A Model-based Learning Pedagogy for Conceptualizing and Solving Real-world Graph Problems

Indra R
Educational Technology
IITB, Mumbai, India
indra.r@iitb.ac.in

Prajish Prasad
School of Computing and Data Sciences
FLAME University, Pune
prajish.prasad@gmail.com

Sridhar Iyer
Educational Technology
IITB, Mumbai, India
sri@iitb.ac.in

ABSTRACT

Our research is an extension of the modeling theory framework proposed by Hestenes [1]. An exploratory study examined how Computer Science (CS) students use mental and conceptual models to solve real-world problems using graph algorithmic concepts. The study results reveal the profound use of conceptual models in successful students more than in unsuccessful students. The cognitive process in problem-solving depends on the schemata constructed during learning concepts and concept mastery. This poster presents the model-based learning pedagogy to progressively construct correct conceptual models in CS engineering students to solve real-world graph problems.

KEYWORDS: CS2, Graph Algorithms, Shortest path algorithms, path-finding algorithms, Problem-solving, mental models, conceptual models and modeling theory

Background Work

Investigating Hestenes's modeling theory and Seel's model-centered instruction in CS education [1,2]. We conducted an exploratory study to identify the impact of subjective knowledge and conceptual knowledge of CS students in solving graph problems related to path-finding algorithms. The findings corroborate the significant use of conceptual models in solving graph problems. Literature shows the importance of the learner's conceptual model for problem-solving tasks [3]. Bidlake, recent work investigates the progression of mental models in parallel programming based on evaluation rubrics [4]. Sorva's work emphasizes the impact of mental models in understanding variables in programs and suggests tailoring instructions to overcome misconceptions and abet equilibration [5]. Albeit there is no sufficient emphasis on building learners' conceptual models in solving algorithm problems. Seel identified several learning processes and proposed instructional strategies for model-centered instruction. Hence, we are proposing a model-based learning pedagogy to progressively build a conceptual model that is substantial in domain-specific problems. Our target learners are students who have a basic understanding of graph algorithms (who have already gone through an algorithm course).

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Proposed pedagogy

In solving graph algorithmic problems, the learner employs three levels of conceptual models. i. Base model - The learner abstracts the problem as a graph of nodes and edges with suitable labels. ii. Intermediate model - He/she identifies the appropriate graph algorithm to apply and find the solution for an instance with a personal understanding of the problem, and conceptual knowledge. iii. Target model - The learner traces the algorithm to validate the chosen algorithm and makes modifications to the algorithm if required based on the problem to find the optimal solution. The intervention employs constructivism that facilitates the progression of the learner's conceptual model from base to intermediate and intermediate to target model. The intervention's pedagogical elements help learners gradually build conceptual models through sequential activities. A Chatbot will assist the learner throughout the problem-solving task by progressively building the correct conceptual model. The sequential activities are- i. Guiding questions and representation assistance help learners build a base model, the learner uses mental models to understand the problem and abstract the problem as a graph. ii. Reasoning questions guide the learner to identify the appropriate algorithm to solve the problem and write a reflection to justify the algorithm chosen, thereby conceptualizing the algorithm for solving the problem. The bot provides necessary feedback and hints to improve the conceptual model. iii. Guiding questions for algorithm tracing to improve or modify the algorithm aid in building target conceptual models in learners. We aim to conduct a pilot study to examine the proposed intervention, test the hypotheses using worksheets, and further implement the system.

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