Analysis of Learning Effectiveness Based on Knowledge Graph

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Abstract. Based on the construction of the knowledge map of "Data Structure and Programming" course, the data of PTA platform, rain class data, MOOC and other platforms are integrated, and the comparative analysis is carried out according to the different granularity of knowledge points, trying to find out students' learning difficulties and blind spots, so as to provide more specific and effective help for students' learning. At the same time, it provides the basis for the adjustment of the follow-up curriculum exercises, the targeted adjustment of the textbook and the concrete implementation of the teaching work.

Keywords: blended teaching · Knowledge graph · Data structure · Programming · Effectiveness analysis

1 Introduction

In recent years, with the deepening integration of big data and artificial intelligence technology into the field of education, the research of intelligent education has attracted wide attention. In the Development Plan for the New Generation of Artificial Intelligence issued by The State Council in 2017, intelligent education was written into the plan as a key task [1]. In February 2019, the CPC Central Committee and The State Council issued "China's Education Modernization 2035", which proposed that one of the strategic tasks for educational reform in the information age is to accelerate the reform of personnel training mode by using modern technology and realize the organic combination of large-scale education and personalized training.

Artificial intelligence, especially cognitive intelligence technology with knowledge graph as the core, plays an important role in the intelligent development of education [2, 3]. Knewton uses the knowledge graph to build an interdisciplinary knowledge system that includes concepts and their prerequisite relationships. Khan Academy also uses the knowledge graph as the basic organizational structure for courses in mathematics, science and engineering, computer science and other disciplines [4]. Penghe Chen et al. proposed KnowEdu, an automated knowledge graph construction system based on heterogeneous data in a specific teaching field [5]. Wentao Wang et al., from the industry, proposed a design idea of course knowledge graph for the purpose of improving the

X. Yuan et al. (Eds.): ICEKIM 2023, AHCS 13, pp. 1742–1749, 2023.
https://doi.org/10.2991/978-94-6463-172-2_193

efficiency and experience of online learning, aiming at the specific scene of online education [6]. Yanyan Li et al. discussed the construction path of subject knowledge graph in intelligence education from three aspects: overall process, automatic acquisition of subject knowledge and integration of subject knowledge, and analyzed three challenges faced by subject knowledge graph in the application of intelligence education [7]. Yuji Yang et al. systematically studied the construction method of domain knowledge graph, proposed an accurate and efficient construction method of domain knowledge graph -- "four-step method", and carried out practice in the construction of knowledge graph of some basic disciplines. However, existing researches on knowledge graph construction have some shortcomings in visual display, practical application of teaching and iterative evolution of knowledge graph [8]. At the same time, most of the existing researches on knowledge graph construction are oriented towards K12 basic education disciplines with relatively convergence in the field, while there are still deficiencies in the existing researches on higher education disciplines that are more open, more diverse and more focused on the combination of theory and practice [9, 10]. How to closely combine the characteristics of higher education disciplines to explore the construction path and application methods of higher education curriculum knowledge graph is a problem that we need to further study.

2 Curriculum Knowledge Graph

When students preview and review the course, how to better let the students have a comprehensive understanding of the course, how to let the new teacher training teachers can quickly get familiar with the course? These questions can be easily identified by the curriculum knowledge graph. Curriculum knowledge graph is the construction tool of curriculum content outline. Knowledge graph is a structured semantic knowledge base, which is used to describe concepts and their interrelationships in the physical world in symbolic form: entities are connected through relations to form a network knowledge structure [11].

In the construction of knowledge graph, it mainly completes how to visually represent the knowledge content system, how to integrate rich online learning resources to establish the matching relationship between knowledge points and learning resources, so that students can quickly locate knowledge points and clarify the internal logical relationship between the left and right knowledge points. We take the course "Data Structure and Programming" as an example to study the construction of curriculum knowledge graph. Usually, there are a lot of knowledge points in a course, but this list-like arrangement ignores the correlation of knowledge points. The relationship between knowledge points in the course is mainly the inclusion relation, that is, the course - chapter - knowledge point, but there are also a small part of correlation and subsequent relation. In the tree structure relation diagram, complete binary tree, heap and heap sorting are all subsequent relation. Therefore, it is necessary to establish knowledge point attribute and relation attribute when constructing curriculum knowledge graph. Knowledge attribute includes: course, chapter, knowledge point, resources. Relation attributes include: inclusion relation, association relation and subsequent relation.

3 Data Analysis Based on Knowledge Graph

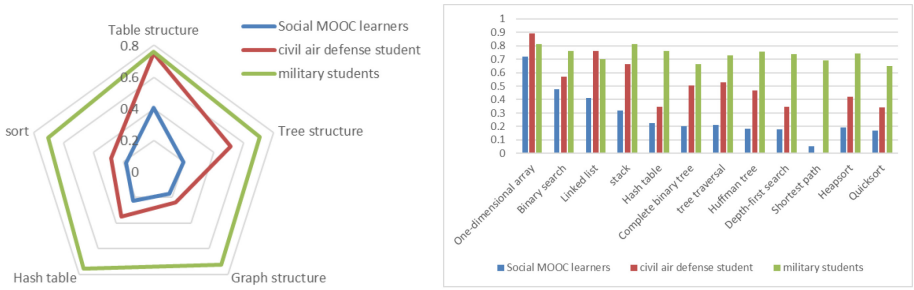
The PLA has been systematically reforming its curriculum since 2019. As one of the three pilot universities, the Army Engineering University will carry out comprehensive curriculum transformation in 2020, simultaneously exploring innovative teaching and training models with distinctive features. Based on platforms such as "Chinese University MOOC", "PTA(programming Teaching Assistant)" and "Rain Classroom", we have completed the exploration work based on "Internet + " and "AI + " learning environment, formed the basic form of online teaching, online and offline mixed teaching, and accumulated a large number of online learning data. Can we make better use of these data to provide accurate and reliable support for course teaching, teaching materials and resource construction? Therefore, according to these online learning data, we dig deep into the hidden information in the data, trying to find out students' learning difficulties and blind spots, so as to provide more specific and effective help for students' learning. At the same time, it also provides the basis for the adjustment of the follow-up curriculum exercises, the targeted adjustment of the textbook and the concrete implementation of the teaching work.

Our data comes from the learning data collected by the PTA platform, Rain Classroom data, MOOC and other platforms from 2017 to 2021. There are three levels of students: military students, civil air defense students, and MOOC social learners. Military students covers six shifts from fall 2017 to fall 2021; The students will have 4 shifts from autumn 2019 to autumn 2021; Social Learners consists of nine shifts, from fall 2017 to 2021.

3.1 Data Analysis of the Overall Grasp of the Knowledge Point

Firstly, we take the problem set data of different categories of students as the research object, and choose the average score rate as the index to measure the performance of students. Figure 1 shows the three types of students' mastery of each chapter and each knowledge point. As can be seen from the figure, in general, the command of each chapter and knowledge point is "military students > civil air defense students > social learners". The command of table structure of military students and civil air defense students is basically the same, and the gap in the command of tree structure begins to widen, with a gap of about 0.2. When it comes to figure structure, hash table and sorting, the gap between them exceeds 0.4. At this time, there is not much difference between the mastery of civil air defense students and social learners, about 0.1. As can be seen from the figure, graph structure, hash table and so on are the chapters we need to focus on, so we need to strengthen the guidance of teachers in these chapters.

Military students account for the majority in the whole group, so we re-analyze the data of military students. Figure 2 shows the statistics of the average score rate of military students in knowledge points. It can be seen from the figure that the classification of some knowledge points is too general, such as the basic concept of tree, which includes multiple concepts such as binary tree and regular binary tree. In order to understand what knowledge points students do not understand, it is necessary to refine the knowledge points.



(a) (b)

Fig. 1. Three types of students' mastery of knowledge points

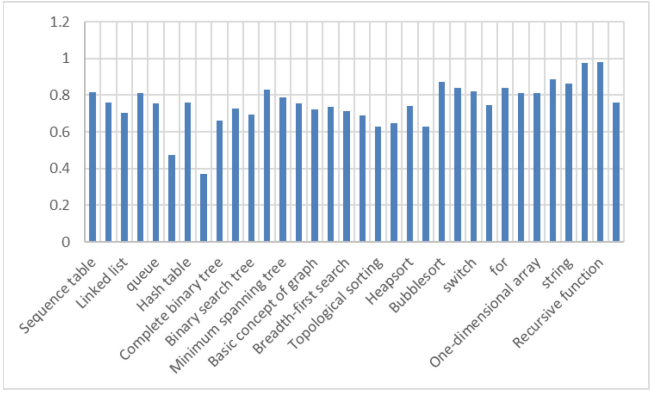
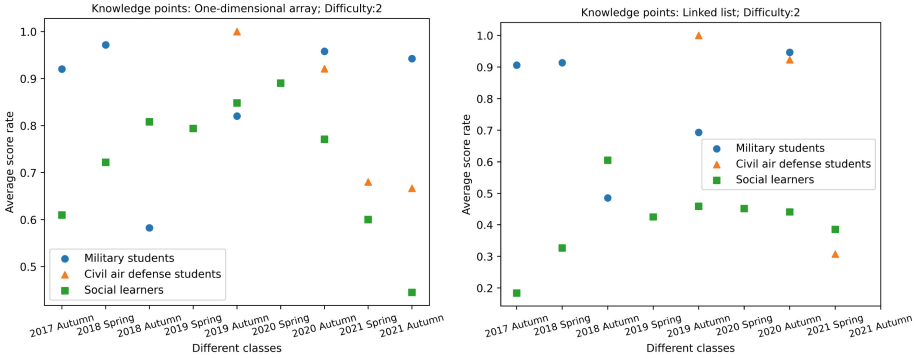


Fig. 2. Average scoring rate of knowledge points

3.2 Data Analysis of Mastering the Same Knowledge Points

Then we consider that for the same knowledge point of the same difficulty topic, different categories of students may have different performance. Figure 3 shows the average scoring rate of different categories for one-dimensional array and linked list two knowledge points (difficulty level 2). As can be seen from Fig. 3, on the whole, military students have the highest average score rate, while social learners have the lowest. When the difficulty level is 2, there is little difference between the three types of students. Especially in the one-dimensional array of knowledge points, the average scoring rate of the three types of students in different shifts is little different. However, in the linked list knowledge points, the difference between military students and social learners is slightly obvious, which indicates that the learning of linked list knowledge points still needs the intervention of teachers.

Figure 4 shows the average scoring rate of different classes of students in different shifts when the difficulty level is 3. Two knowledge points, namely, binary tree, traversal and Huffman tree, with difficulty level 3, are selected. At this time, the average scoring rate of military students is obviously better than that of social learners, and there is a clear distinction between the two. The difference between the minimum average scoring rate

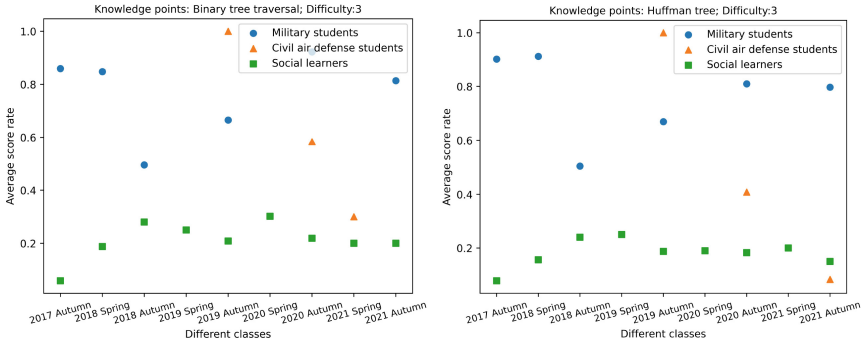


(a) (b)

Fig. 3. Average scoring rates of different categories of students (difficulty = 2)

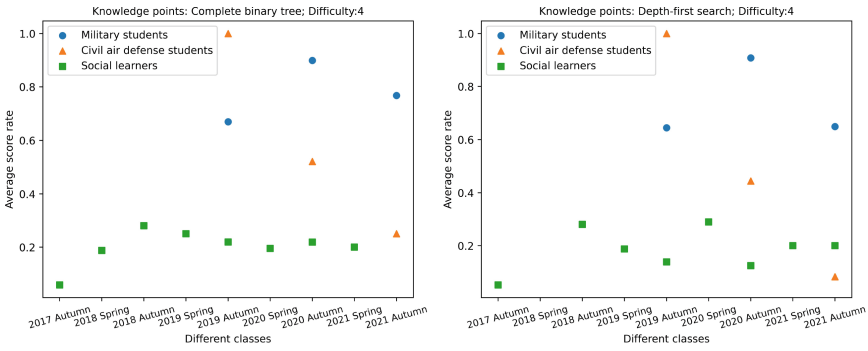
of military students in different shifts and the maximum average scoring rate of social learners is defined as the degree of differentiation between the two. Then, in Fig. 2, the degree of differentiation between military students and social learners in the binary tree and its traversal, and in the knowledge points of the Huffman tree are 0.193 and 0.255 respectively. It can be seen that the differentiation between the average scoring rate of military students and social learners increases as the difficulty of the questions increases. However, the difference between different shifts of civil air defense students is relatively large, and can not be significantly different from the other two types of students.

Figure 5 shows the average scoring rates of different classes of students in different shifts when the difficulty level is 4. Two knowledge points, complete binary tree and depth-first search, with difficulty level 4, are selected. There are also obvious differences between military students and social learners. The distinction between them in complete binary tree and depth-first search is 0.45 and 0.356 respectively. It can be seen that the degree of differentiation between military students and social learners is further



(a) (b)

Fig. 4. Average scoring rates of different categories of students (difficulty = 3)



(a) (b)

Fig. 5. Average scoring rates of different categories of students(difficulty = 4)

improved with the increasing difficulty of the questions. However, students of civil air defense cannot be distinguished from the other two categories.

From Fig. 3, 4, and 5 it can be seen that when the difficulty of the questions is low, although the average scoring rate of military students and social learners is different, the difference is not obvious, and the difference becomes very obvious as the difficulty of the questions increases. Civil air defense students are somewhere in between, with good and bad results from different shifts. The main reason for the above phenomenon is that military students adopt mixed teaching, teachers more face-to-face guidance and strict management of student teams to supervise students' learning, while social learners do not have any constraints, there is no effective face-to-face guidance of teachers, learning is lack of guidance. Air defense students are purely offline teaching, less than military students in teacher guidance, and less strict management than military students. It can be seen that when the difficulty of the topic is low, the teacher's guidance has a certain effect, but the help to the improvement of students is limited. When the difficulty of the topic is increased, the teacher's guidance and supervision will become very helpful, and have a significant promoting effect on the learning of students. This also gives us a clue as to whether our own definition of difficulty level is accurate and how to define the appropriate difficulty level. According to the learning feedback, the difficulty level of each topic can be set according to the students' completion rate, and the teacher can judge whether it is necessary to add different levels and types of exercises or explanation videos for this knowledge point.

A total of 556 students have benefited from the "Data Structure and Programming" course since it was launched in 2018. Statistical analysis of the data shows that the improvement rate of good and good is about 6% per year on average.

4 Conclusion

Through the construction of the knowledge graph of the course "Data Structure and Programming", we unified and integrated the resources of multiple platforms, analyzed the knowledge points at different granularity, and realized the accurate portrait of all

students with these data. In the next step, we need to conduct more in-depth data mining on the performance of individual students, and combine the curriculum knowledge map to form a more micro portrait of learners, so as to promote the effect of personalized learning.

Acknowledgement. Supported by Fund Project: Industry-university Cooperative Education Project of the Ministry of Education (202101151012,202101244033), Virtual Teaching and Research Section construction Project (Ministry of Education Letter [2022] No.13, Participation Letter [2022] No. 215), the 14th Five-Year Plan Project of National Education Science, National Defense and Military Education Discipline (JYKY-D2022013).

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