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A Study on Developing Computational Thinking in Junior High School Based on Bebras Competition Test Questions

Xiaoyan Jian[1,a,*], Guo Yang[1,b]

[1]*Higher Vocational and Technical College, Chengdu Neusoft University, No. 1 Neusoft Avenue, Qingchengshan Town, Dujiangyan, Chengdu, China*
[a]*JianXiaoYan@nsu.edu.cn*, [b]*GuoYang@nsu.edu.cn*
**Corresponding author*

Abstract: *With the development of technology, citizens in the digital age need to learn not only to use computer technology and equipment but also to learn the disciplinary thinking and methods of computer science. Computational thinking, as one of the core literacies of information technology, is closely related to our life, work, and study, and even affects the future development and progress of our society, so it is crucial to cultivate students' computational thinking. Since domestic information technology focuses more on basic computer knowledge and basic operations, and neglects the cultivation of computational thinking, to cultivate students' computational thinking, the article analyzes and introduces the Bebras competition test questions and the keywords of the test questions, and finds that by solving the Bebras competition test questions, the five skills of abstraction, algorithm, decomposition, evaluation, and generalization of computational thinking need to be used, which is conducive to improving Then, we analyzed the application of Bebras competition test questions, and finally, we summarized and looked forward to the Bebras competition test questions.*

Keywords: *Computational Thinking, Information Technology, Bebras Competition Test Questions*

1. Introduction

Computational thinking is a series of thinking activities that cover the breadth of computer science, such as problem-solving, system design, and understanding human behavior using the basic concepts of computer science [1].It is a basic ability that digital citizens should have. By searching CNKI with "middle school computational thinking" or "middle school computational thinking" as the subject term, we found that the cultivation of middle school computational thinking in China is mainly distributed in Information technology courses, graphical programming, programming teaching, mathematical computing, python, artificial intelligence, etc., but there is less research on the development of computational thinking through test questions like Bebras. Therefore, the purpose of this paper is to introduce the Bebras competition questions and analyze how computational thinking is reflected in the Bebras competition questions, and make some suggestions to help develop students' computational thinking in China.

2. Computational Thinking and Bebras Competition Questions

2.1. Computational Thinking

In recent years, more and more attention has been paid to the cultivation of students' computational thinking abilities in China. Curriculum Standards for Information Technology in Senior High Schools (2017 edition) include computational thinking as one of the core literacy of information technology. The curriculum standard points out that: "Computational thinking refers to a series of thinking activities generated in the process of solving problems by individuals using the thought methods in the field of computer science. Students with computational thinking can define problems, and abstract features, establish structural models and reasonably organize data in information activities in a way that can be processed by computers. Through the judgment, analysis, and synthesis of various information resources, using reasonable algorithms to form a solution to the problem; Summarize the process and methods of using computers to solve problems, and transfer them to other related problem solving [2]."

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For the cultivation of computational thinking, many countries are trying to incorporate it into the K-12 education curriculum, trying to improve students' computational thinking ability from the aspects of computer science, information technology, writing, painting, reading, final examination, programming, and so on [3]. As for the elements of computational thinking, Cynthia Selby et al. proposed that computational thinking techniques include five elements: abstraction, algorithmic thinking, decomposition, evaluation, and generalization [4]. At present, there is no unified definition of computational thinking in China, but many scholars agree on the main elements of computational thinking. Five elements should be included: abstraction, algorithm, decomposition, evaluation, and generalization [5]. The identification of each element is shown in Table 1. Next, this paper will analyze the questions of the Bebras competition from these five elements, and demonstrate that the questions of the Bebras competition are conducive to improving students' computational thinking.

Table 1: Computational thinking skills and identification methods

Computational thinking skills	Computational Thinking Skills Ways to Identify Computational Thinking Skills
Abstraction	Remove unnecessary details; Discover the key elements of the problem; Select a systematic form of description.
Algorithm	Thinking in order and according to rules; Executing algorithms; Creating algorithms.
Decomposition	Decomposition of tasks; Thinking in terms of components; Making divisions with integration in mind.; Decision making for tasks.
Evaluation	Finding the best solutions; Making decisions about the rational use of resources; Adequacy of objectives.
Overview	Identify patterns as well as similarities and connections; Solving new problems based on those already solved; Using generalized solutions, such as induction.

2.2. Bebras Competition Questions

The Bebras competition questions come from the Bebras International Computational Thinking Challenge, which was first held in Lithuania in 2004 and has a history of 16 years. The goal of the competition is to improve students of all ages' abilities in informatics and computational thinking and promote algorithm-based, logical, and operational thinking based on informatics. The International Bebras Organizing Committee determines the following criteria for questions: they reflect information science, computer science, or computer literacy; Can learn from experience; It can be solved in three minutes; There are levels of difficulty; Age appropriate for participants; Independent of any curriculum; Independence from specific information technology systems; Have an easily understood problem system; Can be displayed on a screen page; Can be solved on the computer, does not depend on other hardware, software, paper, pen; Politically correct; It should be interesting; There should be pictures; There should be interactive elements (simulation, solution activities); Immediate feedback should be given [6].

The test item structure of the Bebras Competition consists of nine parts: title, difficulty, classification, keywords, questions, answers, analysis, knowledge related to computational thinking, and contributors. Domestically, the test items of the Bebras Competition are divided into six levels according to grades, and the difficulty of each level is further divided into difficult, medium, and easy. Each question may appear in different grades, so the questions in the Bebras competition spiral upward and move forward in waves [7]. The classification of test questions involves five knowledge fields of informatics. Core concepts are integrated through vivid and interesting stories, colorful pictures, concise tables, and principles of games, thus shaping the characteristics of lifestyle, gamification, and scenography [8]. The test questions of the Bebras Competition are also widely used. Kyungbin Kwon et al developed an assessment framework using Bebras questions to determine students' level of problem-solving [9]. Vinikien and Lina et al. proposed that the concept of programming could be introduced into primary education through Bebras questions [10]. Chiazzese G et al. regarded the Bebras competition questions as a tool to measure students' computational thinking [11]. P Hubwieser

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et al. To test and adopt the methodology of future PISA surveys in Computer Science[12] To test and adopt the methodology of future Pisa surveys in computer science [12]

Based on 149 test questions of junior high school Bebras Competition from 2010 to 2018 as samples, the keywords were statistically analyzed and visualized through the Ciyun website "Weiciyun", as shown in Figure 1, it could be seen that knowledge in the field of informatics was most commonly applied, which had a lot in common with knowledge points of information technology courses. Thus, Bebras Competition questions can be integrated with information technology courses, which will be further explained below.

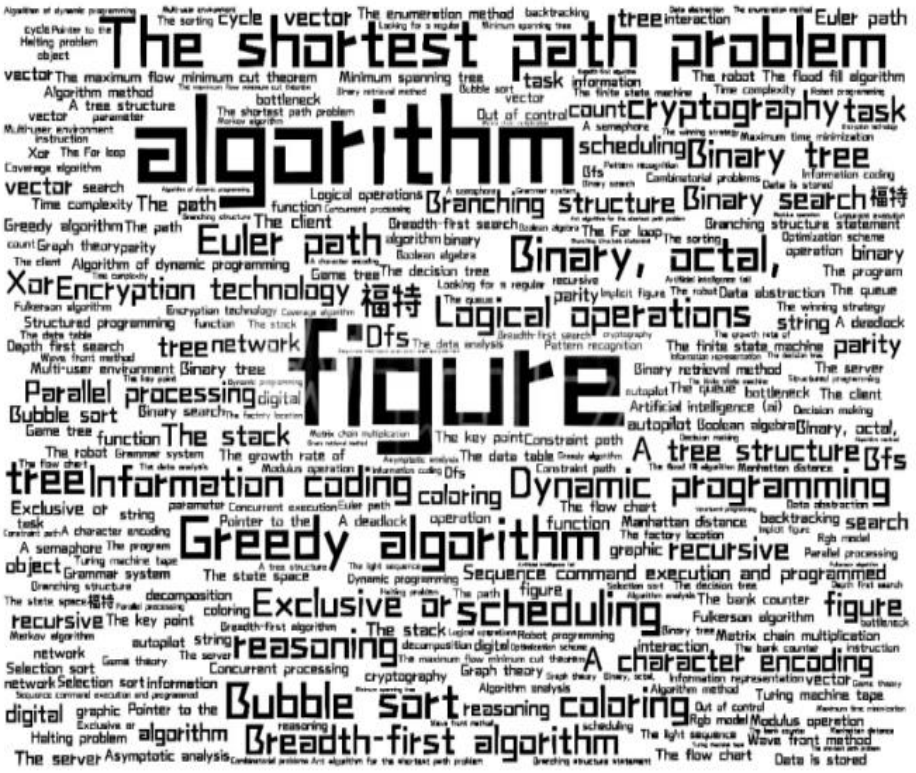

Figure 1: Bebras competition test keyword graph cloud.

3. Computational Thinking in the Bebras Competition Test Questions

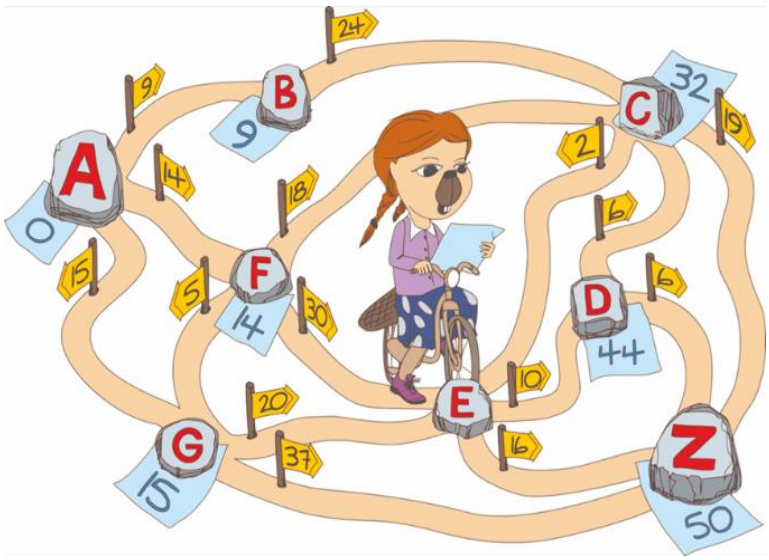

Figure 2: Exploring the Path.

In order analyze how computational thinking is reflected in the Bebras competition questions, we

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focused on the computational thinking skills needed to solve the questions. In this analysis, one question from each of the five knowledge areas of the Bebras competition was randomly selected for the junior high school level, for a total of five questions, as shown in Table 2. The computational thinking skills column was not included in the original text, but was analyzed by the author based on a table comparing the content of the questions with the computational thinking content and methods of identifying them. The table shows that each question uses several computational thinking skills, and the following will be an example of the "2016-LT-08 Exploring Pathways" question to analyze how computational thinking is reflected in the test questions.

Table 2: Computational thinking in the Bebras competition test questions

Field of Informatics	Test title	Brief description of test questions	Test keywords	Computational thinking skills
Algorithms and Programming	Swimming	The options give the beaver a swimming route. Repeat the actions of the options to determine which will take him farther from the starting point	Algorithms logo programming spiral structure	Abstraction Algorithm induction
Algorithms and Programming, Data, Data Structures and Data Representation	Explore the path	Beavers visit villages by bicycle, each village is marked with a letter, and the distance and direction between villages are marked with yellow flags. Beavers mark the distance from village A to other villages with a slip of paper in each village to determine the exact meaning of the numbers.	turtle drawing algorithms shortest path problem Dijkstra algorithm graph	abstraction Algorithm Evaluation Induction
Computer Processing and Hardware	Magic Numbers	Alina uses a table to control the numbers displayed by the LEDs and needs to determine what numbers will be displayed in the given table	7-segment display LED Encoding	abstraction decomposition induction
Interaction, Systems and Design	Fake News	There are four beavers with different views on the truth or falsity of the news, and it is necessary to determine what situation can make all four beavers think the news is true	Redundancy True or False Fake News	Decomposition Evaluate Summarize
Communication and Networking	Beaver Network	There are three gray and black beavers each, by rule through the channel network, the order of known beavers at the exit, to determine the order of beaver entry is what	Finite State Automata Reset sequence	Abstraction Decomposition Evaluate

Clavia rode her bicycle around the various nearby villages to find routes through them. As shown in Figure 2, each village has a stone with a single letter marker, and all roads between villages are marked with distances and directions on small yellow flags.

After many different rides, Clavia leaves a blue slip of paper under each village rock. The number on the slip is the distance she measured from village A to this rock.

What is the exact meaning of the number she marked on the blue note?

A. The length of the shortest path from village A to the village with the least number of villages.

B. The shortest distance from village A to that village.

C. The shortest path from village A to the village that turns left if it meets a junction.

D. The shortest path from village A to the village that turns right if a junction is encountered.

This question examines the knowledge content belonging to the field of informatics algorithms and programming, data, data structures, and data representations. From the keywords it can be seen that the topic examines the Dijkstra shortest path implementation of the graph as well as the algorithm, which mainly examines the ability to learn computational thinking of abstraction, algorithm, evaluation, and generalization, which is reflected in the topic as follows.

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Abstraction: In the process of reading the question students need to ignore unnecessary graphical information in the graph, such as bicycles, beavers, small yellow flags, rocks, etc., extract the key elements such as the letters on the rocks, the numbers and directions on the flags, and the numbers on the blue paper strips, in addition to the need to refine and summarize the stem of the test question, abbreviated as the meaning represented by the numbers on the paper strips according to the numbers and directions on the flags, and then according to the This process requires the use of abstraction skills.

Algorithm: This question mainly investigates the shortest path problem. In the process of solving the problem, students have a series of problem-solving processes in mind and need to think in terms of rules, which is equivalent to creating an algorithm and then executing this algorithm, i.e. Dijkstra's algorithm, which is characterized by expanding from the starting point to the endpoint and calculating the shortest path from one node to other nodes. Although students do not necessarily know this algorithm during the problem-solving process, they will be able to understand that the solution they use is Dijkstra's algorithm through the analysis of the Bebras competition questions and the detailed explanation of this algorithm made by the knowledge related to computational thinking, and they can use Dijkstra's algorithm to solve the shortest path problem. This process requires the use of algorithmic skills.

Evaluation: When solving the problem, students can exclude the wrong option by elimination. When judging the options, students need to use the option as a hypothesis and then verify this hypothesis by calculation, for example, if option C is correct, then the numbers under the stones of village C, village D, and village Z should be 45, 45 and 52 respectively, so option C is wrong; the same goes for options A, B and D. Finally, the correct answer is B This process is to find the best solution to the problem, such as elimination, or reasoning based on the topic, and then use the known information to infer, make a decision, and finally find the option that fits with the inference, to get the correct option, here the skill of assessment is used.

Summarize: Through the topic analysis and computational thinking related knowledge inside the explanation and cases, students can understand the shortest path, Dijkstra's algorithm, in life, if encountered similar to transportation network selection, food delivery range planning, urban rail transit, intelligent parking, communication line construction of such shortest path problems, to find the similarity and connection of the problem, and then based on the solved The Dijkstra algorithm is applied to solve the shortest path problem. This process uses the skill of induction.

Through the above analysis, we can find that solving the test problem "Exploring Paths" requires the skills of abstraction, evaluation, algorithm, and induction of computational thinking, which are mainly reflected in reading the problem, solving it, checking the analysis, and summarizing and transferring knowledge. Students can use these skills implicitly by doing the problem, and they need to use the computer to solve the problem in a way that can be processed, and in the long run, students' computational thinking skills will be improved.

4. Application of Bebras Competition Test Questions

4.1. Integrating Bebras Competition Test Questions into the Information Technology Curriculum

Research shows that there is a significant relationship between computational thinking and the quality of computer programs [13]. Therefore, the application of Bberas competition questions in information technology courses can effectively improve students' computational thinking ability. In January 2018, the release of Information Technology Curriculum Standards for Ordinary High Schools (2017 edition), It teaching materials for junior middle schools take the IT curriculum standard and academic quality level of senior high school as the target benchmark and connect from the aspects of concept, content, practice, and evaluation [14]. The content includes optimization processing strategy, bubble sort, choice sort, insertion sort, exhaustive method, recursive algorithm, binary search, greedy algorithm, backtracking algorithm, and other knowledge points.

As these contents require strong computational thinking for junior high school students, the knowledge is relatively boring, and the information technology courses are usually conducted in the computer room, the change of the environment may make students become impetuous and distract their attention. Since the questions are short and do not require much time, it is feasible to integrate the questions of the Bebras Competition into the information technology courses. On the one hand, information technology courses can be used as context introductions to arouse students' enthusiasm for learning. Let the students quickly enter the learning state, and cultivate computational thinking. The

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method used to do the questions is also equivalent to previewing the content of the course and preparing for the following learning. On the other hand, it can be used in the course to test the learning situation of the students in this class. According to the keywords of the questions of the Bebras Competition, Table 3 lists some questions of the Bebras Competition corresponding to the knowledge points of junior middle school information technology courses. For example, when talking about the section on the preliminary exploration of sorting algorithm, the questions related to sorting can be selected from Table 3 and integrated into the class, taking "Sorting by Weight 2013-FR-13" as an example.

Table 3: Bebras competition questions corresponding to the knowledge points of junior high school IT curriculum

Course content	Bebras item name	Bebras competition keywords
Optimum processing strategy	The way home	Dynamic programming
	T way	Graph theory method, dynamic programming, algorithm
	COINS	Directed graph, the greedy algorithm
	Hide and seek	Tree traversal, the optimal value data analysis
	To collect pollen	Greedy algorithm
	The selfish squirrel	Swarm intelligence, ant algorithm
	Arrange a fireman	Tree traversal, the optimal value data analysis
	The postman tour	Euler path, China's postal problem (CPP), shortest path, and optimization
	Multiple road	Graph theory, the website
Bubble sort	Line up	Bubble sort, looking for a final state, finite state machine, the finite state automata
Selection sort	Sorted by weight	Bubble sort
Insertion sort	An integer sorting	cycle
	Bowl factory	Filling, bubbling sinking
Exhaustive method	Latin square	Latin square, match, the exhaustive method
A recursive algorithm	Invalid character sequences	The recursive method
	t-junction	Graph theory method, dynamic programming, algorithm
Divide and conquer algorithm	Help lonely beaver looking for companions	Figure, complete graph, recursive algorithm
	warehouse	Binary search
	One half	Scheduling, parallel processing
	Find out the thief	Collection, repeat in half, binary retrieval method, an ordered list
Greedy algorithm	COINS	Directed graph, the greedy algorithm
	To collect pollen	Greedy algorithm
	Cargo ship problem	Problems of optimization, the greedy algorithm
	Transport of logs	Greedy algorithm
	Super hero	Scheduling problem, the greedy algorithm

4.2. Using Bebras Competition Questions as a tool to Evaluate Computational Thinking Skills

Because the purpose of the Brabras International Computational Thinking Challenge is to improve the ability of informatics and computational thinking, while the reliability of the questions in the Bebras Competition is greater than 0.50 in decomposition, abstraction, logical deduction, etc., with good internal consistency and reliable reliability [14]. Lockwood also adopted Bebras competition questions in the teaching process to evaluate students' computational thinking ability [15]. It is feasible for this Bebras competition question to serve as a measuring tool to evaluate students' ability of computational thinking. For example, the Bebras trial can be used as a pre-testing tool. Since the questions of the Bebras competition are independent of the specific information technology system, there are easy-to-understand question systems that students can answer even without prior knowledge of informatics, and their abilities in abstraction, algorithm, decomposition, evaluation, and induction of computational thinking can be explored through pre-testing. It can judge students' initial computational

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thinking ability, to better grasp what each student has advantages in and what ability needs to be further strengthened, to serve the future teaching and teach students according to their aptitude. In addition, the questions from the Bebras competition can also be taken as a post-test. For example, after taking the information technology course of a chapter, multiple questions from the Bebras competition related to the chapter can be extracted to understand students' mastery of the chapter. Through the pre-test and post-test, the higher the scoring rate of the students, the higher the ability of computational thinking, can apply the concepts of computer science to solve problems in other fields.

4.3. Using Bebras Competition Questions as a Tool for Developing Students' Computational Thinking

H Delal et al. based on the Bebras competition questions as unplugged classroom activities in the classroom, and found that the grades of the classes that implemented the activities were significantly improved. Therefore, to improve students' computational thinking ability, the Bebras Competition questions could be given to students when they were able to study. Let students practice according to their own time and willingness, because the test itself is interesting, open, and innovative, and the solution method given by the analysis is often a new way. For example, in the question of "Exploration Path" above, students may guess and mask when solving the problem, but through the analysis, they can know that this problem uses Dijkstra shortest path implementation. Dijkstra's algorithm is also introduced so that students have a deeper understanding of it. Students not only exercise their computational thinking but also gain different problem-solving methods from the analysis. In addition, they cultivate their computational thinking ability and innovative thinking, so that they can not stick to traditional problem-solving solutions and improve their problem-solving ability.

5. Summary and Prospect

Computational thinking is an important concept of IT core literacy, which is fundamental to people's thinking and problem-solving, and is a necessary skill for students in the digital era. To improve students' computational thinking skills, this paper analyzes the content of the test questions and finds that in solving each test question, 3-4 of the five skills of abstraction, algorithm, decomposition, evaluation, and generalization of computational thinking are applied, which can effectively improve students' computational thinking skills. In addition, through the analysis of junior high school information technology textbooks, it is found that the curriculum content has a certain correspondence with the Bebras competition test questions, and the Bebras competition test questions can be integrated Bebras can be integrated into the IT curriculum and used as a pre-test and post-test tool to evaluate students' initial computational thinking skills and their mastery at the end of the course, as well as a tool to develop students' computational thinking.

Since Bebras tests are not yet popular in the field of computational thinking in China, the advantage of Bebras tests over other tools for improving computational thinking is that they do not require students to have a priori knowledge of informatics and are not dependent on computer equipment, they can be used more easily and flexibly in teaching and learning, so teachers can use Bebras tests as a disciplinary and assessment tool in the classroom in the future. In addition, they can also encourage students to actively participate in these computational thinking competitions to improve their computational thinking skills.

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