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Research Article

PCK Study of Middle School Chemistry Teachers in Yan'an Based on the Core Quality of Chemistry Subject

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Abstract: The new round of curriculum reform requires the promotion on the development of students' core literacy, and how the core literacy of chemistry can take root in the chemistry classroom is inseparable from the guidance and nurture of teachers in the teaching process. The "Professional Standards for Secondary School Teachers" clearly stipulates that pedagogical content knowledge (PCK) is regarded as the professional knowledge of teachers. PCK is the core content of teachers' professional knowledge and an important guarantee for teachers to carry out teaching activities. Teachers' PCK level is not only a direct measure of their teaching achievements, but also an important criterion for guiding novice teachers to become experienced teachers. The research subjects selected for this study are the middle school chemistry teachers in Yan'an City. By using the Delphi method to investigate the understanding of Yan'an middle school chemistry teachers on the core literacy of chemistry and to explore the PCK mastery of middle school chemistry teachers at different stages, it serves to deepen the Yan'an middle school chemistry teachers' own knowledge and learning of PCK while help to promote the improvement of the teaching level and professional development of chemistry teachers in Yan'an middle schools. At the end of the paper, the relevant suggestions made based on the investigation of the chemistry PCK study of middle school chemistry teachers in Yan'an City on the core literacy of the chemistry subject will improve the overall building level of the middle school chemistry teachers of Yan'an City.

Keywords: Chemistry subject core literacy; Middle school chemistry teacher; Pedagogical content knowledge

1 Raising the Question

PCK is the abbreviation for pedagogical content knowledge, which was originally proposed by Schulman from Stanford University[1]. It integrates general teaching knowledge, teaching context knowledge, subject knowledge, and student knowledge to establish a theory for identifying teacher knowledge. Since then, scholars began to conduct PCK research one after another, and different researchers have different perception and understandings of the connotation of PCK, and they have more specific connotations for chemistry teaching knowledge[2].

Foreign research on PCK can be divided into two categories: one is the understanding and perception of its composition, which is a static analysis. For example, in Grossman (1990)'s research on the connotation of PCK, she believes that the pedagogical content knowledge proposed by Schulman should also include "knowledge about the purpose and beliefs of specific subject teaching" and "curriculum knowledge"[3]. The second is the study of its development approach, which is a dynamic analysis. Currently, foreign researchers mainly divide the PCK dimension around teaching purposes, subject content,

courses, students, teaching feedback and evaluation, teaching strategies and characteristic knowledge[4].

As the new curriculum reform progress, the selection standards and professional level requirements of teachers have become more stringent[5]. PCK, as the core content of the teacher's profession, has also attracted widespread attention from domestic scholars. Chinese scholars first began to study PCK in 2005, and the pace of research has been increasing year by year in recent years[6]. Currently, the research topics of domestic scholars mainly focus on the connotation, characteristics, constituent elements, development paths and strategies, influencing factors of development, and formation process of PCK. Because the grasp of PCK affects the professionalism, teaching quality, teaching effects of every teacher, it indirectly affects the development of students[7]. Therefore it is used as a criterion for judging the professionalism of teachers.

Therefore, the research on the PCK of middle school chemistry teachers in Yan'an can promote the development of teacher professionalism.

2 Research Method

2.1 Literature Review Method

By reading domestic and foreign literature, extract information related to this research for sorting and analysis, clarify the related concepts of PCK, understand the research process of PCK by domestic and foreign scholars, understand the composition and structure of PCK, and lay the foundation for subsequent research[8].

2.2 Delphi Method

The Delphi method is to invite some experts to participate in the survey and research. The researcher designs a questionnaire and sends it to the survey subjects by e-mail. The experts score the questions on the questionnaire, and the researchers collect the questionnaire for 3 rounds. After the feedback, the experts provide their opinions. After some opinions of the experts are unified, the researcher conducts the final collation to obtain statistically significant results, which is the consensus result of multiple experts[9].

Because of the Delphi method's "consensus degree" as an assessment index for the completion of the research, this article adopts the "consensus degree" as the standard. When about 66% of the experts score $\geqslant$4 points, or the mode of scores is 5, it can be considered that they have a higher consensus.

3 Research Content

According to the composition and structure of the PCK, taking into account the number and direction of the expert group, the following 30 middle school chemistry teachers in Yan'an City were selected as the research subjects: special-grade teachers, teaching group leaders, front-line teachers with many years of teaching experience, newly joined novice teachers, internship graduate students and undergraduate students majoring in education were divided into high school expert group and junior high school expert according to their teaching background. The Delphi method is used to issue three rounds of questionnaires to the 30 expert group members to investigate the middle school chemistry teachers in Yan'an. For the current understanding and grasp of the core literacy of chemistry subject and the actual application in the classroom, statistical analysis of the survey results and relevant suggestions are made after receiving three rounds of questionnaire feedback.

4 Results and Analysis

Through three rounds of questionnaire surveys, we obtained a total of 9 kinds of members who believed that teachers should pay attention to cultivating the core literacy of students in middle school. The researchers conducted statistics and analyzed the collected questionnaires and obtained the following results:

4.1 Result Analysis of the First Round of Delphi Survey Questionnaire

Statistics on the scoring results of the objective questions in the first round of questionnaires was compiled, as shown in Table 1. It can be seen from the table that the average score of each core literacy of chemistry subject in the objective questions is 4 points or more. In terms of subjective questions, two or more experts believe that items such as "logical thinking ability" and "hands-on practical ability" need to be supplemented, and items proposed by two or more experts are added to the objective scoring questions of the second round of questionnaires. Among them, there are some items that were only put forward by one expert, such as "enthusiasm for learning" and

"curiosity about chemistry". Researchers believe that these items are not recognized by other experts and will not be investigated again in the second round of questionnaires.

4.2 Result Analysis of the Second Round of Delphi Survey Questionnaire

Analyzing the second round of questionnaires, it can be seen that 13 core literacy items have been recognized by experts from the scoring results of the objective questions (see Table 1 for details). The average scores of these items are all over 4 points, and the standard deviations are all less than 1. Among them, the item "Spirit of Science" has the highest average score and the smallest standard deviation, indicating that the members of the expert group highly value this core literacy. According to the scoring situation of the objective questions in this round, the items with low scores and overlapping repetitions were deleted, and the rest collated into 9 core literacy items (see Table 2 for details) to form the objective question part of the third round of questionnaires.

Table 1. Data analysis results of the objective questions in the first and second rounds of questionnaires

Scientific ability, values and character	First round			Second round		
	Average	Number	The standard deviation	Average	Number	The standard deviation
The concept of chemical terminology dominated by symbols of elements (View of chemical elements)	4.20	4	0.85	4.53	5	0.78
Concept of material structure and properties	4.40	5	0.97	4.77	5	0.50
Ideas of change and balance	4.50	5	0.90	4.60	5	0.62
Knowledge of matter and concept of material transformation	4.30	4	0.87	4.77	5	0.50
Ability to identify and judge, make decisions and summarize information	4.40	5	0.77	4.53	5	0.82
The ability to categorize and characterize, to combine the macro and micro	4.50	5	0.57	4.63	5	0.67
Ability to learn independently, participate in a team, communicate and cooperate	4.40	5	0.85	4.47	5	0.90
Experimental inquiry ability	4.60	5	0.81	4.77	5	0.50
Innovation and Creativity	4.40	5	0.67	4.70	5	0.53
Awareness of chemical safety and sustainability	4.60	5	0.62	4.77	5	0.50
Be realistic and pragmatic	4.70	5	0.53	4.67	5	0.66
The scientific spirit	4.60	5	0.61	4.80	5	0.48
Humanistic feelings and strong sense of social responsibility	4.40	4	0.61	4.20	4	0.89
Change of matter and conservation thinking	-	-	-	4.43	5	0.86
To understand the interaction between chemistry and life, technology and social environment	-	-	-	4.57	5	0.68
Evidential reasoning ability and model building ability	-	-	-	4.50	5	0.78
Practical ability	-	-	-	4.53	5	0.63
Triple representational thought	-	-	-	4.17	4	0.79
Logical thinking ability	-	-	-	4.50	5	0.68

4.3 Result Analysis of the Third Round of Delphi Survey Questionnaire

The data processing and analysis results of objective questions are as follow (see Table 2 for details). It can be seen from the table that the average score of all items is greater than 4, and the average score of 7 items is greater than 4.5, and the standard deviation is less than 1, indicating that the expert group has reached a high degree of consensus on these items.

Table 2. The analysis results of the objective question data of the third round of questionnaire

Scientific competence, values and character	Scientific competence, values and Character (integration)	Average	Number	The standard deviation
(1) Concept of material structure, property and use (2) Material understanding and material transformation view (3) The ability of classification and characterization, and the combination of macro and micro	Macroscopic identification and microscopic analysis	4.73	5	0.58
Ideas of change and balance	Changing ideas and balancing ideas	4.70	5	0.47
(1) Ability to identify and judge, make decisions and summarize information (2) Evidential reasoning ability and model building ability	Evidential reasoning and model cognition	4.70	5	0.47
(1) Experimental inquiry ability (2) Innovation and creativity (3) Practical ability (4) logical thinking ability	Consciousness of scientific inquiry and innovation	4.90	5	0.31
(1) Realistic and pragmatic spirit (2) Scientific spirit	Scientific spirit and social responsibility	4.73	5	0.58
The concept of chemical terminology dominated by symbols of elements	Chemical terminology and symbolic representation	4.30	5	0.95
Awareness of chemical safety and sustainability	Chemical safety and green development	4.67	5	0.80
Ability to learn independently, participate in a team, communicate and cooperate	Teamwork spirit and cooperative communication	4.53	5	0.94
To understand the interaction between chemistry and life, technology and social environment	Life chemistry and beauty chemistry	4.30	5	0.95

4.4 Consensus Degree Analysis

According to the analysis results of the first two rounds of Delphi questionnaires (see Table 1 for details), the average score of all items is above 4, indicating that the experts have reached a good consensus. In the third round of questionnaire, the expert group reached a consensus on most of the collated items, and the scores exceeded 4 points. Only two items were not recognized by most experts. The specific scoring results are shown in Table 3.

Table 3. Score statistics of the two groups of experts on the objective questions of the third round of questionnaires

Scientific competence, values and character	In the third round			
	Average		The variance	
	High school	Junior high school	High school	Junior high school
Macroscopic identification and observation analysis	4.67	4.78	0.42	0.03
Changing ideas and balancing ideas	4.67	4.72	0.24	0.21
Evidential reasoning and model cognition	4.75	4.67	0.21	0.24
Consciousness of scientific inquiry and innovation	4.92	4.89	0.08	0.11
Scientific spirit and social responsibility	4.92	4.61	0.08	0.49
Chemical terminology and symbolic representation	3.83	4.61	1.61	0.25
Chemical safety and green development	4.50	4.78	1.36	0.18
Teamwork spirit and cooperative communication	4.17	4.78	1.79	0.18
Life chemistry and beauty chemistry	3.83	4.61	1.61	0.25

From Table 3, the the top five core literacy items in average score of the high school group can be seen, while the average scores of the two items of "Chemical Terms and Symbols" and "Life Chemistry and Beautiful Chemistry" were all below 4, indicating that the high school group experts failed to reach a high consensus on these two items. The average scores of the junior middle school group for all items are greater than 4.5 points, which means that the experts in the junior middle school group have formed a more unified opinion.

Experts of different grades have different opinions on the status of the 9 core literacy items of chemistry subject in the chemistry curriculum, which also illustrates the different understandings of different teachers on pedagogical content knowledge, teaching content, and knowledge that students should master. The PCK situation of teachers at different stages is different.

4.5 Differential Analysis

The average score can reflect the level of importance

that the expert group think of each core literacy, but the opinions of different experts in the same group were also different. The variance can be used to judge when this scenario arises. When the variance is greater than 1.5, it is considered that there is a significant difference within the group, and vice versa. It can be seen from Table 3 that there are no significant differences within the junior middle school group, while there are three significant differences within the high school group. Depending on the stage and level of teachers, the results are predictable. Through this survey, the chemistry subject literacy items recognized by most experts were obtained.

5 Results and Suggestions

In this study, we investigated the content of the core literacy of chemistry subject of the middle school teachers at different stages: (1) The scores and rankings of the 9 items of chemistry subject literacy with high consensus are different for the junior high school and high school teachers, which means that teachers of different grades have different opinions on the status of these core qualities in the chemistry curriculum; (2) There are three items in the high school group that have significant differences within the group, reflecting that the high school chemistry teachers' grasp of PCK have deeper influences on teaching.

By reflecting the difference in grasp of the pedagogical content knowledge (PCK) of different teachers, strategies to effectively improve the PCK of middle school teachers in Yan'an can be proposed. The core literacy of chemistry subject with a high consensus degree can be used as a reference for chemistry teachers to achieve rapid growth and the purpose of development.

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