Work in Progress - Enhancement of Problem Solving Techniques with Tablet PC-based Learning Technologies

Ken Stanton
Virginia Tech, kstanton@vt.edu

Abstract - **EC2000 criteria raised the bar for educating engineers in the traditional 4-year degree program, requiring more student learning outcomes and teaching in more innovative ways. A challenge of teaching more in the undergraduate program is that it's hard to do so in the time available. After recognizing a deficiency in problem-solving skills, an initiative was developed which will use classroom technologies to improve the skills yet have minimal time requirements. The initiative will enhance small, currently-existing workshops for the first-semester engineering course, which are taught by GTAs. DyKnow's interactive software used on tablet PCs will enhance problem-solving techniques as suggested in literature. Integration of these technologies and techniques will be implemented in spring of 2008 when there are fewer students, assessed via quantitative and qualitative methods, and finally revised before the next large student cohort arrives in fall of 2008. This paper will highlight the problem-solving techniques being enhanced, the technologies used and their implementation, assessment of the initiative, application of relevant literature, and future work.**

Index Terms – Classroom Technology, First Year Courses, Problem Solving, Tablet PC.

INTRODUCTION

Problem solving is one of the most critical skills of any aspiring engineer to master in their studies. This skill enables a person to take on any problem and work towards a solution systematically and objectively, regardless of the context. Criterion 3(e) of the ABET Engineering Criteria 2000 (EC2000) deals with students' "ability to identify, formulate, and solve engineering problems" and points towards the importance of problem solving skills [1].

While nearly any skill can be developed with ample dedication to it, time in undergraduate engineering programs is scarce, making it hard to address deficiencies. Complaints from industry, professors of upper-level classes, and students themselves that student problem-solving skills are inadequate demand attention and are the motivation of this work. However, addressing this presents a challenge. Additional coursework would compete with heaps of content and skill-building activities that are already packed into the baccalaureate program. As such, this work sought to implement problem-solving techniques from literature in innovative ways so as to increase the efficiency of teaching problem-solving skills. Workshops for the first-semester engineering course were targeted for applying the resulting plan of action.

The McMaster Problem-Solving Program highlights knowledge gathered from 25 years of research on developing problem solving skills and lays much of the groundwork for this work [2]. Transfer of skill in, methods of implementation of, essential building blocks of, and the working definition of problem-solving are examples of contributions. Other works discussed using analogies [3]-[4], the value of ill-structured problems [5], and holistic approaches to teaching [6], and supplemented this work.

Tablet PCs, which are required for all incoming freshmen, are being used to implement particular aspects of this problem solving initiative. Interactive network software called DyKnow provides the tools needed to bridge the pen-on-screen capabilities of tablet PCs to the problem solving activities. It gives the instructor a fast and effective way to interact with students as they perform in-class activities, and also enables the anonymous sharing of student work, to discuss their work and enhance learning. These functions are the foundation of the improvements reported in this paper.

METHODS

I. Implementation Methods

To successfully teach problem solving skills, it is necessary to do more than simply demonstrate the process or assign practice problems. The skill must be taught by:

1) Introducing and discussing the skill to build a basic understanding;
2) Applying the skill to a simplified problem in a target subject and discussing the process;
3) Extending the application to a challenging problem.

Further, the key to these being successful is to direct activities and choose problems that:

a) Give an opportunity to see the skill in a content-independent domain;
b) Allow the students to compare their performance with the desired outcome(s);
c) Give an opportunity to practice the skill and get feedback on their performance [2].

To implement this problem solving initiative and satisfy the above recommendations, input was taken from the course instruction team: the GTAs and the course professor. The

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first task was to define problem solving, which led to some debate. According to [2], problem solving deals with "the processes used to obtain a best answer to an unknown, or a decision subject to some constraints." This contrasts to "exercise solving" which most typical textbook word problems qualify as and was what the team envisioned as problem solving. It was however agreed that word problems serve as excellent opportunities to practice the problem solving process and should be used as a stepping-stone to real problem solving, as it is defined.

Following, the team discussed the additional aspects and agreed upon the implementation plan is as follows:

a) Workshop problem-solving activities will focus on each of the seven steps of the course textbook's word-problem solving process, which align well with the steps/processes of problem solving [7];
b) In-depth discussion of the skills to be developed will precede each activity;
c) A word problem will be given as an in-workshop assignment which has specific challenges aimed at developing particular skills;
d) The word problem will be given to the students via DyKnow, which allows them to work on their tablet PC screen and the instructor to collect and save that work;
e) The collected work from DyKnow will be shared and discussed in the workshop to explore common mistakes and share various approaches to the problem.

II. Assessment Methods

To assess gains from the problem solving initiative, a few methods are being used currently, and others are being considered. Currently, pre- and post-tests are being incorporated into each in-workshop activity, taking input on students' knowledge of the skill(s) being focused on and comparing it to performance in the activity word problem.

These assessments are being complemented with reviews of homework and exam word problems [3],[4]. Also, qualitative feedback will be sought from students on their perceived value of the activities, influence on their problem-solving self-efficacy, and suggestions for improvement. Additional assessments are being considered, but must not over-tax the students or the GTAs.

RESULTS

To date, only two problem-solving activities have been realized, hence this paper remains a work-in-progress. The feedback from students has been mostly verbal, as technical problems arose during the post-test and qualitative feedback portions of both activities, unfortunately. Despite the setbacks, input revealed that they like the simplistic nature of the exercise problems and they are starting to understand the steps of the problem solving process better. Further, in the second activity, the exercise problem forced them into a bad assumption. This later caused a failure of the design being evaluated, which raised a good discussion regarding assumptions. This is merely anecdotal evidence of success, but changes and improvements in the implementation and assessment will provide better evidence.

In reviewing student homework, only minor gains have been observed in problem solving ability, where some additional depth was observed in work for each of the seven problem solving steps.

DISCUSSION

Given the initial results from the problem-solving initiative, the team believes that the activities show promise and should be continued. However, the current 15-minute activities seem to only have minor effect. As such, some revisions and an additional activity are being considered.

It has been shown that the use of analogies helps to not only improve problem solving ability, but transferability to other contexts [3]-[4]. Further, ill-structured problems should be considered to improve selection of information sources in problem solving [5]. Finally, requesting that problems be solved with multiple approaches could help transferability further [6]. With the help of the efficiency of software like DyKnow, it is possible to implement many of these approaches in the time allotted. An optional, hour-long problem solving workshop is also being considered for additional development of skills.

With the revisions in progress, we hope that to develop an organized and systematic approach to improving problem-solving skills that can be easily implemented when the large freshmen cohort arrives in the fall. At the FIE conference in October, this initiative should have enough feedback from the refined methodology to present thorough findings.

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