

Visualization based intelligent tutor system to improve study of Computer Algorithms

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Abstract: Algorithms are like roadmaps for accomplishing a given well-defined task. It may be regarded as a backbone to the study of computer science. A Visualisation based intelligent tutor system (ITS) is a computer system that aims to provide immediate and customized instruction to learners, usually without intervention from a human teacher. This instructional strategy have the common goal of enabling learning in a meaningful and effective manner as students can 'see' whats happening with each problem and get instruction for each next move. This environment provides smart way of learning through the website "visualgo.net"; a visualization based intelligent tutor system provides a mean for active leaning with previous knowledge of the subject. This tool explains the stepwise working of algorithms along with visualization. It helps the learner to clarify concepts more precisely. The Control group and experimental group results are presented in this paper partially; supporting the effect of the usage of the visualisation based intelligent tutor system on student learning. The study shows that the use of visualization tool enhances the students learning ability and improves their concentration and interest in the subject. The test results are also improved accordingly.

Keywords: Visualization, Algorithms, Learning ability, Tutor, Instructional strategy

1. Introduction

According to popular book on algorithm by Coreman, it is defined as "algorithm is any well defined computational procedure that takes some value or set of values as input and produces some values or set of values as output". Algorithm is a core subject for computer science & engineering branch as it is used in almost each and every field from searching, sorting for a common man to organize the large dataset and scheduling of processes in operating system. By just entering a keyword and clicking a mouse, you can get what you want....so what lies behind all this??? One key feature is algorithm design and analysis. The subject Design and analysis of Algorithm focuses on algorithm design, analysis and application, to evaluate algorithm complexities and to equip students with different design techniques. At the end of the course student will be able to apply different algorithm design paradigms and methods of analysis and also able to synthesis efficient algorithm in common engineering design situation.

In Traditional "black board method " - teaching method ,teacher write an algorithm on the blackboard and student note it in their notebook and then teacher gives them assignment problem and student solve simultaneously with teacher .Class room consist of

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student of different nature and with different mental ability . When teacher teaches with writing on board, some students are just copying it in their notebook, some students just drop it, some are busy in chatting with writing while some note down it carefully ... So those who note it down without interest may lose interest while solving assignment question. If some algorithm is lengthy, it may create distraction by learning algorithm in part. At the time of submission because of their different writing habit they are not able to get the complete algorithm answer.

Intelligent tutor system a "computer system" based on "artificial intelligence" designed to deliver content. The main goal of intelligent tutor system is to interact with students similar to a human tutor. The program personalizes the instruction based on the background and the progress of every individual student. It consists of four basic components based on a general consensus amongst researchers as shown in Figure 1.

1. The Domain model containing expert knowledge.
2. The Student model checks student's level of understanding.
3. The Tutoring model provides assignments and task for completion.
4. The User interface mode through which interaction is done.

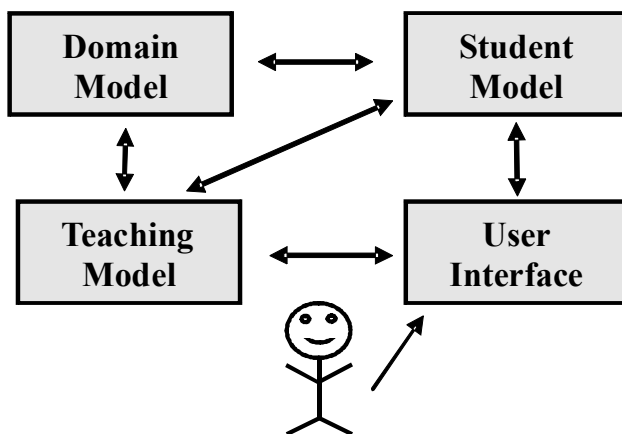


Fig. 1: Intelligent Tutor Model

Visualization, as term suggests is a technique to communicate a message through pictures, graphs, diagrams, and animation. The visualization means that the student can actually check the execution of the algorithm. It shows all the steps of algorithm. Visualization provides users a quick view with better understanding. The representation of any information or mathematical problem in visual form helps users in

solving problems. The visualization technique is used almost in all computer application fields with the use of graphical power.

Visualization based Intelligent tutor system is a combination of visualization with Intelligent tutor system. A web-based algorithm visualization tool "visualgo.net" [1] is used as an intelligent tutor. Through this visual tutor the computer algorithms are visualized with the data set and its working steps are provided in a graphical notation. The student can specify their own input to algorithm and visualization will work to produce output. In addition to this it also offers a collection of algorithm visualizations with unified interface. While solving the problem students receive feedback immediately.

The experiment is conducted for the third year Computer Science and Engineering undergraduate students for the course of Design and analysis of algorithm. The concepts are taught in theory class and the assignment given in the tutorial sessions with a small batch of students.

2. Literature Review

By solving assignment exercise own students can learn better but if some problem occurs they get more learning so that they can understand their limitations. Because of intelligent tutor, student gets dynamic working of any exercise which facilitates learning [2]. Now a days many web based tutors are used by students with different backgrounds and goals with previous subject knowledge [3]. Human Brain includes a working of limited capacity and duration with separate visual and audio channels [4].

Most education Institute use traditional blackboard method for teaching ,But now a days Intelligent Tutor system provides step by step guidance during assignment exercise solving. It also helps students to enhance learning.[5] Visualgo is a web based tool with collection of algorithms and online quizzes. [6] Student gets more interest in visualization than theory books and they get more guidance because of intelligent tutor system for correcting the exercise problem solutions with clear concepts. [7] Engineering student learn the design and analysis of algorithms without additional tutorial sessions or visuals.[8] The exercise problems complex to solve because of which students are not able to understand and it effects their concentration and interest for the subject. Because of Visualization

student will grasp subject easily. [9] Active learning of student can increase pedagogical values of student. Including Tutor provides correctness about each step. [10]

3. Features of Intelligent Tutor System

Visualgo.net is a web-based algorithm visualization freeware tool with the features as:

- It does not require any additional software to install.
- It is a collection of algorithm visualizations with user interface.
- It explains the algorithm behavior with dynamic input.
- It also consist of online quiz Components with grading system.

The tool visualgo.net is used for teaching the Design and analysis of Algorithms course. Figure 1 shows the Home screen of visualgo.net showing the main menu with different options like sorting, searching, minimum spanning tree, graph, trees etc.

With different attractive colours, it holds the attraction of students. Students can choose from given menu the main topic which can elaborated further. From Minimum cost spanning tree. Student can choose accordingly among different methods. The fig. 2 shows the Home screen of web based tutor system. Visualizations are available for different methods of algorithms. Students can choose accordingly.

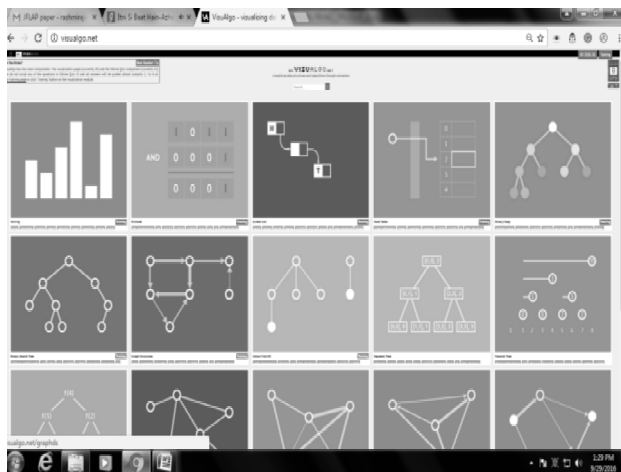


Fig. 2 Home Screen

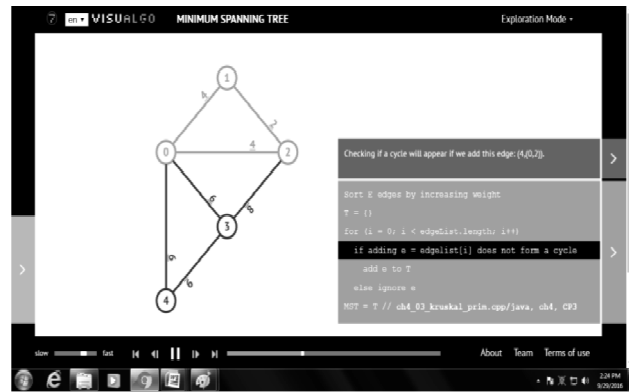


Fig 3 Minimum Cost Spanning Tree Algorithm Visualization

Figure 3 shows Visualisation of Finding Minimum Cost Spanning Tree using Kruskal's method along with intelligent tutor system. It shows how the algorithm executed in stepwise manner and accordingly how the corresponding diagram works.

4. Implementation

The experiment is conducted for third year Computer Science and Engineering class for the course Design and analysis of algorithms taught in class through traditional teaching approach using regular blackboard method during lecture session. Usually the concepts are elaborated in a theoretical way and they are more focussed on the notations and concepts with examples. The teacher explains Quick sort technique on black board. She writes the algorithm on blackboard and then simulates it using an example on the blackboard only.

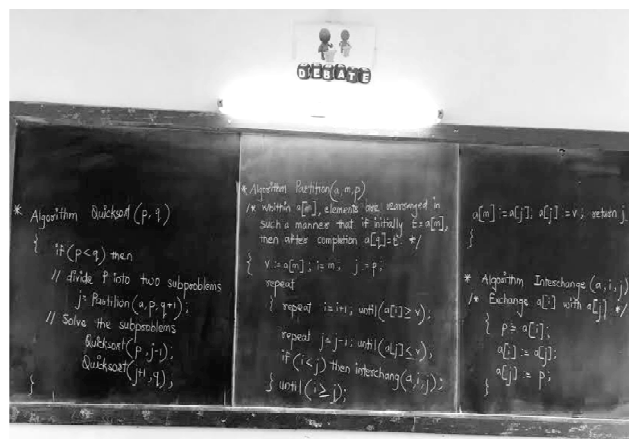


Fig. 4 Blackboard - Traditional Approach

Figure 5 shows exercise problem stepwise solving by teacher on a blackboard in a traditional approach. Teacher solves Quick Sort Algorithm in a stepwise manner on a blackboard.

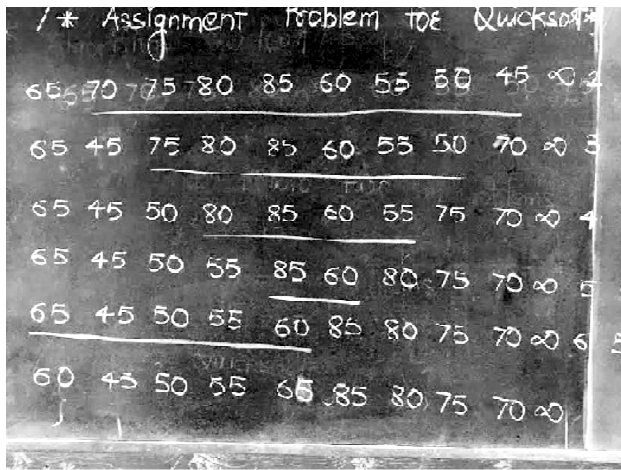


Fig. 5 Exercise problem on blackboard

Some Active students note down or solve problem correctly in a stepwise manner as per the execution of stepwise algorithm. They add their own comments or notes for their learning.

Figure 6 shows the sample copy of active student whose write each thing clearly.

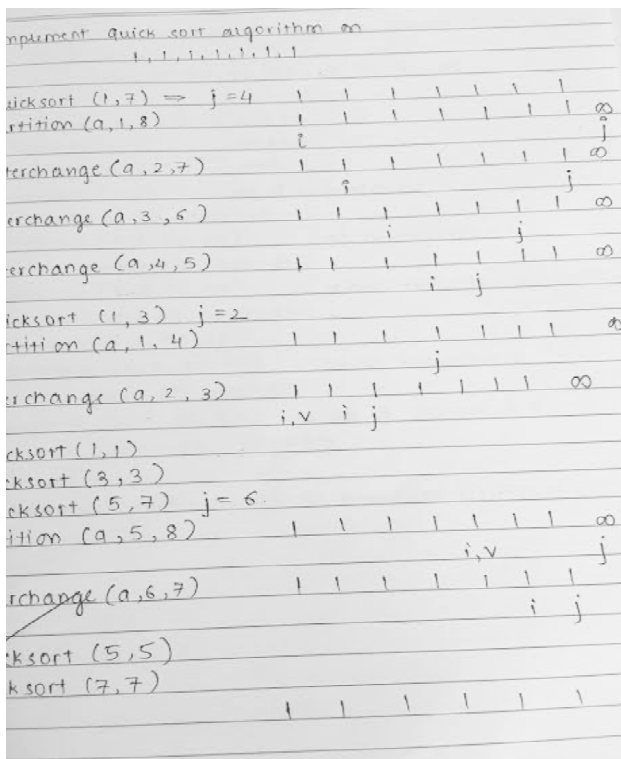


Fig. 6 Sample notebook pattern of Brilliant/Active Student

But as class is a mixture of active, passive, naughty such all types of students'. Their notebook patterns are also different. As shown in previous fig some note it correctly and vice versa as shown in below figure some stop at the middle of problem solving.

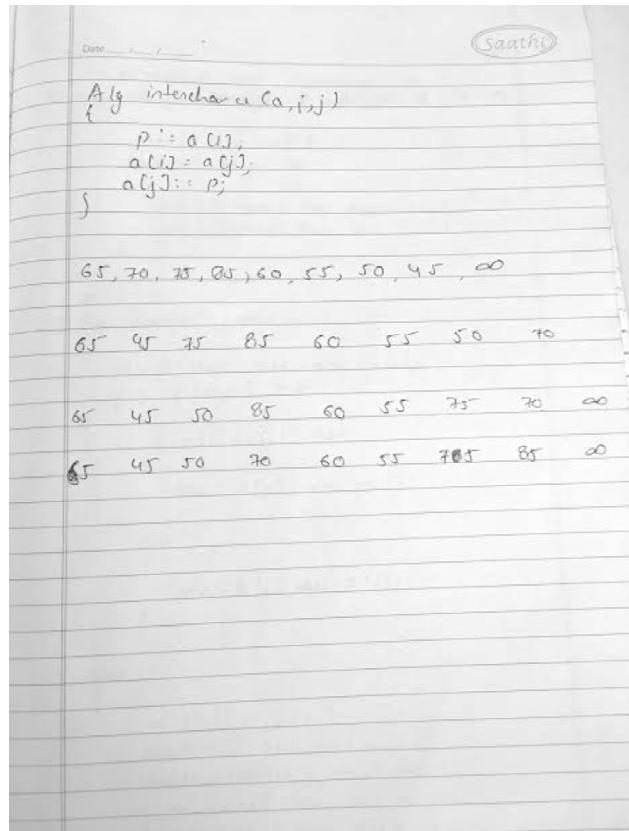


Fig. 7 Sample notebook pattern of passive student

During study at the time of exam they are unable to recover what actually they wrote. Books explains concept in a theoretical manner. Teacher may or may not available to explain them. So its better to start practising with the help of intelligent tutor which also provides visualisation after class theory lecture.

During tutorial exercise problem are given to student. The "visualgo.net" is used in two batches during tutorial sessions for solving problems. The students use the tool for different exercise problems based on different concept like sorting - merge sort, graph structure, Graph Traversal, recursion, Suffix tree, cycle finding, Minimum Spanning Tree, Binary search tree, Link list, Hash table etc.

Figure 8 shows student can provide input dynamically. 15 numbers are given as an input to Quick Sort Algorithm. According to inputs visuals are arranged.



Fig. 8 Input to Quick sort

As the Student start execution, another window shares screen which act as Intelligent Tutor. It gives stepwise execution of algorithm and main screen shows the visual effect along with algorithm as shown Figure 9.



Fig. 9 Stepwise Algorithm execution

At the end of execution of algorithm, it gives output in a visualised form as shown in figure 10.



Fig. 10 Sorted Elements

In this tool, you just have to supply dynamic input depending upon type of assignment problem.

The Visualization based intelligent tutor provides visualization as well as tutor provides stepwise assistance.

5. Experiment & Result

As per university syllabus, subject Design and Analysis of Algorithm is included in the curriculum of Third Year Computer Science & Engineering first

semester. The course is scheduled as 3 Hrs. Theory lectures and tutorial of 1 hour weekly.

Class strength is approximately 78 students, during lecture session. For the tutorial session four batches are grouped comprising of 18-20 students scheduled as batch1, batch 2, batch 3 and batch 4. During the tutorial session Teacher asks batches 1 and 2 to solve Quick sort examples as exercise assignment. The students do pencil work and complete the assignments in their notebooks. Batch 1 and 2 will act as Control Group

Now, teacher asks batches 3 and 4 to use "visualgo.net" - visualization based intelligent tutor system to solve the assignment of Quick sort. Batch 3 and 4 will be the Experimental Group

After completion of Experiment, test is conducted among Control Group and Experimental Group. Same Question paper is given to both groups.

Design & Analysis of Algorithm

Class - TECSE

Marks

: 30

Each Question carries 10 marks

- Sort Following Element with Quick Sort Algorithm (show each recursive call)
1,1,1,1,1,1,1
- Implement Merge sort Algorithm on following array
310,285,179,652,351,423,861,254,450,520
- Find Minimum Cost Spanning Tree of following graph

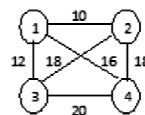


Fig. 11 Sample Paper

By looking at results ,It is observed that those are brilliant and topper perform good , either in control group or in experimental group .But for remaining passive student performance of 3 and 4 batches were efficient as compared to 1 and 2 batches because they practice through Visualization based Intelligent tutor . Their Presentation is also good

Results of Control group & Experimental group are compared. It is observed that students of Experimental group score more marks than control group

Table 1 below shows the analysis of marks among

number of students. Number of students are calculated for different range of marks. It is observed that students in experiments group score more in the range more than 21.

Table 1: Result Analysis

Range of Marks	Control Group	Experimental Group
Below or equal to 10	1	0
11-15	23	2
16-20	5	15
21-25	4	13
26-30	1	4

Figure 12 graphical represent of comparison of student test marks for control group and experimental group. It is observed that students of experimental group scored more than 10 marks. Good number experimental group student score more than 20 marks, approximately 50% of student. Also range of between 16-20 is near about 45%. And only 2 students get marks between 11-15 vice versa in Control group 70% student scored marks between 11-15. Only 15% student score marks more than 20.

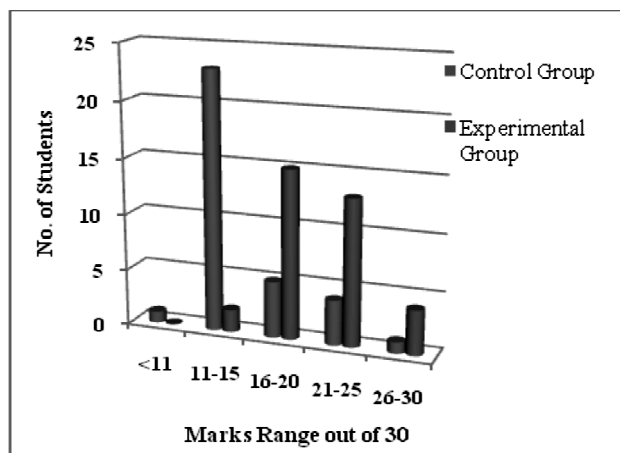


Fig. 12 Graphical representation of students marks comparison

Students Feedback is also collected and they show a positive response for the use of Visualization based Intelligent Tutor System as it increases active learning of student.

Some Points of student feedback are mentioned in figure 13.

1. Visualization of algorithms helps to understand the concepts.
2. We can draw our own graph and compare results; Input can be provided run time to algorithm. It is dynamic not a static
3. Website is flawless, good GUI and user friendly, so it is great tutor
4. GUI Based teaching increases interest in teaching
5. We can use it indecently

Fig. 13 Students Feed back

The results are calculated under t-test Calculator which gives t-value = -6.15947 and p-value = 0.00001.

6. Conclusion

In a traditional class room teaching method with a chalk-and-talk strategy the learners become passive. Generally it depends on teachers effective presentation skills where a good teacher can teach in an effective way and makes the class active. Usually students lose their concentration while learning the theoretical subjects and it decreases their interest towards it. Teaching a course like Design and Analysis of Algorithms is a challenge to a teacher where theoretical concepts are needed to be elaborated in an efficient way with proper visualizations for problem solving. To improve the active learning ability and involvement of student, visualization plays an important role. According to Chinese proverb "One picture worth ten thousand words", human brain is more attracted towards dynamic images and is able to process them properly than a normal text reading. It has been observed by this experiment that the use of visualization web tool Visualgo enhances the understand ability and concentration of the students towards the subject and also increases interest in the subject. The results shows that the students who opted the tool during the tutorial sessions have improved and the involvement of the student also enhanced through active learning.

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