A Structural Model of Error Factors in Mathematical Problem Solving Based on NVivo Qualitative Analysis

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Abstract: Based on the qualitative analysis of 40 documents by NVivo, the main conclusion is that the causes of errors in solving mathematical problems are more complex. Culture, non-intelligence, mathematics learning accomplishment, metacognition, learning strategy and intelligence are at macro level in the cause of mathematics problem solving errors. Students with high efficiency in mathematics should use non-intellectual factors as the source of motivation for learning, with a relatively perfect psychological mechanism as the premise, high-level metacognition as the monitoring system, and effective learning strategies as the learning guarantee, with higher Mathematical learning literacy is the embodiment of the quality of thinking in the learning process. Among them, the status of these six factors is different. Mathematical learning literacy and learning strategies are the two core elements that affect mathematical solutions.

1. Introduction

Improving learning efficiency is one of the means to reduce the heavy burden of learning. Mathematics is an important course in the basic education stage, but under the condition that the students' intelligence level is the same and the learning environment is the same, there are often significant differences in mathematics learning performance [1]. Problem-solving is a means to realize the purpose of mathematics teaching and an important form of mathematics teaching activities. Students' cognitive structure includes knowledge structure and cognitive structure. Problem-solving errors will occur when students' cognitive structure cannot assimilate the topics they come into contact with [2]. There are many reasons for the problem of solving problems, such as the lack of basic knowledge, poor problem-solving ability, psychological influence, and so on. Correcting errors in essence, effectively preventing the recurrence of similar errors, and further consolidating basic knowledge, infiltrating mathematical thinking methods, adjusting students' problem-solving psychology, and guiding students to the correct track [3]. The strength of students' mathematical ability depends to a large extent on the solution of the problem. Therefore, it is of great significance to study and explore the reasons for students' mistakes in solving problems and propose countermeasures from them. It is necessary to strengthen students' thinking training and improve their ability to solve problems. The purpose of this study is to systematically sort out the existing research results, make qualitative analysis of the literature with NVivo software, and construct the structural model of students' mathematical problem solving errors based on the analysis results, and point out the future research directions.

2. Research Method

2.1 Document collection and document object selection

According to the theme of this research, the research objects are identified as domestic mathematics core journals, educational core journals and some foreign journals. Selected document time range: 2014-2018. Subject Scope: A literature that directly studies the efficiency of mathematics learning. Research literature on high-level mathematics students, mathematics gifted

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students, and the efficiency of mathematics learning. When students are questioning, they are easily entangled in many pieces of information. It is difficult to screen or sort out key information from many information or to capture the hidden conditions in the question to reveal the essence of the problem. It is difficult to push the mind to the core of the problem. Although some documents study the factors that affect mathematics learning achievement and do not directly study the factors that affect mathematics learning efficiency, because mathematics learning efficiency also cares about mathematics learning achievement, some researches on the factors that affect mathematics learning achievement, and important research papers related to mathematics learning efficiency are also selected as documents. The real reason is the first requirement of inference, and taking false proposition as the basis of inference violates the sufficient reason law of logical thinking.

2.2 Research tool selection

NVivo is a computer-aided qualitative data analysis software developed and designed by QSR Company. Its greatest advantage lies in its powerful coding function. Can process articles, interviews, survey results, audio, video, pictures, web pages or social media and other content, and encode and summarize information points related to research topics. It can aggregate all the information related to a research topic and integrate a wide range of research topics, which can enable researchers to quickly capture information points in the literature.

2.3 Document encoding method

There are two main coding methods commonly used in NVivo software. One is to determine the coding node according to the research topic and form the research framework. The second is to encode the document information and form several sub-nodes to integrate. The basics of 40 documents based on NVivo software. The coding process is as follows: first, collecting materials, uniform format, editing order; Second, import; Thirdly, based on NVivo10 software, the position of the first-level node in the wrong cause of mathematical problem solving is analyzed. Fourthly, the statistical Table of node codes is derived. Fifth, generate results and use the model function in the “exploration” tool to give an efficient structural model of error causes in mathematical problem solving.

3. Research Results and Analysis

3.1 Analysis of the basic situation of the literature

Based on the coding statistics of the basic information of the 47 selected documents in NVivo software, the surface analysis of the documents was carried out. (See Figure 1).

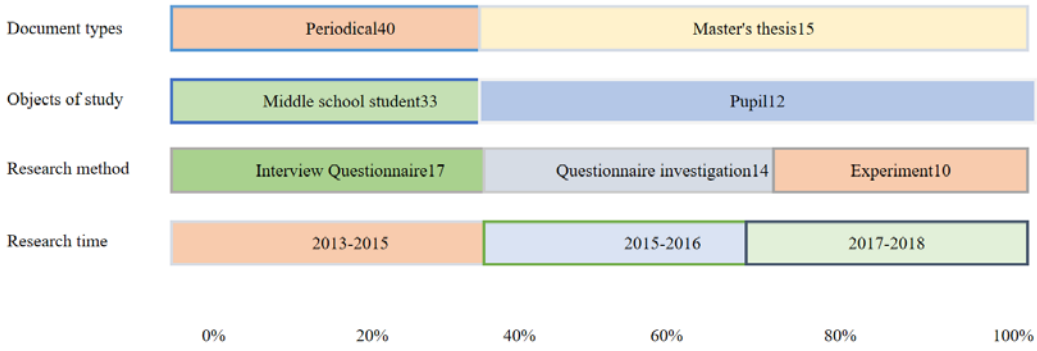

Fig.1. Document basic situation map

As far as the type of literature is concerned, the proportion of journal articles in all the literatures reaches nearly 85%. The research has a wide range of research points. Most of them are cross-cultural studies on mathematics learning by a certain factor or a few factors. The research results are mostly The relationship between a certain factor or several factors, and the master's doctoral thesis is mostly based on the efficiency of mathematics learning. As far as the research

time is concerned, the number of studies in 2013-2018 has remained basically sTable. From the literature situation in the past five years, mathematics education researchers have paid close attention to the issue of mathematics education and the results have become more substantial.

From the research method, it shows a relatively fixed orientation. Psychology literature is mostly based on experiments, combined with clinical conversation methods, and the perspective of mathematics education is more inclined to conduct case interviews and questionnaires. According to the research object, nearly half of them have more literature support. The classification discussion should be based on the rules of concept division in formal logic: the division should be symmetrical, that is, the total extension of sub-items obtained by division should be equal to the extension of parent items. Among them, questionnaires and tests are the most commonly used. Most studies adopt a single survey method, while only a few studies are supplemented with interviews and observation methods on the basis of surveys.

3.2 Primary node and its relationship

The nodes at each level formed by NVivo coding are affiliation, the third-level nodes are the original information points extracted from the literature, and the second-level nodes are the integration of the three-level nodes with similar meanings. Some of the questions in the review seem complicated, and students are easily confused by the problem. It is always difficult to think that there are many words or conditions. This is a psychological process, except for application problems, general mathematical problems do not need to be converted. The coding reference points of different levels obtained by software statistics reflect the hot spots and weak points of the existing research. Among them, high frequency sub-nodes show frequent occurrence in 40 documents, which is the focus of attention of researchers. Secondly, the conditions and objectives of the topic should be clearly defined. Both the primary node and the secondary node are qualitative analysis results of NVivo10, among which the factors that reside in the primary node are macro factors that cause errors in mathematical problem solving.

Proof of any mathematical problem is made up of topics, arguments and arguments. Topics are the topics that need to be determined for authenticity. The true proposition on which the argument is based to prove the authenticity of the proposition [4]; Based on the framework of the research, it can be seen that the error causes of high-efficiency mathematics learning students in solving mathematics problems can be started from two perspectives of psychology and mathematics education, in which metacognition, learning strategies and non-intelligence factors are the common elements from the two perspectives. There are many different topics and various reasons for mistakes. It is impossible to talk about all the situations and problems. There is absolutely no fixed mode to solve them [5]. Some topics don't look similar, but in fact they have a lot in common. The problem-solving methods are very similar. For example, the method of combining numbers and shapes can be applied to many different types of problems. Mathematical concepts, mathematical abilities, and mathematical learning habits represent different aspects of mathematical learning literacy [6]. On this basis, relevant research from the perspective of psychology holds that the psychological characteristics of students with high efficiency also include selective attention and implicit learning. Therefore, when students identify models, they not only search for similar models, but also try to transform the topics or transform their own models. The current model has a good match with the existing models.

Table 1 Number of coded reference points for the primary node and its secondary nodes

Primary node	Secondary node	Number of coded reference points
Psychological mechanism	Selective attention	3
	Working memory	5
	Cognitive strategy	12
Learning strategy	Metacognitive strategy	30
	Resource management strategy	24
	Mathematical ability	18
Mathematics Learning Accomplishment	Mathematical view	55
	Learning methods and habits	27

According to the statistics of coding reference points, the frequency of metacognitive monitoring is as high as 30, far exceeding metacognitive knowledge, while metacognitive experience, on the other hand, is hardly involved. Students may encounter obstacles or doubts in the process of solving problems. For example, when looking for strategies, students find multiple models similar to the topic, but they do not know which is better or which is right or wrong. At this moment, students themselves need to adjust and think. Although intelligence is a primary node, the number of codes is the least in the primary node. There are relatively more coding points for thinking ability in the secondary nodes of intelligence [7]. In some problem solving, because the non-equivalent transformation of the proposition as the basis for solving the problem often leads to the reduction or enlargement of the solution set. This is also a common logic error that violates the same law. It is known from Table 1 that non-intellectual factors The difference between the number of secondary node coding reference points is large, which also shows that the influence of different factors on the mathematics learning efficiency of students is quite different in non-intellectual factors [8]. It can be seen that the relationship between culture and non-intelligence is closely related to other first-level nodes, and it is at the core position [9]. In addition, students need to monitor the process during the process of solving problems, especially when solving problems with the wrong program. If the students do not monitor and adjust themselves in time, it will affect the quality and speed of problem solving.

3.3 Research result

In NVivo, you can use the Relationships tool to give you the interlinkages between the five first-level nodes, paving the way for building the model, and then using the model features in the Explore tool. The mastery of skills and thought methods is based on certain knowledge. Taking the combination of numbers and shapes as an example, it is necessary to grasp the knowledge of the corresponding function images and the knowledge of equations. For the first time, this study applied NVivo qualitative analysis software to solve the problem of mathematical solution error. It was found that there are many factors affecting the mathematical solution, but they are not at the same level. Based on NVivo software, it can be seen that these five first-level nodes are the five structural elements of the psychological characteristics of efficient mathematics learning, and there are different degrees of relationships between them, thus obtaining a preliminary model of the psychological characteristics of efficient mathematics learning, as shown in Figure 2. Here mainly refers to operational skills, that is, the ability to operate formulas and principles. Obviously, if the daily use of operational skills is small and the accumulation is small, it is difficult to extract [10] when facing problems. Culture, non-intelligence, mathematics learning accomplishment, metacognition, learning strategy and intelligence contain their own sub-factors, and the sub-factors have different positions. These five core elements are not absolute causal relationships, nor do they play a role in students' learning process in stages.

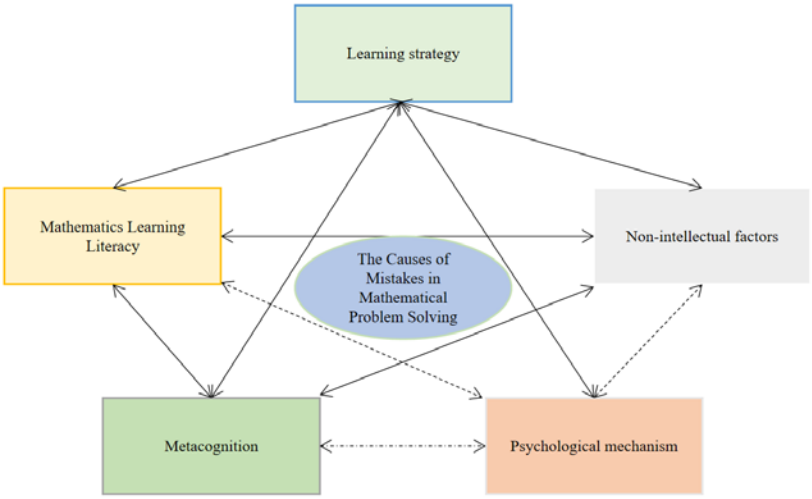

Fig.2. Efficient mathematics learning student psychological structure model

4. Discuss

In this study, through qualitative analysis of the existing researches, a structural model of the error causes in mathematical problem solving was initially constructed. Students do not have a good grasp of the thinking method of combining numbers with shapes. Although in terms of procedural knowledge, students' mistakes are mainly in their wisdom and skills. Students do not have a good grasp of the thinking method of combining numbers with shapes. Although the students' errors in procedural knowledge are mainly in their wisdom and skills, in the process of document coding, the subjectivity of document understanding may lead to errors in the coding of some boundary information, thus leading to errors in the research conclusion. Some domestic research results are not clear or lack of definitions for efficient mathematics learning students and their operational definitions. There are mathematical results in quantitative research as a substitute for mathematical learning efficiency, resulting in the inconsistency between operational concepts and definition concepts; It is simply a memory or a form of memory, but a deep understanding of the nature of the concept, including the context and process it produces. Various questionnaires and scales have problems of low reliability and validity, which leads to the conclusion that the research conclusions of the literature are not all reliable. For these reasons, the mathematical problem-solving structure model based on the NVivo research method is still a hypothesis. The focus of future research is on college students as the main research object.

5. Conclusion

Mathematics problem-solving is complex. We use NVivo research method to get a preliminary understanding of the causes of mathematical problem-solving. Psychological mechanism, meta-cognition, learning strategies, non-intelligence factors and mathematics learning literacy are five structural elements of the psychological characteristics of efficient mathematics learning, and there are different degrees of relationship between them. Among them, culture and non-intelligence are the two core elements that affect the minority nationality's mathematics learning psychology. Students need a clear thinking route to solve problems more effectively, and the wrong cause model and its extended model for mathematical problem solving just provide students with such a steering wheel. With a high level of metacognition as the monitoring system, effective learning strategies as the learning guarantee, and higher mathematics learning literacy as the embodiment of thinking quality in the learning process.

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References

[1] Mulbar U, Rahman A, Ahmar A S. Analysis of the Ability in Mathematical Problem-Solving Based on SOLO Taxonomy and Cognitive Style[J]. Social Science Electronic Publishing, 2017, 15(1):68-73.

[2] Chamberlin S A, Moore A D, Parks K. Using confirmatory factor analysis to validate the Chamberlin affective instrument for mathematical problem solving with academically advanced students[J]. British Journal of Educational Psychology, 2017, 87(3):págs. 422-437.

[3] Priyani H A, Ekawati R. Error analysis of mathematical problems on TIMSS:\r, A case of Indonesian secondary students[J]. IOP Conference Series: Materials Science and Engineering, 2018, 296:012010.

[4] Özcan, Zeynep Çigdem, Bayrakli V K, Imamoglu Y. Analysis of Sixth Grade Students' Think-Aloud Processes While Solving a Non-Routine Mathematical Problem [J]. Kuram Ve Uygulamada Egitim Bilimleri, 2017, 17.

[5] Giacomoni J, RDulescu V, Warnault G. Quasilinear parabolic problem with variable exponent: Qualitative analysis and stabilization[J]. Communications in Contemporary Mathematics, 2017:1750065.

[6] Wulandari R D, Lukito A, Khabibah S. The Elementary School Students' Mathematical Problem Solving Based on Reading Abilities[J]. Journal of Physics Conference Series, 2018, 947.

[7] Hakim L L, Nurlaelah E. Mathematical mindsets: the Abstraction in mathematical problem solving[J]. Journal of Physics Conference Series, 2018, 1132.

[8] Hamda,. Mathematical Problem Solving Strategy based on Conceptual Thinking[J]. Journal of Physics Conference Series, 2018, 1028.

[9] Jacinto, Hélia, Carreira S. Mathematical Problem Solving with Technology: the Techno-Mathematical Fluency of a Student-with-GeoGebra[J]. International Journal of Science and Mathematics Education, 2017, 15(6):1115-1136.

[10] Natalie O, Brünken Roland, Markus V, et al. Multiple symbolic representations: The combination of formula and text supports problem solving in the mathematical field of propositional logic[J]. Learning and Instruction, 2018, 58:88-105.