HiLL PUBLISHING

Advances in Computer and Communications, 2023, 4(5), 283-288
https://www.hillpublisher.com/journals/acc/
ISSN Online: 2767-2875

Design and Development of Machine Learning Curriculum for Middle School Students' Computational Thinking Development

Yanan Cao

Yongcheng Municipal Party Committee Office, Yongcheng, Henan, China.

How to cite this paper: Yanan Cao. (2023) Design and Development of Machine Learning Curriculum for Middle School Students' Computational Thinking Development. *Advances in Computer and Communication*, 4(5), 283-288.
DOI: 10.26855/acc.2023.10.004

Received: September 20, 2023
Accepted: October 16, 2023
Published: November 14, 2023

***Corresponding author:** Yanan Cao, Yongcheng Municipal Party Committee Office, Yongcheng, Henan, China.

Abstract

Computational thinking, as a core skill necessary for the 21st century, has become an indispensable ability to adapt to the future digital intelligence era. It is also the most effective way for countries around the world to cultivate top-notch creative talents. With the growing recognition of the significance of computational thinking, it has gained popularity and has been extensively developed in countries worldwide. Python programming and machine learning have revolutionized the field of programming education. Therefore, this paper develops a set of courses for junior high school students using the KNN algorithm in machine learning. The courses focus on air quality prediction and are designed to enhance students' programming ability and computational thinking skills by incorporating the 5E teaching model. Moreover, applying the KNN algorithm to curriculum teaching makes a significant contribution to improving the teaching level of junior high school curriculum and the learning efficiency of students. It also provides a more effective approach to cultivating students' comprehensive literacy.

Keywords

Computational thinking, Python, machine learning, course design

1. Introduction

With the rapid development of information technology, human beings have gradually entered the era of intelligence marked by computers, the Internet, and big data. The application of these new technologies is widely affecting various fields in society and promoting the innovation of various industries. Education, as the best way to train students to adapt to the current intelligent era, is bearing the brunt of the impact. In this trend, the education field should be oriented to the current field of highly advanced technology to cultivate students' abilities in all aspects, and it is the best way to cultivate the top innovative talents. Computational thinking, with its universality in all disciplines, has become a vehicle for this change, gaining widespread attention not only from society, schools, and parents but also from countries around the world.

There are various ways to cultivate computational thinking, common visual programming software, such as Scratch software, Micro: bit and other drag-and-drop software, software and hardware combined with robotics programming, tangible programming, as well as card-based, puzzle-based unplugged programming education methods are all important ways to cultivate computational thinking [1]. However, this visual or unplugged programming approach can only improve students' computational thinking skills from the thinking level, but not for programming skills or even deeper applications of computational thinking. At the same time, the current programming curriculum is loosely organized, with unreasonable difficulty gradients, making it boring and difficult to stimulate students' interest in programming. Machine learning, as a hot research field in the direction of artificial intelligence, is often taught at the

university level to explore the implementation of its algorithmic principles, and how to downscale it to the junior high school level is also very valuable. powerful functions. Therefore, this study attempts to develop machine learning-related content based on the Python language, deconstructing and rearranging the content to meet the cognitive level of middle school students and to master the content related to artificial intelligence and machine learning.

2. Literature Review

2.1 Global trends in the development of computational thinking

The development of computational thinking is always inseparable from its core literacy skills, such as problem-solving, solution design, and problem-solving. Since middle school is an important time for "competency development," the development and improvement of computational thinking cannot be bypassed. In recent years, education leaders around the world have committed to integrating computational thinking into the process of curriculum development, and constantly revise the current curriculum standards or introduce corresponding national policies, trying to align with the international frontier of computational thinking, such as the United Kingdom from 2014 to include computational thinking in the curriculum standards of junior high school [2]. Poland, a country with a long history of computer programming education, also incorporated computational thinking in its 2016 reform of the compulsory education curriculum standards and set goals to be achieved at each year level; in 2019, the Australian Institute of Computing released the "Coding and Computational Thinking, What is the Evidence?" research report, clearly stating that programming has become a core literacy like listening, reading, and writing, enabling students to acquire problem-solving skills in all subject areas [3]. Meanwhile, in 2022, the European Commission Joint Research Centre published the report Reviewing Computational Thinking in Compulsory Education, stating that 27 EU countries in a new round of surveys have identified computational thinking as an important competency to be developed in compulsory education [4]. This shows that the boom in the development of computational thinking abroad has reached full coverage.

In China, the importance of computational thinking in the future development of the digital intelligence era is also clear, and we continue to promote the popularization of computational thinking at all levels. 2018, the Ministry of Education issued the report "Education Informatization 2.0 Action Plan", pointing out the need to improve programming curriculum programs and curriculum standards related to programming [5]. In the response letter to the 2020 proposal, the Ministry of Education replied clearly that it needs to develop relevant policies to promote the development of programming education, and also focus on the integration and arrangement of programming courses and programming resources [6]. Even the content related to programming and computational thinking has been added to the secondary and high school exams in various provinces and cities to integrate the learning of programming and computational thinking into the compulsory subjects. In the report of the 20th Party Congress, General Secretary Xi Jinping pointed out that the development of science and education is a strategic support for the comprehensive construction of a modern socialist country, and to realize the trinity of education, science and technology, and talent training in all aspects, and to focus on creating talents that meet the needs of the era of digital intelligence. The gradual improvement of national policies is accompanied by the gradual development of local programming features, forming a double-wheel-driven development rhythm of top-level construction and local policies.

2.2 Conceptual evolution of computational thinking

The first mention of the concept of computational thinking should be traced back to 1980 by Professor Simon Papert in his book Mindstorms: Children, computers, and Powerful Ideas [7]. However, a clear definition of computational thinking was not given, and at this time, computational thinking was mostly biased towards computer thinking and therefore not well known. It was not until 2006 that Jeannette M. Wing, with her unique insight into the future value of computer education from the perspective of computer science, creatively clarified the exact concept of computational thinking, stating that computational thinking encompasses all thinking activities of problem-solving, system design, and understanding human behavior with the mind of a computer [8]. Subsequently, Jeannette M. Wing added two more additions to the concept of computational thinking in 2008 and 2010. At this point, the concept of computational thinking was clarified and attracted the attention of many domestic and international scholars, while the exploration and definition of its concept did not end, but also has not yet reached a unified opinion. However, researchers mostly agree that computational thinking is a variety of abilities that extend from the process of procedural problem-solving. In 2015, ISTE jointly with CSTA gave an operational definition of computational thinking:

computational thinking is an integrated thinking skill that includes a problem-solving process based on computer science knowledge and the development of the learner's personality, attitude, and other competency dimensions in this process, as reflected in the five dimensions of algorithmic thinking, problem-solving, critical thinking, creativity, and communication and exchange skills [9]. Among them, Brennan and Resnic, on the other hand, proposed a three-dimensional framework for computational thinking based on visual Scratch programming, dividing computational thinking into various programming concept dimensions such as loops, objects, sequences, etc.; the practical dimension of designing problem solutions using computational concepts; and, the perspective dimension of how to view the surrounding world and problems with a computer perspective [10]. In contrast, Zhang Jinbao, a domestic scholar, thinks that computational thinking actually extends from computing education and gradually becomes independent in the process of computing education development [11]. Therefore, a three-dimensional perspective of computational science, cognitive development, and generalization should be integrated to rethink computational thinking. The concept and core competencies of computational thinking have also been gradually refined in the exploration of scholars around the world and have different developmental goals and requirements at different school levels.

2.3 The effectiveness of machine learning in developing computational thinking

Machine learning, as the core of the field of artificial intelligence, can effectively contribute to the development of education, computing, and other fields, and provide a constant impetus for educational innovation [12]. Python language has developed rapidly and has long been introduced into the teaching of primary and secondary school classrooms, and writing code for machine learning using the Python language is an excellent way for middle school students. A curriculum developed based on the Python programming language can combine the abilities of various dimensions of computational thinking to drive students' learning. Fu Qian et al. decomposed the computational thinking competencies into problem definition, problem-solving, pattern matching, data abstraction, and algorithm design, and designed a Python curriculum system for developing computational thinking in high school students, which broke the traditional teaching model and enabled students to show more logic and motivation [13]. Yue Yanlong et al. combined gamified programming with the Python programming language, breaking the limitations of traditional programming and working to develop the core goals of the IT curriculum and computational thinking skills [14]. Singapore has even implemented the "All for Kids" program, which aims to cultivate students' interest in machine learning and artificial intelligence and to introduce programming into the classroom to practice basic problem-solving skills for everyday life [15]. This shows that the development of students' programming skills and computational thinking literacy should undoubtedly start with the specialized Python text programming language.

3. Python language-based machine learning course design

This study is oriented to the cultivation of computational thinking and promotes the cultivation and development of students' computational thinking skills through the content related to machine learning, and teaches the course content by adopting the easy-to-use Python text programming language. On the one hand, it deepens students' understanding of programming concepts and improves their understanding of programming; on the other hand, it integrates computational thinking knowledge into the classroom content and implicitly improves students' computational thinking. In this study, we designed a series of machine learning courses for middle school students based on the theme of "air quality" and applied the "5E" teaching model to practice. After learning this course, students can master the basic usage of Python language, the principle and usage of crawler, and how to use the KNN algorithm to implement air quality detection.

3.1 Teaching content design and analysis

Instructional content serves the achievement of instructional goals and enables learners to acquire knowledge, skills, and sources of competence. The instructional content needs to be set according to a certain hierarchy of competencies and organized in such a way that it can contribute to the acquisition of the corresponding competencies by the students [16]. In this study's curriculum, the teaching activities are divided into three modules, which are conducted over a total of 16 weeks. The specific teaching activities are shown in Figure 1.

The difficulty of the content in this study follows a spiral and is divided into three main modules of knowledge learning, with three sub-modules included in each phase. In the first phase of the study, which lasts for 6 weeks, understanding machine learning includes the basic principles of machine learning, classification, and application in

real life. The basic syntax of Python includes the syntax of Python, sorting algorithms, file reading, lists, functions, and other knowledges. The basic operation of Pycharm includes the installation of the software, the use of the pip command, and the interface and basic operation of the coding software. In the second phase of the 4-week study, you will learn the principles of crawler technology and use crawler technology to obtain data about air quality and clean the data to complete the pre-processing to facilitate the subsequent processing of the data. In the third phase, the 6-week study includes learning the basic principles of the KNN algorithm and using the KNN algorithm to predict air quality and find the most accurate K value by continuously changing the K value.

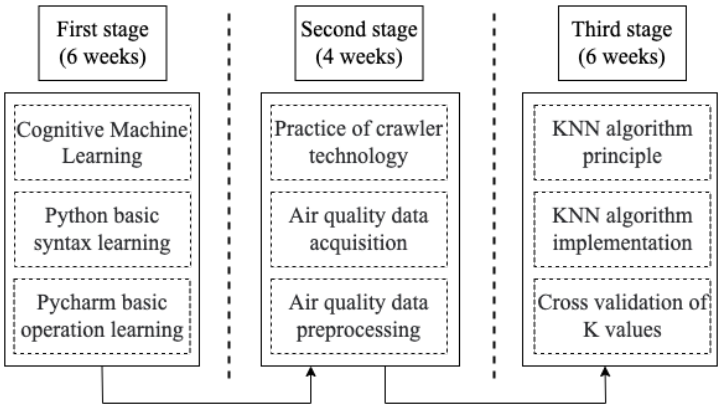

Figure 1. Design of teaching activities.

3.2 Design of "5E" teaching model

With the continuous advancement of educational philosophy and educational reform, higher requirements are placed on the construction of educational models. Such targeted reform of students' actual situation and teaching status, while focusing on students' learning motivation and the development of their potential, is an important trend of the current era [17]. The 5E teaching model is a model based on the constructivist theory of teaching and learning, which was initially applied to biology-related courses and describes specific teaching procedures for one or more lessons dedicated to attracting students' interest in learning [18]. The 5E teaching model mainly consists of five stages: engagement, exploration, explanation, elaboration, and evaluation. In each of the five different stages, teachers and students have teaching behaviors corresponding to them. In the engagement stage, we need to create a realistic situation to stimulate students' interest in learning and stimulate them to take the initiative to conduct inquiry; in the exploration stage, we need to set corresponding inquiry tasks to guide students' direction of inquiry and construct appropriate solutions to problems based on their existing knowledge. In the elaboration stage, the results obtained in the inquiry stage are analyzed in depth. In the exploration stage, the results obtained in the investigation stage are analyzed in depth, which helps to internalize the learned knowledge and improve the existing cognitive framework; in the elaboration stage, students need to apply the required knowledge in different real situations to improve their knowledge application and transfer ability; in the evaluation stage, the teacher's evaluation can be combined with students' mutual evaluation and self-evaluation to, we can combine teacher's evaluation with students' mutual evaluation and self-evaluation, so that students can understand the degree of knowledge mastery and adjust the learning process in time. In this process, the main role of learning is returned to the students, and the teacher plays the role of tutor and helper. Students are usually guided by the teacher through the different stages of the teaching task [19].

3.3 "5E" teaching practice design

This study uses the example of air quality prediction in a machine learning course, which is taught according to the "5E" model to improve students' programming and computational thinking skills.

3.3.1 Engagement phase

How to stimulate students' interest in learning is most important in the classroom introduction session. At this stage, teachers can first give examples of common AI cases in life. Such as showing the driverless technology launched by various car R&D companies, and meta-universe technology. Even intelligent robots, such as Siri, Xiaodu, and other

artificial intelligence products, as a way to attract students' interest in learning. The teacher can ask: Since there are so many AI technologies in life, do you know how our usual air quality is predicted? This will lead students to answer: It is achieved through artificial intelligence technology, or more precisely, machine learning technology.

3.3.2 Exploration phase

In traditional teaching and learning activities, students are usually passive recipients of knowledge imparted by teachers, and this kind of forced duck-fill education does not improve teaching effectiveness. In the 5E teaching model, students are the main subjects of teaching activities and need to be explored by them, with the teacher as the guide and navigator of classroom activities. In this stage, students combine the content related to machine learning and KNN algorithms taught earlier to explore air quality prediction. Students first divide the acquired data into training and test sets, then calculate the Euclidean distance between the data in the training set, and arrange the distances between the data in order with the help of sorting algorithms (e.g., bubble sort, fast sort algorithm), and finally determine when the prediction is most accurate by taking different K values.

3.3.3 Explanation phase

In this stage, students need to prepare a PowerPoint presentation on the results of air quality prediction and explain the code written, mainly including data normalization processing, data set division, Euclidean distance calculation, sorting algorithm implementation, and cross-validation of K-values. In this process, students will deepen their understanding and mastery of the knowledge.

3.3.4 Elaboration phase

In this phase, students need to apply what they have learned in other disciplines, or even in other fields. For example, how to use the KNN algorithm for the classification problem of iris, which is based on the same idea as air quality prediction. Even in this research problem, it is still possible to extend it accordingly. Specifically, the students only predicted the air quality of a single city for a particular year or years, and the dataset chosen for the prediction was all the data for a year. For a given day, the predictions can be biased by the season, and the students need to consider how to address this bias.

3.3.5 Evaluation phase

In the process of teaching evaluation, attention should be paid to both the students' performance in teaching activities and the level achieved in the core literacy of computational thinking to promote the consistency of teaching objectives and teaching content [20]. It is also important to focus on the plurality of teaching evaluation; therefore, at this stage, a combination of teacher evaluation, student mutual evaluation, and student self-evaluation is used. The teacher reviews the students' classroom reports, then the students evaluate each other, and finally, the students self-evaluate according to the level they have achieved. This is used to accurately grasp the effectiveness of the teaching activities and to provide feedback and corrections.

4. Conclusion

Currently, countries around the world are actively implementing pedagogical reforms related to computational thinking [21]. At the same time, teaching text-based programming is becoming a popular and growing trend. Although there are various ways to develop computational thinking, most of them revolve around graphical interfaces that are easy to operate or a combination of software and hardware programming. These approaches are all focused on the development of critical thinking skills. Therefore, this study focuses on machine learning in the field of artificial intelligence and the easy accessibility of the Python programming language. It aims to develop a series of machine learning curriculum systems for middle school students. The goal is to improve students' computational thinking literacy, cultivate well-qualified artificial intelligence talents, and accelerate their adaptation to the digital intelligence era.

References

[1] Sun, L. H., & Zhou, D. H. (2019). Research Status and Action Path on International Children Programming Education. Open Education Research, 25(02):23-35.

[2] Brown, N. C., Sentance, S., Crick, T., & Humphreys, S. (2014). Restart: The resurgence of computer science in UK schools. ACM

Transactions on Computing Education (TOCE), 14(2), 1-22.

[3] Curran, J., Schulz, K., & Hogan, A. (2019). Coding and Computational Thinking—What Is the Evidence. NSW Department of Education: Sydney, NSW, Australia.

[4] Bocconi, S., Chioccariello, A., Kampylis, P., Dagienė, V., Wastiau, P., Engelhardt, K., ... & Stupurienė, G. (2022). Reviewing computational thinking in compulsory education: state of play and practices from computing education.

[5] Zhang, S. Z. (2020). Education Informatization 2.0: Issue Construction and Path Selection: A Perspective Based on the Analysis of Policy Tools. Educational Academic Monthly, (09), 57-63.

[6] Gong, X. Y. (2022). Analysis of the current situation of programming education in primary and secondary schools in China. Western Quality Education, (18), 139-142.

[7] Papert, S. A. (2020). Mindstorms: Children, computers, and powerful ideas. Basic books.

[8] Wing, J. M. (2006). Computational thinking. Communications of the ACM, 49(3), 33-35.

[9] ISTE & CSTA. (2011). Operational definition of computational thinking for K–12 Education.

[10] Brennan, K., & Resnick, M. (2012, April). New frameworks for studying and assessing the development of computational thinking. In Proceedings of the 2012 annual meeting of the American educational research association, Vancouver, Canada (Vol. 1, p. 25).

[11] Zhang, J. B. (2019). Computational thinking education: conceptual evolution and challenges. Modern Distance Education Research, 31(06):89-101.

[12] Wang, J. Y., Zhou, D. H., & Yang, Y. W. (2022). Machine learning in academic education research: analytical framework, international comparison and inspiration. Digital Education, 8(05):85-92.

[13] Fu, Q. & Wang, Y. R. (2019). A study on programming teaching for the cultivation of computational thinking: an example of teaching Python programming to high school students. The Education of Innovative Talents, (03):47-54.

[14] Yue, Y. L., Yuan, Y. N., & Zhang, X. J. (2021). A Study on Teaching Design of Python Gamification Programming for High School Students' Computational Thinking Development [J]. China Education Informatization, (22):93-96.

[15] Zhang, D., & Cui, G. Z. (2022). Research on Artificial Intelligence Education in Primary and Secondary Schools. Modern Education Technology, 30(01):39-44.

[16] Nan, G. N. (2011). The new stage and mission of China's education informatization development. e-Education Research, (12),10-12.

[17] Zhou, J., & Li, G. F. (2022). A Study on the Innovation of History Classroom Teaching Mode in the Context of New Liberal Arts. Chinese Journal of Education, (S1):174-176.

[18] Wu, C. J., & Zhang, M. (2010). The connotation, examples and essential features of the "5E" teaching model of American biology. Curriculum, Teaching Materials and Methodology, 30(06):108-112.

[19] Zhao, C. L., Zhao, W. J., & Jiang, Z. H. (2018). Design of 5E inquiry-based teaching model for STEM education. Modern Education Technology, 28(03):106-112.

[20] Shi, L. (2022). Exploring multidimensional teaching evaluation and promoting students' core literacy development--Exploring multidimensional teaching evaluation of high school history based on subject core literacy development. History Teaching Issues, (04):149-155.

[21] Bers, M. U., González-González, C., & Armas–Torres, M. B. (2019). Coding as a playground: Promoting positive learning experiences in childhood classrooms. Computers & Education, 138, 130-145.