Search Algorithms Learning Based on Cognitive Visualization

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Abstract. Search algorithms are considered to be the classical Informatics problems due to their great applied significance. Hence, these algorithms mastering is an integral component of the expertise of any Informatics teacher. Thus, it is important to find out efficient ways of the search algorithms learning, realization, and implementation in the process of the pre-service teachers' vocational training. The aim of the paper is to offer the technique of the algorithms mastering that is based on the leading ideas of cognitive visualization (CV) enhanced with the elements of choreography. The theoretical basis of the elaborated technique includes CV concepts in their connection with the stages of learning and cognitive activity; ideas of bodily-kinesthetic intelligence as a factor of CV functions enhancing; choreographic ideas and their links with algorithms representation. The technique (which is given in the paper on the examples of linear and binary search algorithms in arrays) is represented as a set of connected tasks for students that determine direction of their collaborative activity. This detailed learning strategy, based on bodily-kinesthetic enhancing of CV functions, can be also successfully applied to the acquisition of key algorithms arrays processing. The peculiarities of the offered technique are analyzed. Such an approach to the algorithms learning is implemented for the pre-service Informatics teachers' training. It might cause a positive impact on the level of their knowledge and cognitive eagerness, which makes a prospect of our investigations.

Keywords: teachers' vocational training, search algorithms learning, technology of cognitive visualization enhanced with the elements of choreography.

1 Introduction

Search algorithms (especially the algorithms in arrays) are considered to be the classical Informatics problems due to their great applied significance. In general way, the problem of search is formulated as a task to find out in a set an element (or some elements) which has a curtain property (absolute or relative one). The performance and

results of such algorithms can be met in daily life, therefore they have been attracting attention of experts since the middle of last century. Hence, these algorithms mastering is an integral component of the expertise of any Informatics teacher. However, the process of the algorithms learning embraces some stages from taking in the idea of the algorithm itself to program development. Search algorithms mastering as a learning element of the pre-service teachers' training must result in students' (1) comprehension of the algorithm's differences, details, complexity etc.; (2) readiness to apply the algorithms to various problems solving; (3) ability to develop an effective computer programs for their realization; (4) readiness to transmit their own knowledge on the algorithms for their potential students of secondary school.

It is clear that achieving of these goals can cause a number of teaching and learning difficulties. Methodical problem of search algorithms mastering is complicated by the students' formal attitude to the task of searching itself. The matter is that the algorithm explaining on the specific example with a visible set of data (numbers, symbols, etc.) bumps with the drastic difference between a person and a computer. The person can see the set of elements and immediately finds searched element (or detects it absence). Thus, the problem of the algorithm development and realization loses its necessity for the student, and is taken rather formally, without proper motivation.

On balance, it is important to find out efficient ways of the search algorithms learning, realization, and implementation in the process of the pre-service teachers' vocational training.

One of the ways to do this is to apply cognitive visualization technology which enables to elaborate a special learning strategy (technique) that involves trainees into personal physical activity, provides effective poly-sensory information processing and facilitates understanding of the search algorithms peculiarities by the students.

In addition, it is significant to give pre-service teachers methodological knowledge of using similar technique in their own teaching practice in future. So, it seems to be necessary not only to develop a proper technique of learning, but also implement it in the process of teachers' vocational training in order to provide them with personal experience of cognitive visualization implementation in various forms.

The aim of the paper is to represent technique of the search algorithms mastering by pre-service Informatics teachers that is based on the leading ideas of cognitive visualization enhanced with the elements of folk choreography.

2 Technique of the Search Algorithms Learning Based on Cognitive Visualization

Developing the technique of the algorithms learning, we addressed to the pedagogical and psychological fundamentals of cognitive visualization (CV) technology, as it has powerful influence on the trainees' learning processes and helps to encourage their cognitive activity, which is really important in terms of contemporary education.

According to a number of studies, CV is considered to be multidimensional data presentation in a single image, that allows to find quickly the source of the problem and contributes to the creation of new knowledge [2; 1; 8]. Phenomenon of CV ena-

bles to optimize and streamline common challenges of teaching and learning activities such as efficient feedback, tasks performance, reasoning process etc. It can be explained [4; 7] by the fact that perception of information as well as its comprehension, processing, knowledge creating etc. at really high pace is supported by the construction of a mental pictorial image within trainee's working memory. Then subsequent construction of mental images comes, when the trainee arranges the complex of images into a coherent mental representation, creating a pictorial model. The process involves the selection, organization and integration of images which is often called visuo-spatial thinking [4; 7]. We can conclude that leading role in these activities belongs to three final stages. They embrace the set of basic learning and cognitive actions, such as: projecting of concept image and reconstruction of the learnt object (4^{rd} stage); modeling of the actions and reconstruction of actions (5^{th} stage); actions with real object and actions control (6^{th} stage). These stages which involve trainees into both mental and physical activities are supported by the number of CV means like concept image, manner of actions, and regulation system.

The analysis of the mentioned stages and CV means testify their strong relation to real motions of human body, and makes it significant to enhance CV technology with elements of physical activity. They can provide moving on to manipulating with the learnt object involving trainees' own bodies and applying all their sense organs, which might encourage poly-sensory information processing, including kinesthetic interaction with educational information. It seems to be especially relevant if the object of learning means a sequence of actions (e.g. algorithms, technical processes, devices etc.).

These our suggestions are confirmed by a number of research which cover experience where physical actions (body motions, rule-based art making, process imitations etc.) first of all enhance the power of CV technology. Scientists claim than corporeal qualities may be done available through materializing acts for the dynamic visualizations [3]. As a result, they facilitate basic learning and cognitive actions as for creating mental images, contribute to easier understanding of complicated mathematical and computational ideas, provide their stronger remembering due to involving various types of thinking and memory [8].

Special attention in these terms has to be paid to dancing as a focus for interdisciplinary and intercultural creativity as well as integration of physical, cognitive and artistic activities. In the special sources we can find results of investigations and samples of choreography implementation to the learning of difficult concepts, objects, processes etc. Among them it is relevant to point out works where authors demonstrate strong connections between computing ideas and folk dance ideas [11]; establish links between algorithm visualization and dance writing [9]; represent choreography as an experience of "dancing mind" and "thinking body", which generates "physical thinking" and visual images that can contribute to deeper awareness of really complicated things [10].

On balance, we created a theoretical basis which allowed us to elaborate the technique of search algorithms learning. The basis includes CV concepts in their connection with the stages of learning and cognitive activity; ideas of bodily-kinesthetic

intelligence as a factor of CV functions enhancing; choreographic ideas and their links with algorithms representation.

Resting on the theoretical basis, the technique of the search algorithms mastering for pre-service Informatics teachers was developed. The technique (which is given below on the examples of linear and binary search algorithms in arrays) can be represented as a set of connected tasks for students.

Task 1. Learn the description of the two algorithms and answer the questions:

- What are the requirements to the initial arrays? Can you apply the algorithm to any kind of arrays?
- Which algorithm can be applied only to the sorted array?
- Which algorithm finds the searched element faster and why?
- What might be a result of the search? What is the result if the searched element is not found?
- On what condition the algorithm comes to the conclusion that the searched element is absent in the array?
- Give examples of real-life problems which might be solved applying the algorithms. What difficulties did you have answering the questions?
- What could help you to answer them?

Task 2. Work in pairs. Try to explain each other the work of the algorithms using verbal means. Try to visualize the algorithms. What forms of visualization would you use? Find in the Internet static and dynamic forms of the algorithms visualization. Make a list of algorithms features which your partner was able to understand better after applying these forms of visualization.

Task 3. Learn the articles on the problem of cognitive visualization and explain how means of cognitive visualization and their functions are connected with different stages of learning and cognitive activity. What is the role of specific actions in the cognitive process? What physical acts could help to visualize the work of the algorithms?

Task 4. Work in group. Try to imitate the work of linear search algorithm where each of the students is an element of the array with a proper value. As a value, use Ukrainian folk exclamations from the proposed set. Choose your “value”, but do not sound it. The “searched value” is a student-soloist’s “value”. Pick up specific actions and motions in order to imitate “comparing of the elements values”, “moving on to the next element”, the situations “when the element is found”, “when the element is absent” etc. Answer the questions:

- Did you have “to sort the elements” to imitate this algorithm?
- How many steps of comparing did you have to do till the student-soloist found the searched element?
- Choose different values for the array elements including the searched value. Imitate again the same algorithm and calculate the number of steps. Make conclusions.
- Which tools of the programming language do you have to apply to program the algorithm? Why?

Task 5. Try to imitate the work of binary search algorithm. Repeat previous activity and answer the same questions of the task 4. Make conclusions.

Task 6. Find in the Internet Ukrainian folk music and samples of folk choreography. Chose the music and dance elements which match the computing ideas of the algorithms. Consult with a choreographer and try to "dance" the algorithms.

Task 7. Make a video of the choreographic visualization of the search algorithms.

Task 8. Watch the video and analyze its effect as a visual tutorial. Answer the questions:

- How certain are the algorithm instructions are reflected in the dance?
- What might be the didactic aim and methods of its using at the lessons?
- What questions would you ask to trainees, if you used this video as a visual tutorial?

The proposed technique of the search algorithms learning is implemented for the pre-service Informatics teachers' training during their classroom and extra-curricula activity. Giving analysis of the technique implementation, we would like to emphasize a number of its peculiarities which include some important dimensions.

First, students imitate the work of the algorithms being the "array elements" and storing the "value of the element" which is invisible to a "searcher" like it is "invisible" (or "unknown") to a computer. The value is opened only at the moment of the searcher's addressing to the "array element". In such a way we managed to overcome the problem of the students' formal attitude to the task of searching.

In addition, we use the set of Ukrainian exclamations as the values of the array elements, which are randomly chosen by the students before the imitation (or the dance). The same way the searched value (the exclamation) is chosen. Students remember their values and sound them only at the moment when the searcher addresses to the specific "array element". Dance developing follows this or that way, according to the sounded exclamation. In other words, data variability is reflected in the variability of the dance (the algorithm realization), which makes a bridge to a computer realization.

Finally, within our technique, the students themselves fulfill the roles of (1) "dances" (algorithms) developers and performers, what facilitates their understanding of the algorithms details due to their poly-sensory processing, trainees' involvement into personal and collaborative physical activity and effective creation of mental pictorial images; (2) users of the visual tutorial; (3) teachers who estimate the tutorial's quality. It is important to point out that watching the video of the ready-made dance on the final step of our technique, students can see the dance scheme as a cognitively visualized algorithm, which causes the re-construction of mental pictorial images within their memories. Moreover, students can analyze the results of their work from the standpoint of a trainee and a teacher.

3 Conclusions

The technique of the search algorithms learning by pre-service Informatics teachers is covered in the paper. The theoretical basis which allowed us to elaborate the technique includes CV concepts in their connection with the stages of learning and cognitive activity; ideas of bodily-kinesthetic intelligence as a factor of CV functions enhancing; choreographic ideas and their links with algorithms representation. The technique (which is given in the paper on the examples of linear and binary search algorithms in arrays) is represented as a set of connected specific tasks for students that determine direction of their collaborative activity. This detailed learning strategy, based on bodily-kinesthetic enhancing of CV functions, can be also successfully applied to the acquisition of key algorithms of arrays processing.

The peculiarities of the offered technique are analyzed. The technique includes integration of analytical practices with bodily-kinesthetic imitations; rules-based art making tasks; links establishing between algorithm visualization and dance writing. It was implemented for the pre-service Informatics teachers' training during their classroom and extra-curricula activity at Kharkiv national pedagogical university named after G.S. Skovoroda.

Such an approach to the algorithms learning might cause a positive impact on the level of students' knowledge, cognitive eagerness, and motivation, which makes prospects of our research.

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