theorem (17 points)	Whether the students can master the Pythagorean theorem or not?	(a) Students can master it (16 Points) (b) Students can master it but the design is not perfect or specific (6-12 points) (c) Students can't master it (0 points)
	Students can apply the Pythagorean Theorem to solve related mathematical problems and practical problems (17 points)	Whether the students can apply the Pythagorean Theorem to solve related mathematical problems and practical problems or not?	(a) Students can apply it to solve the problems (17 points) (b) Students can use it to solve the problems but the design is not perfect or specific (6-12 points). (c) Students can't apply it to solve related the problems (0 points)
Question 2：Summation of Arithmetic Sequences (50 Points)	Students understand the properties of an arithmetic sequence (16 points)	Whether the students can understand the properties of the arithmetic sequence or not?	(a) Students can understand it (16 Points) (b) Students can understand it but the design is not perfect or specific (6-12 points)

			(c)Students can't understand it (0 points)
	Students master the summation formula of the arithmetic sequence (17 points)	Whether the student can master the summing formula of the arithmetic sequence?	(a) Students can master it (16 Points) (b) Students can master it but the design is not perfect or specific (6-12 points) (c) Students can't master it (0 points)
	Students can solve practical problems with the summation formula of arithmetic sequence (17 points)	Whether students can apply the summation formula of the arithmetic sequence to solve practical problems or not?	(a) Students can apply it to solve the problems (17 points); (b) Students can apply it to solve the problems but the design is not perfect or specific (6-12 points); (c) Students can't apply it to solve the problems (0 points)

*3.2.4 R*aters *and Score Calculation*

To ensure the reliability of the scores, each question should be evaluated by multiple raters, and the average rating by the multiple raters is taken as the final score. In addition, to ensure the reliability of scores, raters should have strong instructional design ability and extensive teaching experience.

Therefore, mathematics teachers in middle school with more than 10 teaching years and outstanding teaching ability to be invited to this evaluation as raters. Among them, 3 mathematics teachers in middle school as the raters of question 1, and then took the average as the final score of question 1. 3 mathematics teachers in high school as the raters of question 2, and then took the average as the final scores of question 2. Finally, the scores of the two questions are summed up to get the total scores.

4. Conclusion

From the relevant definition of instructional design ability, it can be seen that the evaluation of instructional design ability should observe the speed and quality of completing an instructional design. The key point of evaluating the quality of instructional design is whether instructional design can achieve the teaching objectives or not. Therefore, the test method of instructional design ability of pre-service mathematics teachers, the test questions, and the scoring criterion should be focused on whether instructional design can achieve teaching objectives, and take it as the core of testing and evaluation. Only in this way can the final evaluation results be more convincing and can ensure good reliability and validity.

References

1. Li T, Dai B. Study on the current situation of instructional design ability of mathematics normal university students. Education modernization. 2019;9(6):92-93.
2. Zuo K. Research on instructional design ability of mathematics teachers in Junior Middle School.Journal of Mathematics Education. 2011;19(2):41-44.
3. Zhang XJ. Research on pre-service teachers' learning ability and influencing factors about their school (Master's thesis, Northwest Normal University, Lanzhou); 2016.
   Available:https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD202201&filename=1021662447.nh
4. Liu FF. A comparative study of mathematics instructional design ability and development of pre-service teachers at different levels (Master's thesis, Liaoning Normal University, Dalian); 2016.
   Available:https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201701&filename=1016244280.nh
5. He XY. Research on the development of mathematics instructional design ability of pre-service teachers (Master's thesis, East China Normal University, Shanghai); 2020.
   Available:https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD202002&filename=1020636546.nh
6. Zhao, Y. Research on the current situation of information teaching ability of a university in Wuhan as an example（Master's thesis, Central China Normal University, Wuhan); 2021.
   Available:https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD202201&filename=1021149817.nh
7. Huo J. Research on the Construction of Experimental Teaching Ability (Doctoral Dissertation, Southwest University, Chongqing); 2021.
   Available:https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CDFDLAST2022&filename=1021768566.nh
8. Pi LS. Instructional design-The Theory and Technology of Psychology. Beijing: Higher Education Press; 2002.
9. Wu MN. Instructional Design. Beijing: Higher Education Press; 1994.
10. Li ZX. Ability Psychology. Xian: Shanxi People's Education Press; 1985.
11. Ye YQ. General Psychology. Shanghai: East China Normal University Press; 1997.
12. Yang ZZ. Mathematics Learning theory and method. Zittau: Weser Books; 2019.
13. Li Y, Yang K. Investigation on the instructional design Ability of Normal University Students of Independent University. Journal of Changchun Education Institute. 2019;35(6):59-61.