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Enhancing Peer-Learning Using Smart Devices

Prof. Zahed Siddique, University of Oklahoma

Dr. Siddique is currently a professor at the School of Aerospace and Mechanical Engineering of University of Oklahoma. His research interests are in areas of product design, product platform design, and engineering education. He is the faculty advisor of the Sooner Racing Team (FSAE) and coordinator of the Mechanical Engineering Capstone program.

Dr. Firas Akasheh, Tuskegee University
Dr. Gul E. Okudan Kremer, Pennsylvania State University, University Park

Dr. Gül E. Okudan Kremer is an associate professor of Engineering and Industrial Engineering at Pennsylvania State University. Her research focuses on decision analysis and design theory applied to improvement of products and systems. She has co-authored over 200 peer-reviewed papers to date and received several best paper awards. She has also been a National Research Council-US AFRL summer faculty fellow of the Human Effectiveness Directorate for 2002, 2003 and 2004, and a 2010-2011 Fulbright scholar.

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Abstract

Our approach is to capitalize on the research findings on linkages between higher-order thinking and peer learning to create and evaluate a learning environment, entitled Teaching to Learn (TeatoL). TeatoL blends mobile smart devices and traditional approaches to enhance critical thinking and competencies essential for students to solve open-ended problems. The main objective is to understand, develop, implement and evaluate a peer-learning environment utilizing mobile technologies and devices. The focus is on peer learning mode, where students are instructors to share their experience and then learn from fellow student instructors. In this paper, we present our vision of this learning medium along with the foundation we have built it upon. Within TeatoL students are introduced to a "flatter" instructional environment; all participants have dual roles as students and instructors who are embedded in a collaborative environment where all learn collectively from each others' experiences, even the instructor. We also discuss hypothesized benefits and plans for assessment.

Introduction

Globalization[1] has put engineering education[2,3] and the profession at a challenging crossroad. On one hand, the impact of rapid technological innovations on modern societies has been amplified by the globalization of the economy[1]; hence, better living standards afford increasing equity in education. Despite this fact, students' graduation percentages in U.S. engineering schools have been decreasing over the years [4-5] with the exception of top academic institutions[6-10]. The competitiveness of the U.S., which is linked to our standard of living, is dependent on our ability to educate a large number of sufficiently innovative engineers[11-14].

Several high-level reports[3,7,15-20] have been published recommending learning skills and ability to formulate and solve open problems as critical to prepare the next generation of engineers. U.S. needs a well-trained workforce in science, technology, engineering, and mathematics that is also equipped with these critical skills. With the research unfolded here, we *explore the effectiveness of peer learning through mobile smart devices to address the need for inculcating engineering competencies related to open-ended problem solving.* We adopt our definition for peer learning from Baud, Cohen, and Sampson[21] as, "the use of teaching and learning strategies in which students learn with and from each other without the immediate intervention of a teacher" (pp. 413-414). In this paper, we present our vision and initial development of a system to support peer learning to enhance open-ended problem solving skill development.

Motivation and Background

Open-ended problems significantly differ from the well-defined book problems, and require critical thinking and problem solving experience. In most instances, applying engineering principles to solve open-ended problems is a very challenging task for students. Students struggle when confronted with ambiguous challenges often faced in practice where they need to use analytical skills to formulate, solve and interpret results, for example, from Computer Aided Engineering (CAE) software. One of the reasons for this is that much of engineering education continues in a "teacher-centered" mode that emphasizes content mastery and supports reliance on standard book problems solved in well-defined step-by-step processes. Common traditional teaching approaches fail to nurture the development of higher order cognitive skills needed by today's engineers. These methods often fall short to move students from acquiring to applying knowledge and creating solutions[22-23].

In order to reshape engineering education the medium of instruction needs to be modified to play a significant role in engaging students to learn the complex engineering concepts in a useful format. Instruction modes need to allow students to grow as critical thinkers with proficiency in learning, and in creative problem solving for increasingly complex and uncertain engineering environments.
For example, students are shown to learn more effectively when actively involved in the learning process[11], and such active learning strategies promote higher order thinking. As a result, several non-traditional learning approaches, such as project-, problem-, or case studies-based learning, have been developed and applied in engineering courses. These approaches allow students to learn through inquiry, which is a natural process of human learning through gathering information and processing data through applying the senses[12,13]. According to Bransford et al.[6], students learn best when presented with organized information that relates it in some way to their own experiences, and are given the opportunity to test themselves on their own understanding and to work to develop their understanding with other students[6].

Starting from childhood humans learn via observation, especially from peers[24-26]. Learning in peer-led, problem-based learning settings[27,28] can be a highly effective means to encourage student engagement for more profound learning[29-31]. Meaningful learning emphasizes active, constructive, intentional, authentic and cooperative learning[32]. Peer learning encourages meaningful learning that involves students teaching and learning from each other as well as sharing of ideas, knowledge and experiences, and emphasizes interdependent as opposed to independent learning[33]. Peer learning is a 'two-way reciprocal learning activity' [34: p.3] as students do not hold power over each other by virtue of their position or responsibilities; hence, it is a learning environment that is "flat".

In active, peer-learning environments the technology participants possess a potential to facilitate learning. 63% of students own internet-capable hand-held devices[35]. Hand-held devices like smartphones and tablets are fast becoming the primary way many people use the Internet. 43% of all college students used mobile gear to get on the Internet every day in 2010, compared with 10% of students in 2008[36]. Hence, peer learning strategies and applications for hand-held devices can enhance the learning experience of a large number of students. A recent survey of students[37] indicate that students learn best when professors balance their uses of instructional technology with human interaction.

It is not always clear, however, how the principles of peer learning transfer to technology-enhanced learning environments where transfer of discussion, communication and articulation of ideas can pose a challenge. Virtual learning communities are knowledge based social entities where knowledge is the key to their success[38]. An important activity in a virtual learning community is the collaboration. Seamless linking of learning collaborators is essential to create a learning environment for mobile devices[39].

An important factor in peer learning is providing feedback to others. Bransford et al.[40] suggested that the quality of feedback can be improved by allowing students to work collaboratively, and that the feedback is particularly useful when students can use it to revise their work and thinking on a project. Reviewing is an evaluative process of detecting problems, diagnosing them, and generating solutions to improve the problems. In review process, students may develop important strategies for problem solving and revising[41]. Peer review provides student reviewers with frequent opportunities to practice problem-solving strategies important for improvement. Peer review activities may provide the reviewer with concrete and solid experiences on how to improve problem solving by connecting diagnosed problems with solution types[42]. Participating in review encourages student reviewers to reflect upon their own skills while examining peer work[43-44]. Online videos changed the way we create, view and share video online today. With smartphones like the iPhone, and phones running on Android and Windows operating systems, it's effortless to create and share video using the basic features the phones offer. Videos can be an effective media to quickly generate content and provide feedback to peers.

Overview of Teaching to Learn: The System

The TeatoL concept for peer learning using mobile devices is implemented initially using an open-source application called Canvas developed by Instructure. Students use TeatoL to create videos and instructions, based on their experience and process for solving open-ended problems, with the mindset of teaching the process and sharing the learning experience with others. Students are teachers uploading their approach to solving the problems in the system. The posts are viewed using Canvas App. The students then critically evaluate and critique posted approaches, submitted by other teachers (students), to improve their open-ended problem solving technique. The students have the opportunity to use comments from others to critically evaluate and modify and improve their approaches. These steps can be recursive focusing on the entire or part of the process. The final step of the process involves students writing a short report on their modified problem solving process and then applying the process to a new open-ended problem in a similar topic. An overall flow of activities in TeatoL is shown in Figure 1.

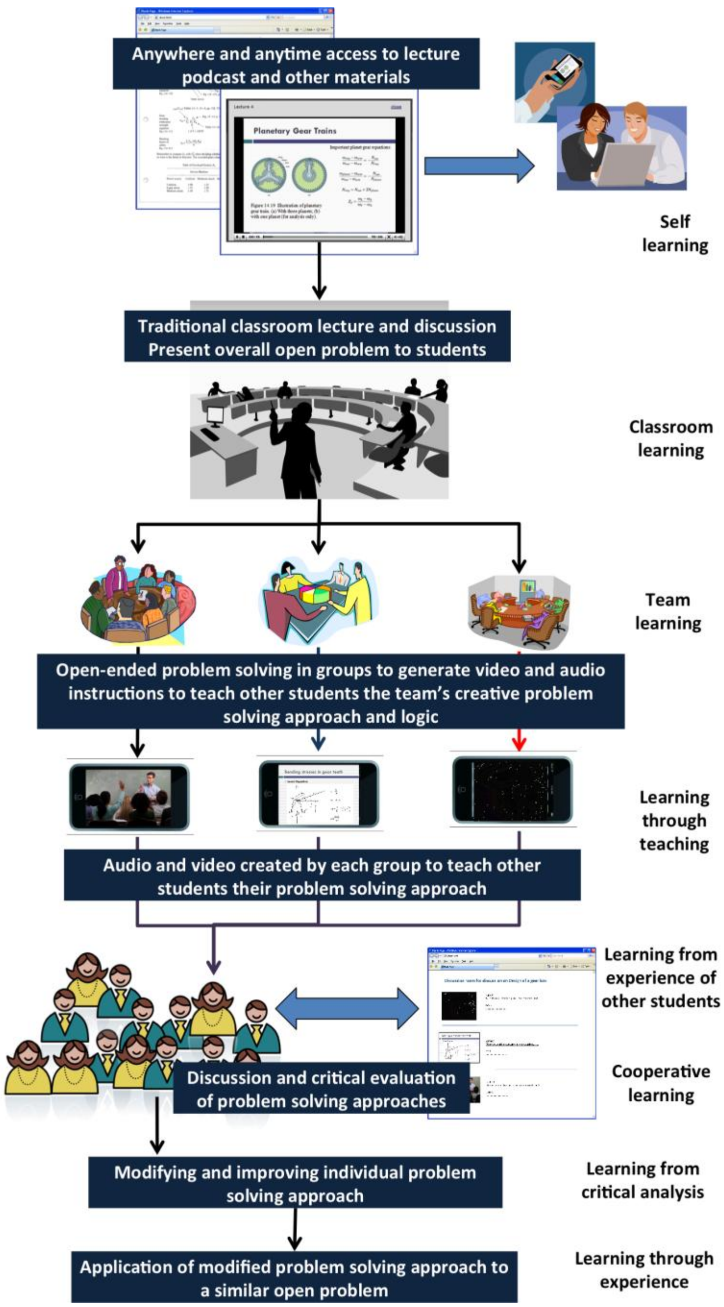

Figure 1 - Steps and activities in *TeatoL* environment along with target mode for learning

Architecture and Components of TeatoL

eCourse Materials: We recognize the potential of eCourses[45,46] as effective tools for facilitating and enhancing the learning of engineering fundamentals. Web-based materials, including eBooks and eLectures will be used to present theoretical course materials to students. In the *TeatoL* environment, students will be introduced to the theoretical material in an anytime and anywhere virtual lecture/class fashion. The developed eBooks and eLectures will be rich with content such as animations, interactive simulations, examples, collaborative sketching pads, and other tools for students. The web-based materials are used in the environment to ensure that the students have the proper theoretical background, with the class periods utilized for more engaging peer learning and reflections on open-ended problem solving approaches.

Collaborative Applications and Capture/Delivery Tools: The housing of the *TeatoL* environment is an important consideration that will affect the interests from students. In the proof-of-concept stage, the open-ended problem will be introduced in a regular classroom setting. After the problem has been introduced to the class, student teams will have the tools (Apps) and process to develop a solution for the problem, along with capturing the problem solving process of the group using mobile devices. The application for hand-held device will allow students to develop the solutions and the problem solving process outside regular lectures without confining learning to time constraints. Collaborative tools will include white boards, flow-chart development tools, presentation sharing tools, and conferencing tools (e.g., text, audio, video). Output from these tools can be used by the student groups to create podcasts.

Canvas App in *TeatoL*: The Canvas App in *TeatoL* will allow students to upload multiple types of instructional materials to present their problem solving style. Using the App students send their audio, video and other instructional materials to the server to make it available to the entire class for review and suggestions. This will allow students to have time to critically evaluate and reflect on problem solving process of other groups in the class. Critical evaluation and comments (text, figures, audio, videos etc.) on proposed approaches will be created and posted using the App for mobile smart devices. The Canvas App and associated web-page already has a discussion framework to support posting of comments related to each problem.

Other Apps can also be used to aid in creation of video or audio files students upload to the Canvas App. For the purpose of this study, Keynote and SonicPics for the iOS format will be used to create a slideshow presentation and narration, respectively.

Initial Implementation

In order to achieve the Objectives O1 through O4, course materials are developed for relevant topics in three courses (AME 3353, EDSGN 100, and MENG0314).

The project PIs will create an interactive environment that divided it into areas based on different course topics. Each area in the environment contains: eBooks, and eLectures. *TeatoL* App and *TeatoLNe*t provide the tools for the virtual learning community.

Across the implementation settings, for the proof-of-concept implementation, students will be required to review the course eMaterials related to fundamental concepts. During class, instructor first briefly discusses the fundamental concepts and approaches to solve problems. After completing the discussions of the fundamental concepts, different student teams are sent similar open-ended design problems using the *TeatoL* App. Each student team then is required to solve the problem in *TeatoL* to explicitly capture steps, and associate reasoning to develop Podcasts on how to solve the assigned problem. Student teams electronically present the problem solving technique to the entire class. Electronic presentation is used so that all students in the class can critically evaluate the presentations and reflect on their problem solving technique, without time constraints. The electronic presentations allow the instructor to also evaluate if students have understood and learnt the theoretical concepts for open-ended problem solving. During class period, the instructor leads a discussion on the different approaches used by teams for further reflection by students to facilitate learning.
An example to illustrate *TeatoL* environment for Design and Selection of Springs (component of the OU course) is given below. The steps and activities in the *Learning to Teach* environment are shown in Figure 1.

Step 1: Fundamental concepts will be available to students through eBooks, eLectures and web-based content (self-learning). The general steps in selecting a gear involves first determining the space requirement and the desired speed or torque ratio. Then, pitch, diameter, and arrangement of gears are determined. The next steps involve identifying different factors to determine bending and contact stresses and associated safety factor for expected loading conditions. Flow diagrams that show steps to solve structured problem will be available to students as part of the eBook. These problem solving templates are essential to understand the fundamental concepts.

Step 2: Open-ended problems are presented to the students by the instructor. Each student team then is assigned a component design problem in *TeatoL*. The design of the components assigned to different groups has varying requirements.

Step 3: Student in teams solve the assigned open-ended problem (team learning).

Step 4: Each student team prepares electronic materials, using *TeatoL* App (Figure 2), for broadcast (RSS Feed) to teach their problem solving approach for the assigned open problem (learning through teaching). The eMaterials are uploaded on the *TeatoL*Net for all students (learning from experience of other students).

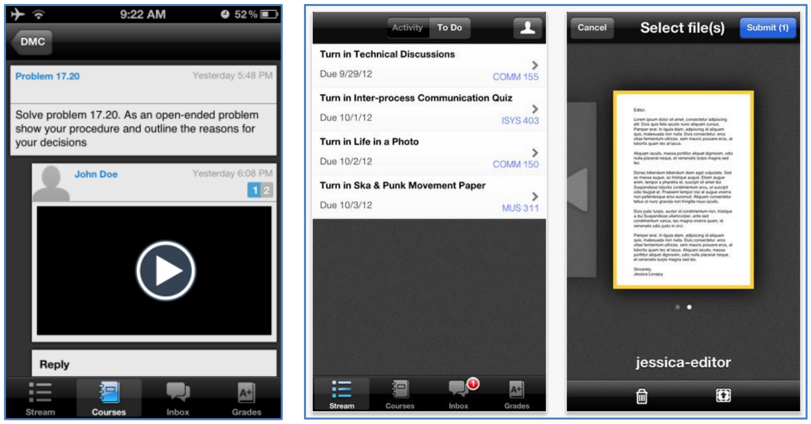

Figure 2: Examples of the Canvas App on an iOS format

Step 5: Students and instructor critically evaluate and comment on the problem solving teaching materials in *TeatoL* App (learning from critical analysis) electronically before class. Class discussion on presented methods for problem solving are also conducted (Figure 3).

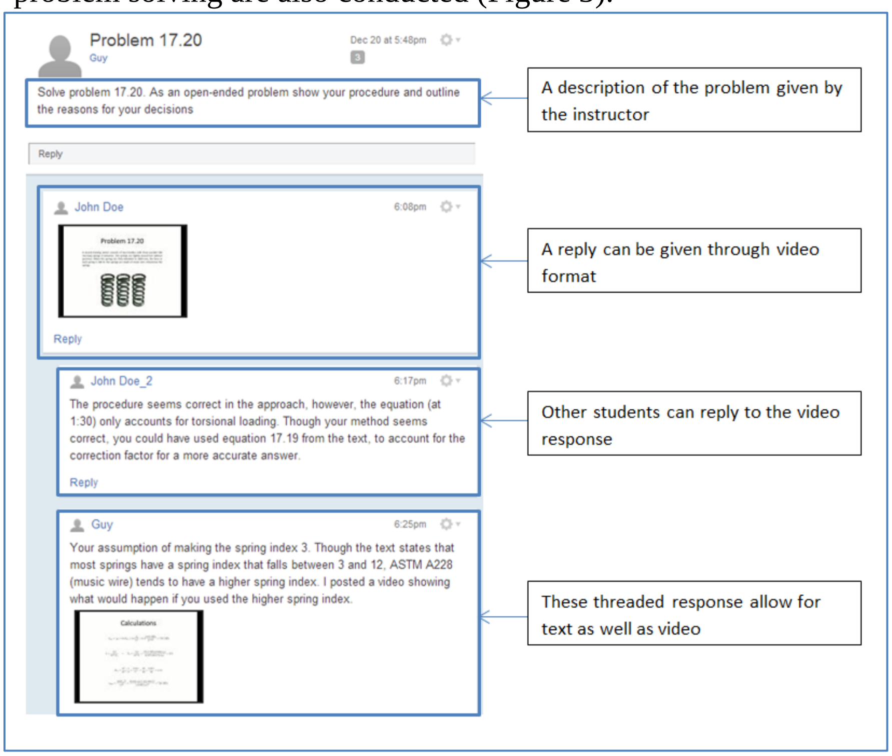

Figure 3: A threaded discussion showing a group solving an open-ended problem

Step 6: Each student submits a short report on their modified problem solving approach and then apply the method to solve a second open-ended problem on the same topic (learning through experience).

Step 7: Critical evaluation of submitted reports are used by the instructor to determine if the course materials can be presented more effectively.

Evaluation Process

To ensure an engaging and satisfactory student learning experience, throughout the development of the TeatoL environment, usability evaluation methods are applied to evaluate and improve the usability of TeatoL environment. Effectiveness assessment is conducted at three sites: University of Oklahoma (OU), Tuskegee University (TU), and Pennsylvania State University (Penn State).

Along with the course module development and implementation, formative and summative evaluation techniques based on both subjective and objective data are used to test the TeatoL environment's pedagogical effectiveness (Table 1). At this stage of the development the student evaluation has not started; however, the evaluation plan has been developed, and it is provided in Table 1.

Table 1: Summary of Evaluation Plan

Evaluation Points	**Data Points**	**Methods**
1. Assessing Cognitive Level Gains of Students	"Rubric for Assessing Cognitive Learning Levels of Students" Mclaughlin and Johnson (2006)[47]	Evaluate written student work using the rubric to evaluate the extent to which students demonstrate achieving specific levels of cognition guided by Bloom et al. (1956)[48] and Anderson and Krathwohl (2002)[49]. In evaluation of student work using rubrics, consistency of the judgments is important. In order to achieve an acceptable level of consistency (~95%), we train raters and calculate inter-rater reliability, first in a small sample for training purposes, and then for the overall evaluation. Clearly, this requires the same students' work to be evaluated by more than one person which will in itself bring additional confidence to the evaluation process. Across the three project locations, we will contribute to the assessment of students' written work; thereby bringing engineering faculty members who have no conflict of interest given the change of location. For example, Dr. Kremer (from Penn State) will evaluate student work in blind fashion (not knowing if the sample is coming from experiment or control section) for Dr. Siddique's implementation at OU.
2. Gauge student interest, motivation and self reflection	Classroom Assessment Techniques (one-minute paper), SALG, Focused reflection, Focus Group	Use one-minute paper technique to have students reflect on how the learning strategy affects motivation as compared to other approaches. Include items on SALG. Conduct focused reflection after peer review and as part of final project. Student prepared, one-minute papers and other focused reflection documents will be analyzed using computational and unbiased approaches (to a high degree) and compared to each other across control and experimental groups. For this purpose software programs such as N-Vivo or wordle (http://www.wordle.net/) can be used.

Evaluation Points	Data Points	Methods
3. Student responses to peer teaching and learning	1. SALG 2. Peer Evaluations	Question Format – 1a. To what extent did leading peer learning contribute to your gains in learning subject X. 1b. To what extent did learning from your peers contribute to your gains in learning subject X. 2. Students will conduct peer evaluations on the peer teacher using a rubric focused. The assessment of these items will be coordinated by assessment specialists using on-line surveys whose data will not be available to the faculty during the course of the semester student subjects are enrolled in courses. Even after the semester is completed, specific student data will not be personally identifiable to faculty who are teaching (through the use of a numbering system for subjects). This will be another measure of unbiased data collection.
4.Student responses to TeatoL App	Individual Interviews, Focus Group and SALG	Gather data from three sources to describe how the overall TeatoL App contributed to learning, motivation and interest. Focus groups and interviews will be conducted by assessment specialists.

Concluding Remarks

In this paper we presented our vision and relevant system architecture for TeatoL that is being setup to capture, review and improve competencies to solve open-ended problems of our students in a collaborative setting. The main objective is to understand, develop, implement and evaluate a peer learning environment utilizing mobile technologies and devices. The focus of TeatoL is on peer learning mode, where students are instructors to share their experience and then learn from fellow student instructors. Besides eMaterials (eBooks and eLectures, TeaTol incorporates collaborative tools which would allow students to create and share content and feedback anytime anywhere. Students are introduced to a “flatter” instructional environment where they will learn from the experiences of other students to enhance their own learning and to enhance their problem solving competency and critical thinking. In this environment, all participants have dual roles as students and instructors who are embedded in a collaborative environment where all learn collectively from each others’ experiences, even the instructor. Finally, a coherent assessment method for the learning outcomes of TeaTol concept was presented.

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