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Research on the Relationship between Knowledge Types of High School and Problem Solving

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ABSTRACT. *By taking part in all kinds of chemistry learning and problem solving activities, students have accumulated abundant factual knowledge, conceptual knowledge, procedural knowledge and metacognitive knowledge, and those knowledge will have an effect on problem solving in chemistry. During the procedure of problem solving, students were limited by the immediate memory span, and as a result, perceptual system selectively recognizes information in a problem situation. What's more, differences in recognition of problem solving were depended on students' type and degree of knowledge, which vary from students to students because of different learning level, and at the same time, offer a new perspective for the study on problem solving.*

KEYWORDS: *Factual knowledge, Conceptual knowledge, Procedural knowledge, Metacognitive knowledge, Problem solving*

1. Introduction

Problem solving is the most important thinking activity of human beings. It is the most common way for human beings to adapt to the environment and solve various problems in survival and development. Polya (Polya, G.1957)Pointed out that when we are faced with a problem, if we have little knowledge about the subject, it is difficult to produce a good idea; And if we don't have any knowledge, it's completely impossible. But the problem solving research in this period did not give knowledge its due status .The importance of knowledge was not really appreciated until the early 1980s. Larkin's research, published in Science, highlights that the expertise required to solve some problems goes well beyond the general knowledge required. Although it is difficult to determine cognitive variables related to problem solving, the problem solving model or practical research conclusions constructed by different theoretical researchers all hold that:Professional domain knowledge is the foundation and key to problem solving. Chi&Glaser pointed out that the two most important factors influencing problem solving are: the nature of the task and the type of domain-specific knowledge that the solver faces. Brenda Sugrue (Brenda Sugrue,2010) research on the influence of students' understanding of the knowledge level of professional fields on problem solving shows that students may have conceptual knowledge of relevant fields, but may lack the connection criteria (principles and laws) between these concepts. In addition, students who have professional knowledge and guidelines on how to connect knowledge are likely to have limited professional procedural knowledge. Heyworth (Heyworth, 1999) had studied the chemical expert and novice to deal with the problem of the titration of capacity analysis of different performance, found that the concept of expert knowledge is accurate, integrated, and connected to underlying procedural knowledge, and novices have new concept of myth, the understanding of important concepts exist strong fuzziness, the formula, rules, and lack of meaning to understand. The major differences between a chemical expert and a novice are the understanding of concepts (represented by transitions between macroscopic, microscopic, and symbolic representations), procedural knowledge, and the use of strategies. In recent years, more and more researchers have paid attention to the role of metacognition in the process of student problem solving and its influence on the cognitive process of student problem solving. The research on the evaluation of students' problem-solving ability shows that: when individuals or difficulty encountered an unprecedented situation, metacognitive process plays a very important role in solving the problem situation, to reflect on their knowledge, skills and experience, to awareness of their own ability and how to adjust them. Students with high level of metacognition skills perform better than those with low level of metacognition, and students with high level of metacognition can make up for the defects of low level of ability.

Aims of this study:(1) discuss the differences between students at different learning levels in the category of knowledge continuum.(2)The correlation between different types of knowledge and students' performance in solving chemical problems.(3)To explore whether the difference in knowledge among students of different learning levels is the cause of the difference in performance of chemical problem solving or discuss the essence of the difference in cognitive process of chemical problem solving among students of different learning levels.

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2. Experimental Design

2.1 Theoretical Basis

Generally speaking, the cognitive process of problem solving is divided into four stages: understanding and representation, strategy selection, strategy application, evaluation and reflection. There is a correspondence between specific cognitive processes in problem solving and different types of knowledge. Mayer & Wittrock's studies have shown that, the problem of understanding and characterization of mainly rely on factual and conceptual knowledge, the cognitive process of strategy selection stage mainly depends on the procedural knowledge and strategic knowledge in metacognitive knowledge, the cognitive process of strategy application stage depends on the procedural knowledge, evaluation reflection phase of the cognitive processes involved in monitoring of metacognitive knowledge, self-regulation, and self-efficacy. According to the classification of knowledge in Anderson's latest education target taxonomy, the cognitive process of problem solving involves chemical factual knowledge, conceptual knowledge, procedural knowledge and metacognitive knowledge. These four types of knowledge form a continuum from concrete (factual knowledge) to abstract (metacognitive knowledge).

2.2 Samples

This sample is taken from the students of a second-level demonstration high school in Sichuan province of China. Samples by using stratified sampling and random sampling method, according to last year's chemistry, difference in the final exam grade point average is divided into advantages and three levels (for ease of data processing to “learning eugenics, middling and poor student” respectively Numbers for 1, 2, 3), and then randomly selected respectively in these three levels of 24 (27%) in the number of each level students sample, sample total 72 people. All the students have learned electrochemistry related subject knowledge, but have not entered the electrochemistry review stage, the chemistry teacher has not carried on the targeted training and the examination to the student's college entrance examination really problem.

3. Test Tools

3.1 Test with Paper-Pen

Those test tools includes test 1, test2 two parts. The main purpose of test 1 is to evaluate students' mastery of various knowledge types of electrochemical topics, including redox reaction, galvanic cell, electrolytic cell and electrolyte solution. Test 2 is composed of 6 comprehensive questions, the purpose of which is to evaluate students' ability to solve electrochemical problems.

3.2 Metacognition Scale Tool

Likert scale in the form of self-report is often used to evaluate students' metacognitive variables. For example,Cooper,M.M.,&Sandiurena,S.(Cooper,M.M.,& Sandiurena,S.,2009) design of the five point Likert scale to solve chemical problems as the basis, according to Anderson, metacognitive knowledge content characteristic has carried on the corresponding modification, design 15 respectively subject metacognitive knowledge to the student three kinds and self-reported. Students' attitude towards each item is expressed by selecting the corresponding Likert 5-point scale (from “1 -strongly disagree” to “5 - strongly agree”).

4. Data Analysis

SPSS22.0 software was used to analyze the reliability of paper-pen test questions by means of homogeneity reliability test. The processing results are shown in table 1. The Cronbach's Alpha coefficient of the test questions is 0.764 > 0.70, indicating that the reliability of the paper-pen test questions is relatively good.

Table 1 Reliability Statistics

Cronbach's Alpha	Cronbachs Alpha based on Standardization terms	number of terms

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.764	.823	11

To test whether there were significant differences in problem-solving performance among the three groups of students, Anova was conducted on the problem-solving performance of the three groups of students, and the results were as follows.

Table 2 Levene Test for the Equivalence of Error Variance [a]

Dependent variable: achievement			
F	df1	df2	Sig.
.055	2	33	.947

Test zero hypothesis, that is, error variance homogeneity of dependent variables in all groups.

As can be seen from table 2, the associated probability is the Sig. Value 0.947>0.05, so it can be considered that the overall variance of each group is equal, which meets the precondition of variance test. LSD method was used for multiple comparisons, and the results were shown in table 3.

Table 3 Significant Analysis of Students' Problem-Solving Achievement in Three Groups

(I)group	(J) group	Mean difference (I-J)	standard error	Sig.	95%confidence interval	
					lower limit	superior limit
1	2	3.67*	1.801	.050	.00	7.33
2	3	8.67*	1.801	.000	5.00	12.33
	3	5.00*	1.801	.009	1.34	8.66

*p<0.05

As can be seen from table 3, the concomitant probability between the variables of the three groups is less than or equal to the significant water (*p<0.05), indicating that there is a significant difference in the problem-solving performance of students in the three groups. In order to detect what knowledge led to differences in problem-solving performance among the three groups of students, correlation analysis was conducted between the four dimensions of knowledge and problem-solving performance (table 4).

Table 4 Correlation between Knowledge Types and Problem Solving Achievements

	A Factual Knowledge	B Conceptual Knowledge	C Procedural Knowledge	D Metacognitive Knowledge
Mark	.719**	.790**	.754**	.581**
A Factual Knowledge		.367*	.350*	.286*
B Conceptual Knowledge			.772**	.790**
C Procedural Knowledge				.925**
D Metacognitive Knowledge				

Note: **p<0.01. *p<0.05

As can be seen from table 4, all knowledge dimensions are significantly correlated with students' problem solving scores, among which conceptual knowledge is most correlated with chemical problem solving scores, followed by procedural knowledge, factual knowledge and metacognitive knowledge. Although metacognitive knowledge about problem solving performance direct correlation between the youngest, but study each other and influence each other between metacognitive knowledge and procedural knowledge, belongs to the strong correlation , the second is the conceptual knowledge and metacognitive knowledge , the conceptual knowledge and procedural knowledge has a very big influence each other, both belong to the strong correlation .

5. Analysis and Discussion

Four different types of Chemical knowledge are significantly correlated with problem solving achievements, and most of them are strongly correlated. Further analysis shows that there is no significant difference between students' achievement in solving chemical problems and the “term knowledge” and the metacognitive knowledge subcategory “knowledge about self” in factual knowledge, and there is a significant correlation with other knowledge subcategories.

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There was no significant difference in the learning of the three groups of students at different learning levels in Factual knowledge, but there was significant difference in the learning of dimension Conceptual knowledge, Procedural knowledge, and Metacognitive knowledge.

Factual knowledge refers to isolated and separated knowledge, which will not change with the change of the context of the problem. It refers to the knowledge of elements and compounds reflecting the nature, existence, preparation and use of substances and the practical connection between chemistry and society, production and life. As can be seen from table 4, students of the three groups of factual knowledge with different learning levels, whether “term knowledge” or “detail knowledge”, tend to have a good grasp of the knowledge. It is worth noting that although there is no significant difference between the three groups of students in the dimension of factual knowledge, “detail and element knowledge” has a strong correlation with students' problem-solving performance.

Conceptual knowledge is considered as “knowledge with rich connections” , which indicates that more complex and organized knowledge forms are knowledge requiring students to understand and finish processing. Categories and categories are the basis of principles and generalizations, which in turn form the basis of theories, models and structures. As an aspect of chemical knowledge, conceptual knowledge of chemistry is theoretical knowledge abstracted from chemical phenomena and facts by means of comparison, analysis, synthesis, induction and analogy. It is the way chemists think about macroscopic and microscopic phenomena. Conceptual knowledge and factual knowledge are relatively similar, both involving “what” knowledge, but conceptual knowledge is deeper, more organized, more integrated, and more systematic than knowledge of terms and isolated facts.

Procedural knowledge is the knowledge of how to do something, especially the action to be taken under certain conditions. It usually refers to the operational ability, which comes in the form of a series of steps to be followed, including chemical skills, algorithms, techniques and methods, and the knowledge of when to use chemical rules.

Students' metacognitive knowledge evaluation includes strategic knowledge of problem solving, knowledge of cognitive tasks and knowledge of self. According to the results of the test, there was a strong correlation between the achievement of solving chemical problems and the “strategic knowledge” and “knowledge about cognitive tasks”, respectively. The “strategic knowledge” and “knowledge about cognitive tasks” presented significant differences between the three groups of students. Strategic knowledge significant performance in learning eugenics realized for different types of chemical problem sets all know in different ways to solve, and often from teachers, classmates, or himself and summed up the same topic of method, technique or rules, will summarize and accumulate some of the same type of problem different problem solving methods. Excellent students' “knowledge about cognitive tasks” can form a knowledge network through classroom, after-class teacher's explanation, self-summary and other methods to learn chemical concepts, principles, experiments, calculations and so on In the process of solving chemical problems, it is very clear to complete the classification of these problems and what chemical knowledge is needed. Middle school students either cannot find the meaning connection of these chemical concepts, principles and other knowledge, or cannot skillfully use the production rules of problem solving; The use of chemical concepts, principles and rules that students with learning difficulties choose in the process of solving problems often leads to mistakes, which lead to the unsolvable problems. These two types of students do not know how to master or skillfully apply these rules.

Can be seen from above, the Factual Knowledge, Conceptual Knowledge, Procedural Knowledge, and Metacognitive Knowledge each other show significant correlation relationship between four types of knowledge, namely a kind of knowledge learning depends on the kind of knowledge of other, on the basis of the former and provide conditions for other types of knowledge, knowledge is a continuous process of learning. At the same time can also see that metacognitive knowledge and other significant related to three kinds of knowledge is different, the most significant correlation between metacognitive knowledge and procedural knowledge, achieve strong correlation, followed by the correlation between metacognitive knowledge and conceptual knowledge learning also reached the strong correlations, and the learning factual knowledge also has significant correlation.

References

[1] Polya, G (1957). How to solve it. Princeton University Press Princeton Nj, vol.11, no.1, pp.12-13.
[2] Larkin, J., Mcdermott, J., Simon, D. P., & Simon, H. A (1980). Expert and novice performance in solving physics problems. Science, pp.1335-1342.
[3] Simon, H. A., & Newell, A (1971). Human problem solving: the state of the theory in 1970. American Psychologist, vol.26, no.2, pp.145-159.

ISSN 2616-7433 Vol. 2, Issue 8: 54-58, DOI: 10.25236/FSST.2020.020812

[4] Sugrue, B (2010). A theory-based framework for assessing domain-specific problem-solving ability. Educational Measurement Issues & Practice, vol.14, no.3, pp.29-35.
[5] Heyworth, & Rex, M (1999). Procedural and conceptual knowledge of expert and novice students for the solving of a basic problem in chemistry. International Journal of Science Education, vol.21, no.2, pp.195-211.
[6] Mayer, R. E., Wittrock, M. C (2006). Problem solving. In P A. Alexander & P H, Winne (Eds.).Handbook of educational psychology (2nd ed.). Mahwah,NJ: Lawrence Erlbaum Associates, pp.287-304.
[7] Smith, M. U., & Good, R (1984). Problem solving and classical genetics: successful versus unsuccessful performance. Journal of Research in Science Teaching, vol.21, no.9, pp.895-912.
[8] Dunbar, S. B., Koretz, D. M., Hoover, H. D (1991). Quality control in the development and use of performance assessments. Applied Measurement in Education, vol.4, no.4, pp.289-303.
[9] Bodner, G (1991). A view from chemistry. In M. U. Smith(Ed.), Toward a unified theory of problem solving: views from the content domains. Hillsdale, NJ: Lawrence Erlbaum Associates, pp.21-33.
[10] Cooper, M. M., & Sandiurena, S (2009). Design and validation of an instrument to assess metacognitive skillfulness in chemistry problem solving. Journal of Chemical Education, vol.86, no.2, pp.240-245.