Research on the Design of Primary School Students' Programming Curriculum Based on Scratch

Xiaoya Yang[1], Qi Chen[1, 2, *]

[1]Computer and Information Engineering College, Hubei Normal University, Huangshi 435002, China

[2]Graduate School of Hubei Normal University, Huangshi 435002, China

[*]Corresponding author: 106062628@qq.com

Keywords: Scratch, Programming, Primary School Students, Curriculum Design.

Abstract: In recent years, artificial intelligence has received widespread attention, and programming education has gradually become popular. With its unique advantages, Scratch, an educational software for children's programming, has been welcomed by more and more people. How to use the Scratch, set it as a curriculum and apply it to education is a question that information technology educators have been studying and thinking about. The research starts from the highlights of the Scratch programming software, combined with the characteristics of the physical and mental development of primary school students, and designs from the aspects of curriculum goals, curriculum content, curriculum organization methods, teaching methods and evaluation methods, in order to provide some useful ideas for teachers who engage in the construction and development of primary school Scratch programming courses.

1. Introduction

With the rapid development of big data, cloud computing, and artificial intelligence technologies, society will gradually enter a new era of intelligence. In 2017, the State Council issued the "Development Planning for a New Generation of Artificial Intelligence", incorporating the youth programming plan [1]. In 2018, the Ministry of Education issued the "Education Informatization 2.0 Action Plan", which requires the improvement of the programming curriculum for primary and secondary schools [2]. As an important way of cultivating young people's information literacy, information technology has gradually upgraded with the advance of the times. Scratch programming software has been continuously recognized and promoted in recent years. With its visual and modular language, it has become one of the most widely used and most popular programming tools in the field of children's programming [3].

2. Research status

Taking "Scratch curriculum design" as the key word, the research searches relevant papers (with April of 2021 as a deadline) on CNKI. The result is 56. CiteSpace software is chosen to carry out co-occurrence analysis of the key word, count the results of word frequency, and then present the top 10 in descending order. (Table 1), the word frequency table selects the top 10 keywords in descending order. It can be seen from Table 1 that the current research hotspots are concentrated in Scratch, computational thinking, school-based curriculum, curriculum design, maker education, and Scratch teaching. However, there are very few research on curriculum designs related to Scratch. Therefore, the design of Scratch courses can help elementary students master certain information technology, understand algorithmic problems in life, cultivate students' innovative spirit and overall thinking, and provide a certain reference for the promotion of Scratch programming language in elementary school information technology classrooms.

Table 1 "Scratch Curriculum Design" word frequency and centrality analysis

Co-occurrence frequency	Key words	Centrality
29	Scratch	**0.73**
14	Computational thinking	**0.32**
8	Maker Education	**0.13**
8	School-based curriculum	**0.21**
7	Instructional design	**0.14**
5	Course Design	**0.08**
5	Micro course	**0.27**
4	Scratch teaching	**0.18**
4	Scratch programming	**0.11**
3	Creativity	**0.08**

3. Analysis of Scratch's relevance to elementary school students

3.1 Software introduction

Scratch software is a children's programming tool designed and developed by the Massachusetts Institute of Technology. The design of Scratch is inspired by the Scratch Toy logo and block-based programming concepts [4]. Scratch integrates a full-featured building block that can provide support for multimedia images, sounds, videos, etc. The interface is simple and easy to use. Children only need to drag the building blocks with the mouse to complete their own works. Besides, it is not only rich in style and wide in coverage, but also can share and communicate with other creators, reflecting the social nature of learning. Scratch, as an iconic graphical programming language, is popular around the world and has been translated into more than 40 languages.

3.2 Characteristics of Primary School Pupils

Primary school students generally refer to students who enter elementary school at the age of 6-12. They are interested in new things in specific images and have rich imagination, but it is difficult for them to focus on a specific learning activity for a long time because of the lack of clear learning goals and steady attention [5]. Students at this stage are interested in visualization, and Scratch’s visual graphics are more in line with the characteristics of primary school students’ cognitive development.

3.3 Relevance analysis

The basic characteristic of pupils' thinking development is the gradual development from concrete image thinking to abstract thinking, but this kind of abstract logical thinking is mainly supported by perceptual experience. The Scratch software programming method is graphical, with diverse instructions, rich meaning, and visualization. Scratch deepens the memory of students and helps them to transit from concrete thinking to abstract thinking [6]. Scratch software programming show the imagination and creativity of primary school students by stimulating their imagination and encouraging them to design their own creative works. Students’ imagination has evolved from fragmented and fuzzy images to more and more accurate and complete reflections of reality.

4. Curriculum Design for Primary School Students Based on Scratch

The design of primary school Scratch curriculum is a key step in the implementation of primary school programming education. The Scratch course needs to be designed based on the characteristics of low threshold, high boundary, wide range of subjects, cooperation and sharing, strong interest, and strong system, combined with the psychological characteristics of elementary school students. Therefore, this research is designed from the basis of curriculum design, the determination of curriculum objectives, the selection of curriculum content, the way of curriculum organization, teaching methods, and teaching evaluation.

4.1 Design Basis

The extension module of "Basic Education Information Technology Curriculum Standard (2012 Edition)" contains related content of "algorithm and program design" [7]. The curriculum standard stipulates that at the elementary level, teachers should use the "building block" programming language to enable students to understand the basic ideas, components, and development tools of "programs" and experience "algorithmic thinking". Based on this standard, this research integrates knowledge points into specific projects and divides them into "trilogy" according to the difficulty and comprehensive knowledge level, allowing students to complete the construction of programming knowledge in practice. According to psychological development levels and knowledge levels of different ages, it sets educational goals, select appropriate educational strategies, provide diversified education, encourage students to practice information technology and innovation. The teaching method can adopt gamification or task-based mode, respect individual differences of students, and pay attention to the special development needs of individual differences when setting tasks so as to guide students to "learn by playing", improve their learning efficiency, and lead them to adopt a spiral learning style.

4.2 Establish course goals

There is currently no institution in our country that clearly sets out the goal of the Scratch course. However, the content of the content of information technology related to programming in elementary schools in my country's compulsory education stage requires programming experience and algorithmic thinking as the main content. Students can understand programming structure, the meaning of algorithm and problems appeared in real lives through programming learning. As a result, this research raises a three-dimensional goal which is in line with the Scratch curriculum in primary schools.

(1) Knowledge and ability objectives

Understand the meaning of programming ideas and programming structure; use information technology to collect relevant information to solve problems, analyze problems, determine information needs, and design solutions based on information needs; apply computational thinking to problem solving; understand the characteristics of software and be good at Programming; can use programming software such as animation and games.

(2) Process and steps objectives

In the teaching process, teachers use teaching methods such as lecture method, task-driven method, inquiry method, and collaborative method to integrate creativity into programming in the process of learning programming, and use the network platform to publish their own programs to cultivate students' expression Ability, logical thinking ability, independent problem-solving ability, etc.

(3) Emotional attitude and values objectives

Cultivate students' logical thinking through programming-related learning, and cultivate students' active and rigorous learning attitude and curiosity through autonomous exploratory learning. Collaborative learning cultivates the spirit of communication and mutual support, cooperation and sharing among students. Script writing, cultivate students' innovative thinking. Teaching students correctly use information technology and become qualified citizens of the information society.

4.3 Select course content

The content of Scratch courses in elementary schools should be based on the content that students are interested in, mobilize students' enthusiasm for learning, and focus on cultivating students' innovative thinking and collaborative learning abilities. Therefore, the course theme is usually taken from the document of the course standard. The choice of learning topics should take the cognitive level of primary school students into consideration and be closely related to students' lives.

Since there is no unified Scratch textbook in our country, this research designed the content of the curriculum based on the national curriculum standards and the characteristics of elementary school students, combined with teachers' previous teaching experience. This research selects the textbook *Scratch 3.0 Fun and Gaming Programming for Kids* which shows the process of creating 15 interesting

mini games and mini programs in Scratch3.0 with pictures and texts [8], and distinguishes elementary, intermediate and advanced levels according to the age and psychological development of elementary school students. It also introduces the basic skills, ideas and methods of Scratch3.0 programming.

Table 2 Scratch course content

learning stage	course project	knowledge point
Grade 1	Getting to know Scratch	**Scratch3.0 editor introduction, environment construction, “Hello World” applet**
Grade 2	Scratch programming preparation	**Scratch basic concepts (9 points), basic concepts of programming (6points)**
Grade 3-4	Elementary Game Programming One	**Let’s find the difference, explore the maze, hit the moles, flip through the fun**
	Elementary Game Programming 2	**Underwater world, pinball, electronic photo album, white Christmas**
Grade 5-6	Intermediate game programming	**Runaway bunny, greedy snake, double gomoku, "rock, paper, scissors" man-machine battle National Airplane Battle, Bubble Shooter, Plants vs. Zombies**

4.4 Course organization design

Since the release of Scratch in 2007, scholars at home and abroad have begun to practice, explore and research Scratch teaching. At present, typical teaching modes include gamification mode, innovative thinking spiral mode, fun and creative mode, flipped classroom mode, and interdisciplinary teaching mode [9]. According to the design requirements of the teaching strategy, combined with the characteristics of the Scratch course and the game, this paper designs the following gamified and task-based teaching strategies.

Design based on gamification teaching mode.

First, game level design strategy: in the process of gamification teaching, the most important thing is to teach knowledge to students, and the knowledge should be combined with games through design. In gamification teaching, teachers can design the entire teaching content as a "clearance map". According to the difficulty and level of Scratch's teaching content, different tasks are set up.

Second, motivation and reward strategy: In order to stimulate students' learning motivation and cultivate students' interest in learning, it is necessary to use some real game situations and reward settings. In addition, in order to effectively make students more focused in class, an appropriate punishment system can also be adopted.

Third, the communication feedback strategy: in the process of gamification teaching, it can provide students with a space for free communication and create opportunities for interaction. In the process of the game, there may be some unachievable cooperation, through communication and interaction to solve the problem, not only mastered the programming knowledge, but also greatly improved the student's learning efficiency and interpersonal skills.

Fourth, competition and cooperation strategy: The design of competition mechanism in gamified learning can stimulate learners' challenge spirit and self-motivatedness, but the choice of competitive partners should be based on their own level and choose the right one for both parties. Collaborative strategies can cultivate learners' cooperative spirit and a sense of collective honor. In promoting competition and collaboration, teachers can also provide some performance display tools, such as rankings, so that students can clarify their learning progress and promote positive motivation.

Fifth, evaluation strategy: evaluation should run through the entire process of the game, and teachers should also evaluate the overall performance of students' learning.

(1) Design based on task-driven teaching method.

It is designed according to the new Scratch curriculum standards and combined with the characteristics of task-driven teaching methods.

First, create situations and educate through entertainment. Before the class, teachers create a suitable situation according to the personality of the students, combine with the content arrangement of scratch, stimulate students' interest and learning motivation, create a favorable situation and propose their own design tasks.

Second, lead students and adopt task-based teaching. Teachers should not hurry to explain and analyze tasks. They should provide students with some time and motivate them to explore. Teachers need to guide students to think and encourage them to boldly find ways to solve problems.

Third, solve problems and complete tasks. At this stage, the teaching mode and the student's collaboration to complete the task is the core. Teachers actively participate and guide students to ask questions. Students need to experience the process of completing the task, rather than solving problems with the help of teachers.

Fourth, present learning outcomes and exchange evaluations. In Scratch's task-driven teaching, there are many kinds of evaluation methods and evaluation subjects. Evaluation mainly depends on the enthusiasm of students to complete the task. Each group can be evaluated between groups or within groups. Teachers can set up a target evaluation scale to evaluate each group.

4.5 Choice of teaching method

The teaching method emphasizes the organization of teaching, the transfer of knowledge, and the way of knowledge expression. Commonly used teaching methods generally include task-driven, inquiry-based, collaborative, demand-driven, competitive, etc. [10]. The research is based on Scratch's four teaching principles of "creation, personalization, sharing, and reflection"[11], Combining different course content and course objectives, choose the appropriate teaching method. In the design of the Scratch course, you can consider a variety of design methods such as scenes and role-playing to experience the fun and educational nature of game learning. Teachers should stimulate children's learning motivation based on the primary school students' play-loving nature's psychological characteristics and interests, so as to finally make them have a good command of programming and experience the joy of learning.

4.6 Evaluation of Scratch Children's Programming Course

(1) Evaluation on students

Children are the main body of educational activities. Through the implementation of Scratch children's programming courses, they can be evaluated in a process-oriented manner, and students' procedural performance can be evaluated and recorded and appropriately guided. Create opportunities for students to communicate, help them understand their own learning, stimulate their interest in learning, and promote personality development.

(2) Evaluation on teachers

As the leader of educational activities, teachers are important participants in the Scratch programming project for all children. Teacher assessment helps to understand the strengths and weaknesses of teachers, and can further help the construction and growth of the teaching staff.

(1) Evaluation on courses

Scratch's children's project through the evaluation of the course itself, helps to understand whether the course content meets the actual situation of education, and helps to carry out the follow-up construction of the Scratch children's programming course.

5. Conclusion

Scratch, as a representative of graphical programming tools, has clear operating characteristics and a solid theoretical foundation. At the same time, whether subject teachers can combine the scratch media environment or programming principles with appropriate subject knowledge content, there are many factors that need to be considered in practice. For example, programming education and subject

integration, technical equipment support, and the proficiency of teachers and students in technical operations need to be further discussed. Through the design process of this research, we found that children's programming education model can be implemented in school classrooms. The education model provides a wider range of choices, and we need to create a diversified environment for children's programming education in more depth.

Acknowledgements

The authors gratefully acknowledge the financial support from 2019 Hubei Normal University Basic Education Intelligent Education Service Innovation Model and Technology Research Project (2019CZ011) funds.

References

[1] Chinese Government Network. The State Council issued the "New Generation Artificial Intelligence Development Plan" [J]. Radio and Television Information, 2017, 304(08): 9.

[2] Jia Cuiju. Scratch programming education teaching design and practice research for primary school students oriented to the cultivation of computational thinking[D]. Hebei University, 2020.

[3] Xiong Qiu'e,Ge Yue. An Empirical Study on Scratch Game-based Programming Cultivating Primary School Students' Computational Thinking[J].Basic Education,2019,16(06):27-35.

[4] Sun Lihui,Zhou Danhua. The design and construction of children's programming education teaching model based on Scratch——Take elementary school science as an example[J].Education Research,2020,41(06):75-82.

[5] Xie Ying. Design and practice based on Scratch2.0 elementary school information technology programming teaching module[D]. Mudanjiang Teachers College, 2019.

[6] Chen Guihua.Using Scratch programming teaching to cultivate students' innovative ability[J]. China Modern Educational Equipment,2020(12):44-46.

[7] Information Technology Education Professional Committee of China Educational Technology Association. "Basic Education Information Technology Curriculum Standard (2012 Edition)" [EB/OL]. http://www.ictedu.cn/upload/2012_05/12050408248528.pdf.

[8] Li Qiang, Li Ruoyu. Scratch2.0 fun programming for children's games [M]. Beijing: People's Posts and Telecommunications Press, 2018.

[9] Yang Hainan.A Literature Review of Scratch Programming Teaching Model in Primary and Secondary Schools[J]. Education Modernization,2018,5(22):167-168.

[10] Peng Xufu,Du Shuangyun.Construction of four-tier teaching model and example design of demand teaching model[J].Journal of Hubei Normal University (Philosophy and Social Sciences Edition),2020,40(01):115-118.

[11] Wang Xuqing.Learning to program, programming aids-A review of the 2014 Harvard University Scratch Course[J]. Modern Educational Technology,2016,26(05):115-121.