Research on the Application of Graphical Programming to Promote Students' Computational Thinking

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Abstract. Computational thinking is an essential core quality of talents in the new era. Graphical programing language such as Scratch builds runnable programs through drag and drop, which is intuitive and easy to learn. Graphical programing can help cultivating students' computational thinking greatly. This paper introduce the design and implementation by Scratch of the popular "Mid-Autumn Festival Bo cake" game in China to show how Graphical programming helps develop students' computational thinking. Firstly the rules of Bo-cake is introduced, then the flow chart is introduced to help clarify the train of thought, afterwards the runnable program is implemented. In the process of teaching and edutainment, introducing abstract concept with concrete realization, we should spread national culture, cultivate students 'advanced ability such as computing thinking and practical innovation, improve students' problem-solving capability. This paper provides a guidance example on teaching computing thinking for front-line teaching.

Keywords: Computational Thinking · Graphical Programming · Mid-Autumn Festival Bo cake · National Culture

1 Introduction

With the sweeping of the Internet wave, the social needs of all walks of life have changed tremendously. Knowledge is updated faster and faster, industry changes from time to time. In April 2018, the Ministry of Education released the Action Plan of Education Informatization 2.0 to promote the development of education informatization in the new era and cultivate a new engine for innovation-driven development, which is based on emerging technologies such as big data, artificial intelligence and Internet of Things [1]. With the rapid development of society, the traditional information literacy is facing many challenges. The new era of information literacy with "computational thinking" as the core has attracted much attention.

X. Yuan et al. (Eds.): ICEKIM 2023, AHCS 13, pp. 1094–1103, 2023.
https://doi.org/10.2991/978-94-6463-172-2_115

Computational Thinking (CT) [2] is a method of thinking in computer science, including the entire process of analyzing problems, dismantling them, proposing and implementing a solution to them. Programming education is an important tool for developing "computational thinking", which involves multiple links such as problem analysis, model abstraction, algorithm design, program implementation, debugging and optimization. These processes can effectively inspire students' creative ability, enhance their abstract thinking and logical thinking, and cultivate their hands-on ability to solve practical problems. The traditional mode of cultivating computational thinking is mainly realized through programming language such as C language and C + +. Code-based programming has a rigorous program structure and clear process, but it is not easy to learn and difficult to understand when reading. This is not friendly enough for most of the programming beginners, and it is easy to discourage learning enthusiasm. In fact, any programming language is essentially a tool, and the focus of developing computational thinking is to guide students to use it to express their creativity or ideas and solve some problems in life.

Scratch is a graphical programming tool for children aged 6–16 which is developed by MIT. It is easy to understand and has been known as the software version of Lego. The block-based programming language, which weakens the syntax of programming languages, allowing students to focus on the design and creation of their work. Users only need to drag the relevant building blocks to complete the construction of simple programs, which is of great significance for teenagers and liberal arts students to practice programming skills, develop computational thinking, and express creative ideas. It is very suitable as an introductory programming course.

In the United States, Scratch is not only widely offered in elementary and middle schools, but also recommended as an introductory programming software for students in the basic computer courses of world-renowned schools such as Harvard and University of California, Berkeley [3]. In this paper, we present a detailed introduction of programming methods for the development of computational thinking based on the Scratch platform, using the "Mid-Autumn Festival Bo cake" game as an example. This paper integrates the development of computational thinking into the traditional culture of "Mid-Autumn Festival Bo cake"game, in order to provide reference experience for front-line teachers to design and teach computational thinking in the curriculum.

2 Related Research

Computational thinking is considered to be an essential skill for digital citizens. How to cultivate computational thinking has attracted lots of attention from domestic and international scholars. In abroad, research on computational thinking started earlier and has achieved many rich and valuable academic achievements. Gamification, visualization and physical programming are the current classical models for the cultivation of computational thinking. Some scholars have also guided students' thinking through mind maps [4] to promote the development of computational thinking. Countries such as United States, England and Finland have incorporated the development of computational thinking into their K-12 curriculum [4]. Wang [5] even introduced computational thinking into preschool education, and research has shown that educators' professionalism influences the development of computational thinking in young children. Finland advocates

interdisciplinary education and adopts a de-computerized teaching model which integrate computational thinking development into the curriculum of physical education and music [6]; Berk [7] uses English learning as a vehicle for cultivation of computational thinking. In recent years, domestic scholars have also explored the cultivation of computational thinking from different perspectives. XiNa Jiang [8] constructed a framework for children's games to cultivate computational thinking based on children's gamified programming; XuQiuxuan [9] proposed a model for cultivating computational thinking based on "experiential learning circle" and applied it to the theme of "future smart classroom" practice programming; Ding Shiqiang [10] explored the idea of project-based teaching model to cultivate students' computational thinking, and conducted a comparison experiment in the course of "Algorithm and Programming" with remarkable effects. Zhang Wenlan [11] pointed out that educators (teachers) is the important role in the cultivation of computational thinking. LiYang [6] studied the interdisciplinary model of computational thinking education in Finland, who called on the government and schools to attach importance to the education of computational thinking, interdisciplinary and game-based instructional design thinking, and improve the programming literacy of normal students. Based on Piaget's stage theory of cognitive development, Sun Lihui [12] divided the stages of computational thinking cultivation and explored the teaching strategies in each stage to provide reference options for teaching practitioners.

Nowadays, many scholars have conducted explorations related to the development of computational thinking, mainly in conceptual explanation, literature review, methodological exploration, and empirical research, and less in programming classroom exploration integrating traditional culture. The" Mid-Autumn Festival Bo cake" game is an exploration of programming teaching that integrates Chinese traditional culture to promote THE development of computational thinking.

3 Design and Implementation of "Bo Cake" Game in Scratch

Culture is an important force for national survival and development. General Secretary Xi Jinping clearly put forward that we should adhere to the four self-confidence. Cultural self-confidence is the most important, which is a significant soft power of building the strong socialist country in China. The 14th Five-Year Plan puts forward the strategic goal of building a strong cultural nation by 2035, further enhancing the influence of Chinese culture and strengthening the cohesion of the Chinese nation. The " Mid-Autumn Festival Bo cake" game is an important intangible cultural heritage in China. It originated in the Qing Dynasty, which was invented to relieve the soldiers' homesickness and inspire their morale when Zheng Chenggong expelled the Dutch and barbarians to recover Taiwan in 1661 coincided with the Mid-Autumn Festival. After the accumulation and precipitation of history, it has become a popular folk custom around southern Fujian. "Bo cake" game have functions of divination, game, blessing and educational. The whole process is an educational and fun cultural transmission process [13].

3.1 Contextual Experience, Game Design

Situational teaching method [14] uses specific activity scenes to build a teaching objective and teaching content theme, which can effectively stimulate students' learning initiative, enhance their creativity and deepen their understanding of the learning content. Contextual experience has special value and significance in cultural transmission and thinking cultivation. In the teaching of "Bo cake" game, we first let the participants initially understand the rules and experience the game. Subsequently, the rules of the game are summarized together through teacher guidance, and the background and roles included in the game are designed, etc.

"Bo cake" is designed by the title of the imperial examination system, which contains 1 "Number One Scholar", 2 "Opposite Hall", 4 "Three Hongs", 8 "Four Entries", 16 "Two Lifts", 32 "One Show". In order to simplify the programming, we grouped all the different types of scholar as "Number One Scholar". The classical rules of "Bo cake" are shown in Table 1.

The case integrates computational thinking into the problem solving process of "Bo cake" game. The "result" role has 7 shapes, including "official rank" and a state of not winning. Participants need to use 6 dice to play the game and can shake them randomly, so the switch "shake" and 6 dice roles are added, where each dice contains 1–6 six shapes. The roles and rules of game can be seen in Table 2.

Table 1. The rules of "Bo-cake".

Official Rank	Alias	Description
XiuCai	One Show	one 4-point out of six dices
JuRen	Two Lifts	two 4-point out of six dices
JingShi	Four Entries	four 4-point out of six dices (except for four 4-pointers)
TangHua	Three Hongs	three 4-point out of six dices
BangYan	Opposite Hall	The six dices are "1", "2", "3", "4", " 5" and "6"
ZhuangYuan	Number One Scholar	five or more of the same number out of six dices / four or more 4-point out of six dice

Table 2. Roles and rules in game

Role	Game Rules
Shake	Click "Shake", six dices shake at the same time
Dice(6shapes)	Click "Shake", the dice shake a random time and then stop
Result(7shapes)	Judging result of "Bo cake",according to state of six dices after the shaking stops

3.2 System Design, Built in Layers

Flowcharts visually describe the specific steps of a problem solution. Empirical studies [15] show that flowcharts can promote students' computational thinking skills. In this part, we sort out the specific process of the Mid-Autumn Festival "Bo cake" game with the help of flowcharts.

1) **The overall process of "Bo cake"**

The game involves three roles: shake, dice and result. Scratch can realize the communication between multiple roles through broadcasting function. When the button "shake" is clicked, the role broadcasts a message of starting the "Bo cake" game to the six dices and plays the music; the dices receive the message, start to rotate, stop at a certain number in a random time, and then send results to the "result". When the "result" receives the message that all the dices are finished, it gives the corresponding "Bo cake" result shape. Figure 1 shows the flowchart of the communication between the various roles of the "Bo cake" game process.

2) **Discerning the result of "Bo cake"**

The result of "Bo cake" game is determined by state of six dices. Computer can't discriminate directly like the brain, so we need to help to calculate the result in some way. Analysis of the "Bo cake" game, we know that the results of "Bo cake" are divided into 6 categories, and there are many different sub-categories in each category. For example, the most popular "Number One Scholar", the rules are 5 or more identical numbers or 4 or more 4 points in six dices. Which requires a large number of conditional combination judgments to discriminate, slightly cumbersome to implement directly. Similarly, "Opposite Hall" needs to be"123456″ in six dices, and "Four Entries" is 4 dices with the same number of points in six pices (except for four 4-point). Others, "One Show", "Two Lifts", "Three Hongs" can be directly judged by the number of points 4. Therefore, this paper provides a layered design for the "Bo cake" results, breaking down the big problem into smaller problems and modularizing the implementation. Figure 2 shows the flowchart of the role "result". Among them, the three results of "Number One Scholar", "Opposite Hall" and "Four Entries" are designed with customized blocks to realize the modularization idea. The rest of the results are presented directly with conditional judgment statements.

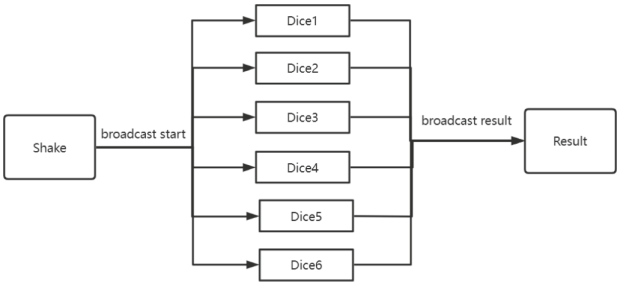

Fig. 1. Flowchart of communication between roles

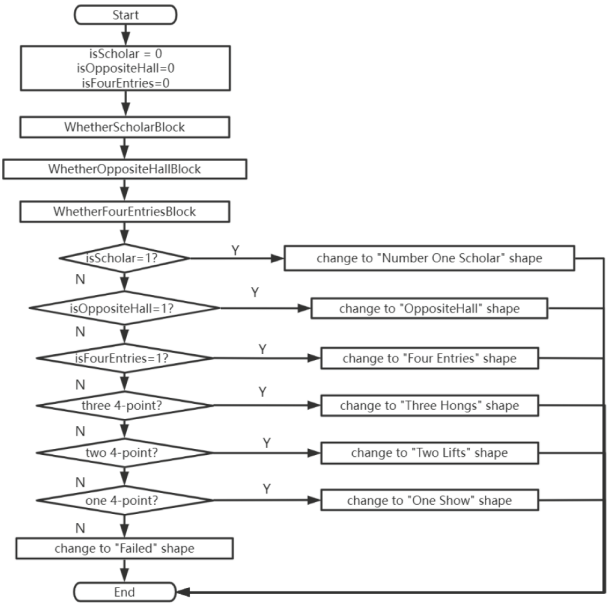

Fig. 2. Flowchart of "Bo cake" game

3.3 Key Code Design and Implementation

Program = Data Structure + Algorithm. Based on the reasonable storage of data, the data can be processed more efficiently, and thus achieve an efficient program [16].

The "Bo cake" game involves six dices, and the intuitive idea uses six variables for storage. However, if they were stored in this way, the implementation of the program would be quite cumbersome when determining the results. Looking at the six dices variables carefully, they all store the number of dice points and have the same properties. We can use an array storage structure which is list variables in Scratch. And then, the value of relevant element can be quickly traversed by a loop. For this purpose, in the "Bo cake" project, we create a list of 6 items "dice points", which holds the number of dice points. For example, the result is stored in the list "dice points" as "010203", which means that the number of "1" is 0 and the number of "2" is 1, the number of "3" is 0, the number of "4" is 2, the number of "5 " is 0, the number of points "6" is 3, and the corresponding "Bo cake" result is "Two Lifts". Other "Bo cake" results refer to the "Bo cake" rules in Table 1.

Problem solving, modular thinking is one of the important indicators of computational thinking. According to the previous analysis and design, we introduce the modularization idea for "Number One Scholar", "Opposite Hall" and "Four Entries". The three types of "Bo cake" with relatively complex rules are extracted into independent sub-problems to be solved. Take the example of the "Number One Scholar"., we customize a block to determine the result: whether it is "Number One Scholar".When the list of "dice points" has four or more 4-point or 5 or more same number of points, the result is the "Number One Scholar". In the process of implementation, we introduce the

variable “isScholar” (the initial value is set to 0) and iterate through the list data by loop. If current list item is the 4th item (i = 4) and the corresponding value is greater than 3, then we set the “isScholar” to 1 and exit the program (stop the script). Otherwise, if the i-th item in the list is greater than 4, the “isScholar”is also set to 1 and the program is exited. The concrete implementation is shown in Fig. 3.

Regarding to “Opposite Hall”, We determine whether all six dices points are 1, which is more troublesome to implement directly. Adopt reverse thinking, suppose the result of the “Bo cake” is “Opposite Hall”. As long as it has a number of dice that is not 1, then it is not “Opposite Hall”. Therefore, we introduces the variable “isOppositeHall” and initializes it to 1.The other parts and the design idea of “Four Entries” are similar to that of “Number One Scholar”, no further elaboration here. The specific process of determining the results of “isOppositeHall” or “isFourEntries” is shown in Fig. 4 and Fig. 5.

Fig. 3. Modular code implementation of custom blocks “whether NumberOneSchola or not”

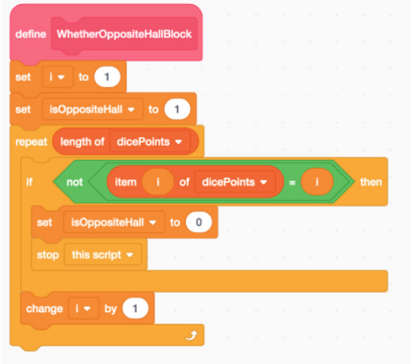

Fig. 4. Modular code implementation of custom blocks “whether OppositeHall or not”

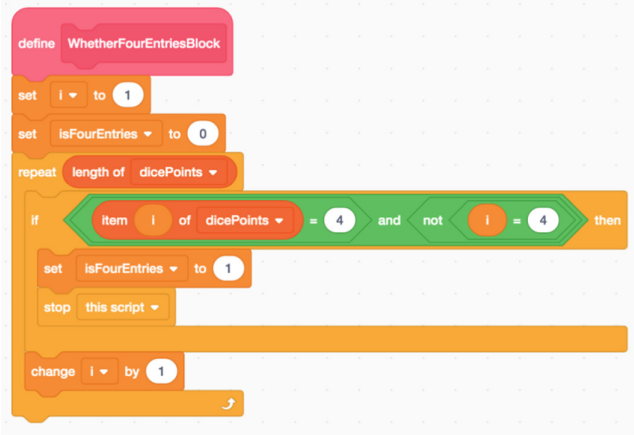

Fig. 5. Modular code implementation of custom blocks "whether FourEntries or not"

So far, the "Bo cake" game that is close to life has been basically realized, and its operation effect is shown in Fig. 6. During the teaching process, We create problem situations that is conducive to the cultivation of computational thinking, guide students to summarize the rules of game, analyze the overall task and the flow of communication between roles and write key codes for each role. So as to complete the training process of computational thinking that uses the basic concepts of computer science to solve problems, system design and understand human behavior. In specific projects, teachers can guide students to experience the application of computational thinking in programming projects through various attempts, so that they can realize the linkage between behavior and consciousness of "thinking and doing" when solving problems. It allows students to experience the joyfulness of success and enhances their interest in active exploration, ultimately achieving the goal of consolidating knowledge and improving their personal problem-solving ability.

Fig. 6. The effect of *"Bo cake"* game

4 Conclusion

The cultivation of computational thinking is based on life, guiding students to observe life, think about life in practice, and deepen their understanding of computational thinking. The "Bo cake" game is an example to demonstrate the programming method based on computational thinking, which integrates computational thinking with the teaching of folk culture and guides students to use computational thinking to solve concrete problems in life. The whole realization process, tracing the origin of cultural and being close to the reality of life, not only conducive to cultivate students' abstract thinking, but also helps them to understand and integrate into learning, cultivating computational thinking, practical innovation and other abilities while having fun. In the future, we will try to design and implement a series of courses on Chinese traditional festival customs with the help of graphical programming tools to promote the cultivation of computational thinking and spread Chinese traditional culture. During the learning, it will deepen students' understanding of Chinese culture, inspire students' patriotism and love for family, and establish students' national self-confidence and cultural self-confidence.

Acknowledgment. This research was funded by Education and Research Projects for Young and Middle-aged Teachers in Fujian Province (Science and Technology, Build a topic analysis platform for computing thinking research based on Flask framework, JAT220481). Thank you for their support.

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