

# *The Influences of Mind-Map on Cultivating Students' Metacognitive Capacity*

Chengxin Ding<sup>1,a,\*</sup>

<sup>1</sup>College of Science, Qiongtai Normal University, Haikou, Hainan, 570000, China

a. Alicecheng@fsu.edu.pa

\*corresponding author

**Abstract:** Mind mapping is an effective graphic thinking tool for expressing divergent thinking proposed by Tony Buzan, a world-renowned psychologist and educator. It is a practical thinking tool that is simple, yet effective and efficient at the same time. Mind mapping develops students' thinking skills, logical skills, etc. This study aims to investigate the development of metacognitive ability of students through the production of mind mapping. Through a review of related literature, the study found that mind mapping can promote students' categorization and organization skills, help students discover and understand new relationships, improve problem-solving skills, and facilitate the deposition of learning outcomes. In addition, mind mapping production requires student participation, thereby improving students' metacognitive ability. The literature access suggests that the production of mind mapping has a significant effect on the development of students' metacognitive ability, and it should be introduced into education. In the future, the production method of mind mapping should be further optimized, and its application scenarios should be studied to improve students' learning effectiveness and metacognitive ability development.

**Keywords:** mind mapping, students, metacognition, metacognitive ability, lifelong learning

## 1. Introduction

The Development of Core Literacy for Chinese Students proposes independent development and learning to learn, two key points of which are enjoying learning and learning well and reflecting diligently [1]. It is expected that students can correctly understand and appreciate the value of learning, have a positive learning attitude and a strong interest in learning, develop good learning habits, and master learning methods that suit them. It is hoped that students can learn independently, have the consciousness and ability of lifelong learning, etc., and have the consciousness and habit of reviewing their own learning status, being good at summarizing experience, and being able to choose or adjust learning strategies and methods according to different situations and their own reality, etc. At present, most primary and secondary school students receive exam-oriented education, and their subjectivity and initiative cannot be enhanced, and many of them appear to be averse to learning. Therefore, it is very important to develop their metacognitive ability at present.

Metacognition is the process of reflecting on one's own thinking, which plays an important role in learning and problem solving. Developing students' metacognition is a key goal in education and it has been found to improve academic performance and lifelong learning skills. One effective tool for developing students' metacognition is the use of mind mapping or concept mapping. Mind mapping,

also known as spider mapping or concept mapping, is a graphic representation of information that shows the relationships between ideas. Mind mapping can promote critical thinking, foster creativity, and help students organize complex information. As a result, mind mapping has been used in a wide range of educational settings, from elementary school to college. In recent years, the use of mind mapping has become increasingly popular in elementary education. This is because mind mapping can improve students' cognitive skills and help them develop a more organized and systematic approach to learning. However, the effects of mind mapping on elementary school students' metacognition development have not been fully explored. Therefore, the purpose of this study is to examine the effects of mind mapping production on elementary school students' metacognition development. This study will examine the role of mind mapping in facilitating students' ability to categorize and organize information, discover and understand new relationships, and solve problems. This study will also explore the role of student involvement in the process of mind mapping production and its impact on elementary school students' metacognition development. This study aims to explore the impact of studying mind mapping on metacognition and to provide educational implications for the use of mind mapping in elementary education.

## **2. Literature Review**

### **2.1. Study Definition**

#### **2.1.1. Mind Map**

Mind mapping is a tool for presenting the thinking process and its results in a graphical way. It can help people organize and express their thoughts more effectively, sort and categorize ideas, and improve memory and creativity. Mind mapping usually consists of a central theme and related branches and sub-branches, which can be a series of key words or phrases, diagrams, pictures or other easy-to-understand graphic elements. Mind mapping is a non-linear way of thinking, unlike traditional notes and outlines. By using mind mapping, people can more easily remember information, connect ideas, and discover connections to more fully understand problems and create new ideas. Mind mapping can be used for learning, management, project planning, meeting notes, innovation, and other areas.

#### **2.1.2. Metacognition**

Metacognition, first proposed by the American child psychologist J.H. Flavell, refers to the cognitive activity by which people monitor, modify, manage and evaluate their cognitive processes [2]. In short, metacognition is a type of thinking about cognitive processes that allows people to understand and control their thinking activities at a deeper level. Metacognitive ability includes the ability to be aware of cognitive tasks, to regulate attention, to select and apply strategies, and to understand and remember information. It can usually be measured by several assessment tools and strategies, such as introspection during thinking, self-evaluation, and transfer of consciousness. The development of metacognition is influenced by a variety of factors, including genetic, environmental, learning, and sociocultural aspects. Research has shown that people with high levels of metacognitive ability are usually better able to face challenges and changes in learning and life, and have better academic performance and adaptability. Therefore, metacognition is also considered a very important cognitive ability in the field of education, which can help improve the quality of learning and learning efficiency of students.

## 2.2. Nature of the Mind Map

The essence of mind mapping is the application of the left and right side of the human brain, applying the logical capabilities of the left brain and the figurative thinking capabilities of the right brain. Mind mapping is non-linear in nature. Unlike traditional outlines and notes, mind mapping is a polycentric, non-linear graphic that can be freely combined, expanded and reduced to present information and relationships related to the topic. Mind mapping presents information in graphics, colors, and symbols that are pictorial, colorful, and visual, making it easy for people to remember, understand, and innovate with information. Mind mapping can also present complex information and concepts in a hierarchical manner, allowing the observer to clarify the thinking process at a glance and facilitate subsequent thinking and operation. Mind mapping is highly flexible and adaptable, allowing it to be extended, modified, and integrated as needed for a variety of disciplines and application scenarios. Mind mapping can simplify, summarize, and condense complex problems and concepts by simplifying and summarizing information, and can uncover the main information and ideas. In short, mind mapping can provide individuals and organizations with an efficient way to process, organize, and present information.

## 2.3. The Structure of Metacognition

Based on previous research, this paper examines the theoretical foundations, research progress, and future trends of metacognition structure, including metacognition components, dimensions, and key competencies. In addition, a review of empirical studies on metacognition structure will be conducted to explore the relationship between metacognition structure and learning strategies, learning effectiveness, subject competence, and individual differences to reveal the impact of metacognition on learning and cognition. They divided the metacognition structure into several aspects, such as emotion regulation, metacognition awareness, metacognition control, and so on, which together form the structure of metacognition and can facilitate the understanding of cognitive processes and control at different levels of metacognition. Scholars have different views and understandings about metacognition structure and metacognition process. Some scholars believe that the metacognition structure consists of three parts: metacognition strategy, metacognition monitoring and metacognition assessment [3]. Among them, metacognition strategies include the strategies used by learners in learning tasks. Metacognition monitoring includes the personal monitoring and control of the learning process. Metacognition assessment includes the self-evaluation of learning outcomes. This perspective views metacognition as a three-part structure that emphasizes learners' awareness and control of different dimensions of their own learning process.

Other scholars view metacognition as a continuous process that includes the perception, monitoring, regulation, and assessment of cognitive tasks [3]. In this view, metacognition is not a discrete structure, but a continuous process. It emphasizes the process of perception and control of learners in cognitive tasks, as Dong Qi mentioned in his article "On metacognition" that metacognition includes three aspects, namely, metacognition knowledge, metacognition experience, and metacognition monitoring. These are also the three components of metacognition structure that are currently recognized by everyone. According to the former study, the metacognition structure introduced in this study is divided into three dimensions - metacognition knowledge, metacognition experience, and metacognition skills [4].

## 2.4. Mind-mapping Methods to Improve Metacognition

Mind mapping is an effective method for developing metacognitive ability. By creating mind mapping, students can create conceptual frameworks related to their knowledge and organize these concepts to develop a more systematic and coherent way of thinking. This visual presentation of

information helps students to better understand, analyze, and solve problems, facilitating the development of their metacognitive ability. Specific metacognitive abilities include: Making mind mapping requires sifting, abstracting, and integrating information. This helps students to better control their attention and avoid getting caught up in unnecessary details of information. Besides, in the process of making a mind mapping, students need to integrate and consolidate information, and it can improve memory and recall skills. This helps them to better remember and recall subject knowledge. Mind mapping helps students develop abstraction, generalization, and analogy skills by organizing knowledge into subordinate relationships to develop the ability to generalize and draw analogies. In the process of mind mapping, students need to reorganize and redesign information, which fosters the development of creativity and problem-solving skills. After organizing what they have learned, they will reflect on their learning status and whether they have achieved the learning objectives at that stage.

### **3. Influence of Mind Mapping on Students' Metacognition**

#### **3.1. Mind Mapping Usage**

According to literature research, mind mapping presents a thinking process, which is the expression of radioactive thinking. From the perspective of the creation method, it mainly starts from a central word, with the deepening of thinking, associates a series of related things, and then forms an orderly schema. Mind mapping has been widely used and has a positive impact on educational applications. By reading the relevant literature and making field observations, the current state of mind mapping in education can be summarized in the following four aspects:

##### **3.1.1. Instructional Design and Classroom Teaching**

Mind mapping is widely applied in instructional design and classroom teaching. Studies have shown that by using mind maps, teachers can better plan and organize instructional content, clarify knowledge structures, and design effective teaching strategies [5,6]. Mind maps help students to better understand knowledge, promote thinking, and discover relationships between different pieces of knowledge.

##### **3.1.2. Learning Aids**

Mind mapping is widely used as a learning aid to help students organize and consolidate knowledge. As an effective teaching tool, mind mapping has its own superiority and development space. Research has shown that students can better understand, remember, and review knowledge through the creation of mind maps. Mind mapping helps students to visualize knowledge and present it in a structured way, facilitating their understanding and memory.

##### **3.1.3. Facilitating Creative Thinking and Problem-solving Skills**

Mind mapping is seen as a tool that can promote creative thinking and problem-solving skills. Studies have shown that through the use of mind maps, students can think, associate, and organize information more flexibly, thus cultivating their creative thinking abilities [7]. Mind maps help students explore and solve different aspects of problems, fostering deep thinking and innovative thinking.

### **3.1.4. Cultivating Metacognitive Abilities**

Mind mapping is widely used in cultivating metacognitive abilities. Research has shown that by creating mind maps, students can have a better understanding of their learning processes and strategies, helping them to reflect on and evaluate their learning outcomes [8,9]. Mind maps help students recognize their learning preferences and weaknesses and adjust their learning strategies accordingly.

In conclusion, the current state of mind mapping in education shows its significant role in instructional design, learning aids, fostering creative thinking and problem-solving skills, and developing metacognitive abilities. With the implementation of the “reducing workload and improving quality” policy in China, the use of mind mapping has been introduced by educators to cultivate students’ thinking abilities and enhance overall teaching quality.

### **3.2. Metacognitive Ability in Primary and Secondary School Students**

The term “metacognition” was first introduced abroad, and China’s research on metacognition came relatively late. Therefore, most of China’s research on metacognition is mainly based on the introduction and summary of foreign research. The earliest domestic research on metacognition was Professor Dong Qi’s “On Metacognition”, and subsequent studies on metacognitive abilities by scholars were based on Dong Qi’s theoretical research results [3]. With the emergence of the concept of learning-to-learn among primary and secondary school students, the research on metacognitive abilities of these students in China has received widespread attention. China’s education system is still focused on rote learning, and students often face pressure from society, parents, and teachers without understanding what learning truly means. Research has found that the metacognitive abilities of primary and secondary school students improve with age. Compared to primary school students, middle school students show a higher level of metacognitive abilities. However, overall, primary and secondary school students in China still have a relatively low level of metacognitive abilities and need further improvement. There are differences in the use of metacognitive strategies among primary and secondary school students. Some students are able to effectively apply metacognitive strategies, such as setting learning goals and plans, as well as monitoring and evaluating their learning progress. However, many students have a lower level of awareness and mastery in using these strategies [4].

### **3.3. Cultivation of Metacognitive Abilities Through the Production of Mind Maps**

A literature search on “mind mapping” and “metacognitive skills” revealed that there is little research in China. The only existing research is limited to the development of metacognitive skills through mind mapping in a specific subject. Some of the main directions of the current research are how to improve the organization of learning and structured thinking [5-11]. Many studies have shown that creating mind maps can help students organize and structure their knowledge. Mind maps also promote structured thinking. Students can transform their learning materials into the form of graphs and charts to help them better understand the structure and relationships of their knowledge, thus enhancing their learning [12]. Making mind maps can promote the application of metacognitive strategies and enhance students’ memory and understanding, but there are differences in learning styles and cognitive abilities among students. Therefore, the consideration of individual differences is lacking, and there are few studies related to how metacognitive skills are developed. Therefore, the existing studies have positive findings but still face some challenges and limitations. Further research is still needed to explore its applicability, validity and individual differences, and to provide more specific guidance and support for educational practice.

## 4. The Influences

### 4.1. Help in Organizing and Summarizing Knowledge

As a visual learning tool, mind mapping plays an important role in developing students' metacognitive skills [4]. First of all, mind maps can help students organize their knowledge structure and enhance their learning. By displaying knowledge in graphical form, students can clearly see the connection and hierarchical structure between knowledge, which helps them understand and memorize knowledge. Meanwhile, through the production of mind maps, students need to organize and summarize their knowledge. This process can help them think deeply and understand the knowledge, thus improving their metacognitive skills.

Secondly, mind mapping can promote students' self-monitoring and regulating abilities and enhance their awareness and grasp of the learning process. In the process of making mind maps, students need to constantly think and organize their knowledge, which requires them to reflect on and monitor their learning process. At the same time, mind mapping can also help students see their shortcomings in knowledge acquisition and understanding, thus stimulating their awareness of actively regulating their learning strategies. Through the continuous use of mind maps to guide learning, students can gradually develop good learning habits and metacognitive skills.

The methods and techniques of mind mapping are also key to developing students' metacognitive skills. Students can make connections between knowledge and better understand and apply what they have learned by independently developing the steps and rules of mind mapping. When making mind maps, students can follow certain principles and techniques. For example, they can do the mapping by using key words instead of long notes, using colors and graphics to highlight the key points, etc. These methods and techniques can help students organize and summarize their knowledge in a more structured way and develop their metacognitive skills.

In teaching practice, teachers can adopt some effective strategies to cultivate students' metacognitive ability [13]. For example, teachers can guide students to use mind maps to organize and summarize knowledge in teaching. Teachers can also guide and evaluate students' mind maps to help them establish the correct methods and skills for making mind maps. At the same time, teachers can also provide students with some practical examples of mind mapping, so that students can master the skills of making mind maps through imitation and practice. Through teachers' guidance and instruction, students can better utilize mind maps to improve learning and develop metacognitive skills.

In summary, the production of mind maps plays a positive role in promoting the cultivation of students' metacognitive ability. Through the production of mind maps, students can improve their ability to organize and summarize knowledge, enhance their self-monitoring and regulating ability, and then improve their learning effect and metacognitive ability. Therefore, mind mapping should be actively promoted and applied in teaching to provide more guidance.

### 4.2. Improvement of Learning Outcomes

Mind maps, as a visual learning tool, can help students organize and summarize their knowledge, improve their learning effectiveness, and thus promote the development of their metacognitive skills.

First of all, the mind map can help students sort out the structure of knowledge. By organizing and summarizing the knowledge points, students can grasp the logical relationship of knowledge more clearly and clarify the knowledge vein. This process of organizing and summarizing can help students deeply understand the content of learning and improve their memorization.

Secondly, mind maps can help improve learning. Studies have shown that presenting learning content in the form of a mind map can improve learners' learning efficiency and memorization. With

the characteristics of pictorialization and structuring, mind maps can help students better understand and digest what they have learned and deepen their impression of knowledge. Therefore, by making mind maps, learners can master knowledge more efficiently.

In addition, mind mapping can promote students' self-monitoring and regulating abilities. In the process of making mind maps, students need to reflect on and summarize their learning, and constantly adjust and improve their learning strategies. Through this process of reflection and regulation, students can improve their understanding and grasp of the learning process and enhance their self-monitoring ability.

In conclusion, mind mapping has a positive impact on students' learning outcomes. By organizing knowledge structure, improving learning efficiency and enhancing self-monitoring ability, mind mapping can promote the development of students' metacognitive ability. Teachers can guide students to use mind maps as a learning tool in teaching to help them better understand and master knowledge. Future research can delve into the methods and strategies of using mind maps to further improve students' learning effectiveness and metacognitive abilities.

### **4.3. Facilitation of Self-monitoring and Regulation Skills**

In the process of mind mapping, students need to think about and organize what they have learned and make connections between different concepts or information. This process of thinking and organizing can prompt students to reflect on and assess their own learning process, so that they can better understand their own learning ability and the effectiveness of their learning strategies. Through continuous self-monitoring and assessment, students are able to identify problems and difficulties in their learning and adjust their learning strategies in time to improve their learning outcomes.

In addition, mind maps can help students record the learning process and learning outcomes graphically for better feedback and revision. Students can mark their thoughts and ideas in the learning process and record their learning gains and confusions on the mind map. Such records and feedback can help students review and summarize the learning process and deepen their understanding and memory of the learning content. At the same time, it can also provide more specific and direct feedback information to help students adjust their learning strategies and correct their mistakes.

To summarize, mind maps can help students organize their knowledge structure and improve their learning effect. At the same time, it can also help students carry out self-monitoring and assessment, regulate learning strategies and improve learning efficiency.

## **5. Make Suggestions for the Problem**

### **5.1. Production of Mind Maps**

There are still major problems in the process of students creating mind maps. For example, students copied and reproduced the phrases of the table of contents and did not organize the knowledge points they learned. They just draw directly according to the key words in the catalog. This reflects that students did not think deeply and summarize the learning content, so that the cultivation of self-monitoring and regulating ability in metacognitive ability could not be reflected. Each student has different learning styles and cognitive abilities, and individualized teaching methods are needed to use mind maps effectively. However, the current commonly used mind mapping teaching methods are not necessarily suitable for all students, and further research is needed to personalize instruction to the needs of different students. Teachers may not have enough time for specialized mind mapping training due to time issues, teaching pressure and curriculum constraints. Nowadays, with living in the information age, mind mapping tools are not just limited to hand-drawn paper versions, but there are many different types of mind mapping tools to choose from, including both electronic and online

tools. Teachers and students need to choose the right tool for their needs and technical skills. However, for some teachers and students who have not been exposed to these tools, there may be difficulties in selecting and using the appropriate tool.

To address these problems, teachers should try to gather training and resources to understand the concepts and use of mind maps and how to effectively use them to develop students' metacognitive skills. Teachers should focus on teaching students in accordance with their aptitude. They should personalize the teaching of mind maps according to students' learning needs and ability levels, and provide teaching materials and guidance suitable for different students. They should encourage students to use Mind maps in their independent learning and practice during teaching to develop their ability to think independently, organize knowledge and solve problems. And they should provide students with appropriate production tools according to the characteristics of their school age groups. For example, primary school students' cognitive ability and self-control are not high, so the production of mind maps is mainly in paper form. While secondary school students have a certain degree of independent learning ability and study time is tight, electronic tools can be provided to produce mind maps.

## **5.2. Development of Metacognitive Skills**

The development of students' metacognitive skills is often limited by the learning environment, and is therefore problematic in one way or another. For example, some in some schools and education networks, the focus is on test scores and knowledge transfer, and there is a lack of emphasis on the development of students' independent learning and metacognitive skills [8]. This may limit students' development in metacognition. Students have limited time in school and teachers may not have adequate teaching methods and strategies to develop students' metacognitive skills. They need more training and resources to understand how to effectively guide students to think and practice metacognition. Second, the development of metacognitive skills requires students to have positive motivation and self-directed learning. However, some students may lack the autonomy and initiative towards learning to engage in effective metacognitive practices.

To address these issues, schools and teachers should emphasize the importance of metacognition in learning and growth and explain the concept and meaning of metacognition to students. This can help students understand and actively apply metacognitive strategies. Schools and teachers can also try to create positive learning environments that encourage active learning and self-directed exploration. This can be achieved by providing individualized learning tasks, encouraging students to take responsibility, and giving them choices. Secondly, teachers can also provide specific metacognitive guidance, including discussing learning objectives, developing learning plans, monitoring the learning process and assessing learning outcomes [9]. They can use teaching tools and methods to help students develop metacognitive skills. Teachers can also organize cooperative learning activities to promote interaction and collaboration among students. In addition, teachers can develop students' independent learning skills through activities such as critical thinking, problem solving and decision making.

## **6. Conclusion**

### **6.1. Summary of the Role of Mind Maps in the Development of Metacognitive Skills**

Mind maps are a visual learning tool that can help students organize and summarize their knowledge, improve their learning effectiveness, and promote the development of their metacognitive abilities. This paper summarizes the role of mind maps on the development of students' metacognitive ability through the review and analysis of existing studies. First of all, mind maps can help students sort out their knowledge structure. By displaying the knowledge points in graphical form, students can see



the connection and hierarchical relationship between each knowledge point more clearly, so as to better understand and memorize the knowledge. This helps to improve students' learning effect and academic performance. Secondly, mind mapping can promote students' self-monitoring and regulating ability. In the process of mind mapping, students need to think about and organize their knowledge, and at the same time, they need to establish the connection between knowledge according to their own understanding and needs. This process requires students to continually reflect on and adjust their cognitive processes, thus improving their self-monitoring and regulation skills. This has a positive impact on students' learning autonomy and the application of learning strategies. In addition, the methods and techniques of mind mapping provide students with an effective way of learning. By independently formulating the steps and rules of mind mapping, students can actively participate in the learning process and improve their understanding and application of what they have learned. At the same time, teachers can use relevant teaching strategies and practical examples to guide students in the production of mind maps in order to develop their metacognitive abilities.

Overall, Mind maps have positively contributed to the development of students' metacognitive skills. However, there are still some problems and challenges, such as how to further improve students' use of mind maps and how to integrate mind maps with other teaching methods and tools. Therefore, it is hoped that future research will explore these issues in depth and provide more guidance and support to promote the overall development of students' metacognitive skills.

## 6.2. Outlook for Future Research

The drawing of mind mapping is an effective method for the development of metacognitive ability. The correlation analysis found that mind mapping is relevant to the three dimensions of metacognitive ability throughout the stages of pre-reading, learning, and reviewing. This study is beneficial for teachers to integrate mind mapping into their teaching.

In future research, teachers can further study the use and cultivation methods of mind maps to explore how to better guide students to use mind maps to organize and summarize their knowledge and further improve their learning effects. At the same time, teachers can also try to apply mind maps to different disciplines and teaching scenarios and explore the effects of their application under different fields. In addition, teachers can look for ways to optimize and improve the rules and steps of making mind maps to provide more detailed guidance and support.

In terms of teaching practice, efforts can be made to further research and develop specific teaching strategies and practice cases to help teachers better develop students' metacognitive abilities. At the same time, teacher can make an attempt to combine other teaching tools and methods, such as learning logs and study plans, in order to further enhance students' metacognitive abilities. By studying the role of mind mapping production on the development of students' metacognitive abilities, it can provide teachers and students with an effective teaching tool and method to promote the overall development of students' metacognitive abilities. In future research, it is expected to investigate the use and cultivation methods of mind mapping more deeply and provide more guidance and support for the improvement of students' metacognitive ability.

## References

- [1] Flavell, J. H. (1979). *Metacognition and cognitive monitoring: a new area of cognitive-developmental inquiry*. *American Psychologist*, 34(10), 906-911.
- [2] The Core Literacy Research Group. (2016) *Chinese students develop core literacy [J]*. *China Journal of Education*, (10): 1-3.
- [3] Dong Qi. (1989) *On Metacognition [J]*. *Journal of Beijing Normal University: Zhe She edition*, (1): 68-74.
- [4] Hu, Xiaoli. (2020). *Curriculum design and development based on mind mapping to develop elementary students' metacognitive ability (Master's thesis, Guangzhou University)*.
- [5] Wa, Yunyan. (2023) *Promoting the use of mind maps in teaching [J]*. *Elementary Science*, (6):97-99.

- [6] Sun Haolei. (2021) *Research on the enhancement of elementary school students' mathematical thinking ability by mind mapping [C]*. *Compilation of papers from South China Education Informatization Research Experience Exchange Conference (XI)*.
- [7] Chen Fei. (2021) *Practical research on improving the metacognitive ability of high school students by using mind mapping [D]*. Jiangxi Normal University.
- [8] Wu Y. (2021) *Research on the application of mind map in the English reading teaching of art and sports college students [D]*. Guangxi: Guangxi Normal University.
- [9] Cao Duanxi. (2018) *Research on the cultivation strategies of metacognitive ability in high school chemistry Teaching [D]*. Hubei: Central China Normal University.
- [10] Xu Mengfan. (2021) *Cultivating Language Thinking Skills of Upper Elementary School Students with Mind maps[J]*. *Knowledge Base*, (03):77-78.
- [11] Yang Guangping. (2021) *Mind map, so that the language knowledge clear "number" Talk about the development of students using the mind map to sort out the ability of language knowledge [C]*. //*Proceedings of the Symposium on Curriculum Teaching and Management (Chongqing)*. 1-3.
- [12] Fei Chen. (2021) *A practical study of using mind mapping to improve metacognitive ability of high school students [D]*. Jiangxi Normal University.
- [13] Chen Jinhua. (2015) *Teaching practice of improving the metacognitive ability of fifth grade students in mathematics [D]*. Shanghai Normal University.