C-TOOLS:
Concept-Connector Tools for Online Learning in Science

PROJECT DESCRIPTION

Introduction

How many of us have walked away from a wonderfully engaging class feeling confident our students understood the material we presented, to later be disappointed with the exam? We have observed brilliant students that could teach their peers the intricacies of DNA replication but were stumped by the 'easy' question on the exam that required them to explain the relationship between a gene, DNA and a chromosome. Students often seem to understand the details, but do not see the big picture or the connections between a new concept and the last.

In our own learning as scientists, we use visual models to understand complex systems, to communicate our ideas to our peers, and to deduce testable hypotheses. Models are one of the common themes in science; they are "the main vehicle by which science actually produces its explanations and predictions" (Casti 1990, p. 31). Students and scientists alike can use models to describe, evaluate and learn science. In our own quest to find modeling approaches that could help our students reflect on the big picture, we discovered a cornucopia of educational tools. Vee diagrams, venn diagrams, concept maps, flow charts, and storyboards were all developed by experts to resolve this dilemma. But what does the research say about the effectiveness of each tool? And can we get a good online version?

In our research we found that many tools showed potential, but the concept mapping approach developed by Novak et al (1984, 1998) is the best studied and validated visual tool for student learning. It forces students to confront and grapple with the conceptions and misconceptions they bring to their learning. Twenty years of research and numerous studies show concept maps can succeed as both an effective instruction and formative assessment tool for higher-level learning. Currently, online formative assessment tools are rare and web-based concept mapping software is either not readily available or does not exist. Therefore, we propose to create software that delivers online concept mapping capability with automated feedback.

Overview of Proposed Project

The investigators of this project proposal are encouraged by the strong reviews of this proposal from the first submission and have implemented all the suggestions of the panel. Over three years we propose to develop, validate, and disseminate a new assessment tool called the 'Concept Connector' (now in beta version). The Concept Connector is a web-based concept mapping Java applet that we will develop and pair with automatic scoring and feedback functionality. This tool will enable students in large (and small) introductory science courses to visualize their thinking online as well as to receive immediate formative feedback. The assessment tool and the methods of its application in the classroom will be designed to motivate students to reflect, revise and share their thinking with peers as an extension of the learning process. The value of knowledge scaffolding tools such as concept maps, flow charts and venn diagrams is that they reveal student understanding about the direct relationships and organization among many concepts, elements not easily assessed by multiple choice questions or even extended responses.

Automated scoring algorithms will be developed and embedded in the Concept Connector to allow for immediate feedback to students. The Concept Connector's flexible scoring system, based on tested scoring schemes as well as instructor input, will enable automatic and immediate online scoring. As expert faculty score connections on a graduated scale, their input will be added to a growing computer-based library that will ultimately have full capacity to score all connections stored in the library automatically. Criteria for scoring will be based on agreed upon structure and connections by "expert" faculty in the content area. Faculty will conduct and analyze students' dialogue as they use the Concept Connector and conduct focus group interviews about the students' use of the tools and their resultant maps. In this project we strive to develop a tool for detection of problems in learning that include inaccurate, incomplete or vague conceptual understanding. The Concept Connector will enable faculty and students to readily recognize when students do not understand concepts and motivate both to address these deficiencies.

The validity of the Concept Connector will be determined by a 'design' experiment (Suter and Frechtling 2000) that involves testing the tool with undergraduate science-majors in introductory biology, physics and chemistry courses. A potential cohort of over 1000 students, those enrolled in participating courses, will be recruited to test the effectiveness of the tool to assess (mis)understanding. In each class, faculty will design two online homework problem sets to assess students' understanding of important concepts taught in the course. Students will use the Concept Connector as a part of online homework. We predict (1) faculty will become better able to identify their students' areas of misunderstanding, and (2) students will confront their misconceptions and be able to reflect on, organize, and integrate their learning.

Investigators and faculty collaborators are part of an interdisciplinary team of faculty from the College of Natural Science and the Lyman Briggs School at Michigan State University (MSU). The people participating in this project are: the C-TOOLS "Faculty" meaning the PIs (core faculty) and other instructors (affiliate faculty) who teach with the Concept Connector software, the C-TOOLS "Programmers" who build and revise the software, and the C-TOOLS "Students" who will use/test the software (Figure 1).

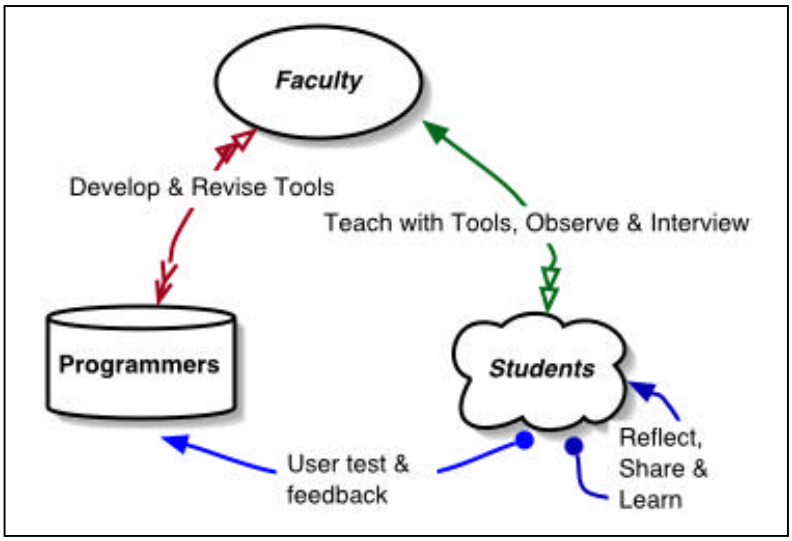

Figure 1: Faculty will work with Programmers to develop the software, as well as the problem sets and concept maps for their courses. Faculty will teach using the Concept Connector in online homework assignments and arrange to observe and interview some students working on the homework. Students will work individually and in groups reflecting on the concepts they learned in class and also talk to the Faculty and Programmers about problem sets, software and science.