Collaborative Writing Software for Problem Solving in Math

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Abstract

Although many different forms of collaborative writing exist, the definition proposed is any procedure whereby two pedagogical assumptions are met: (1) writing helps students discover their thinking process, and (2) sharing critical thinking methods can show students the divergent ways people find solutions. Computers are useful in collaborative writing because repeated use of tutorials can help students learn problem-solving methods, allow students to share their work in a flexible manner suited to many classroom environments (K-12 and college), and serve to give teachers a window into the thinking process of their students. The SEENMath software, developed through a National Science Foundation (NSF) grant, comes with a tutorial in mathematical problem-solving (based on Polya's four-step heuristic) that allows students to accompany their writing with drawings, calculations or graphs. Students share their completed explorations of a problem with other students through a built-in bulletin board that allows peer review. Use of the software at Indiana University-Purdue University, Indianapolis (IUPUI) with large sections of Finite Mathematics shows the practicality of including collaboration as homework (for predominantly non-science majors) via a computer program at a commuter campus.

Keywords — math, problem-solving, writing, commuters, non-science majors.

1. Introduction

Mathematics educators, through the National Council of Teachers of Mathematics' STANDARDS, have called for more active learning at all levels of mathematics education. Students especially have problems with "word problems." Our project is to encourage active learning by modifying the structure of SEEN (an award-winning humanities software program). The initial tutorial models Polya's four-step problem-solving heuristic: understanding the problem, devising a plan, carrying out the plan, and looking back to evaluate and apply. However, SEEN-Math also allows an instructor to revise an existing tutorial or create a new one.

The new software, SEEN-Math, is being implemented in a Finite Mathematics course at Indiana University-Purdue University at Indianapolis (IUPUI), an urban commuter university in which most sections of the class are large, most students are non-science majors (primarily Liberal Arts, Education or Business), and student collaboration outside class is difficult to arrange. SEEN-Math is being introduced at IUPUI to promote learning through writing and collaboration in a way that fits the logistics of an urban commuter university. It is being assessed on the basis of student use and outcomes. In addition, SEEN-Math is being incorporated into the methods courses for elementary education and secondary mathematics education majors, because the student work recorded in SEEN-Math provides a window on the thinking process of novice learners.

2. Basis in Learning Strategies

The use of writing in assignments throughout the curriculum has been growing based on research-based recommendations and assumptions (first published on a large-scale study of British schools by Britten et al.): that writing is important not only for communication but also for the discovery of ideas and a holistic understanding of a subject. The inclusion of collaborative activities grows from educational theory that group work necessarily involves the articulation of goals as well as ideas--and that these metacognitive activities improve learning and retention (Hillocks; Bruffee).

Computer-based materials can employ these strategies, making classrooms and homework assignments more flexible in scheduling. SEEN (designated as EDUCOM./NCRIPTAL Distinguished Software in 1985) has always included tutorials that present open-ended but structured questions for discovery learning and a built-in bulletin board that aids peer review.

The program is based on the following assumptions about learning:

(1) Informal writing engages students with material and leads to the discovery of new ideas.

(2) Seeing the work of peers helps students see different points of view (and the need for supporting evidence for their ideas) and compare their own work to that of others.

(3) Participation in peer review and revision gives students experience in evolving knowledge in contrast to the idea of knowledge as memorizing truth.

(4) Repetition of tutorial questions (such as sets of questions--or "heuristics"--that lead a student through character analysis in literature) helps students internalize those heuristics.

(5) A teacher who reads student output gains a window into the thinking process of students and thereby gains a better idea of what students need for guidance.

The humanities tutorials, without multi-media utilities, have been described as helping students internalize heuristics (Schwartz), as providing feedback with which students can revise papers (Hastings) and as involving students with their evolving ideas more effectively than paper-and-pencil responses (Schwartz, Fitzpatrick and Huot).

3. An Illustrative Example

In Spring 1995, students have used SEEN-Math in conjunction with a large lecture section of Finite Math along with a standard textbook. In addition, they work three special problem sets using SEEN-Math. Going to any campus computer lab during free time, a student calls up SEEN-Math from the campus network. She enters her name and id number (so that her activities can be noted by the administrative part of the software). Then she is ready for the questions (with questions and answers shown in the sample included below).

Help is available from two sources to the student as she proceeds. First, an example of a completed tutorial is available from any screen on the tutorial. Second, each question has an associated advice text that gives an example for answering that question or gives further explanation.

The network management utilities make sure that students get the tutorials and groups they have been assigned, make note of the activities they perform, and store copies of work posted on the bulletin board. The authoring utility allows the writing of completely new tutorials or revision of the questions, advice and example in existing tutorials.

4. An Actual Example

This section shows, first, the problem students were asked to solve with the SEEN-Math tutorial questions and then a sample student response:

> A study of 150 high school juniors was conducted to determine the use of alcohol and cannabis. The term "use" is defined as at least once a month. The results of this study were published through the following statements. How many females use either alcohol or cannabis?
>
> 52 males were in the study
> 37 students use cannabis
> 77 students use alcohol
> 21 males do not use either alcohol or cannabis
> 0 females use alcohol and cannabis
> 10 males use alcohol and cannabis

Here is an actual response provided by a student in one section of Math 118 (with SEEN Math questions in boldface):

<u>**Understanding the Problem**</u>

Identify the source of your problem so others can find the original wording:
Watt, supplementary question #2 to chapter 1

State the problem in your own words.
A group of males and females who use booze and pot. Some males use neither, some use one or the other, some use both. However, no girl uses both.

What are you trying to find?
How many females use either alcohol or cannabis.

What are the data that might be useful to find the unknown: How many females use either alcohol or cannabis?
150 students
52 M, 37C, 77A
21 M don't use either
0 F use both
10 M use both

Find the connection between the data and the unknown. List any equations, facts or formulas you might use to find the unknown: How many females use either alcohol or cannabis? For ADVICE, click on the ADVICE button.
Males are complement of females.

Devising a Plan

Can you think of a problem similar to this that you have seen before?

[If the students says no, s/he is taken to the next new question. If s/he clicks on "yes," she is asked to answer the following question: **Describe the similar problem and what you remember about the method that solved that problem.**

> In the text p. 26, #12. Students were grouped into 3 subsets: domestic, import, or bicycle. With Dom and Impt cars being mutually exclusive (0). The key was not to overlap the two types of cars. I am not sure if it was even possible to solve for all of the partitions in the Venn diagram.

How are the data and the unknown (How many females use either alcohol or cannabis) related in your problem? (You may want to back up to review the data you thought would be helpful. use the Previous and Next arrows to go back and forth in the tutorial.)

> [student did not answer this]

Put into your own words the essential steps and methods of your plan to solve the problem and state why these methods should produce the solution to the problem.

> Draw a Venn Diagram.
> Be careful not to overlap sets for females.
> Calculate the numbers for as many partitions as possible
> Shade the areas that add up for the solution (that is, labem them x and y).
> Add up the numbers to the areas for females that use either.

Carrying Out the Plan

[The student carried out the plan by using the Paint program to draw the Venn diagram, which was then pasted into the text of the tutorial, as shown in Figure 1.]

Your plan was to solve for the unknown: How many females use either alcohol or cannabis. Now that you have carried out your plan, what solution did you find?

> x + y = 73

Looking Back

Does your result, x + y = 73, make sense to you?

[If the student clicks on "yes" (as in our example), the student is taken to the next question below. If the student clicks on "no," s/he is told, "Describe why your solution (x + y = 73) does not make sense to you." and then is given the chance to go back to review his/her plan.]

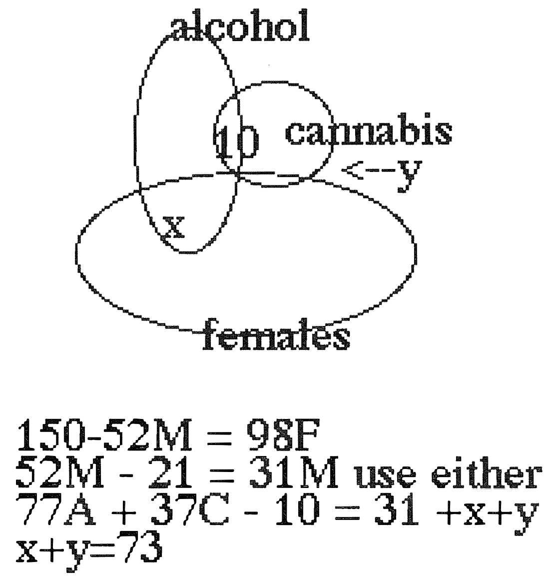

Figure 1. Venn diagram.

How would you describe your feelings and thoughts about this problem--for example, to a friend?

> I still don't know why on these problems I can't get numbers for all the particitions. etc. Why did I not use the fact that there were 98 females?

Describe how you can use this result or method to solve other problems. For example, write a related problem of your own that would use this same plan. (Use the ADVICE button to get an example)

> A survey is taken before the debates. Each person was asked who they would still consider voting for (none, one, or more than one) Perot, Bush, Clinton. No person who was considering Perot was still considering Bush.

5. Elements of Tutorials

Tutorials are constructed from 3 kinds of screens and several strategies for presenting material. Possible screens include information screens (which call for no response), limited-response questions (which require answers limited to about 100 characters so that they can be embedded in subsequent questions) and open-response questions (which accept virtually unrestricted imput). In addition, a pseudo-branch can be arranged by preceding a question with a yes/no question (for example, if the user says "no" to the question, "Can you think of a similar problem?" the question about similar problems is skipped). A yes/no question also allows the repetition of a question to which there may be more than one answer. Finally, a feature of the authoring program allows the input of one screen to be brought forward to another screen as a prompt; in effect, this strategy allows complex thinking processes to be divided into parts. For example, when asking for a comparison and a contrast, one question can ask 'in what ways are X and Y similar?' Then on the next screen, the output appears, followed by the word BUT, and the question prompts the student further: 'In what ways are X and Y different?'

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