STUDENTS' ACCEPTANCE OF ANIMATED INTERACTIVE PRESENTATION OF SORTING ALGORITHMS

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ABSTRACT

Programming courses are very important and challenging part of computer experts' education process. However, abstract nature of these courses makes them rather difficult for most students. In order to increase students' motivation and level of comprehension regarding programming an approach that includes less abstract presentation of programming concepts using visualization techniques is proposed and implemented through the tool SortExpert that is designed to help the students to cope in a more suitable and easier way with various sorting algorithms. Discussion about the effectiveness of existing visualization tools and research about the evaluation and acceptance of SortExpert are also presented.

1 INTRODUCTION

Programming as a profession is in high demand and this fact puts a lot of importance on the education of young computer experts and programmers. Understanding programming concepts and paradigms is a challenging task for most of undergraduate students that are in many cases seeing computer code for the first time. Abstract computer code format and syntax is not always the best way to make students understand programming principles, program constructs and data structures.

In order to increase students' motivation and to increase the number of students that successfully finish programming courses with sufficient understanding of algorithmic approach and various data structures, an approach that includes students as an active part of educational process through interaction with learning software that enables animated presentation of targeted concepts and structures as well as their mutual comparison is researched and discussed.

2 STUDENTS AND PROGRAMMING

Programming is a fundamental part of all computer science studies and curricula [8] and its importance in modern business world cannot be overstated. However, many authors agree that to learn how to program is a very difficult and challenging task [1, 9, 14, 7, 11]. Students tend to spend a lot of time and effort on grasping pure syntax of programming languages which leaves them with rather little time for understanding the main concepts that lie beneath the written syntax. This fact asks for means to increase the speed with which students are able to fully understand a particular algorithm or data structure. Nevertheless, most of programming classes still use mainly traditional way of teaching [10], omitting high-tech visual techniques. Visualization and SortExpert tool are one step in the direction of changing this kind of state in programming education.

3 VISUALIZATION IN PROGRAMMING COURSES

Adoption of visualization as well as willingness and ability of professors to make this kind of materials available is of vital importance. Research has also shown that passive graphical representation is not sufficient for proper understanding [13], so it can be stated that an interaction between students and visualization tools is also of great importance [12].

There are many existing visualization tools such as [16]: BALSA-II, XTANGO, JHAVE, BlueJ, Jeliot, TRAKLA2, ALVIS and ViLLE. Studies however still show variations in results of using these kind of tools [3] which indicates that there still remains a need for new concepts and improvement.

All this points in the direction of creating visualization models that would be complex and high-tech but would also include some form of interaction with the students. Interaction and customization of visualization model would support constructivism learning theory in which students are creators of their knowledge based on their existing knowledge and new presented paradigms [2]. It can be concluded that it is generally indicated that visualization is beneficial for students [15].

4 SORTEXPERT

SortExpert enables students to visually observe the whole process of sorting for some particular sorting algorithm. Sorting algorithms have been chosen because of their complexity and many problems that students have reported regarding this area of programming. SortExpert is aimed at providing students with visual representation of sorting algorithms that are dynamic is their nature and require more effort to be understood properly than programming concepts than can be presented in purely static way. In SortExpert every step is animated and students are able to experience the sorting process in much more vivid and clear way than by presentation which uses just static images. Since most of students are visually oriented the pure usage of graphics makes them more focused and more willing to deal with sorting algorithms.

SortExpert's design is simple and minimalistic with clear and intuitive navigation and options providing students with environment that enables them to focus on sorting animations. This is one of important characteristics that frequently lacks in many visualization tools. Another advantage of SortExpert is its interaction component which is an essential part of SortExpert that is aimed to further increase the focus and motivation of students to learn sorting algorithms. SortExpert supports several well-known sorting algorithms that are commonly found in programming courses: Bubble sort, Heap sort, Insertion sort, Merge sort, Quick sort, Selection sort and Shell sort.

When SortExpert is launched an initial set of numbers is displayed as a general set to be sorted. This set of numbers is also visualized through graphical representation. Students are able to select which sorting algorithm will be applied to generated set of numbers. Generated set of numbers can be changed by generating new set in one of four modes: random numbers (generates the set of some random numbers), reversed order (generates the set of numbers that are initially sorted in decreasing order), almost sorted (generates the set of numbers that are almost sorted) and few unique sets (several chosen examples of various sets of numbers). There is also possibility of changing the speed of sorting animation in order to see particular steps more accurately and possibility to pause the animation process. After the animation of selected sorting algorithm is done, in the details section at the bottom of the screen the students are able to see how many comparisons and how many replacements have occurred during the sorting process so they are able to quickly determine the complexity of particular sorting algorithm. All described features are shown in Figure 1.

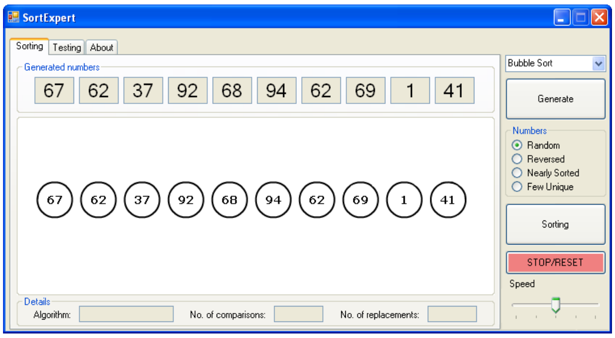
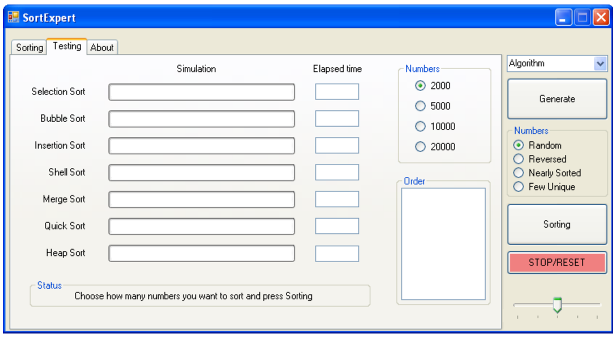


Figure 1: *Features of SortExpert*



Status: Choose how many numbers you want to sort and press Sorting

Figure 2: *Comparison of several sorting algorithms*

Along with the possibility of animated presentation of sorting algorithms, SortExpert also gives the possibility of comparison of several sorting algorithms using array of several possible lengths. Students are able to choose the number of elements to generate in an array and then they can compare sorting speeds in order to see which sorting algorithm was the most efficient (see Figure 2).

SortExpert provides a focused tool that has clean design that is intuitive and easy to use. User interface of SortExpert is composed of two main parts that are divided into two sections (Sorting and Testing) using tab control. Sorting tab is arranged is such a way that numeric array elements are vertically aligned with their graphical representations and the area around this representation contains a lot of free space which creates the minimalistic effect and enables easier focus on animation process. All necessary options are vertically ordered in the right part of the screen to be non-intrusive and easy to apply.

Testing tab consists of all supported sorting algorithms which are sorted vertically. Speed animation and elapsed sorting time are located along every sorting algorithm which enables students to clearly see the speed of every algorithm and to quickly conclude which algorithm is more suitable for array of chosen length. All array options are vertical aligned in the right part of the Testing tab in minimalistic way in order to enable quick change of array length and to show the final order of tested sorting algorithms.

5 SORTEXPERT EVALUATION

In order to evaluate acceptance of SortExpert tool a research was conducted on 182 information science students using TAM (Technology Acceptance Model) [6]. The research was conducted using an online questionnaire that was designed to measure the following aspects: perceived usefulness (U), perceived ease of use (E), attitude towards using (A), and behavioral intention to use (BI). Before the questionnaire was given the students were introduced to SortExpert during one lesson. Likert scale was used in all given questions (1-strongly disagree, 5-strongly agree). Cronbach's alpha coefficient values for every of 4 stated groups of questions were above 0.8 which shows sufficient internal consistency of designed questionnaire [4, 5]. The results of conducted questionnaire are given in Table 1.

Questionnaire item	Mean	Std. dev.
Perceived Usefulness (Cronbach's α = 0.825)		
SortExpert helps me in understanding sorting algorithms	4.730	0.493
SortExpert makes learning sorting algorithms easier	4.736	0.478
Using SortExpert makes learning of sorting algorithms quicker than by using textbooks	4.770	0.472
Using SortExpert enables me to learn sorting algorithms in a way that is more suitable for me than classic school presentations that are mostly based on text	4.713	0.512
I am able to understand sorting algorithms much more clearly by using SortExpert than by using classic textbook presentations	4.632	0.528
SortExpert increases my productivity in studying programming	4.431	0.730
SortExpert reduces time I spend learning sorting algorithms	4.701	0.559
SortExpert improves the quality of my knowledge about sorting algorithms	4.534	0.652
SortExpert gives me better insight into functioning of sorting algorithms than classic school presentations	4.615	0.657
Interaction and visual nature of SortExpert increase my motivation for learning programming	4.161	0.902
Perceived Ease of Use (Cronbach's α = 0.821)		
Using SortExpert is easy for me	4.598	0.624
I found SortExpert's interface to be intuitive and comprehensive	4.557	0.656
It is easy for me to remember how to work with SortExpert	4.649	0.565
I have no problems in using SortExpert	4.534	0.654
I think that learning how to work with SortExpert is easy	4.621	0.602
Attitude Towards Using (Cronbach's α = 0.840)		
I think that SortExpert is very useful in learning programming	4.684	0.555
I find that using SortExpert is helpful in clarifying sorting algorithms	4.747	0.496
I think that usage of SortExpert would be beneficial in programming courses	4.695	0.591
I think that SortExpert would enhance students' understanding and comprehension of sorting algorithms	4.764	0.499
Behavioral Intention to Use (Cronbach's α = 0.856)		
I plan to use SortExpert for learning of sorting algorithms	4.236	0.969
I intent to use SortExpert as a learning tool in my programming courses	4.305	0.867
When needed, I will use SortExpert to recall the concepts of sorting algorithms	4.431	0.745
When needed, I will use SortExpert for explaining sorting algorithms to others	4.178	0.981
I would recommend using SortExpert to all students	4.747	0.572

Table 1: *Questionnaire items*

The results in Table 1 show that students find SortExpert useful and easy to use. The results also show that students find SortExpert to be useful and beneficial in learning sorting algorithms. The usage of SortExpert also positively affects the motivation of students to learn programming. 93.40% of students gave answers 5 – Strongly agree or 4 – Mostly agree on the questionnaire item "SortExpert helps me in understanding sorting algorithms". 87.36% of students gave the same answers on the questionnaire item "SortExpert improves the quality of my knowledge about sorting algorithms". 88.46% of students gave answers 5 – Strongly agree or 4 – Mostly agree on the questionnaire item "Using SortExpert is easy for me". The same answers have been given by 91.20% of students on the questionnaire item "I think that SortExpert is very useful in learning programming" and by 91.75% of students on the questionnaire item "I would recommend using SortExpert to all students". According to presented results it can be concluded that students have positive attitude towards using SortExpert and that they find it to be beneficial and useful regarding their present and future learning of sorting algorithms. Simple interface, animation and interaction makes SortExpert usable educational tool for all students that captures their attention and makes them more focused.

5.1 Evaluation of SortExpert's effectiveness

In order to provide more objective conclusion about the usefulness of SortExpert, additional research has been conducted in a form of tests that have been given to students designed to test their knowledge about insertion sort. The same test was given to students after presenting them with insertion sorting algorithm in a traditional textbook way and after using SortExpert and graphical representation. Both tests consisted of 5 questions which were graded with either 0 or 1 point. The results of the test gave 415 points (45.60% accuracy) for the first test and 659 points (72.41% accuracy) for the second test which is increase of 244 correct answers or 59.79% after using SortExpert and visual presentation of insertion sorting algorithm. Stated data shows that SortExpert and graphical representation of sorting algorithms subjectively and objectively are beneficial for students in terms of easier learning and comprehension and increased level of retained knowledge.

6 CONCLUSION

Programming experts are in high demand and this makes their education more important than ever. However, students tend to find programming courses rather difficult because of their abstract nature. In order to make programming courses easier to understand and to increase students' motivation to learn programming an approach that includes visualization techniques and interaction between the students and visualization tool has been proposed. In order to evaluate such approach a tool called SortExpert that enables visualization of sorting algorithms has been developed and evaluated.

Evaluation has been conducted among 182 information science students and the results have shown that students perceive SortExpert tool as useful and easy to use which consequently results in positive attitude towards SortExpert tool and in positive behavioral intention to use this tool. SortExpert's interface simplicity combined with speed-adaptable animation and interaction has proven to be an efficient mean that increases students' focus and makes overall learning process more interesting and more understandable. Usage of SortExpert brings sorting closer to students in a way that is intuitive and comprehensive which helps to decrease students' fear of programming and increases their motivation to learn. Adding new concepts and constructs to SortExpert and further research about effects of visualization will be main part of future work.

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