FY10 Innovations in Teaching with Technology Awards: Development and Assessment of Web-Based Student Generated Cause and Effect Diagrams in Science Education

**FY10 Innovations in Teaching with Technology Awards**

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<th>Proposal Title:</th>
<th>Development and Assessment of Web-Based Student Generated Cause and Effect Diagrams in Science Education</th>
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| Investigators: | Principle investigator: Fred R. Dee  
Collaborators: Stephen Hendrix, PhD.  
Department of Biology  
College of Liberal Arts and Sciences  
Brian Lai, PhD.  
Department of Political Science  
College of Liberal Arts and Sciences |
| Org Unit: | Carver College of Medicine |
| Department(s): | Pathology |
| Funding Awarded: | $32,000 |

Causation (or cause and effect) has underpinned acquisition of scientific knowledge and scientific inquiry for centuries and is integral to all of the sciences including biologic, physical, environmental, political, economic, and social. In defining causation as “anything producing an effect”, Webster’s Unabridged Dictionary, also defines the Law of causation: “every event or phenomenon results from an antecedent cause”. Diagrams depicting cause and effect relationships are excellent teaching tools that abound in textbooks and articles in the sciences. In our pathology course we implemented student generated cause and effect exercises that require the student to diagram the development of observed phenomenon from etiologic factors, risk factors, and intermediate events or processes. Although students and instructors believe these student generated cause and effect diagrams are effective teaching aids (as is true for traditional concept maps) they are difficult and time consuming for students to create and display in small group discussions. Additionally if used on examinations, it is difficult to efficiently and reliably score the diagrams.
Aims:
1. We aim to create novel web-based exercises in which students can intuitively and efficiently construct multi-step diagrams with arrows depicting causal relationships (i.e. leads to, results in, produces, influences) between and among a set of etiologies, risk factors, events, processes, findings and/or observed phenomena.

2. The exercises will be easily created and edited by teachers from a scripted editor interface.

3. These exercises will have efficient scoring and feedback mechanisms in that they will be automatically scored from a teacher generated diagram that serves as the key.

4. Finally we aim that the exercises will be reliable and valid measures of student’s ability, so that they can be used to improve learning in a University of Iowa course.

Working with Steve Wessels this summer and fall, we have developed a proof of concept pilot interface (scripted in Flash) in which the student, after reading a brief real-life or theoretical scenario, is directed to create a “cause and effect” diagram. See Appendix 1a and associated link to the diagramming instrument. Appendix 1b shows the manually drawn instructor diagram that was used to create the exercise shown in the pilot link in Appendix 1a.

The next steps in development of the exercises will be to create a load/save extension of the pilot that captures the stage coordinates of the text box word items (i.e. etiologies, risk factors, events, processes, findings and/or observed phenomena) and arrows as they are arranged on the stage. This version will also capture the cause -> effect associations (which have been created by arrows connecting the word items) in an xml file as shown in Appendix 2. The captured coordinates will allow students to save the diagram and display it at a later time in a discussion group. The xml file will save the student’s associations for purposes of scoring against a teacher generated xml file key. To create the xml file key, the teacher in an edit mode first generates a list of word items to be used in the exercise and then uses them to create an ideal diagram by moving them on to the stage and connecting them with arrows. This edit mode automatically generates the xml file scoring key, and the stage coordinates are used to provide the ideal diagram electronically to the student as feedback after they compete and submit their diagram.

Finally, we will need to develop a secure login mechanism so students’ diagram data can be associated with their password. We also need to develop a mechanism to confidentially capture and transfer student scores to other databases if the exercises are used for progress examinations.
Venues for use

We will initially target undergraduate students and medical students.

The software can be used in at least 4 different venues:

1) Small group discussion or labs where students will work on assigned diagrams outside of class and bring their solution to class to present and discuss and/or submit to be graded.

2) In Team Based Learning where groups of students work together to create and discuss diagrams.

3) Progress exams and self-assessment exams where student generated diagrams will be graded against an instructor’s “correct” diagram.

4) The instructor can use the software to create diagrams for specific cases and examples to use in lecture and discussion groups.

Outcomes/Objectives

The long term expected outcomes/objectives are that students who participate in these exercises will have a more in-depth understanding of cause and effect relationships in science, and be better able to explain how observed phenomenon develop from preceding events. An additional outcome is that students will acquire information about etiologies, risk factors, observed phenomenon and other entities as they prepare to create the diagrams. Active application of this knowledge in a diagramming exercise will in turn augment longer term retention of the information.

In small groups these diagrams can also be used to facilitate followup discussion of: 1) known interventions that can interrupt the causation depicted in the diagrams, to produce an altered outcome, 2) gaps in our knowledge of causal relationships and interventions, and 3) hypotheses for investigation of these gaps to increase scientific knowledge.

If successful at the University of Iowa, sets of these exercises could be made available to other institutions over the internet. These longer term goals might form the basis for a proposal for federal funding from the National Science Foundation.

Evaluation:

During the year of funding Dr Hendrix and Dr Lai will each develop 10 exercises for undergraduates in their departments (see examples in Appendix 3 & 4). We would then recruit 15 junior and senior students in each department to engage the 10 exercises. These students, who would be paid volunteers recruited with IRB approval,
would help us evaluate the program and content for student satisfaction, difficulty, discrimination, and reliability. Dr. Dee would do the same study with medical students using 10 pathology scenarios. He would also pilot an additional 10 exercises in pathology small group case analysis sessions. If used for measurement of student’s ability on examinations we would also need to measure inter-teacher agreement on the “correct” key for grading purposes. The results of the above formative evaluations would result in a publication.

The results, which we expect to be positive, would encourage teachers on campus to integrate and evaluate the exercises in their courses the following year. We would also pursue evaluation of validity by: student and teacher satisfaction questionnaires, comparing student performance on these exercises with other measures of ability, comparing outcomes of students in courses or course sections with and without the exercises, and/or correlating students’ scores on the exercises with time in training.

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<th>What resources will you need?</th>
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**Budget Total = $35,500**

$20,000 personnel costs for programming of the load and save version and associated functionality described above. This will be carried out by Steve Wessels. Note that we have already received $8500 for programming from a Carver College of Medicine seed grant (OCRME-EDF) to defray the cost of initial programming of the proof of concept pilot shown at the URL location in Appendix 1.

$5,000 personnel costs for database development and management to develop the secure login mechanism, and a database structure to capture and report individual and aggregate results and interface with ICON and electronic progress examinations. We may also investigate the potential for integration of the exercises into commercial products.

$7,500 for personnel to help create content for exercises. This might be in the form of student fellows.

$3,000 to pay for bioscience student formative evaluations. We have already received funding from the OCRME grant for $1500 for the medical student portion of the formative evaluations.

**Appendices**

- Development and Assessment of Web-Based Student Generated Cause and Effect Diagrams in Science Education.pdf
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