THE IMPORTANCE OF VISUALIZATION IN EDUCATION

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ABSTRACT

How does visualization play a role in education? How do different types of visualization affect different areas of Education? In this work, we will discuss the use of visualization from a theoretical and empirical point of view, as well as reveal some general concerns when using or choosing suitable types of visualization. We synthesize the experiences of previous studies and try to give a new look at the meaning and importance of using visualization in the field of Education.

Keywords: visualization, empirical epistemology, visual image hypothesis (VIH), dual coding theory (DCT)

INTRODUCTION

What is visualization? Visualization is a series of techniques that use a graphical representation to display data. Carriers such as images, diagrams or animations are used to convey the essence of the message. Visualization can manifest itself in various forms. Often they can be divided into four different categories: quantitative, spatial, statistical and temporal. Thus, data can be studied from different angles to enhance the understanding of a particular area.The use of visualization. Since empirical epistemology differs significantly in different areas, each industry may require different means of applying these visualization techniques to make full use of its effectiveness. In the field of artificial intelligence, deep learning is an important way to visualize network structure. With visualization, researchers can better understand the flow of data to identify potential problems in the network. In healthcare, researchers often use maps to help identify infectious sources and clusters of sensitive people. These maps display geographic information intuitively and simplify the identification of object relations. Theoretical perspective on visualization in science. The use of visualization can mainly be explained in two theoretical ways: dual coding theory (DCT) and visual image hypothesis (VIH).

In DCT theory, external information can be divided into two parts: verbal and nonverbal. Oral information usually refers to information carried by words, sentences, or other information in a linguistic form; nonverbal information may include images, sounds, smells, emotions, etc. Typically, these two types of data are stored in different locations and handled differently, but the two systems can interact with each other. strengthens memory and enhances understanding of information.

The main goal of DCT theory is to use visualization as an auxiliary method to interact with verbal information and help understand them. They believe that a combination of verbal and non-verbal information can double-empower learning and help us acquire knowledge.

Another aspect, the visual image hypothesis (VIH), is the focus on visualization objects. They rely on more efficient processing of graphic information, i.e. nonverbal information, compared to simple verbal information. Not only efficiency, but also information of this type can be processed with less load on memory. VIH theory emphasizes the importance of visual objects, such as the isolation and organization of key components, which they believe make it easier to manipulate information and can facilitate the process of solving this problem. Nevertheless, VIH theory has the assumption that the presented visual objects contain the necessary information to independently solve the problem, but this may not always be true. In visualization in Informatics Education [Naps, 2003], the authors studied the effectiveness of using visualization to study concepts of Informatics. They created questionnaires for Informatics students to fill out and asked them to show the benefits of using visualization. This visualization often comes in the form of visualization of algorithms through some form of graphical representation. For example, visualization can show how the first search in width achieves its goal step by step. Table 1 shows the results of the survey by students and teachers when assessing the impact of the use of visualization in the classroom.

Table 1: survey results by students and faculty

Student evaluation of visualisations	Educator evaluation of visualisations
90%: the teaching experience is more enjoyable	93%: time required to search for good examples (on the Web, in the literature)
86%: improved level of student participation	90%: time it takes to learn the new tools
83%: anecdotal evidence that the class was more fun for students	90%: time it takes to develop visualizations
76%: anecdotal evidence of improved student motivation	83%: lack of effective development tools
76%: visualization provides a powerful basis for discussing conceptual foundations of algorithms	79%: time it takes to adapt visualizations to teaching approach and/or course content
76%: visualization allows meaningful use of the available technology	69%: lack of effective and reliable software
72%: anecdotal evidence of improved student learning	69%: time it takes to transition them into the classroom
62%: (mis)understandings become apparent when using visualization	66%: unsure of how to integrate the technology successfully into a course
52%: objective evidence of improved student learning	66%: time it takes to install the software
48%: interaction with colleagues as a benefit	59%: lack of evidence of effectiveness
	55%: concerns about the equipment or presentation location (e.g. darkened room)
	48%: unsure of how algorithm visualization technology will benefit students
	38%: students are too passive

The main consensus is that visualization technology can greatly benefit students and teachers. However, there are still two main obstacles that prevent the application of visualization in the educational system:

- From the reader's point of view, visualization technology may not be useful for education.
- From the point of view of the teacher, visualization technology can cost a lot to make it useful.

Consequences of using visualization

The goal of visualization is naturally of great importance. It is important that visualization designers keep the end user in mind and do not develop visualization for their personal needs. As mentioned above, there may be different requirements for the types of visualization in different areas. The use of animations to understand the algorithm for computer science was deemed ineffective [Naps, 2003]. This is because users have little time to learn patterns within the algorithm. Thus, the student will not have practical learning experience when using animation only as a source of knowledge.

In addition, teachers who are engaged in visualization should devote more time to the teaching materials that will be added to it, rather than one-sided attention to visualization graphics. That is, visualization should serve as an additional aid to the process of learning concepts. For example, to study the sorting algorithm, a student can use animation to support understanding of the algorithm. Although, the student must perform well-structured exercises to better understand the algorithm.

In [Naps, 2003], they suggest that students should actively do something in the learning process instead of relying on seeing something. They argue that this can have the greatest impact on learning, which also exists

Visualization in mathematics education

In [Presmeg, 2006], the authors describe a three-year case study in which 13 math teachers in high school were surveyed. The authors use the recommended teaching visualization score, which shows how much the teacher incorporates visual elements into teaching, to assess the ability of teachers to apply visualization in the classroom. Table 2 shows the visual textbook score of the 13 teachers surveyed.

Table 2: visualization teaching scores for 13 teachers

Nonvisual Group		*Middle group*		*Visual Group*	
Teacher	*Score*	*Teacher*	*Score*	*Teacher*	*Score*
Mrs Crimson	2	Mr Blue	7	Mr Red	9
Mr Black	3	Mrs Turquoise	7	Mrs Gold	9
Mr Brown	4	Mrs Green	7	Mrs Silver	10
Mr White	3	Mr Grey	6	Mrs Pink	9
				Miss Mauve	10

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In Table 2, those in the middle group use only visualization for generalization for teaching. However, combined with student performance (not shown in the table), the result shows that students benefit more from middle-group Teachers, which is to some extent contradictory. From the above result, we can conclude that the average use of visualization tools helps students to better understand abstract concepts; however, overuse, on the contrary, neutralizes this positive effect.

Potential problems

When people enjoy the comfort of visualization, there are still problems that can be caused by them. In this section, we will try to identify some important problems when using visualization methods and provide possible solutions that can alleviate problems to a certain extent.

Visualization for people with disabilities

It is natural that visualization methods include a large number of visual objects. These visual objects can help ordinary students better understand basic concepts or gain additional knowledge. However, for students who cannot interpret the visual world, an excessive number of such elements can widen the gap between them and ordinary students.

For students who have conditions with their eyes, for example, a blind, friendly way is to make materials audible. Techniques such as text-to-sound (TTS) are already widely used, not limited to disabled people. However, designers can face serious difficulties to hear their schedules. For example, even with the TTS technique, it is difficult to compare the intuition provided by a simple linear diagram; animations, blurring, etc.k. let alone tables with more beautiful visual effects, such as.

Misinterpretation of visualization. Given a simple linear diagram, the typical expectation represents an X-axis independent variable and a dependent variable to which the Y-axis corresponds. People, especially students, can easily fall into this idea. One common mistake is that when the X and Y axes are replaced, students misinterpret the slope and the rate of change shown in the graph.

Color can also cause problems to different audiences. Green can mean "benefit" for people in the field of economics, but for medical workers they can also mean "infected". When visualization designers do not have a sufficiently general idea of the target area, they can be confused when choosing suitable colors.

Conclusion. In this work, we formulated the use of visualization in terms of dual coding theory and visual image hypothesis. Next, we will consider the use of visualization in the field of Informatics and mathematics education. In both of these areas, visualization can be of great help in better digesting concepts and improving learning outcomes. However, this visualization should not be used as the end of everything in learning. They should only be used as an additional tool that helps students to more easily understand concepts to the learning process. In addition, it is important to keep in mind the visualization goal and the end-user group so that the target audience is fully informed.

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