G. REPRESENTATIONAL SCAFFOLDING

External Representations for Collaborative Learning and Assessment

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ABSTRACT

This interactive session brings together researchers and educators interested in using external representations to facilitate and assess learning. The session will juxtapose four systems, each of which takes a different design approach. The representations include concept maps, metaphorical textual descriptions or visualizations for helping students learn in complex domains such as science or programming.

Keywords

External representations, concept maps, algorithm visualizations

INTRODUCTION

External representations in many forms (e.g. concept maps, animations, visualizations, etc.) are now increasingly being used in interactive learning environments under the assumption that they provide affordances that are significantly different from expository environments (Jacobson & Archodidou, 2000; Suthers, 2001). External epresentations are believed to be especially helpful in helping students learn in complex domains such as science (e.g. White & Fredrickson, 1998) or programming (Hansen Schrimpsher & Narayanan, 1998). External epresentations can accentuate relevant characteristics of a concept and make higher-order relations more accessible. Collaborative learning can be enhanced through the negotiations that arise when co-constructing representations and through the subsequent role that collaborative representations play in coordinating discussion. Four systems, using external representations in different forms will be presented in this interactive session. Of the four, ALVIS (Hundhausen) and CAROUSEL (Hübscher-Younger) use algorithm visualizations and CoMPASS (Puntambekar) and Belvedere (Suthers) use concept maps as external representations.

ALVIS

ALVIS (<u>AL</u>gorithm <u>VI</u>sualization <u>S</u>toryboarder) is an interactive algorithm visualization system designed to make constructing a visualization as easy as constructing a "storyboard" out of simple art supplies such as construction paper, scissors, glue, and pens. We will demonstrate the ease with which one can create "cutouts"—virtual scraps of construction paper—and lay them directly out on the ALVIS animation surface. Underlying ALVIS is SALSA (<u>S</u>patial <u>AL</u>gorithmic <u>L</u>anguage for <u>S</u>torybo<u>A</u>rding) a high-level, interpreted language for programming animations based on spatial relations. We will demonstrate how one programs an algorithm visualization in SALSA by creating a *spatial analogy* of the algorithm to be visualized. Finally, we will describe three key features of ALVIS specifically designed to support conversations about algorithms: (1) fine-grained execution control; (2) dynamic mark-up; and (3) dynamic modification. Drawing on ethnographic studies of algorithm visualization construction and presentation exercises in an actual undergraduate classroom, we will illustrate the ways in which these features, along with specific features of "low fidelity" (sketched) visualizations, mediate and facilitate meaningful conversations about algorithms. We also consider ways in which algorithm visualization construction and presentation exercises can form the foundation for assessing students in an undergraduate algorithms course.

CAROUSEL

CAROUSEL (Collaborative Algorithm Representations Of Undergraduates for Self-Enhanced Learning) helps students engage in an active process of algorithm representation *creation, sharing and collective evaluation.* Learners relying on a single representation of an algorithm often misinterpret the limitations and specifics of that representation. A representation highlights or emphasizes different aspects of a concept and places less emphasis on or even ignores other aspects. A complete understanding is more likely to emerge from multiple different representations of a single concept. Students do not consider all representations equally, however. Representations similar to those presented by their instructor are often invested with more authority. Students are more likely to accept representations as being incomplete and partial when created by their peers. Thus they may be better able to understand that different aspects of the algorithm need to be understood, and that different representations de-emphasize, as well as highlight, different aspects, when creating, sharing and evaluating their peers' representations. We plan to demonstrate how the software supports the sharing of representations and the collective evaluations and discussion of representations. We will illustrate how student representations changed over time and show the variety of the style of representation as well as the variety of content.

CoMPASS

CoMPASS uses situational, dynamic concept maps to aid navigation and to scaffold students in their understanding of Physics. The system has two tightly integrated parts - a textual representation of the content units and a visual representation in the form of concept maps. Both views change dynamically as students choose the concepts. The maps are constructed and displayed with a fisheye based on the strength of relationships between the concepts. There are two main components of CoMPASS. First the software uses conceptual representations for navigation. Students' navigational paths are used to create representations of student learning. The 'pathfinder' graph theoretic technique creates a graphic representation of students' navigational patterns. Students' collaborative representations can be used (a) for assessment of student learning and (b) to assist teachers in getting insights into common misconceptions of a group of learners. Second, CoMPASS allows students to create their own maps. These can be created by a 'drag and drop' mechanism from the system map. Preliminary studies using CoMPASS have shown that students have a richer understanding of the domain and of the interconnectedness of the concept when they used concept maps for navigation. We are studying how student representations can be used to assess student learning, and the roles of student and system representations to scaffold learning.

BELVEDERE

The Belvedere project explores the use of visual knowledge representations to help make scientific reasoning and argumentation more accessible to students. Belvedere 3.x enables students to construct evidence models under any of three representational views: graph, matrix, and hierarchy, and to move freely between these views. External representations constitute an important resource for collaborative learning, particularly when they are constructed and manipulated by the learners. When learners are constructing a shared representation, the necessity of making a joint decision concerning the representational components to be created can lead to negotiations of meaning. Once created, these representations can facilitate subsequent reference to complex ideas through deixis, and can remind participants of these ideas, leading to further elaboration. Recent empirical work with Belvedere has focused on the "representational guidance" hypothesis, which states that the ways in which a given representation plays these roles will depend in part on the characteristics of the representational toolkit itself: what it prompts for, what aspects of represented information are made salient, and what cannot be represented at all. Results from a study testing his hypothesis will be summarized. The next step is to understand how to move between representations in order to most effectively support different subtasks of an inquiry process.

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