Teaching Methods

Student Perceptions of Problem-solving Skills and Evaluation of a Web-based Environment for Case-study Work in Landscape Horticulture

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Additional index words. computer-based, decision-making, ill-structured problem, pedagogy, teaching tool

Summary. **Problem-based learning has become a popular pedagogical strategy for teaching problem-solving skills as well as subject content. However, implementation of this strategy is time-consuming. Use of the Internet and computer software could aide the creation, use, and maintenance of these teaching tools, encouraging more educators to use them. This study focused on 45 Iowa State University students enrolled in Horticulture 342, Landscape Installation and Maintenance. Students were assigned a series of four online, ill-structured case study problems based in a realistic residential landscape. Results indicated students understood the need for developing problem-solving skills, especially as they relate to future employment opportunities. However, students were concerned with obtaining the right answer, not with developing a strategy for solving problems. Students rated the statement about determining the best solution highest in importance (4.75 in 2007, 4.90 in 2008). Conversely, they rated a statement about determining what standards and judgment criteria should be used to evaluate possible solutions of least importance (3.75 in 2007, 4.20 in 2008). Students identified the value of the solution to the customer/client (4.63 in 2007, 4.80 in 2008), how well the cause of the problem was addressed by the solution (4.46 in 2007, 4.30 in 2008), and any potential negative consequences (4.33 in 2007, 4.40 in 2008) as the important factors that influence decision-making on the job. Students rated the online learning environment as adequate and they rated the overall experience as 3.94. Frustrations were primarily technical, including problems connecting to the system. Students liked the variety of resources available and that case information was consolidated in a single location.**

Problems encountered in life range from well- to ill-structured. Well-structured problems require the application of a limited number of concepts or information, and the goal or path toward the solution is clear. These types of problems are often found in textbooks in which students are required to replace equation variables with values from the problem to get the correct solution. Ill-structured problems have elements that are missing or not defined. The problem is situated in a specific context, but the path toward the solution is unclear. There may be multiple solutions that could satisfy the problem. Ill-structured problems are more common than well-defined problems (Jonassen, 1997).

Jonassen (2000) argues that students are inadequately prepared to solve ill-structured problems because they rarely are required to do so during their education or training. Recognizing the need for students to develop competencies in problem-solving, current trends in pedagogy emphasize student-centered learning and increasingly involve problem-based learning (Jonassen, 2000). Recently, many medical schools have modified their curricula to include, or to be entirely based in, problem-based learning (PBL) (Jolliffe et al., 2005). Practitioners of medicine must recognize patterns and traits of a disease without all the related information, an example of an ill-structured problem. Similarly, horticulture professionals must often solve ill-structured problems as part of the landscape management process. Initially students struggle with ill-structured problems (Chin and Chia, 2006) but gain confidence in their ability to solve them and an appreciation for the nature of the problems as they acquire more experience (Akinoğlu and Tandoğan, 2007). Concept understanding and academic achievement are improved through the use of PBL (Akinoğlu and Tandoğan, 2007).

Case studies provide valuable PBL experiences for students, especially when hands-on experiences are not feasible. Colleagues in the workplace share their experiences and what they have learned by telling stories to each other. These stories are like those used to develop case studies and encourage students to reflect on, interpret, and share information as they solve problems (Jonassen and Hernandez-Serrano, 2002). Problem-based learning experiences promote development of higher-order thinking skills, like those identified in Bloom's taxonomy (Jonassen, 1997; VanDerZanden, 2005). Unfortunately, these types of real world-based, ill-structured problems require substantial time investments to create and assess learning. They also present class scheduling difficulties because students work through problems at different rates (Akinoğlu and Tandoğan, 2007; Chin and Chia, 2006).

The combination of case-based problem-solving and computer-based instruction has the potential to meet educational goals and limit financial

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and time restrictions that had previously prevented instructors from including these techniques in their classrooms. Unfortunately, current computer packages and online course management systems do not support pedagogy required in PBL. Consequently, existing software must be supplemented or new software must be developed to support PBL (Jonassen, 2002).

The Problem-solving Learning Portal (PSLP) online environment was developed by faculty at Iowa State University in the Department of Industrial and Manufacturing Systems Engineering and the Department of Educational Leadership and Policy Studies (Ryan et al., 2004). The environment includes a database with resource documents, an Internet interface, and instructor-provided questions to promote higher-order problem-solving among students. The PSLP environment can be customized to scaffold students thinking through the problem-solving process with periodic check-in points where the instructor can review the students' work. Automatically populating some fields with previously submitted student work streamlined the whole process for students. The PSLP environment also includes a function for students to share documents back and forth as they work through the problems. Currently, instructors in industrial and manufacturing systems engineering, physics, and curriculum and instruction use this online tool in several courses. The PSLP environment is flexible enough to accommodate well- and ill-structured problems. A pilot of the system in a large physics course proved successful, inspiring further research into other subjects that could benefit from using the tool. One of the additional subject areas was horticulture.

The objectives of this study were to 1) learn how junior- and senior-level horticulture students perceive their problem-solving skills when presented with ill-structured problems; and 2) to evaluate the online PSLP environment for use in solving an ill-structured horticulture case study online.

Materials and methods

Case studies. The four case studies used in this course were developed by faculty and graduate students in the Iowa State University Department of Horticulture. Content was related to installation, maintenance, and pest management associated with a fictitious residential landscape in U.S. Department of Agriculture hardiness zone 5. A fifth case was provided as an example. The four case studies increased in difficulty as the students progressed through the series.

Students were provided a map of the site, a problem description, and several resource documents. Resources for all four case studies included digital images of affected plants, audio files with transcripts of conversations between the homeowners and contractors, soil test results, and extension publication web sites. Students were required to summarize the situation or problem, provide a series of preliminary diagnoses that might be causing the observed problem, make a final diagnosis using supporting evidence from the resources, and lastly, make a recommendation for the homeowners.

All resources were made available to students through a password-protected web site that was available to students whenever and wherever they could establish an Internet connection. Students were initially introduced to the PSLP environment during class time, but they were expected to work on the case studies outside of regular class time.

Implementation and data collection. Students enrolled in Horticulture 342, Landscape Installation and Maintenance, during the fall semesters of 2007 and 2008 were asked to participate in this study. This course is offered to juniors and seniors. All students were required to complete the case studies regardless of their participation in the study.

Data were collected from students through three questionnaires with Likert-type and short-answer questions as well as in small group discussions. Additionally, student actions (clicks) while completing the online case studies were collected by the software. All questionnaires were approved by the Institutional Review Board at Iowa State University. Students worked in randomly assigned groups of four to complete each of the four case studies.

Individually, they were asked about their perceptions of their own problem-solving skills, attitudes about problem-solving, and previous experience with solving problems before and after completing the case studies. Students were also surveyed after completing the final case study for more specific information on their problem-solving process for that case. Questions were specific to their problem-solving process for this case study, not about problem-solving in general. This case study was selected because it was the last and most challenging in the series.

Finally, students were asked to participate in a group discussion that focused on the web-based interface. Students discussed several questions about PSLP in small groups. Then each group reported their ideas to the larger group. During this discussion, students also completed an individual assessment of the tool. Student-reported data were compared with user data (clicks) collected by the software. Descriptive statistics, including mean and SD, were computed by using Excel (Microsoft, Redmond, WA).

Results and discussion

Demographics. A total of 45 students were enrolled in the course during the 2007 and 2008 semesters, and 42 students participated in the study. Of those who participated, 78% were men and 22% women and the average age of the participants was 21.8 years. Study participants were from a variety of horticulture options, including environmental horticulture, greenhouse and nursery production, turfgrass management, and planting design and installation. A few students were from related disciplines, including natural resources and ecology management and landscape architecture. Participants categorized their previous job experience that required problem-solving as follows: design/installation (28.6%), retail/customer service (16.6%), non-horticulture-related (14.3%), golf course/sports turf (14.3%), education/school (9.5%), farming/field work (7.1%), nursery/garden center (7.1%), and public gardens (2.4%).

Students' perceptions about problem-solving. Students were asked to rate nine parts of a generic problem-solving sequence on a scale from 1 to 5 (1 = unimportant; 5 = very important) (Table 1). On the pre- and post-case surveys, both groups of students rated the statement about determining the best solution

Table 1. Mean student responses to nine commonly used criteria in the problem-solving process.[z]

	2007				2008			
	Pre-case		Post-case		Pre-case		Post-case	
Statement to be valued	Response (1–5 scale)[y]	SD	Response (1–5 scale)[y]	SD	Response (1–5 scale)	SD	Response (1–5 scale)	SD
Determining the best solution	4.75	0.66	4.61	0.50	4.90	0.30	4.79	0.42
Determining what the problem to be solved is	4.75	0.52	4.72	0.43	4.50	0.50	4.26	0.65
Putting the decision into action	4.63	0.63	4.50	0.50	4.60	0.49	4.63	0.50
Evaluating the outcome of your decision and action steps	4.42	0.49	4.11	0.71	4.30	0.78	4.26	0.93
Generating ideas for possible solutions	4.38	0.75	4.33	0.47	4.60	0.66	4.47	0.70
Determining why the problem should be solved	4.33	0.75	4.28	0.83	4.20	0.75	4.32	0.75
Determining what variables are involved in the creating the problem	4.29	0.61	4.39	0.50	4.90	0.30	4.68	0.48
Using your standards and judgment criteria to determine the pros and cons of each possible solution	3.88	0.73	4.24	0.43	4.80	0.40	4.37	0.83
Determining what standards and judgment criteria the solution should meet	3.75	0.83	4.11	0.44	4.20	0.75	4.32	0.82
Respondents (no.)	23		17		9		19	

[z]Data reflect student responses before and after completing four online problem-solving exercises (case studies).
[y]1 = unimportant, 5 = very important.

highest, 4.75 and 4.90 (in 2007 and 2008, respectively). The 2007 group also rated the statements about determining the problem to be solved and putting the decision into action as highly important. Additionally, the 2008 group rated the statements about determining what variables were involved and using standards and judgment criteria to evaluate possible solutions as highly important. In both 2007 and 2008, the three statements ranked with the greatest importance were the same in both the pre- and post-case surveys.

Before completing the case studies, both groups rated the statement about determining what standards and judgment criteria should be used to evaluate possible solutions of least importance, 3.75 and 4.20 (in 2007 and 2008, respectively). After completing the case studies, the 2007 group continued to rate the statement about determining what standards and judgment criteria should be used as the least important, whereas the 2008 group rated the statement about determining the problem to be solved of least importance. Both groups reduced their ratings of the statement about evaluating the outcome of their decision and actions so it was among the lowest in importance in the post-case survey.

Students were also asked nine questions about decision-making on the job on a scale from 1 to 5 (1 = unimportant; 5 = very important) (Table 2). Students identified the value of the solution to the customer/client (4.63 in 2007, 4.80 in 2008), how well the cause of the problem was addressed by the solution (4.46 in 2007, 4.30 in 2008), and any potential negative consequences (4.33 in 2007, 4.40 in 2008) as important factors that influence decision-making on the job. The ease of implementing the solution was rated low, 3.88 and 3.90 (in 2007 and 2008, respectively).

Students were asked a series of questions about their problem-solving process for the Swamp White Oak case study, the last and hardest in the series. When asked if they prioritized the information resources, 73% of respondents said that they did not prioritize the information. This is supported by the data collected on student clicks, in which there was no pattern to the students' activity within the PSLP environment; many students repeatedly accessed unrelated resources in a time span of a few minutes. This seems to indicate that students did not approach their problem-solving with a plan or process.

During the group discussion, students reported using knowledge from previous coursework in plant pathology, woody and herbaceous plant identification, agronomy, biology, turfgrass, and communications to solve problems. Students also relied on work experience such as retail sales and customer interactions, landscape design-build jobs, machine operation skills, and working as part of a team in their problem-solving process.

Evaluation of the web-based interface. The results from students regarding the evaluation of the web-based interface in 2007 and 2008 were combined in Table 3. Students

Table 2. Mean student responses to nine statements about factors that influence decision-making or problem-solving in a work environment both before and after completing four online case studies.

	2007		2008	
Statement to be valued	Response (1–5 scale)[z]	SD	Response (1–5 scale)	SD
Value to customer/client	4.63	0.63	4.80	0.40
How well the cause of the problem is addressed by this solution	4.46	0.71	4.30	0.78
Cost of implementation (for example, money and time)	4.33	0.80	4.20	1.25
Potential negative consequences	4.33	0.75	4.40	0.66
Safety, health, or environmental factors	4.17	0.94	4.00	0.89
Time until solution is fully implemented	4.08	0.64	4.10	0.70
Support of others to the solution	3.92	0.81	4.20	0.87
Ease of implementation	3.88	0.83	3.90	1.14
Opposition of others to the solution	3.33	0.94	4.22	0.79
Respondents (no.)	23		9	

[z]1 = unimportant, 5 = very important.

Table 3. Mean student responses to 17 statements about the usability of the Problem-Solving Learning Portal (PSLP) interface and the content materials provided after completing four online case studies.[z]

Statement to be valued	Response (1 = 5 scale)	SD
Which of the following best describes your overall experience with the case studies in PSLP?		
(1 = terrible, 5 = wonderful)	2.83	0.74
(1 = frustrating, 5 = satisfying)	2.28	1.14
(1 = dull, 5 = stimulating)	2.86	0.87
(1 = routine, 5 = educational)	3.11	0.89
The appearance of text on the screen was (1 = terrible, 5 = appropriate)	3.94	1.07
Links were (1 = hard to find, 5 = easy to find)	3.67	1.15
Locating resources was (1 = hard, 5 = easy)	3.86	0.96
Feedback you received on completion of a task was (1 = unclear, 5 = clear)	3.78	1.07
Pop-up windows were (1 = annoying, 5 = helpful)	3.67	0.99
Information provided on task pages was (1 = insufficient, 5 = sufficient)	3.67	0.86
How the information was displayed on the page was (1 = confusing, 5 = logical)	3.39	1.23
Locating task and problem statements was (1 = hard, 5 = easy)	3.06	0.98
Submit button on task pages was (1 = hard to find, 5 = easy to find)	3.08	1.52
Competing the approval process was (1 = difficult, 5 = easy)	2.86	1.27
Overall navigation of the case studies within PSLP was (1 = difficult, 5 = easy)	2.58	1.27
Using the shared workspaces to save and share solutions was (1 = difficult, 5 = easy)	2.69	1.17
Going back and changing answers was (1 = confusing, 5 = logical)	2.09	1.07
Respondents (no.)	36	

[z]Data for 2007 and 2008 combined. Scale provided with each statement.

were asked to rate a series of Likert-type statements about their overall experience followed by several statements about specific elements of the interface. Scales varied by statement to match possible perceptions. When asked to evaluate their overall experience, students rated the experience as somewhat terrible (2.83 out of 5) and moderately frustrating (2.28 out of 5). On a scale of 1 being routine and 5 being educational, the students rated the overall experience as 3.94. Students felt overall navigation and use of the shared workspace were difficult. The group discussion revealed that students felt navigation improved once they understood how to use the interface. Changing answers on a previous screen before submitting was confusing for students. The appearance of text on the screen was relatively appropriate and the links and locating the resources were fairly easy for students. They also felt feedback provided by the instructor on completed assignments was fairly clear. When asked how much time each group spent working on the four case study assignments, respondents reported a mean of 4.6 h. Total hours reported on other assignments for class, not including the case studies, was 5.6 h. Other assignments included a set of landscape calculation problems, three other written assignments, and three oral presentations spread throughout the 15-week semester.

When asked what other resources would be helpful in solving the case studies, 29% of the responses indicated all necessary resources were provided. Those who felt more resources were needed requested more details on assignment setup and guided assistance with the problem-solving processes (16%), more pictures of the plants (16%), and additional external web links (13%). Respondents stated they relied on web searches, previous coursework, and personal experience to answer the case study questions.

The most frustrating items talked about during the group discussion were: navigating the site and case study assignments, inability or difficulty connecting to the site when off campus, and computer errors that lost students' answers and assignments. Students also reported having problems using certain computer platforms

and Internet browsers during the 2008 semester. Helpful items included: having a consistent layout and navigation, consolidated information and resources, and resource documents in various forms (text, images, and audio files). The group discussion revealed many students felt the case studies involved an overwhelming amount of work.

Discussion

Students perceive problem-solving as an important skill and they are concerned with finding the best solution to problems. In the work environment, the best solution is the one that resolves the problem and meets the needs of the client. In an academic situation, students often think the best solution is the correct solution as determined by the instructor. The students rated finding the best solution, in either context, among the more important aspects of problem-solving (Tables 1 and 2). This indicates that students understand how their problem-solving impacts the people they are trying to satisfy in either an academic or a business situation. It might also be indicative of their ability to apply problem-solving skills they learn in college to the problems they encounter in the workplace. However, when asked about the importance of determining and using standards and judgment criteria, the 2007 group decreased their rating from the pre- to post-case survey, whereas the 2008 group increased their rating. Perhaps this shows that students do not think abstractly about their problem-solving method and how they personally determine the appropriateness of a possible solution. In the workplace, the standard for judging the appropriateness of a potential solution is a balance between the value to the client and the cost to the company. This is supported by the responses related to the importance of the solution being of value to the client (Table 2). These student responses show that there may not be as large a discrepancy between school-taught problem-solving skills and workplace application as suggested by Jonassen (2000).

Although the students understood the importance of having a process to solve complex, ill-structured problems when asked about it abstractly, they did not report that they applied that understanding to their own problem-solving activities for these case studies. This is supported by their self-reported reflection on their problem-solving process and the click data captured by the software (not presented here).

Jonassen (2002) states the online environments that support problem-solving need to engage learners in solving the problems and to support associated intellectual and collaborative activities. The environment also needs to put solving the problem ahead of concept retention. With these criteria in mind, the PSLP platform can be used to facilitate student problem-solving in horticulture. In general, students felt PSLP was helpful in facilitating the case studies (Table 3), but from the group discussion, it was clear students were also frustrated with the format. The frustration stemmed mainly from technology problems, which did not support learning. Some frustration may have stemmed from discomfort with solving ill-structured problems, although few students admitted this. Chin and Chia (2006) found students often were frustrated with the undefined nature of solving ill-structured problems. Frustration with technology could be solved by a technical support group to assist both instructors and students. Jolliffe et al. (2005) recommended having experienced tutors guide students and instructors through development and use of case studies.

Current work at Iowa State University on the online PSLP environment is focusing on a more user-oriented interface that would allow instructors to create, manage, assess, and gather data on their cases without depending on limited, technology-focused support staff. The environment is also being integrated with other ill-structured problem-solving systems being used at Iowa State University and other universities.

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