

The Design and Application of High School Mathematics Collaborative Knowledge Construction Teaching Model

Jin Zhang^{1*}, Ping Li¹

¹ College of Mathematics and Information Science, Henan Normal University, Xinxiang, Henan, China

Email Address

1773301409@qq.com (Jin Zhang), liping18937760683@126.com (Li Ping)

*Correspondence: 1773301409@qq.com

Received: 10 May 2023; Accepted: 27 May 2023; Published: 10 August 2023

Abstract:

Cultivating innovative talents is an important mission of today's education. Designing effective collaborative knowledge construction teaching models to improve teaching effectiveness is one of the important research topics. Based on the theory of knowledge construction, this paper combs the teaching principles of knowledge construction, integrates intelligent technical means, and constructs the teaching model of high school mathematics collaborative knowledge construction. On the basis of the model, the progressive knowledge construction inquiry cycle of high school mathematics curriculum is discussed to break the artificial segmentation between knowledge in the discipline. The model has been explored and practiced in high school mathematics teaching, and it is found that it is helpful to cultivate learners' higher-order thinking ability such as mathematical thinking and innovative thinking, help the cultivation of innovative talents, and promote the high-quality development of education.

Keywords:

Collaborative Knowledge Construction, High School Mathematics, Mathematical Thinking, Teaching Model

1. Introduction

With the rapid development of the digital age, collaborative knowledge has become the basic form of learner interaction. In the high school mathematics classroom, it is also urgent to introduce collaborative learning to increase students' classroom interaction and thinking development. "Mathematics Curriculum Standards for Senior High Schools (2017 Edition 2020 Revision)" clearly points out that the core literacy of mathematics is a comprehensive embodiment of thinking quality, key ability, emotion, attitude and values with basic mathematical characteristics. Its development is a process of self-construction and continuous improvement. Teachers should closely focus on the key links of the development of the core literacy of mathematics, guide students to actively carry out constructive learning, inquiry learning and

collaborative learning from the real problem situation, and promote the transformation of students' mathematics learning methods [1]. In order to develop students' core literacy and promote the change of students' learning style, we must change the way of classroom teaching, pay attention to the overall design of real situation and classroom activities, guide students to construct independently and cultivate students' mathematical thinking. Therefore, it is necessary to construct a collaborative knowledge construction teaching model and introduce it into high school mathematics classroom teaching.

2. Knowledge Construction Teaching Principles

In the whole process of collaborative knowledge construction teaching, students are the main body of classroom teaching and the constructors of knowledge and cognition. The classroom has changed from 'teaching' to 'guiding'. Zhong Zhixian believes that the construction of knowledge includes individual construction and collaborative construction, and the two complement each other to make knowledge construction more complete and rich. [2] The teaching of knowledge construction is based on the 12 basic principles of its theory. Knowledge construction teaching seems to have no rules to follow. In fact, it is based on the principle of knowledge construction for independent teaching, so that students can develop independently. [3] Combing the teaching principles of knowledge construction as the theoretical basis for constructing the teaching model of collaborative knowledge construction.

Table 1. Teaching principles of knowledge construction.

Principle	Interpretation
Understanding starts from the real problems in life.	In knowledge construction, students try to deal with real problems and establish profound ideas and concepts to construct new knowledge.
All concepts and ideas can be improved.	Students' concepts and ideas are regarded as improving. Students construct knowledge in the process of continuously improving ideas and concepts.
Diversified ideas and ideas	It is a necessary process of knowledge construction for students to put forward diversified ideas and ideas.
Consciously enhance the level of discussion, to carry out more in-depth discussion	Through diversified and complex discussions, students continuously improve their ideas and understanding of knowledge, gradually integrate knowledge, create new theories, and learn broader principles and higher-level concepts.
Consciously participate in the process of leading knowledge construction	- Students take the initiative to find ways to improve knowledge; - Students independently set learning goals and plans, actively participate, and make self-assessment.
Common knowledge, collective responsibility for cognition	- Students contribute to the common learning goals of the group; - Students provide their own learning opinions and jointly assume the responsibility of improving group knowledge.
Create new knowledge democratization	All students can participate in the process of knowledge improvement and are proud to be involved in creating new knowledge.
Common growth in knowledge	Groups and members share and exchange their knowledge, which can promote common knowledge growth.
Constructing new knowledge without the limitation of time and space	Knowledge construction is not limited by specific situations or subjects. It is necessary to infiltrate the construction of knowledge into daily life.

3. The Construction of High School Mathematics Collaborative Knowledge Construction Teaching Model

```

graph LR
    A([Interpretation of curriculum standards, textbooks]) --> B([Determine learning])
    B --> C([learning situation analysis])
    C --> D([Create real problem situations])
    D --> E([Inquiry learning])
    E --> F([Explore independently])
    E --> G([Cooperative inquiry])
    F --> H[Self-construction]
    G --> I[Collaborative knowledge building]
    H <--> I
    H --> J[Preliminary improvement]
    I --> K[Deep improvement]
    J <--> K
    J --> L([Knowledge migration])
    K --> M([Knowledge migration])
    L --> N([near migration])
    L --> O([far migration])
    N --> P[Knowledge construction]
    O --> Q([Summary and review])
    P <--> Q
  
```

In the teaching model of high school mathematics collaborative knowledge construction, teachers determine the learning theme according to the high school mathematics curriculum standards and textbook content, and preliminarily understand the students' existing knowledge structure through learning situation analysis. On this basis, the real problem situation is created to carry out collaborative knowledge construction teaching, and the teaching method combining independent inquiry and cooperative inquiry is adopted. Independent inquiry middle school students form a preliminary cognitive structure through independent construction. In the learning group, they share their learning opinions with the help of knowledge construction dialogue in the way of cooperative inquiry to produce a new cognitive structure, and

then improve the knowledge structure through knowledge transfer, and finally complete the knowledge construction in the summary and evaluation. [5]

4. The Application of Collaborative Knowledge Construction Teaching Model

The constructed collaborative knowledge teaching model is applied to high school mathematics teaching. This process adopts a teaching method centered on cooperative inquiry and supplemented by independent inquiry to provide all students with opportunities to improve their knowledge. In cooperative inquiry, a progressive knowledge construction inquiry cycle is adopted, which is taken from the study of scientific research and emphasizes the cooperative inquiry that different learners can carry out. As shown in Figure 2, this progressive knowledge construction inquiry cycle process includes four main stages: (a) generating a preliminary view; (b) Connections of views; (c) Improving perspectives; (d) Forming knowledge. The center of this cycle is to improve the point of view. In the specific practical application, attention should be paid to starting from the real problem situation, causing students to put forward the initial point of view, exchange views to improve the point of view, and finally form knowledge construction.

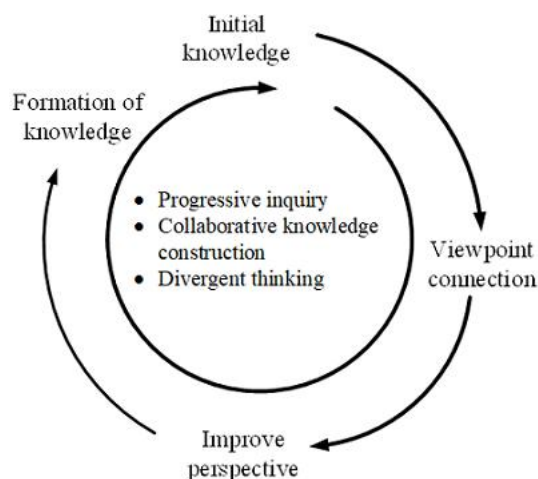


Figure 2. Progressive knowledge construction inquiry cycle process.

4.1. Forming problem situation-starting from the real situation

The teaching of knowledge construction begins with the formation of problem situations combined with students' real life. Students find interesting problems in real problem situations, and then trigger knowledge construction activities. In order to find the 'zone of proximal development' of each child, and then lead to deep constructive activities.

The purpose of forming a problem situation is to select scalable views or ideas from real problems. This requires teachers to return to the high school mathematics curriculum standards in teaching, rather than the teaching content of specific textbooks; so as to turn to the students' real concerns, from each student's recent development area to start teaching activities. There are many teaching strategies to form real problem situations in practical teaching. The main purpose is to link the teaching theme to real life, to observe natural phenomena outside the classroom, and to provide guiding hands-on experience. [6] For example, when learning the verticality of straight lines and planes in the second volume (2019 edition) of the

general high school mathematics compulsory textbook of the People's Education Publishing House, teachers can lead students to observe the vertical relationship between the flagpole and the ground projection on campus, and lead to the verticality of straight lines and planes from the real situation.

4.2. Lead students to put forward ideas-knowledge construction dialogue

Knowledge construction is centered on views and their development. In the teaching process, it is necessary to guide each student to put forward the corresponding correct or wrong, appropriate or inappropriate views that they feel or recognize in the problem situation. Knowledge construction starts from the real problem situation. Teachers use knowledge construction dialogue to guide students to generate theme-related ideas and problems in the cycle process, and further use dialogue to guide students to compare and contrast their own ideas with other different ideas to achieve the connection of ideas. The problems in the dialogue and inspiration teaching method of knowledge construction are different. Most of them are not instructive or suggestive. They mainly stimulate students to diverge their thinking and express their personal views freely to promote the formation of group knowledge structure.

4.3. Continuous improvement perspective-learning scaffolding support

In cooperative inquiry, a progressive knowledge construction inquiry cycle is adopted. In this cycle, students' improved views are the center of inquiry. Teachers need to use some learning scaffolds to guide the continuous growth of students' views in teaching.

Guide students to continuously improve their views with the help of knowledge construction circle. Establish a knowledge construction circle in the class, which is divided into individual, group, class and other levels of knowledge construction discussion circle; in the knowledge construction circle, learning individuals share personal views, and peers understand each other's ideas and debate and compare; find the basis of their own views, want to peer interpretation of their own views to defend; by communicating and debating with peers to improve their views, and timely modify and record views. In this process, teachers can design a series of teaching activities, such as related teaching experiments. [7] In the process of experiment, it can help students revise their theories or give them inspiration for the next experiment.

4.4. Forming knowledge-visualization

In theory, knowledge construction has been continuing in high school mathematics learning. Its short-term goal is to achieve the flexible standards described in the ordinary high school mathematics curriculum standards, and its long-term goal is to train students to become qualified citizens in the information age. Therefore, in a knowledge construction learning community, staged learning is guided by the gradual formation of 'theory'. For example, in the chapter of vertical line and plane, the origami experiment is used for cooperative inquiry. Students gradually form a group knowledge structure on the basis of self-construction, and then summarize the judgment theorem of vertical line and plane. This process will form knowledge visualization. Based on this, the theory of knowledge construction should be 'complex', comprehensive and regular. Of course, these theories can be personalized. The formation of class group knowledge is not instilled by teachers, but naturally formed by class groups.

4.5. Evaluation-the combination of process and value-added evaluation

In collaborative knowledge construction teaching, teachers 'evaluation of students' progress is a continuous behavior throughout the whole learning process, including process evaluation and value-added evaluation. Collecting and using a large amount of information in the learning process provides a well-founded and comprehensive description for students' learning. Some examples of reliable sources of evaluation data include: student questions, inquiry records, classroom observation tables, student works, etc. At the end of the learning process, value-added evaluation is carried out, focusing on the starting point and process of learners' learning. By collecting the performance data of learners before and after participating in knowledge construction, such as the scores of tests before and after teaching, and comparing these data vertically, the learning effect of learners is evaluated.

5. Conclusions

In the construction and application of the teaching model of high school mathematics collaborative knowledge construction, we should pay attention to the overall design of real situations and classroom activities, change the traditional classroom methods according to the teaching principles of knowledge construction, and carry out the progressive knowledge construction inquiry cycle in a combination of independent inquiry and cooperative inquiry. In the process of construction, we should use the corresponding learning scaffold to help students become better knowledge builders and cultivate students' mathematical thinking.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Funding

This work was supported by the 2023 Henan Normal University Graduate Research and Practice Innovation Project, grant number YZ202301.

References

- [1] Ministry of Education of the People's Republic of China. Mathematics Curriculum Standards for Senior High Schools (2017 Edition 2020 Revision). Beijing: People's Education Press, 2020.
- [2] Zhong, Z.X. Knowledge Construction, Learning Community and Understanding of the Concept of Interaction. *Electrified Education Research*, 2005, 11, 20-24.
- [3] Zhang, Y.B. Knowledge construction: the reform of teaching and learning from the perspective of new educational equity. Nanjing: Nanjing Normal University Press, 2018.
- [4] Ding, M.R.; Wang, T.J. Design and Application of the Trinity Teaching Model of "Knowledge Building, STEM and Maker Education" in Artificial Intelligence Teaching. *Electrified education research*, 2021,42(04), 108-114.
- [5] Wang, X.G.; Yang, S. Research on Collaborative Knowledge Construction Activities from the Perspective of Group Dynamics. *Modern Educational Technology*, 2020, 30(11), 55-61.

- [6] Guan, C.H. Research on the evaluation design and practice of individual knowledge construction supported by cloud class.Tianjin Normal University, 2022.
- [7] Tang, X.Y.; Xiong, Y. The realistic reflection, ability development and practice path of teachers' teaching autonomy under the new normal of teaching. *China Adult Education*, 2021, 519(14), 68-73.



© 2023 by the author(s); licensee International Technology and Science Publications (ITS), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (<http://creativecommons.org/licenses/by/4.0/>)