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Analysis of teaching function concepts in high school based on contextual cognitive learning theory

Fei Li, Jinhui Dong

Huanggang Normal University, Huanggang, China

Abstract: *Contextual cognitive learning theory is an important branch of the cognitive psychology school that places emphasis on developing students' problem-solving skills in different contexts and on the integration of students' knowledge and action. Under the guidance of contextual cognitive learning theory, teachers can analyse students' nearest developmental zone to understand their knowledge readiness and set multiple teaching objectives, so as to select appropriate contexts and cognitive strategies for instructional design. The introduction of contextual cognitive learning theory into the conceptual teaching design of high school functions can facilitate the transfer of knowledge to everyday life contexts, provide a reference for other researchers' research on contextual cognitive learning theory, and help high school teachers to use the theory in teaching in a complete and systematic way.*

Keywords: *contextual cognitive learning theory; high school functions; teaching concepts*

1. Introduction

In senior secondary mathematics, the traditional conceptual classroom is a closed learning environment where the knowledge acquired is too simplistic and prone to inertia, i.e. it is less likely to reflect the complexity of real-life contexts.[1] . The new curriculum standards proposes that the content of the senior secondary mathematics curriculum should be based on concrete real-life contexts, linked to real life and reflecting the value of mathematics in life. Functions are an important part of the secondary mathematics curriculum and the main content, and play a role in the senior secondary knowledge network.

Contextual cognitive learning theory is an important branch of cognitive psychology that emphasises the development of students' problem-solving skills in different contexts and the integration of students' knowledge and action. The introduction of contextual cognitive learning theory into the conceptual teaching design of high school functions can facilitate the transfer of knowledge to everyday life situations, provide reference for other researchers' research on contextual cognitive learning theory, and help high school teachers to use the theory in their teaching in a complete and systematic way.

The learning process of mathematical concepts is not only the process of students actively constructing knowledge, but also the process of learning to think mathematically, developing mathematical ability, perceiving mathematical ideas and accumulating experience in mathematical activities.[2] . The concept of function in high school is different from the concept of function learned in junior high school, which is more abstract and requires understanding the essence of function through realistic situations.[3] Li Yi explores the essential properties of the concept of function by analysing the existing textbooks and puts forward the shortcomings of the human version of the definition. Zhang Jiangyue starts with the teaching design, using the form of problem strings, and through interaction, triggers teachers to rethink the teaching of concepts.[4] . The research that has been conducted does not bring out the advantages of contextual cognitive theory in teaching concepts, and it is to be studied how to further integrate it into the teaching design.

Based on the requirements of the new curriculum and students' cognitive development, this paper uses the contextual cognitive theory as a guide to study the teaching design of the section on the concept of function. It aims to deepen senior secondary teachers' understanding of the contextual cognitive learning theory through this case study, and at the same time to provide guidance on the teaching of the concept of function and put forward corresponding teaching suggestions.

2. Contextual cognitive learning theory and its pedagogical implications

Contextual cognitive learning theory, established and developed by American psychologists Maslow

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and Rogers, emphasises that the individual mind often emerges from the environment that constitutes, guides and supports cognitive processes, and that the nature of cognitive processes is determined by context, which is the basis of all cognitive activity.

Contextual cognitive theories of learning focus on the interaction between physical and social scenarios and the individual, arguing that learning cannot be produced in isolation from specific contexts and that knowledge is constructed in context and cannot be separated from its contextual context. Wilson and Myers argue that thinking and learning are only meaningful in specific contexts and that context is the basis of all cognitive activity; knowledge is a highly context-based practice, a human ability to coordinate a range of behaviours to adapt to a dynamically changing and evolving environment.[5]

Dan Liu mentioned that contextual learning is to provide students with real tasks and activities, and that the creation of context has certain limitations in teaching mathematics, and that the creation of context should be more integrated with the knowledge learned.[6] Liu Yi and Gao Fang analyse the contextual cognitive theory view of learning, which classifies the essence of learning as a process in which the individual interacts with the environment, and in which the individual can continuously improve social practice.[7]

Many researchers argue that knowledge cannot be transferred without concrete contexts, otherwise the knowledge acquired by learners is 'dead knowledge' that cannot be used in a rational way. In traditional teaching, however, the focus is on the learning of abstract concepts and rules, and problem solving is seen as the application of concepts and rules, without problem solving as a direct teaching objective. It is therefore necessary to change the linear logic of traditional instructional design and to increase its adaptability and openness, which can be improved in the following ways: analysing students' preconceptions and understanding the nearest development area; considering the cultural context appropriate to the learning and choosing learning situations that reflect the transfer of knowledge and skills. The use of storytelling, cognitive apprenticeships, authentic activities, etc.; the use of the 'legitimate peripheral participation' learning model, which allows students to experience the process from peripheral participation to core knowledge acquisition, and collaborative learning to enhance learning outcomes.

3. Contextual cognitive learning theory-based design for teaching function concepts in high school

3.1 Textbook analysis

The concept of function is the 2019 Human Education A version of high school mathematics must be Chapter 3, Section 1, Lesson 1, junior high school has been the initial study of the concept of function, to understand the representation of two relational quantities and will use the five-point drawing method for function sketch, the high school level of learning is the concept of function of in-depth understanding, for the subsequent study of the basic elementary functions to lay the foundation, the idea of function is also an important mathematical ideas in secondary school mathematical ideas One of the most important mathematical ideas in secondary school.

3.2 Teaching priorities

Key points: mastering the use of sets and correspondence to describe functions and understanding that functions are important mathematical models for describing the laws of change in the objective world.

Difficulty: understanding the nature of the concept of a function and its notation $y = f(x)$, clarity$f(x)$ and $f(a)$ the differences and connections between

3.3 Teaching methods

The teacher uses a contextual introduction method to inspire students to inductively explore, and students engage in group work and communication to explore.

3.4 Teaching and learning process

3.4.1 Review of old knowledge

Question 1: Please recall how the functions we have studied in junior school are defined. What functions have you studied in junior high school?

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You have already studied functions in junior high school, so what is different about the functions you will study in senior high school? Ask your students to think about: (1) According to the definition of a function learned in junior high school, can you determine$y = 1, x \in R$ is a function?

(2)$y = x$ and $y = \frac{x^2}{x}$ Is it the same function?

After thinking and discussing, students find that the new questions conflict with their previous knowledge.

The teacher guides that it is difficult to answer the above questions with what we have learned in junior high school, and we need to further investigate the concept of functions, which is what we will learn today.

[Design Intention] Contextual cognitivism emphasizes that context is a necessary condition for learning to occur and take place, and has the function of guiding clues. Creating familiar situations that can be associated with junior high school knowledge allows new knowledge to be found in old knowledge, while making old and new knowledge related. Students have difficulty solving existing problems using the concepts of functions learned in junior high school, thus creating cognitive conflict and triggering students' curiosity and interest in learning.

3.4.2 Creating Context

Situation 1: The epidemic is affecting the whole country. A class has to order a group of masks and the teacher has contacted two shops selling them, both of which have similar quality masks and cost $3 each. After negotiation, shop A offers a 10% discount on each mask, shop B can waive the cost of three masks and offer a 95% discount on the rest of the masks, so which shop is a better deal to buy from?

Students will be able to appreciate the correspondence between variables inscribed in analytic form, so that they can note the range of variables and prepare for understanding the domain of definition later.

Scenario 2: Environmental issues have always been a real concern in various countries. In recent years, air quality has been a major concern for citizens, and Figure 1 below shows a line graph of the change in the air quality index PM2.5 in Xi'an in 2020.

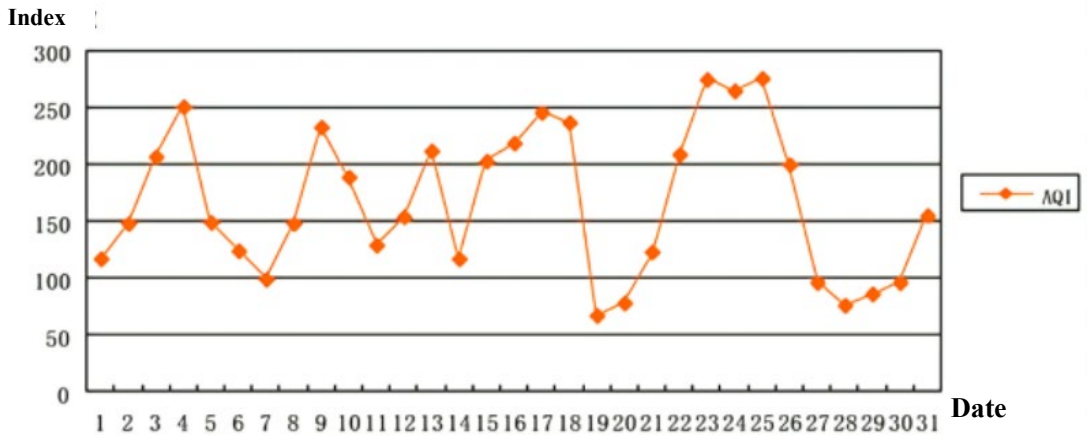

Figure 1: Folding graph of the change in AQI_PM2.5

Think: How is the AQI related to the date? Is the AQI I a function of the date t?

Scenario 3: Recently, I have heard students say that the prices of canteen meals are getting more and more expensive, so how have the prices of canteen meals actually changed in the last 5 years? The teacher created the following table1 by asking questions:

Table 1: Table of changes in food prices

Year (x)	2018	2019	2020	2021	2022
Price (y)	7	7.5	8	9	10

Think: What correspondence exists between the year and the price of a meal? Is the price of a meal, y, a function of the year, x?

Question: 2: What characteristics do the three situations above have in common?

Students get the characteristics of a variable changing with another variable through discussion, and

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get that they are all function relationships according to what they have learned in junior high school. The teacher adds to this by guiding students to summarise: both contain two non-empty sets of numbers, denoted by A,B; both have a correspondence that can be described as follows: each element x in the set A corresponds, according to a specific correspondence f, to a uniquely determined element y in the set B.

The design intention is that learning should take place in real situations. Therefore, we have created three situations that are of interest to students in their daily lives, so that they can experience the use of analytic equations, graphs and tables to describe the correspondence between variables, understand the background of the concept of function, and feel the basic idea that the concept of function originates from "reality". The idea of 'reality'. Students will be able to share and discuss the common features of the three examples, and develop the ability to investigate independently and to see problems from a connected point of view.

3.4.3 Developing the concept

Question 3: How do you understand correspondence? The teacher has thought of a story about a horse race in Tianji, does anyone know it?

Students: Tian Ji raced against the King of Qi, Tian Ji used his superior horse against the King of Qi's medium horse, his own medium horse against the King of Qi's inferior horse, and finally his inferior horse against the King of Qi's superior horse, so that Tian Ji won two out of three games.

Teacher: Tian Ji would have lost every race if he had used his own top, middle and bottom horses against the King of Qi's top, middle and bottom horses respectively, so what did Tian Ji change to win the race?

Students: Law of correspondence

Teacher: Yes, through the Tianji horse race, we find that mathematics is everywhere in life and plays a very big role.

Question 4: What is the range of variation in the price and year of the meal in Scenario 3? Can you represent them in sets?

The teacher guides students to express which numbers x takes, i.e. the range of values of the independent variable, and which numbers y takes, i.e. the range of values the function is worth, to get a feel for the existence of two sets of numbers.

Question 5: Can you describe the concept of a function in terms of a "set" and the corresponding language?

In general, let A, B be two non-empty sets of numbers, if according to some definite correspondence f such that for any number x in set A, there is a uniquely determined number f(x) corresponding to it in set B, then it is called$f: A \to B$ as a function from the set A to the set B, denoted as$y = f(x), x \in A$. where x is called the independent variable, x's range of values A is called the function of the definition of the domain and the value of x corresponds to the value of y is called the function value, the set of function values$\{f(x)|x \in A\}$ is called the value of the function domain.

[Design Intention] Designed under the guidance of situational cognitivism, the context is designed to stimulate students' active learning and to create a sense of achievement and meaning in the learning process. The mathematician Descartes once said, "Every problem we solve will be a model for solving other problems." When faced with a problem that is difficult to solve at a moment's notice, it is worth looking to 'historical experience' for inspiration[8] .History is the best heuristic. "History is the best heuristic".

3.4.4 Application of new knowledge

Example 1 A shell is fired and falls to the ground after 26s to concentrate the target. The projectile is fired at a height of 845m and the relationship between the height h (in m) of the projectile from the ground and the time t (in s) is$h = 130t - 5t^2$. Is the height of the projectile from the ground, h, a function of time t? Why? , as shown in Table 2.

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Table *2: Complete the following table:*

Functions	Linear functions	Quadratic functions		Inverse proportional function
		$a > 0$	$a < 0$	
Correspondence				
Definition field				
Value Range				

The students will be able to use the concepts they have learned to reconceptualize the primary, secondary and inverse functions.

3.4.5 Re-contextualisation

Question 6: Through the study of the concept of function, try to compare the similarities and differences between the traditional and recent definitions of function?

Students think and discuss.

The teacher shows a micro-video on the history of functions, divided into four stages: the "analytic theory" stage, the "variable dependence theory" stage, the "variable correspondence theory" stage, and the the "set correspondence" stage. Teacher's Note: The traditional and modern definitions of a function are essentially the same, with the same domain of definition and value, and the same law of correspondence. However, the traditional definition is described from the point of view of dynamic change, while the modern definition is described from the point of view of sets and correspondence.

[Design Intent] To guide students to do macroscopic thinking and analysis of the function concepts they have learned in junior and senior high schools, to integrate their knowledge from junior and senior high schools, to break through previous cognitive conflicts, and to further understand the nature of senior high school function concepts.

4. Conclusion

With the new curriculum reform, we promote context-based learning, believing that learning in a practical context facilitates understanding the ins and outs of knowledge and the transfer of knowledge. Consequently, teachers should choose contexts that arouse students' interest, engage their enthusiasm, involve them in complex, realistic, problem-centred activities, and support them in gaining the knowledge they want. At the same time, one should not get caught up in the idea of just creating situations; it is also extremely important to de-contextualise and extract conceptual knowledge in a timely manner.

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