Abstract

Discrete mathematics is essential to both computer scientists and software engineers. It develops the ability to reason and think mathematically and logically. A discrete mathematics course is centered on the correctness, logic and algorithms. It is a mandatory course in order to graduate for students majoring in computer science and software engineering. Most of the students find it difficult to learn the concepts in discrete mathematics. In this paper, visualization tools are presented that help the students learn some of the basic concepts in discrete mathematics.
1. Introduction

The development and maintenance of the software depend upon the knowledge the programmers gained while studying discrete mathematics. Discrete mathematics is a powerful tool for thinking and reasoning. It is one of the mandated courses for students graduating in computer science and software engineering. The ACM/IEEE Task Force Report (Joint Task Force on Computing Curricula, 2001), Computing Curricula 2001, mandates discrete mathematics as part of the core knowledge that the computer science students should learn. Apart from the fact that language is essential, the ability to think, reason and to apply that is the most important in developing software. The programmers get that ability from the knowledge they gain from studying discrete mathematics.

Students learning discrete mathematics in a traditional way find it harder to learn most of the concepts. They often practice homework problems as assignments, and take exams to confirm their proficiency. There are a few tools that assist them in learning discrete mathematics. Visualizations are created and used to aid the students in easily understanding most of the fundamental concepts (Visualizations web site, 2006).

2. Previous Efforts

Buchele, S. F (Buchele, S. F., 2005) observed that students found discrete mathematics rigorous and challenging. Discrete mathematics does need reasoning and logic. Some students face great difficulty in applying both. Great efforts have been made by many teachers in order to make learning discrete mathematics simpler and more understandable. A link system (Berry, J., 1997) was introduced as an educational tool, which can be used to visualize and experiment with the discrete mathematics algorithm. Representing the algorithms with the use of graphs helped in understanding the concepts. McGuffee, J.W. (McGuffee, J.W., April 2002) undertook the discrete mathematics enhancement project. The main idea of this project is to show how computer science and discrete mathematics are related to each other, and why they are important for students.

3. Difficulties

Almstrum, etl (Almstrum, etl, 2006) has listed fundamental discrete mathematics concepts with associated difficulties. Learning discrete mathematics is very abstract in nature. Manipulating the propositions and the values of the propositions and predicates are a very important part of discrete mathematics. The students try to manipulate those using symbols that mean nothing. They focus on manipulating the sequences of symbols, thereby trying to postulate as laws or rules without being able to give a meaning to those symbols and rules, or sequence of the symbols. The lack of meaning to those symbols is the source of the main problem in learning discrete mathematics. We plan on providing visualizations that give meaning to those symbols and their sequence, thereby providing
interest and motivation for the students to learn discrete mathematics. Anyone loses interest in whatever he or she does if they don’t have any meaning.

4. Visualizations

Visualization is a powerful tool in improving the skills to program and the program comprehensibility (Kasmarik, K., and Thurbon, J. 2003). The learners can gain the following advantages when they use visualizations to learn: increased accuracy of knowledge, clearer concepts, deeper understanding of the concepts, and easiness of learning the concepts. Diagrams and flowcharts give a more clear and practical view to a concept. They help to comprehend and analyze things more. Visualization supports the important goal of providing a solid foundation for lifelong learning in the life of an individual. We have successfully integrated visualizations in our introductory level Java programming class (Shanmugasundaram, V., Juell, P., and Hill, Curtis, 2006). We now plan to extend providing visualizations for some concepts in discrete mathematics.

5. Visualization Tools

Logic concerns the relationship among statements. It does not focus on the content of any particular statement. The symbols represent the content. Logic deals with propositions represented by the symbols and the use of operators on the symbols. Students face difficulties in learning about logic mainly because the symbols representing the propositions and the effect of operators on them are taught without any focus on the meaning of the propositions. We believe that by providing a visualization that can show the meaning of the proposition and its value, and the effect of the operators on the propositions, students will be able to learn about logic easily. Proposition is a declarative sentence with a subject and a verb. In order to find if it is true or false, we can present the propositions in the form of some visualization as shown in figure 1. This visualization shows three circles with two alphabet letters, A and B, in different positions with two propositions: A is inside the circle, B is inside the circle, a table showing the values of these propositions, and the propositions with the conjunction and disjunction operators. Three questions prompt the students to answer the values of different propositions and the different sequence of operations, with links connecting the correct visualization and the corresponding values. Students can use the first question from the bottom in figure 1 and see the corresponding circle to find the value of the proposition: A is inside the circle – true, which is tabulated in the table at the top and connected by a link. Using the second question from the bottom, the corresponding circle, the value of the result of disjunction operator on propositions A and B in the table connected by the appropriate link help students easily understand the effect of operators on the propositions. Similarly, they can learn about conjunction operators. The students need to learn about logic passively using this visualization.
We provided visualization, as shown in figure 2, which can be used by the students to interact with it actively to learn about the propositions, their values, and the operator’s effect on their values. In figure 1 the students need to learn passively, where as in the figure 2 visualization, students can learn actively. For example, the initial state of the visualization shows the table listing the symbols representing the propositions: one proposition dealing with the shape of the object, another one with the color of the object, its possible values, the operators on the symbols, and their possible results. The buttons for each proposition are named with both ‘true’ and ‘false’ values. The students need to click on the possible buttons which they think are the correct value for the proposition in question. The correct corresponding value of the proposition in question will be highlighted in the table with a red rectangle once the students click on the correct button. For example, the students can click on either of the buttons adjacent to proposition A that represents the meaning ‘The object is a circle’. Only when the students click on the button named true, the true values listed in the first left table under the A column will be highlighted with a red rectangle. Since the students can see the meaning of the proposition in the visualization – that the object is indeed circle, they will be able to identify the correct answer. Similarly, they can use the other buttons interactively to find
the values of other propositions. Even though both visualizations are of some value in learning about logic, we consider the second one better for its interactions.

![Visualizations for Truth Tables](image)

**Figure 2. Visualization to show truth tables for using operators on the propositions**

6. Discussion

Traditionally students learn about propositions and their values and logical operators using propositions expressed in text form and their corresponding values in a table. Students need to mentally visualize the relationship between the propositions and their values. The requirement of making mental visualizations hinders their ability to learn the concepts. By providing a concrete visualization, the students are able to see the relationship between the proposition, its corresponding value, and the meaning of their relationship.

Students can use Figure 1 passively to observe a proposition, its value, and its meaning. For example, let us consider a proposition: A is inside a circle. By looking at the picture, students can easily find the answer for its value, which is true as shown in the table of the visualization. The visualizations help the students clearly see the meaning of the
proposition and its value. In the traditional approach, students will be forced to mentally visualize the situation.

Using Figure 2, students can actively learn about propositions, their values, the effect of operators, and their meanings. For example, students can click on different buttons that are labeled by their propositions, with the operators finding their values as well as their meanings as they relate everything to the visualization. We are in the process of providing more visualization; simulation tools that can help students learn the basic concepts easily. For lack of space and time, we want to limit our discussion to only two examples.

7. Conclusion

We provided visualizations for explaining the propositions, their values, and their meanings, and also for showing the effect of operator like conjunctions and disjunctions on the propositions. We provided two modes of passive and active learning. Our work is unique and worthwhile in the perspective that it tries to remove the difficulties faced by students in learning logic, thereby trying to retain the students in computer science programs.

8. Future work

We have provided visualizations to help students learn propositions, their values, logical operations of conjunction and disjunction. We plan to extend our efforts to provide visualizations for other concepts in discrete mathematics. We also plan to provide simulation tools that help the students understand the meaning of their manipulating symbols to formulate rules.

9. References


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