

Status of PCK level for Master of Chemistry Education under “REDOX” topic

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Abstract: The PCK level of the master of chemical education not only affects the professional development of the individual, but also relates to the future quality of chemical education in our country. Taking the first class of “REDOX reaction” as an example, this paper analyzes the current situation of PCK level of master of Chemical education through questionnaire survey, and obtains the PCK level of master of Chemical education and the level of various elements. Further analysis shows that master of chemical education has poor understanding of curriculum standards and lack of teaching practice experience, resulting in low PCK level. Finally, according to the research results, some suggestions on the development of PCK for master of Chemical education are put forward.

Key words: Master of Chemical education; PCK; Level status; REDOX reaction

With the continuous reform and development of education, teacher professional development has become an important field of education research today. In the Professional Standards for Middle School Teachers (Trial) issued by the Ministry of Education of the People’s Republic of China in 2021, subject teaching knowledge (PCK) is clearly regarded as an important content area in the development of teacher professional knowledge. Pedagogical Content Knowledge (PCK) was proposed by Shulman (1986) at the American Education Research Council. As an effective integration of pedagogical knowledge and pedagogical knowledge, PCK is one of the core factors affecting the professional growth of teachers. It can significantly promote the professional development of chemistry teachers, while whole-time master of chemical education is a special stage of the training of pre-service chemistry teachers in our country. Therefore, exploring the current situation of PCK of master of chemical education can not only provide the basis to improve the training program of master of chemical education, but also promote the professional development of chemistry teachers as a whole. So as to optimize the construction of chemistry teacher education system in our country.

1. Research the theoretical basis

1. This study PCK structure

Since Shulman proposed PCK, the development of PCK has gone through several stages, among which the PCK theoretical model of Cochrane and Parker is more typical in the process of changing from static stage to dynamic stage.

According to Cochrane, PCK is composed of four elements: general pedagogical knowledge, situational knowledge, student knowledge and subject knowledge. These four elements do not play an independent role, but are interrelated, integrated into a whole and develop continuously.

According to Parker, PCK mainly consists of five parts: science teaching orientation, science curriculum knowledge, science learning evaluation knowledge, knowledge about students’ understanding in science, and science teaching strategy knowledge. Parker believes that all five kinds of knowledge are essential because they interact with each other and develop together. Both scholars believe that PCK develops dynamically. In this study, PCK of chemistry teachers is the ability of teachers to monitor teaching effect at any time in the teaching process, select appropriate teaching strategies and representation knowledge based on students’ interests, create real situations, and transform subject content knowledge into knowledge that students can easily understand. It is concluded that the composition elements of the PCK for the master of Chemistry education in this study include five parts: subject content knowledge, student knowledge, teaching strategy and representation knowledge, evaluation knowledge and learning situation knowledge, and the model structure of the PCK for the master of Chemistry education in this paper is constructed by referring to the models of Cochrane and Parker.

2. Research method and theme

PCK has many characteristics such as situational, reticence and complexity, so it is limited to use a single research method and tool to study PCK. At present, the most used research methods include questionnaire survey, interview, observation and so on. According to the research content, this paper adopts the relatively mature questionnaire scale method as the research method of PCK for the master of chemical education.

Ke Fang, Chen Huiyuan and other scholars believe that PCK is thematic, and teachers have different PCK under different subject topics. Xie Hongyan wrote in PCK model construction of Elements and Their Compounds that "Different subject knowledge units have different knowledge characteristics, different ways of representing knowledge and understanding methods. It is necessary to use different teaching situation knowledge to assist teaching", and also believes that teachers have different PCK under different subject topics. REDOX reaction runs through the textbooks of chemistry in middle school and is one of the important and difficult points in chemistry teaching in middle school. Therefore, this paper chooses the topic of "REDOX reaction" to study the factors affecting PCK of master chemistry education, and the questionnaire content is mainly prepared around this topic.

II. Investigation and research design

This research mainly analyzes the PCK level and the level of various elements of the master of Chemical education through the questionnaire, and then analyzes the specific questions in the questionnaire to explore the current situation of the PCK of the master of chemical education, such as: what specific aspects are lacking in their grasp; What content should be strengthened. The core of this research design is mainly research tools, including the preparation of questionnaire scale and reliability and validity test.

1. Questionnaire scale preparation

The questionnaire of this study is based on the questionnaire in the PCK research tool developed by Erikson College in the United States, and the three PCK dimensions in the questionnaire are expanded into the five dimensions of this study, and then three questions related to the first class of REDOX reaction are set according to the content of the five dimensions. The PCK score of the master of Chemistry education was obtained by using Richter's five-level scale, with option scores of 1, 2, 3, 4, and 5 for later statistics. There were 15 questions in five dimensions with three questions in each dimension.

2. Questionnaire reliability and validity test

Before the formal distribution of questionnaires, the author first issued questionnaires to 35 students in our school who are studying for a master's degree in chemistry education, and recovered 30 valid questionnaires for trial test. The Alpha coefficient obtained was 0.951 (>0.8), as shown in Table 1. It can be seen that the questionnaire has high reliability.

Table 1 Reliability coefficient of questionnaire scale

Klonbach Alpha	Klonbach Alpha based on standardized terms	Number of terms
0.966	0.966	15

In order to make the content of the survey truly reflected by the collected data, we analyzed the validity of the questionnaire. Since the research content of the questionnaire was divided into 5 dimensions, the author used the factor analysis method to judge the structural validity of the questionnaire. The KMO value of this questionnaire is 0.888, and the significance level is 0.000, as shown in Table 2. This indicates that the sample size of the questionnaire meets the requirements, and there is a significant relationship between variables, which confirms the applicability of factor analysis. Therefore, this scale also has good structural validity.

Table 2 Results of KMO test and Bartlett test

KMO sampling appropriateness measure	Bartlett sphericity test		
	Approximate Chi-square	Degree of freedom	Salience
0.888	911.468	105	0.000

3. Analysis of survey results

In this study, 60 full-time masters in chemistry education from 3 universities were sent questionnaires, the collected questionnaire data were entered, and then SPSS 23.0 and excel data analysis software were used to analyze and discuss the overall level of PCK of masters in chemistry education, the level of each element and the specific problems in each element.

(1) PCK overall level analysis of master of Chemical education

According to the preparation of the questionnaire scale, it is divided into 5 dimensions, 3 questions in each dimension, the lowest score of each question is 1 point, the highest score is 5 points, the full score of each dimension is 15 points, and the total score of PCK is 75 points. 3-9 of each dimension was divided into the first level, 9-15 into the second level, and 15 into the third level; Then PCK overall 15-45 is divided into the first grade level, 45-75 is divided into the second grade level, 75 is divided into the third grade level. According to the collected data and descriptive statistical analysis by SPSS, the overall average score of PCK for master of Chemical Education is 52.9 points, and the overall level of PCK for full-time master of chemical education is in the second level, the overall level is not high, and the overall level is in the lower middle level of the second level, as shown in Table 3. Among them, the lowest score is 15 points, and the highest score is 75 points. It can be seen that the overall PCK level of chemical education master is unbalanced, and the individual difference is large.

Table 3 PCK overall level score statistics

	Number of Cases	Minimum	Maximum	Average
Total points	60	15.0	75.0	52.9

(2) PCK element level analysis for master of Chemical education

In order to further explore the status quo of PCK level of master of Chemical education, the total score of PCK of each master of Chemical education was calculated, and then the average score of the total score was calculated to obtain the overall average score of each dimension and the corresponding PCK level of each dimension, as shown in Table 4. From the average scores of each dimension, it can be seen that the PCK level of the master of Chemical education is in the second level, and all are at the lower level of the second level. The maximum value of each dimension is 15, and the minimum value is 3. It can be seen that there are large individual differences in each dimension of the PCK, which also conforms to the "individuality" characteristics of PCK. The average scores of each dimension are not much different, and the scores are even, which shows that the development of PCK in all dimensions is relatively balanced.

Table 4 Statistics of PCK scores in each dimension

Dimensions	Average score	Max	Minimum	Grade
Subject content knowledge	10.8667	15	3	The second level
Teaching strategies and representation knowledge	10.6000	15	3	The second level
Knowledge about the student	10.4667	15	3	The second level
Learn the knowledge of the situation	10.6833	15	3	The second level
Evaluating knowledge	10.2833	15	3	The second level

3. Analysis of specific problems in various elements of the PCK for the Master of Chemical Education

1. Content knowledge dimension of chemistry

Based on the above analysis, the content knowledge of the subject is at the second level, but the development of the dimension is unbalanced. In this dimension, the scores of the three questions "I am familiar with the content standards and academic requirements of this class in the chemistry curriculum standard", "I am clear about the teaching objectives of this class" and "I am familiar with the teaching content of this class and the key and difficult points of teaching" are quite different. They are 3.4, 3.6833 and 3.7833 respectively. In

particular, the scores of the first question were relatively low, while the scores of the second and third questions were relatively high. It can be seen that the master of Chemistry education is proficient in the content of the textbook and can accurately grasp the teaching objectives and key and difficult points of this course, while the master of the content and academic requirements of this course in the curriculum standards is weak. This indicates that the master of Chemical Education does not pay enough attention to the content of the course standard, rarely relates to the requirements of the course standard in the teaching process, and rarely integrates the content of the course standard into the elements of his PCK.

2. Teaching strategy and representational knowledge dimension

The content questions of “Teaching Strategy and representation knowledge” are respectively “I will adopt different teaching methods in different parts of this class”, “I will adopt different learning activities to improve students’ learning interest” and “I will choose appropriate teaching strategies according to students’ situation in teaching design”. Their average scores are 3.433, 3.5167 and 3.65 respectively. It can be seen that the scores of the three questions are different. The scores of the first two questions are relatively low, especially the score of the first question is the lowest, and the score of question 6 is high, indicating that the master of Chemical education is proficient in the use of teaching strategies and representation knowledge in teaching design, but is unfamiliar in the use of teaching strategies and representation knowledge when it comes to students and teaching links. It can be seen that the master of chemical education has a good command of teaching professional skills on the whole, such as teaching design. She can design a complete teaching design by applying the learned knowledge and certain teaching strategies through learning situation analysis and textbook analysis, etc. However, she lacks practice and cannot apply theory well into practice, resulting in a lower mastery of questions 4 and 5 than question 6. The content of teaching design has not been transformed in practice.

3. Dimensions of knowledge about students

The content questions in the dimension of “knowledge about students” are respectively “I know the students’ existing chemistry knowledge or learning experience”, “I know the students’ existing chemistry core quality level” and “I know the students’ difficulties and interests in learning in this class”, with the average score of 3.5667, 3.3333 and 3.5667. It can be seen that the score of question 8 is low, the scores of question 7 and question 9 are equal, and the score of question 8 is the lowest, indicating that the master of Chemistry Education has a clear grasp of “students’ existing chemical knowledge and learning experience” and “students’ learning difficulties and interests” in the REDOX reaction class, but has a poor grasp of “students’ core literacy”. It can be seen that, On the whole, the master of Chemical Education has a good grasp of teaching professional skills in the field of learning situation analysis, but the analysis of the level of students’ core literacy is poor, indicating that the master of chemical education has not studied and understood the core literacy in the new curriculum standards too much, and has not taken the core literacy into consideration of students’ knowledge, so it cannot properly diagnose the level of students’ core literacy. As a result, the overall level of “knowledge about students” is not high.

4. The knowledge dimension of the learning situation

Knowledge of learning situation refers to the background knowledge of chemistry generated by teachers based on students’ learning in chemistry teaching. The three content questions in the dimension of “knowledge of learning situation” are “I can create problem situation in connection with daily life and new technology”, “I can learn how to guide students’ cognition based on situation in this class”, and “For this class, I can make full use of chemical experiments to help students learn and explore “, with an average score of 3.6, 3.5833 and 3.5 respectively. The scores of the three questions decreased successively. The average scores of question 10 and question 11 were almost the same, and the scores of question 12 were lower than the first two questions. It indicates that the master of Chemistry Education has a good grasp of “creating problem situations based on REDOX reaction in connection with daily life and new technology” and “guiding students’ cognition based on situation based on REDOX reaction”. It can be seen that the master of Chemistry education has a good perception and utilization ability of the chemical learning environment, which is related to their age and thinking, while the poor ability of “using experiments to help students learn and explore” may be related to the theoretical knowledge of the class, which is difficult to use experiments

for exploration. However, the new curriculum standard aims to implement students' core literacy. In this case, the exploration experiment with the deoxidizer in the mooncake was added as the situational introduction of the REDOX reaction. It can be seen that the master of Chemistry education still needs to work hard on the curriculum standards.

5. Evaluate the dimensions of knowledge

The evaluation knowledge in PCK for master of Chemistry Education also includes three aspects: "I know how to evaluate students' understanding and application of chemical knowledge", "I know how to evaluate students' core quality of chemistry", "I can design evaluation methods to promote students' development for this class", and a descriptive analysis is made on the scores of the three questions. The average score of the master of Chemistry education on the three questions was 3.55, 3.3667 and 3.3667 respectively. It can be seen that the average score of the master of Chemistry education on question 13 in this dimension was much higher than the average score of question 14 and question 15, and their average score of question 14 and question 15 was equal. This indicates that the master of chemistry education can easily evaluate the understanding and application of what students have learned, but cannot accurately evaluate the level of students' core quality of chemistry, and is also lacking in the ability to design evaluation methods to promote students' development. It can be seen that the evaluation knowledge dimension in the PCK of the master of Chemical education is only at a superficial level, and can only make proper evaluation on the knowledge that students need to master; On the other hand, it is difficult to evaluate the core quality of chemistry required by the new curriculum standard, and students are now required to develop in an all-round way, so the master of Chemistry education cannot design an evaluation method to promote students' development. The latter two aspects are extremely lacking, which also shows that the master of Chemistry education fails to integrate itself well into the ranks of the new curriculum reform and lacks practice. The theory failed to combine with practice.

4. Research conclusions and suggestions

1. Conclusion

Based on the analysis and discussion of the questionnaire survey results, the conclusions of this study are as follows:

(1) The overall PCK level and each element level of the master of chemical education are in the second level, and the PCK development of the master of chemical education is uneven, there are individual differences. (2) The two elements of "subject content knowledge" and "learning situation knowledge" developed well, followed by "teaching strategy and representation knowledge", and the level of "knowledge about students" and "evaluation knowledge" was low. (3) Master of Chemical Education has a good grasp of professional knowledge and skills, but poor understanding and application of curriculum standards, and lack of teaching practice experience, unable to combine theory with practice well.

2. Suggestions

According to the analysis results of the current PCK level of master of Chemical Education, the following suggestions are put forward for the development of Master of Chemical education PCK:

(1) The master of chemical education should enrich his own growth path and collect various learning materials. Such as curriculum standards related books to study. (2) Masters in chemical education should seize every opportunity to exercise themselves. For example, take part in more teaching skills competitions and communicate with the outside world. (3) The training institutions should optimize the training mode, intersperse theoretical courses with practical courses, and even increase the proportion of practical courses, so that the master of education can be transformed from a listener to an active demonstrator.

References

- [1] Yongjun Ma, Xueqing Jiang, Zixian Wang. Review and Prospect of Teacher Professional Development Research in China [J]. Journal of Teacher Education, 2019,7(6):22
- [2] Qingquan Wang. Action Research on the development of Chemistry teachers' subject teaching knowledge [D]. Linfen: Shanxi Normal University, 2014:1. (in

Chinese)

- [3] Guihong Liu, Congman Rao, Yong Su. A review of the nature of teachers' subject teaching knowledge [J]. Teaching and Management, 2017(18):14.
- [4] Cochran K.F., Deruiter J.A., King R.A., Pedagogical Content Knowledge: An Integrative Model for Teacher Preparation [J]. Journal of Teacher Education, 1993, 44(4): 263-272.
- [5] Soonhye Park, J., Steve Oliver. Revisiting the Conceptualisation of Pedagogical Content Knowledge (PCK): PCK as a Conceptual Tool to Understand Teachers as Professionals [J]. Research in Science Education, 2008(38):279.
- [6] Shuo Li, Liyan Liu. Evaluation of Foreign Subject Instructional Knowledge (PCK) assessment Tools [J]. Journal of Comparative Education, 2019, 142(6):142-155.
- [7] Fang Ke, Huiyuan Chen, Can Zhang, Shuijin Yang. Teaching design of chemistry with "Five lines in one" from the perspective of PCK: A case study of Sodium oxides [J]. Middle School Chemistry, 2019(8):7-10.
- [8] Hongyan Xie. PCK model Construction of Elements and their Compounds [J]. Journal of College of Education, Taiyuan University, 2014, 32(3):108-111. (in Chinese)
- [9] Fangfang Zheng. Application of Erickson College development tool in teacher PCK assessment research: A case study of PCK assessment of high school novice chemistry teachers under the topic of methane teaching [D]. Central China Normal University, 2015.
- [10] Jinjun Tang. Study on PCK of REDOX reaction in normal university students [J]. Educational Observation, 2016, 5(11):7.

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