

The Inside-Out Classroom: A Win-Win-Win Strategy for Teaching with Technology

Abstract

As costs of higher education soar and many universities face uncertain funding models, institutional pressures have increased to improve instructor efficiency. At the same time, U.S. industry leaders and leading educators have called for improvements in engineering education based on more interactive, hands-on student learning experiences. Although many efforts have been made to take advantage of technology to either improve student learning or to maintain student learning while increasing instructor efficiency, few approaches have been shown to improve both learning and efficiency. A teaching method is proposed to improve student learning and increase student satisfaction while also addressing the instructors' experience and the ongoing efficiency challenge.

The approach is to essentially reverse the traditional model of lectures in a classroom and practice exercises for homework. Instead, the core knowledge content from a class is stored electronically for easy access by students through the internet. In the current study, this has taken the form of video-recorded instruction combined with interactive computer screen capture. The content is broken into digestible "chunks" of approximately ten to fifteen minutes, each corresponding to a key course topic. Students access the course content on-line at their own convenience. They take notes and complete practice tasks as requested in the instruction. The instructor records the content once, with only updates needed during future course offerings. During class meeting times, the instructor leads the students in "working sessions" that may include practice exercises, project work, or other hands-on learning. The instructor, as well as computers, textbooks, and the other students, are available as resources from which the students draw to complete the assignment. Since assignments must be completed and submitted for grade by the end of the class session, the students have an incentive to stay current and prepared in terms of watching the on-line instruction content. Instead of preparing for a formal lecture session, the instructor must simply be available during the working session to assist and coach the students through the assignment.

The first efforts to utilize the method are described in the paper, complete with assessments of student learning and satisfaction. It is of particular interest to determine if learning styles and demographics of the students influence performance under the new class method. Course assignment and exam scores, compared to previous offerings of the course, will be used to assess performance. Surveys of the students will be used to assess their time commitment, comfort level, perception of fairness, and overall satisfaction. Since the method can be thought of as shifting more of the learning burden to the students themselves, a survey will assess motivation and its effect on involvement and performance. An estimate is also made of instructor time efficiency, both in terms of the investment of creating the on-line content the first time and the overall time involved in teaching the class. It is expected that the method provides a more effective, satisfying learning experience for both the students and the instructor and that the increased instructor efficiency will appeal to institutions that are challenged with doing more with less.

Introduction

The development of the global internet infrastructure, in combination with modern advances in computer software and video processing capabilities, has brought the potential for online teaching and learning to almost anyone with a computer. The promise and advantages of online educational content have been well researched and explained¹. The advantages touted include increased access² and convenience for learners as well as increased potential for collaboration and efficiency among educators.¹ There is evidence that students can even learn better in online environments.^{3,4} One report⁴ describes how web-based content fosters constructivist learning and how online resources can help create an environment that “makes a difference in the kinds of teaching and learning experiences that are possible.” Online content also favors “personalized” learning, as listed by the National Academy of Engineers as one of their Engineering Grand Challenges 2010.⁵ A “student-centered approach,” which makes use of local and global resources through web-based sources and outside experts, is even described as a key goal for the future of engineering education.⁶ Despite these trends and the nature of today’s tech savvy⁷ college students, engineering programs have been slow (with the exception of MIT² and a few others) to take advantage of new technology in developing online content for their regular undergraduate programs. The reasons may have to do with the start-up investment or may lie in the difficulty of sharing important engineering concepts that may best be learned in a laboratory and with hands-on experience.

Although online learning can be done with groups of learners, it is most typically done alone, which puts learners at a disadvantage to those in a collaborative environment. Much literature has described the importance of collaborative learning and team skills such as communications and social adeptness, particularly for engineers.⁸⁻¹¹ Students not only learn better in teams, but they enjoy the educational experience more, and are more engaged in their coursework.¹⁰ Employers seek students with collaborative skills and see the value in educational experiences that “promote cognitive development, self-esteem, and positive student-student relationships.”¹² For these reasons, “blended” course offerings, as suggested in Ref. 1, have been introduced as a way to combine online lecture content with some amount of face-to-face time to increase the student engagement¹³ found in student-student and student-faculty social interaction. When possible, it has been found that experiential learning can supplement online learning with very positive results.¹⁴

Shifting course content into online resources also has the potential for increasing the overall efficiency of the educational process both by reducing the individual repetition of lecture material and by promoting the collaborative use of “best materials” by educators across programs or institutions.¹ Although there is no doubt an investment in money and time to initially create online materials, recent articles have shown how some schools are looking to online content as a way to more efficiently use faculty time.^{15,16} Pressures from reduced public funding of higher education¹⁷ have further increased calls for increased efficiency and online content.^{18,19} While the constant interaction with distant students that can be required for success in a course that is completely online may take more effort than a traditional class, a course that blends online lecture content with regular face-to-face meetings may be better able to take advantage of the efficiency of online content (e.g., video-recorded lectures). There are questions, however, as to whether the reduced contact hours in a modern “blended” or “hybrid” class may

actually reduce effective learning.³ This report describes efforts to use on-line content to supplement the regular classroom with no reduction in face-to-face meeting time.

The educational experience described here is called the Inside-Out Classroom. As a few efforts have tried in the past²⁰⁻²³, the approach reverses the traditional teaching mode of lectures and homework by providing video-recorded lecture content for student to watch at home on their own time and by restructuring the classroom experience to focus on homework-like problem-solving activities, typically completed in a collaborative, team environment.

The objective of the current study is to develop a method for teaching engineering courses that takes advantage of technology to improve student engagement and learning while increasing the efficiency and satisfaction of the faculty teaching the course. The technology involved includes web-based software for video and document-based capture of lecture content as well as web-integrated learning management software for organizing the online experience for students. Student engagement and learning is addressed by providing lecture and other content in short, recorded chunks that can be viewed, paused, re-viewed, and studied at the convenience of the student and by setting up an interactive, team-based classroom environment for problem-solving. The faculty member's experience is affected by the lack of repetition of content, the reduced preparation for classes, and the increased level of informal, interactive communication with students in the classroom. This paper describes the initial experiences and results from teaching and learning with the Inside-Out approach at a large, predominantly undergraduate engineering college.

Course Design

The Inside-Out Classroom includes several inter-related components. The most innovative is the use of short, pre-recorded video chunks that are posted online as a replacement for traditional classroom lecture activity. Students use learning management software to link to the lecture videos and any other video or web links that the instructor bundles together with the lecture. Supplemental links, short activities, and/or quizzes are assigned that go along with each week's lectures to make sure that students are keeping up. The more challenging "homework" assignment is saved for the regular class meeting time, in which students work collaboratively to complete the work and submit for a grade prior to leaving the room. These "working sessions" are held once a week, with the second meeting time of the week reserved for reviewing solutions, working other problem examples, and providing an overview and perspective to the lecture material to tie together the chunks that are viewed online.

- Lecture Material

The goal for most of the course content material is to provide it to students in a way that is more convenient, accessible, and engaging to them than the traditional mode of lecturing during a face-to-face "lecture" class session. Of course, in addition to the purpose of providing an alternate viewpoint, lecturing by a human instructor has always been a way to provide a more engaging presentation of material than that contained in a textbook. So, in the same way, online content, with the possibilities for multimedia, hyperlinks, animation, rewind, and other effects, can be more effective than a live lecture. Although efforts are

generally made at the author's institution to encourage active learning methodologies²⁸, in the past it has still sometimes been difficult to keep students' interest while fitting in all of the desired course content. Instead, it was decided to essentially make the entire face-to-face session an active learning experience. In order to be productive in these sessions, however, the students need to have prepared by studying the content ahead of time. While a textbook is provided and textbook-related assignments are often a part of the mix, it is strongly felt that streaming video in combination with screen capture of lecture notes is a more engaging method for conveying the information and one that can be tailored and designed by the instructor.²⁷ The whole of the course content material is therefore broken down into chunks⁴ of approximately 10 to 15 minutes of streaming video time each to be recorded by the course instructor. This seems to be about the right time to take the most advantage of students' attention spans.¹² The students are provided with internet links to the lecture chunks for each week of the class, typically four to six chunks per week. The students watch the sessions on their own time over a network connection prior to coming to class. They have the ability to view, pause, re-view, and focus on different aspects of the presentation (e.g., live video of instructor vs. screen capture of lecture notes) at different points (see also Ref. 20). The students are provided with a hard copy of the lecture notes to have available (and to add additional notes) during viewing and are encouraged to view with a classmate or small group.

The instructor may decide that certain chunks of content (perhaps even most!) are better delivered by another educator, an industry practitioner, or other professional. Such "guest lecture spots" can be a great way to add variety to the lectures, get differing perspectives, or simply give the students an explanation from the person who can best explain a certain topic.²⁴ Sharing of lecture chunks may be one of the best ways to establish collaboration between educators in different programs or across different institutions or between industry and academia.

- Supplemental Online Activities and Links

When traditional homework activities are wholly or partly replaced with online lectures, students that are less organized may have some difficulty since it can be "too easy to put off study with all the freedom technology provides. Perhaps the biggest problem is going to be letting tasks and time get away. A high degree of time management skills are needed for assured success."²⁶ Therefore, it is important to maintain and enforce a "time on task" principle with the students. This idea is that "as students spend more time interacting with, creating, and manipulating information and applying concepts and skills, the more facile, accomplished and confident they will be. Time on task helps students to make the knowledge their own and create the linkages and relationships within their own data knowledge structures."⁴ A variety of content modes and activities can and should be provided along with the short lecture chunks which can "serve as a basis for further reading, research, or other learning"¹² in order to establish time on task. Additional internet links (e.g., YouTube videos, industry websites, software simulations or product demos, etc.) can be provided and bundled with the links to the lecture chunks. Short written assignments that relate directly to the online lecture material or that direct a student to refer to a textbook for content are appropriate as long as the overall time requirements for the course do not go

beyond reasonable expectations. Online or self-paced quizzes that follow the lecture chunks are also a good idea to ensure lecture viewing and help to solidify content knowledge.²⁵ An online “discussion board” or other tool for the timely sharing and answering of student questions on the lecture material is also important.

- Face-to-Face Working Sessions

Since the majority of class content can be conveyed using the online lecture format, the face-to-face meeting time with the students is opened up for more direct collaborative problem-solving. The instructor serves as more of a guide or coach during these sessions rather than a lecturer. Along with textbooks, notes, computers, and other students, the instructor becomes a “resource and facilitator for the learning activities.”⁹ The working session starts with the distribution of an assignment that must be completed in its entirety and individually submitted for a grade before leaving class. In this way, students are forced to have prepared ahead of time (and taken good notes) or risk running out of time to solve the problems. A homework-type problem set or specific project-based activity is appropriate. Students working in groups are able to receive guidance from other students so that they are kept on focus for the problem at hand. Students benefit also from the chance to teach others during the session. All students have access to informal discussion time with the instructor, who can move from group to group answering questions and making sure that individual students are actually learning for themselves. Indeed, the peer pressure from other students is expected to help enforce an environment of mutual collaboration based on being properly prepared. Aside from the academic benefits of collaborative learning, students also gain from the student-student and student-teacher social interaction the sessions inspire.¹³ Opportunities exist for the development of more rewarding mentoring relationships.¹² The working session assignment and any of the supplemental online activities are graded as a formative evaluation of student work. Eventually, a more formal, summative evaluation of the students’ knowledge is obtained from one or two closed examinations.

Methodology

The Inside-Out method was used during 2010-2011 in one of the author’s *Introduction to Manufacturing Process Design* and *Tool Engineering* courses, both required for students in the Manufacturing Engineering program and electives for other engineering students. The lecture portion of the first class covers: an overview of process design topics such as concurrent engineering, DFMA, optimal process selection, and computer-aided process planning; a detailed analysis of casting, plastic molding, powder-metal forming, metal forming, and material removal processes with a focus on design for manufacture for each; and methods for absorption-type and direct-type cost estimating and accounting for manufacturing processes. The second class covers fixture design, datums and geometric dimensioning and tolerancing, fixture cost and mechanical analysis, cutting tool design and process analysis, and tooling design for sheetmetal processes. The classes have similar structures of meeting for 3 hours of face-to-face “lecture” time (usually in two periods of 1½ hours) each week as well as one 3-hour lab session per week, in which hands-on process and tooling design projects are undertaken by student lab groups. The author has taught each class for nearly ten years as fairly traditional lecture-lab courses with regular

homework assignments, lab assignments, closed exams, and a lecture occasionally broken up by a variety of in-class activities, quizzes, and active learning exercises. Class size is normally about 20 (the average class level is third-year) and end-of-term student surveys of the instructor generally result in a very positive evaluation.

Seventeen students (sophomore through senior) took the first class and twenty-four took the second, with a mix of majors from the manufacturing, industrial, mechanical, and general engineering programs. Approximately fifty video-recorded lecture sessions of ten to fifteen minutes in length were produced to cover the content of each class using Panopto® lecture capture software, which enables a split-screen, simultaneous presentation of the instructor via camcorder (real-time capture into PC) and computer screen capture of class notes (MS PowerPoint and Adobe Professional). During the sessions, the instructor wrote on a white board in front of the camcorder and made real-time annotations to the class notes on the computer. Links to YouTube videos, other published videos, industry websites, and other content accompanied the lecture links and were provided to students by way of BlackBoard® learning management software. Weekly at-home assignments and quizzes also accompanied the online lectures. Working sessions, with associated assignments, were held weekly as well, with the second class session each week dedicated to reviewing solutions, solving other example problems, and providing high-level perspective for the short online lectures. In the working sessions, students were encouraged to work together using open notes, open books, open computer/internet, and open access to the instructor, but individual submission of results was required prior to leaving the class. The three-hour, hands-on laboratory also took place each week but was unchanged from previous terms. As with past offerings, final grades for the class were based on lab performance (25%), quizzes and assignments as described above (25%), and closed midterm and final examinations (50%).

Separate evaluations of student satisfaction and performance were conducted to gauge success of the Inside-Out method. Online surveys (mid-term and post-term) and an in-class focus group session (run by a faculty member who was not the course instructor) were conducted using a set of predetermined questions to evaluate the students' experience. The questions inquired about the online content, the technology and software used, the working sessions, and how the course experiences compared to other courses.

Results and Discussion

The results turned out very positive and show an extremely promising new approach. The in-class session was run in the first class and included the entire class, while the online surveys included at least 50% response rate. Survey results from the second class were not yet available as of this writing. The demographics of the respondents were similar across the surveys. About 75% of the students were seniors and about two-thirds male (though no gender differences were evident in the responses). About 80% of the students reported a GPA between 2.5 and 3.0, while 20% reported a GPA between 2.00 and 2.5.

Nearly 95% of the survey respondents indicated that they liked and preferred the Inside-Out method, and many hoped the method would be used more in other classes. The student survey comments seemed to center on three positive aspects of their experience: the group problem-

solving aspect of the in-class working sessions, the convenience and availability of the online lectures, and the more effective use of class time for problem-solving and interaction with the instructor. Typical comments on the group problem-solving experience include:

- “[It’s] great to work together [on the assignments] . . . good social aspects of the class . . . [students] shun cheaters and those not prepared so there is peer pressure to get it done”
- “There were things I never would have thought of if it had been done independently”
- “I like teaching someone – you have to think more”
- “It was a bit hard to get use to preparing for the working sessions. With other classes you don’t need to prepare so much to go to class.”
- “Sometimes when you are not able to answer a few questions in a row, you feel like you are the leech of the group. This is solved by studying more before you attend the next working class session.”

Concerning the online lectures, all but one of the students surveyed watched all or nearly all of the lectures. When asked about their opinion of the necessity of the videos, all but one student indicated that either “every one was necessary” or “all but one or two” where necessary. 85% of the respondents took notes during the videos and reported watching the videos more than once. All responded that the videos were either “very entertaining” or “entertaining enough,” to hold their attention, and they felt the content had sufficient interaction to keep them engaged. They felt that the 10-15 minutes length of the videos was appropriate. Other comments include:

- “[The on-line lectures] give you the chance to pause and do your own work”
- “I’ve re-watched the ones that I didn’t quite understand or couldn’t remember, and that’s been immensely helpful for me.”
- “If you don’t listen to the lectures, you are really behind and lost.”

Students liked the informal nature of the working sessions and the faculty-student interaction. Although there is a time pressure to perform (over half of respondents indicated that they sometimes ran out of time), the students appreciated the instructors’ availability during the working sessions and were able to get their questions answered whenever needed. Comments included:

- “The sessions force you to prepare . . . I never sleep in class!”
- “It’s like forced office hours.”
- “I’m excited to come to the Working Sessions!”
- “The working sessions got me really into [the class]”
- “I found the Inside-Out method to this class extremely useful and effective.”
- “Loved the structure, very good use of class time.”
- “The way the class was taught was interesting and effective . . . I really liked doing the examples in the working session.”

Students felt that they learned better and were learning more in the class as compared to other, comparable classes they’d taken. More than three-fourths of the survey respondents specifically stated that they learned more, based on improved “retention of class materials,” “improved test scores,” and better opportunities for “reviewing material before class.” None felt that they

learned less this way. When students were asked to rate how well the instructor conveyed subject matter and to rate the course overall, 100% of respondents answered “excellent.” The course instructor thus received his first perfect course rating (4.0/4.0) over a 12-year teaching career.

Assignment and exam scores were also tracked for the courses and compared to previous offerings of the same course. The most significant result was that homework completion rates were essentially 100%, as compared to 85-95% in previous years. Even accounting for that difference (i.e., with non-submitted homework scores eliminated), the scores on assignments were significantly higher (85% compared to 82%) than past years for the first class and 1% higher (but not significant) in the second class. In the first class, midterm and final exam scores were not significantly different than in previous years, but in the second class the midterm scores rose significantly by 4%. For that exam, it appeared that the lower half of performers improved, since the lowest score was much higher and the standard deviation of scores nearly $\frac{1}{2}$ compared to previous offerings. Overall, students seemed to be more engaged by the material and felt that they had learned more, while their individual assignment and test scores showed either an improvement or no difference from past scores.

It is to be studied further how much “time on task” has changed using the Inside-Out approach as compared to previous years. Although the post-term survey indicated that students felt that they spent about the same amount of overall time on the course as they had in other courses, the mid-term survey indicated that nearly half felt they “spent less overall time on this class” (the other half spent “the same amount of time”), even though nearly all felt they were learning more. During offering of the second class (*Tool Engineering*), the instructor provided more online quizzes and links and made an effort to require longer at-home practice exercises to ensure that time on task was comparable to previous offerings. It is possible that those efforts had an effect on the improved midterm scores.

The course instructor found the experience very rewarding and positive overall. He was able to be a “coach” rather than a “lecturer” in the classroom, and he enjoyed the personal interaction with the students in the face-to-face sessions and the reduced repetition of content. The instructor felt he was better able to promote individual success on in-class assignments since students had less opportunity to simply copy homework answers than they might typically have. The instructor also found it less stressful to prepare for class when the working sessions were scheduled (similar to “when students are taking an exam”). Although the class has not yet been repeated with the prerecorded videos, it is estimated that overall preparation time for the lecture portion of the class will be “nearly cut in half.”

With these advantages, it was not surprising to find that several other faculty members in the instructor’s department have begun to utilize the Inside-Out approach. By the end of the 2010-2011 academic year, seven courses are expected to be offered this way. \$10,000 in institutional support has so far been committed towards purchase of equipment and software and for developing content with the Inside-Out approach.

A presentation on the approach and ongoing results was made by the instructor to the department industry advisory board, with similarly strong positive responses. The industry advisors

appreciated the effort to teach the new generation of students in the manner in which they typically communicate. Most felt that the companies themselves need to adopt similar strategies in their own training programs. They were excited about the possibilities of partnering on course content as a first step towards establishing a greater collaboration on distance learning opportunities. As of this writing, the industry advisors had committed an additional \$15,000 in cash support, and had also pledged to help record several guest lecture spots to serve as permanent online lecture content.

Although the response to the effort has been very positive, there are certainly several potential problem areas and limitations to be addressed with the approach. The first concern is to continue to monitor student test scores in subsequent course offerings and to make sure that scores do not decline. Efforts will be made to continue to study the students' "time on task" and to potentially add online content (such as regular quizzes) and correlate effort with individualized test scores.

When asked an open-ended question about the course, students indicated overwhelmingly positive benefits. Some indicated they felt it was a more effective learning environment. Others felt the videos themselves were beneficial. One student indicated his appreciation of the instructor. The positive regard for the instructor is definitely a helpful aspect of the method, but it may indicate limited transferability, as other instructors may need to develop skills similar to the current instructor. With the experiment continuing over the academic year with other instructors, the transferability of the method will be put to the test.

A few students surveyed indicated that they either "sometimes ran out of time" or "were almost never able to complete the work," claiming "you have to work fast." Some of these respondents had self-reported learning disabilities and often need more time to complete assignments. When asked about overall satisfaction with the method, all indicated that they prefer the Inside-Out course method, and that they learned either "more" or "a lot more" in the course. One of these students commented that "being able to pause and rewind them (the videos) actually made it easier for me, from a [disability] perspective."

There is certainly an investment in time required for a faculty member to pursue the Inside-Out method. The instructor must not only gain familiarity with the software and the video-recording procedure, but he or she must make the recorded lectures ahead of the actual offering of the class. Although the assignment grading load did not appear to be different under the new approach compared to previous terms, there was some pressure to provide feedback on each working session before the next one was scheduled. Occasional computer server and technology glitches did occur at which time the students were not able to access the online lectures as anticipated. 24/7 access to the online content did not always correlate well with the 8-5 technical support provided at the university.

Given the required time commitment for investing in the online resources, it is of interest to compare the Inside-Out approach described here with a more conventional approach to achieve the same effect; i.e., the use of textbook readings and practice activities alone as a means for students to prepare for face-to-face working sessions, hence eliminating the lecture altogether. Or, as noted above, the instructor may simply provide links to lectures or online content prepared by other (such as MIT's online lectures) in order to prepare students for face-to-face working

sessions, in some sense mimicking a lecture-recitation combination. Although research evidence appears to show the advantages of properly used technology (and students appear to prefer it), questions still remain on how best to leverage that technology to achieve improved learning and increased efficiency.

Conclusions and Future Plans

A new teaching method was developed and implemented in an intermediate-level engineering course. The new method utilizes an “inside-out” approach in which prerecorded lectures are assigned to be watched at home while problem-based “homework” assignments are completed in group work mode during face-to-face classroom meetings. The new techniques are meant to address the desired learning modes of a new generation but are also consistent with educational literature that has praised interactive group-based learning, a self-directed learning trend, and the efficient use of new technology to make content more accessible and available. The investigators hope the new method will both improve learning and make the educational process more efficient for all involved.

Initial results have been very positive. Students, instructors, and administrators alike are excited by the promise of the approach. Students like the convenience and the effective use of classroom time and feel that they learn better and retain more. Instructors like the active classroom environment and the efficiency afforded by pre-recorded lectures. Administrators like the potential for industrial and organizational collaboration and the prospect of more satisfied constituents all around. In the limited set of results so far, measures of student learning showed either comparable or improved scores for class assignments and exams.

Over the next six to twelve months, the authors hope to expand on the method and monitor results. During Spring term 2011, two courses will be run for which the lecture videos have already been created in a previous term. Data from these courses will indicate how student satisfaction and instructor efficiency is likely to be affected over the long run. There have been ideas and student requests to put more kinds of video content online, such as laboratory demos and the working out of problem solutions. The authors hope to investigate the potential these would have for improving lab activities and further increasing the efficiency of face-to-face meeting times. With the institutional and industrial support described above, the authors intend to host local workshops on how other faculty may take advantage of the method and use it in their own classes. Initial dialogue has also been started with another educational institution with which the authors may develop a partnership for sharing well-made video content in similar classes. Finally, the authors hope to garner support from additional industry partners and government funding agencies (e.g., National Science Foundation) to continue to study the effectiveness of the method and to explore the full potential of the method in terms of organizational collaboration.

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