Research on the Instructional Design Ability of Pre-service Mathematics Teachers in China: A Review

Abstract: The pre-service mathematics teachers will work in middle school or primary school in the future. The level of their instructional design ability will directly affect the quality of teaching, the learning efficiency of students in the classroom, and teaching progress. Recently, many scholars have researched the instructional design ability of pre-service mathematics teachers in China. But there is no literature summarizing this aspect. Therefore, We reviewed relevant literature by using the literature research method in this paper and drew the following conclusions: (1) Current research on the instructional design ability of pre-service mathematics teachers in China focuses on the composition of the instructional design ability, the status quo of instructional design of pre-service mathematics teachers, the level of instructional design ability, the influencing factors of instructional design ability, and suggestions to improve the instructional design ability of pre-service mathematics teachers; (2) There are many kinds of research on the composition of instructional design ability of pre-service mathematics teachers and the status quo of instructional design. There are few studies on the influencing factors of instructional design ability of pre-service mathematics teachers. (3) The influencing factors are incomplete, and the deep research is the gaps in current that the relationship of influencing factors, the influencing path, and the main influencing factors. Additionally, the suggestions to improve the instructional design ability of pre-service mathematics teachers are so broad. In general, those conclusions revealed the research situation and found the deficiencies and gaps in the research on the teaching design ability of pre-service mathematics teachers in China. More importantly, which provides the next research directions to improve the teaching design ability of pre-service mathematics teachers in China for scholars and experts.

Keywords: Pre-service, Teacher, Mathematics, Instructional Design, Ability

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1. Introduction

The level of instructional design ability will affect the teaching quality, the learning efficiency of students, and the teaching progress (Zhang, 2016). The pre-service mathematics teachers will be mathematics teachers in middle school or primary school in the future. Their instructional design ability not only reflects the professional level of college students majoring in mathematics education but also influences their employment, teaching level, and professional development (Zhang, 2016; Zuo, 2011). In recent years, many scholars have paid attention to the instructional design ability of pre-service mathematics teachers in China (Gu, 2012). They focused on the composition of the instructional design ability, the status quo of instructional design, the level of instructional design ability, the influencing factors, and suggestions. However, the summary of research on the instructional design ability

of pre-service mathematics teachers is deficient, which shows that the current research is not sufficient and deep (Gu, 2012). Therefore, we intend to analyze the current research status of the instructional design ability of pre-service mathematics teachers in China, and then find out deficiencies and gaps, to promote scholars to do further research, and ultimately promote the development of pre-service mathematics teachers in China.

The research question of this paper is as follows: what is the status of the research on the instructional design ability of pre-service mathematics teachers in China?

Specifically, it includes the following two aspects:

(1) What aspects have scholars studied on the "instruction design ability of pre-service mathematics teachers in China"?

(2) Which aspects are being studied more and less? What are the insufficient spots? Are there any blank spots?

2. Method

2.1 Research method

This study is a research review on the instructional design ability of pre-service mathematics teachers in China. The main research method of this thesis is the documentation method to analyze the research content and research results of relevant articles and find out the deficiencies and gaps.

2.2 Data Sources

This paper selects the literature in the CNKI (China National Knowledge Infrastructure) database as the sources of data. CNKI is the most authoritative document retrieval tool in Chinese academic journals, which approximately contains all the contents of Chinese journals. This database can ensure persuasion and reliability.

2.3. Data Collection

The three keywords of " Mathematics", " Instructional design ability", Pre-service teacher" or "Normal College students" are searched simultaneously by using the advanced search function in CNKI. In this way, the retrieved articles are more comprehensive. Besides, relevant papers from nearly 20 years were selected in order to ensure the reliability and timeliness of the research. Ultimately, the 22 papers on the instruction design ability of pre-service mathematics teachers in China are searched for analysis.

2.4. Data Sorting

Those 17 papers were classified in detail through reading the literature and taking notes. These studies fall into five types. On this basis, the content and results of each research type were reorganized and classified again. The main purpose is to display the different research results clearly.

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3. Results

3.1. The Composition of the Instructional Design Ability

In previous studies, some scholars analyze the composition of instructional design ability from the construction perspective. Du (2011) thought that instructional design ability is one of the basic teaching abilities of teachers. She put forward seven categories of teaching abilities that include teaching design ability, the ability to analyze students, the ability to formulate teaching objectives, the ability to reorganize teaching content, the ability to design teaching process, the ability to choose teaching strategies, and the ability to elastic design. For example, the ability to analyze students includes four observation points: understanding students, understanding students' learning basic, analyzing students' learning style, and predicting learning problems (Du, 2011). Luo (2012) said that the instructional design ability of pre-service mathematics is the ability to put forward a teaching design scheme, which includes six aspects: the ability of pupil description, the ability to analyze teaching content, the ability to set teaching objectives, the ability to choose teaching strategy, the ability to form the teaching plan, and the ability to evaluation (Luo, 2012). Zhang, Jin, and Guo (2004) believe that instructional design ability is embodied in the following six activities: analysis of teaching objects, analysis of teaching tasks, a compilation of teaching objectives, selection and application of teaching methods and teaching media, and evaluation of teaching results (Zhang, Jin, & Guo, 2004).

Other scholars describe instructional design ability from the perspective of solving problems. Some scholars believe that teaching design ability is the ability to analyze and solve teaching problems with systematic methods, which is mainly reflected in teaching task analysis, designing schemes of problem-solving, trailing and evaluating plans, and modifying schemes. Liu (2013) said the instructional design ability of a teacher is the ability to systematically reprocess the teaching content before class, it refers to the characteristics of students and selects appropriate teaching methods to achieve the best teaching effect. It includes the skills of integrating modern educational ideas and technology, the skills of analyzing students' characteristics and combining teaching contents, the skills of designing goals, the skills of determining teaching strategies, and the skills of predicting classroom situation changes (Gu, 2017; Liu, 2013; Wang, 2017).

Some scholars define teachers' ability according to the view of IBSTPI (The International Board of Standards for Training, Performance, and Instruction), which holds that instructional design ability is about teachers' knowledge, skills, and emotional attitudes (Gu, 2017). Wang (2016), Liu (2009), Luo (2020), and Zhang (2020), et al, generally believe that the elements of instructional design ability involved in attitude and consciousness, knowledge level, and instructional design skills (Liu, Liu, & Lv, 2009; Luo, 2020; Sun, 2021; Wang, 2016; Zhang, 2020).

In addition, other scholars have put forward a variety of different views. Sun (2021) believes that teaching design ability includes professional teaching literacy,

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knowledge storage, problem analysis ability, and instructional reflection ability (Sun, 2021). Zhao (2016) believes that the composition of instructional design ability needs three conditions. The basic conditions are the teacher's mathematics knowledge and instructional knowledge. The supporting conditions are the knowledge and skills of instructional design. The developmental conditions are that teachers can reflect on themselves and improve their abilities (Zhao, 2016).

3.2. The Status Quo of Instructional Design

At present, scholars' research on the status quo of teaching design with pre-service mathematics teachers generally includes instructional objectives description, pupil description, text description, teaching process description, and other aspects. Each type of research will be described in detail below.

3.2.1. Instructional Objectives Description

Xu and Fan (2013) believe that pre-service mathematics teachers perform well in the objective description. They can combine the three-dimensional aims of knowledge and skills, process and methods, emotional attitudes, and values to design objectives (Xu & Fan, 2013). Ji (2013) believed that the objectives setting of pre-service mathematics teachers could not guide practical teaching (Ji, 2013). Li and Dai (2019) believed that pre-service mathematics teachers haven't an in-depth understanding of three-dimensional instructional aims and did not know how to apply the objectives of "process and method" and "emotional attitude and values" (Li & Dai, 2019). Wang (2013) believes that pre-service mathematics teachers are not good at describing teaching objectives and analysis of teaching objectives is not comprehensive (Wang, 2013).

3.2.2. Pupil Description

Zhang (2020), Wang (2016), and Li (2019), et al, hold that the learning situation analysis is not comprehensive (Zhang, 2020; Wang, 2016; and Li & Dai 2019). The important reason is that pre-service mathematics teachers do not pay attention to students' physical and mental characteristics (Li & Dai, 2019; Zuo, 2011). Ji (2013) thinks that it is difficult for pre-service mathematics teachers to analyze learning situations. The reason is that pre-service mathematics teachers did not analyze the age characteristics of students, the learning commonness and difference of students, and their knowledge as so on (Ji, 2013).

3.2.3. Instructional Text Description

Xu and Fan (2013) believed that pre-service mathematics teachers could apply the key and difficult points (Xu & Fan, 2013). He (2020) and Wang (2013) believed that the ability of pre-service mathematics teachers needs to be strengthened to analyze teaching content, and they don't know the key and difficult points of teaching content (He, 2020; Wang, 2013). Zhang (2016) believes that pre-service mathematics teachers are good at researching instructional text. They have to refer to network resources (Zhang, 2016). Bi (2016) and Wang (2019) believed that pre-service mathematics teachers were not familiar with the teaching content (Bi, 2016; Wang, 2019).

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3.2.4. Teaching Process Description

Zhang (2016), Ji (2013), and Wang (2019) believed that pre-service mathematics teachers could put forward enlightening questions and choose appropriate interaction methods while lacking judgment, comparison, evaluation, and comprehensive analysis abilities (Ji, 2013; Wang, 2019; Zhang, 2016). Zhang (2016) believes that pre-service mathematics teachers have some ideas for new course teaching design, but it is difficult for them to apply these ideas (Zhang, 2016). Li and Dai (2019) believed that pre-service mathematics teachers were not proficient and even feared that too many discussion links to control the class (Li & Dai, 2019).

3.2.5. Other Aspects

Other research focuses on instructional design methods, teaching strategies, the use of teaching multimedia, and the reflection of teaching design. Li, Dai (2019), and Wang (2013) hold that the teaching method set is too simple. Most pre-service mathematics teachers tend to use lecture-based learning (Li & Dai, 2019; Wang, 2013). Bi (2016), Li (2019), Dai (2019), and Wang (2013) believe that pre-service mathematics teachers have a strong ability to select and use multimedia and other modern technologies, but not be good at integrating information technology with mathematics curriculum content (Bi, 2016; Li & Dai, 2019; Wang, 2013). Bi (2016) believes that the teaching reflection ability of pre-service mathematics teachers behaves well. However, they are not good at self-evaluation and modification of instructional design (Bi, 2016).

3.3. Instructional Design Ability

Some researchers survive instructional design ability of pre-service mathematics teachers used different methods. Bi (2016) conducted a questionnaire survey on the teaching design ability of pre-service mathematics teachers and counted the frequency of the survey results. This study concluded that the actual level of instructional design ability of pre-service mathematics teachers is lower than the cognitive level, but their teaching reflection ability is relatively good (Bi, 2016). Schorl He (2020) mainly studies the changes in the teaching design level of pre-service mathematics teachers after learning mathematics education. She carried out a questionnaire survey on 50 normal colleges. This study shows that the instructional design ability of pre-service mathematics teachers is at the basic level. On the whole, there is no change in their ability level (He, 2020). Lu (2014) conducted twice questionnaire surveys on 183 pre-service mathematics teachers before and after teaching practice. He (2020) thinks that the teaching design ability of pre-service mathematics teachers is low level (He, 2020). Liu (2019) conducted a case study of pre-service mathematics teachers after and before teaching practice. He (2020) calculated the score of the ability and finally concluded that the teaching design ability of pre-service mathematics teachers was at the medium level before and after the teaching practice (Liu, 2019). Wang (2013) made the frequency statistics of 136 questionnaire survey results, analyzed 120 teaching design manuscripts, and found that the teaching design level of pre-service mathematics teachers was not well. Among them, the descriptive ability of teaching objectives is not well, the ability to use teaching strategies and multimedia is strong,

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the ability to analyze teaching materials is not well, and the ability to analyze learning situations and learning objectives are poor (Wang, 2013). Cui (2016) conducted a comparative study on the instructional design ability of a pre-service mathematics teacher and a novice mathematics teacher. This study concluded that there was a small gap in teaching design ability between pre-service mathematics teachers and novice mathematics teachers (Cui, 2016). Shen (2016) conducted the paper test for 188 pre-service mathematics teachers and a T-test on the difference of teaching design ability by using SPSS (Statistical Product and Service Solutions). The results show that the teaching design ability of graduates is higher than undergraduates, and there is no significant difference between male and female students. Besides, there is no significant difference in instructional design ability between different genders (Shen, 2016). Xu (2019) studied the visual instructional design ability of pre-service mathematics teachers. She concluded that the teaching training of integrated technology improved the visual teaching design ability of pre-service mathematics teachers (Xu, 2019). Zhang (2016) conducted a developmental study on the changes in the teaching design ability of a pre-service mathematics teacher before and after the internship. Through investigation and interview, she finally concluded that the design ability of teaching objective, the design ability of teaching content, and teaching evaluation ability were improved after the internship (Zhang, 2016).

3.4. Influencing Factors of Instructional Design Ability

Some scholars have studied the influencing factors of the instructional design ability of pre-service mathematics teachers. The influencing factors of the current research mainly focus on pre-service mathematics teachers, universities, and practice schools.

3.4.1. Pre-service Mathematics Teachers

Wang (2019) and Yu (2013) think that theoretical awareness of pre-service mathematics teachers is not enough. This factor has seriously affected their own teaching design ability (Yu, 2013; Wang, 2019). Wang (2019) believes that the understanding of curriculum standards is one of the influencing factors of instructional design ability. Curriculum standard is the basic requirement to understand mathematics teaching, and it also is an important basis for clarifying mathematics teaching objectives. In addition, Wang (2019) also proposed that a teacher should store a large amount of teaching design knowledge if he wants to have excellent teaching design ability (Wang, 2013). Liu (2019) and Shen (2016) believed that personal professional identity also had an impact on teaching design ability (Liu (2019; Shen, 2016).

3.4.2. University

Bi (2016), Wang (2013), Lu (2014), and Wang (2019) believe that the practice opportunity of pre-service mathematics teachers is a very important factor (Bi, 2016; He, 2020; Lu, 2014; Wang, 2013; Wang, 2019). Bi (2016) believes that the best way for students to improve their teaching design ability is to go to primary school or secondary school (Bi, 2016). Wang (2019) and Yu (2013) think that students learn

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much theoretical knowledge and few practical opportunities, which affects their teaching design ability of them. Lu (2014) believes that the lack of teaching design courses in a normal university will affect the teaching design ability of pre-service mathematics teachers (Lu, 2014).

3.4.3. Practice School

Yu (2013) thinks the practical effect of teaching practice is not obvious. The first reason is the lack of guidance in practice; the other reason is that internship students have no opportunities to attend classes (Yu, 2013). Liu (2019) believes that the system of the practice school is an important factor. The practice school allows the practice teachers to independently teach, practice, observe and learn the teaching plans of excellent teachers, those methods improve the teaching design ability of pre-service mathematics teachers. Liu also proposed that the careful guidance and earnest attitude of tutors in practice schools are also the main factors affecting the teaching design ability of pre-service teachers (Liu, 2019).

3.5. Strategies for improving instructional design ability

According to the results of their research, scholars put forward strategies to improve the teaching design ability of pre-service mathematics teachers that focus on practice schools, pre-service mathematics teachers, and universities.

3.5.1. Practice School

Zhang (2016), Wang (2019), and Liu (2019) put forward that practice schools should enhance guidance on the teaching design of pre-service mathematics teachers (Liu, 2019; Wang, 2019; Zhang, 2016). Yu (2013) pointed out that practice schools should strengthen guidance on teaching plans of interns by organizing them to prepare lessons, guiding them to write teaching plans, and urging them to reflect on their instructional designs (Yu, 2013).

3.5.2. Pre-service Mathematics Teachers

Zhang (2016), Bi (2016), Lu (2014), and Cui (2016) proposed that pre-service mathematics teachers should establish an awareness of lifelong learning and self-reflection (Bi, 2016; Cui, 2016; Lu, 2014; Zhang, 2016). Bi (2016), Liu (2019), and Cui (2016) proposed that the pre-service mathematics teachers should take the initiative to practice. Besides, Bi (2016) proposed that pre-service mathematics teachers should pay more attention to learning excellent teaching cases. teaching design ability can be quickly improved by listening to excellent teachers' lecture recordings and learning excellent teaching videos on the Internet (Bi, 2016; Cui, 2016; Liu, 2019;). He (2020) proposed that pre-service mathematics teachers should conduct research on teaching materials and strengthen the holistic and systematic thinking of their teaching design (Ji, 2013). He (2020), Liu (2016), Cui (2016), and Liu (2016) proposed that pre-service mathematics teachers should enhance their educational theoretical knowledge (Cui, 2016; He, 2020; Liu 2016; Liu, 2019). In particular, Liu (2016) proposed that pre-service mathematics teachers should improve their metacognitive knowledge of mathematics teaching design (Liu, 2016).

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3.5.3. University

Xu, Fan (2013), and Bi (2016) put forward that universities should enhance the educational theories of college students and add educational courses (Bi, 2016; Lu, 2014; Wang, 2019; Xu & Fan, 2013). Xu, Fan (2013), and Wang (2019) et al. believed that teachers should provide more cases to students (Bi, 2016; Fan, 2013; Lu, 2014; Xu & Wang, 2019). Lu (2014) believes that normal universities should appropriately adjust the teaching practice ways, increase the time of teaching practice. (Bi, 2016). Zhang (2016), Lu (2014), and Shen (2016) put forward that universities need to adjust the teaching modes, and combine theoretical knowledge and teaching practice (Lu, 2014; Shen, 2016; Zhang, 2016). Xu, Fan, and Shen raised that professors should cultivate the teaching skills and practice ability of undergraduates (Shen, 2016; Xu & Fan, 2013). Li and Dai think that universities should improve their system of practice (Li & Dai, 2019). Lu (2014) put forward that universities should communicate with secondary schools, and establish a teaching resource database to share teaching resources (Lu, 2014). Wang and Liu put forward that universities should afford more practice opportunities for college students (Liu, 2016; Wang, 2013). Shen (2016) and Yu (2013) also put forward that the career aspiration of undergraduates also affects teaching design ability, and universities should provide undergraduates with different courses and practice opportunities (Shen, 2016; Yu, 2013).

4. Discussion

Scholars have carried out investigations and research on the instructional design ability of pre-service mathematics teachers in China. The research result focuses on the composition of the instructional design ability of pre-service mathematics teachers, the status quo of instructional design, the level of instructional design ability, the influencing factors, and suggestions to improve the instructional design ability of pre-service mathematics teachers.

(1) According to the literature review, there is much research on the composition of instructional design ability of pre-service mathematics teachers, but researchers still have no clear answer (Bi, 2016; Ji, 2013; Zhang, 2016). Most scholars analyze the composition of instructional design ability from the content perspective (Du, 2011; Luo, 2012; Zhang & Jin & Chen, 2004) rather than a capability perspective. Obviously, the research is not complete. This view is consistent with scholar Gu (Gu, 2012, 2017).

(2) As for the influencing factors of instructional design ability of pre-service mathematics teachers in China, most researchers directly obtain the influencing factors by using literature analysis or speculative methods. However, these factors are not complete. Secondly, the instructional design ability of current pre-service mathematics teachers in China is a medium level or even low level (Bi, 2016; Liu, 2019; Lu, 2014; Wang, 2013; Wang, 2019). So, it is necessary to explore the reasons for this phenomenon. But, the deep research is the gaps in current that the relationship of influencing factor, the influencing path, and the main influencing factors. This view is consistent with the research results of scholars Liu and Wang (Liu, 2016;

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Wang, 2020).

(3) The suggestions and strategies to improve the teaching design ability of pre-service mathematics teachers in China focus on practice schools, universities, and pre-service teachers. However, the suggestions and strategies are relatively broad.

5. Conclusion

Through sorting out relevant literature on the instructional design ability of pre-service mathematics teachers in China, we draw the following conclusions:

(1) Currently, the research on the instructional design ability of pre-service mathematics teachers in China mainly focuses on the composition of the instructional design ability of pre-service mathematics teachers, the status quo of instructional design, the level of instructional design ability, the influencing factors of instructional design ability, and suggestions to improve the instructional design ability of pre-service mathematics teachers.

(2) There are many kinds of research on the composition of instructional design ability of pre-service mathematics teachers in China and the status quo of instructional design. There are few studies on the influencing factors of instructional design ability of pre-service mathematics teachers in China.

(3) The influencing factors are incomplete, and the deep research is the gaps that the relationship of influencing factors, the influencing path, and the main influencing factors. In addition, the suggestions to improve the instructional design ability of pre-service mathematics teachers in China are so broad, because those devices lack pertinence to the subject of mathematics.

In general, the above conclusion revealed the research situation and found the deficiencies and gaps. More importantly, which provides the next research directions to improve the teaching design ability of pre-service mathematics teachers in China for scholars and experts.

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