

# Explainable Story and Visualization for Learning Data Structure Concepts

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**Abstract**—The "Data Structure" course is a fundamental subject within the entire computer course system, and it plays a vital role in the field of computer and information disciplines. However, the abstraction and logic of data structures have made this course challenging for many underestimated students. It involves many concepts, which can be difficult to understand. To enhance teaching efficiency and facilitate students' comprehension of data structure concepts, we propose a method that combines storytelling and visualization. Our goal is to present these concepts clearly and promote a deeper understanding among students. We have developed new expressions that serve as a bridge between data structure concepts and their logical structures. Our teaching practice has shown that this approach is highly effective. It not only increases the teacher's confidence in their ability to teach, but also enhances students' subjective initiative when it comes to learning.

**Keywords**—explainable story, visualization, data structure, conceptual understanding

## I. INTRODUCTION

"Data Structure" has always been a fundamental and core course for computer science majors. It has a huge responsibility for cultivating students' computational thinking abilities. It plays a vital role within the entire computer course system [1]-[4]. This course can enhance your intellectual capabilities. Once you grasp its concepts, it can provide lifelong benefits [5]-[8]. It is also a regular subject in postgraduate examinations and written tests for admission to major corporations.

The "Data Structure" course encompasses a lot of new and abstract knowledge. Students are introduced to a variety of data logic structures and storage mechanisms, all of which can pose challenges to learners across various regions [9]-[11]. Students often find themselves confused by a multitude of concepts. Therefore, clarifying these complex concepts for students can have a significant impact on the overall learning of the course.

Currently, both domestic and foreign scholars have carried out various explorations on data structure teaching. He et al [5] introduced the mind map as a GUI tool to organize and manage the data structure contents. Multiple similar software programs are described, and the process of creating a mind map about data structure is presented. Edy Budiman [12] et al created a mobile

learning application for data structure course. The learning content, based on the curriculum-syllabus and learning outcomes of data structures, is visually presented.

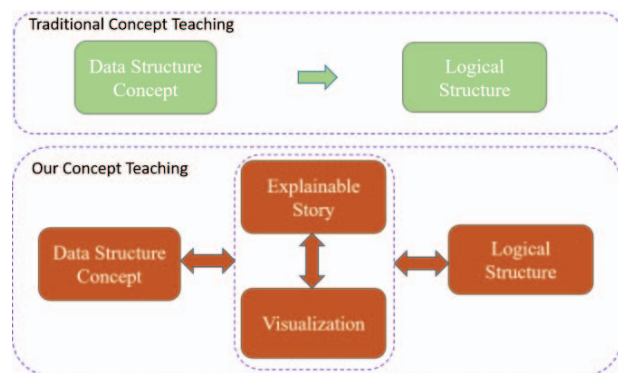


Fig. 1. The proposed teaching method for data structure concepts.

Managing data structure concepts in a systematic manner is considered good practice [13]-[15]. In a study on teaching "Data Structure and Algorithm" to non-computer majors, Wang [13] utilized real-life examples to enhance students' learning interest and application skills. Wang et al. [14] explored and practiced the online teaching of data structure during the epidemic period and proposed an online teaching reform plan based on the MOOC platform. Lin et al [15] proposed an interactive tool using Python to help students understand the communication of data structure and associated data operations. This tool visually presents data structures on the web and is capable of tracing changes to the data structure. However, it can only handle simple data structures.

In addition, there has been a wealth of research conducted on teaching data structures [16-23]. Wu et al. [16] proposed the teaching reform and research approach for data structure courses that utilizes the BOPPPS model and Rain classroom, based on the concept of outcome-based education (OBE). They demonstrated the effectiveness of their approach through a survey that gauged student satisfaction with the course. Al-

Towirgi et al. [19] proposed the use of gamification technology to enhance student participation in data structure courses, leading to positive effects on both their learning performance and engagement.

However, the aforementioned methods tend to place less emphasis on teaching the underlying concepts of data structures. Understanding the abstract concepts in data structure courses serves as the foundation for the entire course system. Therefore, we believe that enhancing students' comprehension of the

course should focus on conceptual understanding, which, in turn, can improve teaching efficiency.

Accordingly, this paper proposes a method that employs explainable stories and visualizations to facilitate the learning of data structure concepts and enhance students' understanding of the subject. It is shown in Fig. 1. Our method diverges from traditional approaches by supplementing concept teaching with engaging and visually appealing explanations, which help learners understand concepts easily.

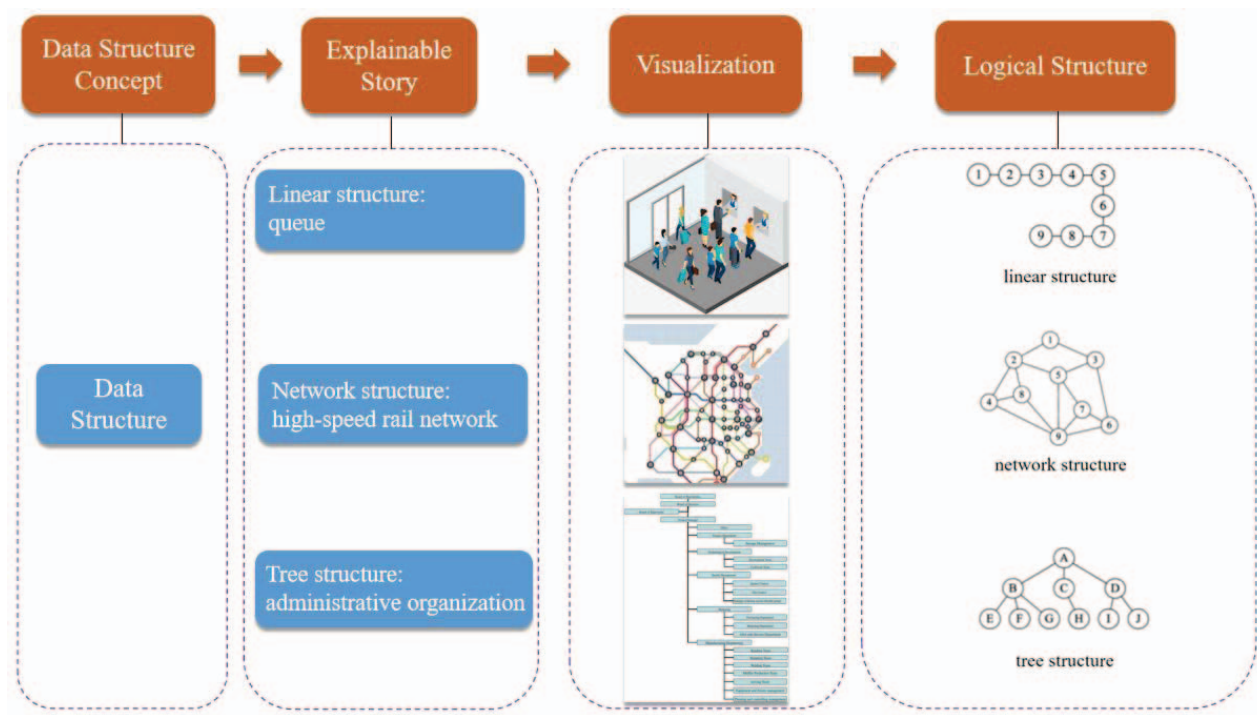


Fig. 2. The generally model of explainable story and visualization for learning data structure concepts.

## II. THE PROPOSED METHOD

Our method utilizes explainable stories and visualizations to illustrate concepts in data structures during teaching. As shown in Fig. 2, we begin by introducing a specific concept, followed by presenting relatable everyday stories. Subsequently, we employ visualization techniques to render the story in a lively and interactive manner, enabling students to immerse themselves in the experience. Finally, based on the visualization, we introduce the specific logical structure to promote students' learning interests.

### A. Concept

The "Data Structure" course contains many concepts, including but not limited to linear lists, stacks, queues, arrays, trees, graphs, etc. They can also be further divided into smaller sub-concepts such as sequential lists, linked lists, generalized lists, sparse matrices, cross-linked lists, traversal, thread, and balanced binary trees. However, excessive concepts are difficult to understand for beginners.

### B. Explainable Story

To generate explainable stories, we can draw inspiration from various sources such as historical allusions, science and technology, and everyday life. For instance, we can relate the characteristics of the stack to the Chinese proverb "The Latecomers Surpass the Old-timers." Furthermore, real-world examples such as the behavior of web browsers, text editors, elevators, and call log displays all demonstrate the "last in, first out" nature of the stack.

The sorting algorithm can be compared to the traditional time sorting methods such as the almanac and the lunar calendar. Additionally, we can use traditional aspects of maps, navigation, and other related fields to explain graph theory. By using such explainable stories, students can better understand and grasp the relevant concepts of data structures in a more intuitive manner.

### C. Visualization

Visualization is a direct and effective method to help students understand the definitions of data structure concepts. Our proposed method utilizes various forms of visualization,

including images, videos, GIFs, etc. These visual aids provide a clear and intuitive representation of complex data structures, making it easier for students to understand the underlying concepts.

For the selection of visualization diagrams, it should be noted that 1) it needs to be consistent with the concepts of explainable stories and data structures; 2) try to choose more visual and suitable diagrams. It can help students better grasp these data structure concepts, and lay a solid foundation for their subsequent studying.

#### D. Logical Structure

The logical structure of data refers to the description of the logical relationship between data elements. It can be divided into two categories: linear structure and nonlinear structure. The four most common types of basic data structures are collection structures, linear structures, tree structures, and network structures.

These four modules can present detailed descriptions of data structure concepts. To have a better understanding of our method, we have also shown two elaborate pictures, as shown in Fig. 3. It details thread and tree concepts through story and visualization.

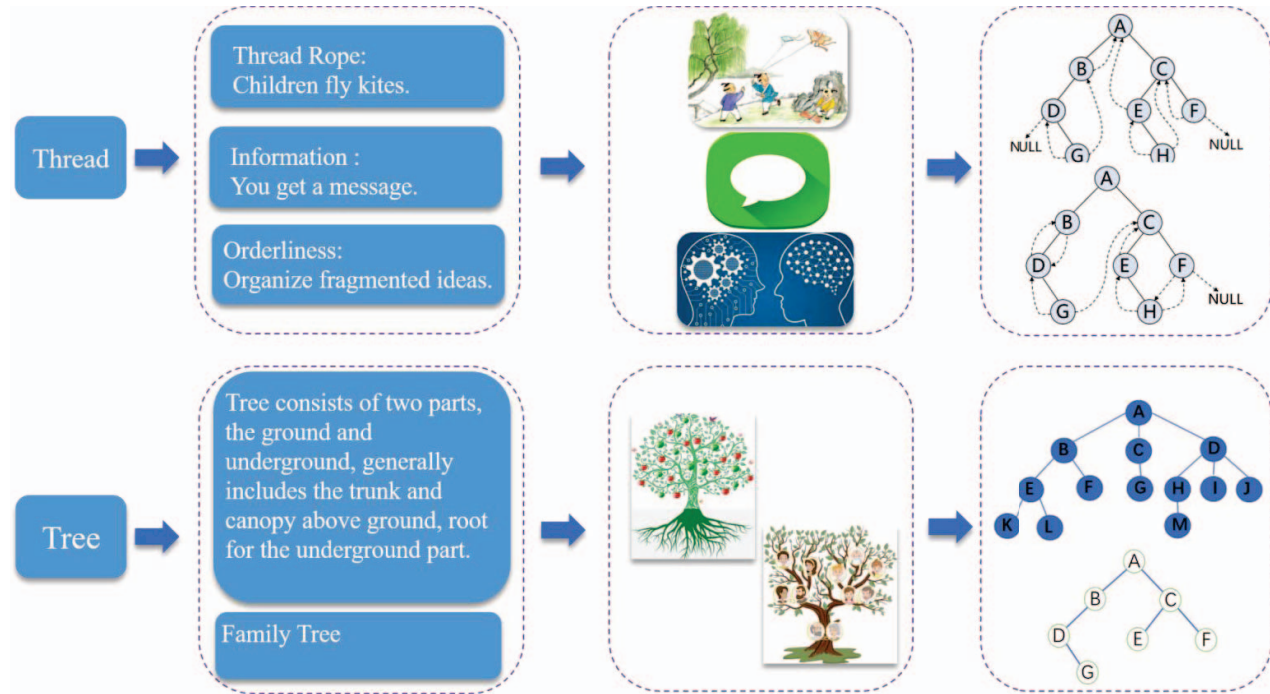


Fig. 3. The thread and tree of explainable story and visualization.

### III. RESULTS

#### A. Help Students Better Understand the Concept of Data Structures

When learning data structures, some concepts and algorithms can be abstract and challenging to comprehend, such as balanced trees, graph theory algorithms, etc. Demonstrating the implementation and operation process of data structures and algorithms through visualization can help students to understand and master them in an accessible manner. Moreover, visualization can stimulate students' innovative thinking and practical abilities.

Additionally, students can actively participate in the transformation process from theory to practice. This not only facilitates their understanding of data structure concepts and algorithms but also stimulates their innovative thinking and practical abilities. Ultimately, this approach lays a solid foundation for their future work in the software industry.

#### B. Enhancing Students' Comprehensive Abilities in "Learning, Practice, and Innovation"

By demonstrating the implementation and operation process of data structures and algorithms, students can intuitively master the related concepts and algorithms, leading to improved grades and a better understanding of actual application scenarios. This allows students to choose the appropriate data structure when faced with a problem and inspires innovative thinking during the practice process. As a result, students can enhance their comprehensive understanding and application of data structures, as well as their problem-solving abilities, ultimately contributing to their success in the software industry.

### IV. CONCLUSION

By visualizing concepts, and using analogy, storytelling, graphics, animation, and other methods, we can simplify and concretize complex and abstract data structures and algorithms. This not only makes it easier for teachers to explain but also for



students to understand, thus leading to better teaching results. This new type of teaching method overcomes the limitations of the previous data structure classrooms, enhances the confidence of teachers in teaching while improving the initiative of students in learning.

With the continuous deepening of education reform, future teaching forms will inevitably move towards a state of diversification and flourishing. It is inevitable that future teaching forms will become more diversified and flourishing. New technologies such as metaverse and chatGPT will continue to drive the reform and development of education.

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