Proceedings of the 2012 ASEE PSW Section Conference
Cal Poly - San Luis Obispo

iLearnIt: An On-line Wiki for Equipment Maintenance and Laboratory Instruction in Engineering Education

Daniel Waldorf, Industrial and Manufacturing Engineering Department
Cal Poly State University, San Luis Obispo, CA

Abstract

In engineering education, students learn to operate, calibrate, and repair laboratory equipment as part of assigned course tasks, as part of team or independent projects, or as part of lab supervision or technician duties. Written lab or equipment manuals can be burdensome to create and update, difficult to interpret or even find, and lacking in the rich media content available in today's computers. While personal demonstrations by an instructor and face-to-face guidance on tasks is important, much efficiency can be gained and errors prevented by having a system of effective step-by-step guides to lab tasks always available at a student's fingertips. A pilot study is described to develop just such a system in the College of Engineering at a large Western university. Course instructors and lab directors are able to develop content for a large number of task manuals with the assistance of engineering students in the required technical writing course for engineers. The manuals include text, pictures, videos, and Q&A links and are hosted permanently on an internet server to minimize the impact of instructor and/or student technician turnover. Updates or corrections to the manuals can be suggested directly by the students themselves as tasks are carried out. Students in turn learn an effective tool for managing and growing the information needed for operation and maintenance of increasingly complex engineering equipment.

Introduction

In recent years several factors have come together to cause an explosive growth in the integration of new technology into the teaching methods in higher education. First, the technology itself has reached a level of maturation such that the purchase price is affordable, the number of bugs and errors in software coding has improved and stabilized, and the ease of use and user interface have become much more friendly to the average instructor. Second, cost pressures have increased on most programs in higher education. Demands for increased efficiency in education have made headlines across the country[1,2], especially in state-funded institutions where state support is dwindling[3]. Most schools see the promise of using technology to increase class sizes, faculty course loads, and efficiency in scheduling and facilities utilization as a means for meeting the challenges of present and future budgets[4]. Faculty are seeing the value of becoming more efficient in the use of their time[5]. Students also recognize the importance of school funding for things like equipment and laboratories rather than for paying high teacher salaries for time-consuming tasks such as traditional lecturing. Third, the second internet revolution, and its focus on user-created content, has opened up tremendous opportunities for both instructors and faculty for using the new technology for truly creating better and more effective tools for linking and sharing educational content. Internet-based learning management systems, on-line wiki tools for content development, cloud storage ability, and the simple acceptance of the internet as a part of the daily educational experience have all made the transition to the use of modern communications technology an imperative in a cost-competitive world. Further, the explosion in on-line educational content[6], provided via YouTube, Apple's iTunes University, or through direct links to the universities themselves, has increased the general belief that a potential learner can find the content they want on the internet. The content may even be presented in a way [Kahn academy] that improves upon the traditional lecture experience[7,8] due to the use of rich media content, the ability to access and replay the content at will[9], and the ability for everyone to "sit in the front seat" during a presentation.

Initial efforts at using technology to increase educational efficiency have focused on low-hanging fruit, such as the repetitive and relatively static nature of the traditional lecture. Although university lectures certainly change from time to time, by their very character they tend to involve repetition by the instructor. Many new efforts for improving student learning and for increasing instructor efficiency have involved pre-recorded lectures made available to students on-line or real-time video capture for synchronous on-line viewing[10-13]. Sometimes this is part of a distance learning program, enabling a geographically diverse student population to take the same course offered by the same instructor. But the methods can also be applied to enhance traditional face-to-face instruction[14]. The Inside-Out teaching method reverses the traditional roles of lecture in the classroom and homework on the student's own time. The author uses this method in several classes by first creating prerecorded video lecture chunks (10 to 15 minutes in length) using a mix of computer screen capture with video of the instructor in front of a whiteboard. The recorded lecture chunks are posted for on-line access through a learning management system. Students watch the lectures and other internet links (e.g., YouTube videos, commercial websites, etc) at home while taking on-line quizzes and completing short assignments. During face-to-face meeting time, a more challenging, "working session" assignment is given, to be handed in by the end of class. The working session is open-notes and students are encouraged to seek assistance from other students or the instructor. Regular closed-notes exams are given to assess summative learning. Instructors at the author's institution have had considerable positive student feedback both in terms of how much students have learned and in how much they have enjoyed the class experience. Instructors also favor the approach since it involves more informal, collaborative interaction with the students and the method appears to reduce overall instructor preparation time by about 25-50% with regards to the lecture.

Despite the success of using technology in the classroom for increasing the efficiency of lecture format coursework, fewer efforts have been directed towards using communications technology for improving a course laboratory experience. A study at Rose-Hulman[15] was performed in which various types of prerecorded videos were used to supplement the student lab experience. The videos, available to the students on-line, show a close-up view of the instructor or lab assistant performing the calibration, experiment, or other task that the student is to accomplish. The videos were created at different depth levels of knowledge to address the novice or more experienced student. Although positively viewed by students in the courses, the demonstration videos are fairly static in terms of format and they are not designed to be of direct assistance at the point of the equipment. The current study describes a new effort to create on-line technical assistance guidebooks that are to be used at computer tablet workstations adjoined to the lab equipment. The guidebooks break user and maintenance tasks down into manageable steps, each with brief media content (photos, text, pictures, video, animation, etc.) to assist the user or technician. The tablet interface allows quick navigation across steps, links to tools or related issues, and a Frequently-Asked-Question (FAQ) section. Best of all, the guidebooks are prepared as an exercise by students in a technical writing course and, since the guidebooks are actually wikis, they are modified and updated by the students or technicians themselves when performing the lab task. The goals are to both improve the student user experience in learning to operate the equipment and to reduce the inefficiency caused by frequent retraining of student technicians in maintaining the equipment.

Methods

A group of four students was selected to act as a pilot group in creating guidebook content during the Winter term 2012. The group was selected to closely mimic one of the groups typically formed in the ENGL 149 class (Technical Writing for Engineers), for which a term project is assigned involving the creation of step-by-step user manuals for small device repair. The intent is to use the success and experience of the pilot student group to seamlessly integrate the new on-line guidebook creation project into the existing ENGL 149 class structure as an optional replacement to the small device repair assignment. That way, guidebooks can eventually be created for much of the equipment in the engineering labs by the technical writing students. Instructors for the ENGL 149 class have been encouraging about the project and see the potential for it to inspire student technical writers who may soon be using or maintaining the very class equipment for which they would create a guidebook.

The group selected a single piece of equipment, a Haas VF-2 vertical milling machining center, as their initial target for guidebooks. The Haas VF-2 is maintained by both a professional technician and a student technician and is used in several undergraduate classes. A new student technician is typically hired every two to three quarter terms to help maintain the machine and class lab teaching assistants are also used to help with the equipment during lab times. Typical maintenance tasks for the VF-2 include ensuring proper coolant recirculation, establishing and correcting hydraulic fluid level and pressure, and setting up properly aligned fixturing elements on the main work table. The VF-2 is used extensively in IME 335 (Computer-Aided Manufacturing I) as students learn how to set up and operate the equipment and controller. It is used in IME 352 (Manufacturing Process Design II) as students use the machines to cut aluminum or cast iron molds for part production. Students in IME 341 (Tool Engineering) also use the VF-2 as they design and implement new fixtures for holding complex parts during processing. A formal printed maintenance and operations manual for the VF-2 is available at the machine and is frequently consulted.

Six guidebooks were created using software provided by Dozuki (http://www.dozuki.com/), the software creation company behind the popular ifixit website for do-it-yourself home projects (http://www.ifixit.com). The software allows the user to create two types of interrelated on-line wikis: step-by-step guidebooks and FAQ pages. The guidebooks are organized by device and common tasks and show the user one task step at a time; each step is enriched by text instructions, notes, warnings, links to tools or related information, pictures, photos, videos, animation, documents, or other content. The FAQ pages are similarly organized by device but can also be readily searched and offer a simple environment for users to ask and answer questions about each device. The structure of the guidebook environment assigns value to user postings and content updates and allows for users to emerge as various levels of experts in terms of using or maintaining the device in question. Although the guidebooks and FAQ pages can be viewed though any internet connection (e.g., on a student laptop), the easiest and most convenient use is on a tablet computer with direct touchscreen navigation. An iPad 2 (with protective casing and lockdown) was purchased for the project and installed semi-permanently at the VF-2 work table for the express purpose of showing the online guidebooks and FAQ pages.

The guidebooks created by the pilot student group include three for maintenance tasks to be performed by a student technician and three for students enrolled in the IME 335, 352, and 341 classes that use the VF-2 for course lab assignments. The maintenance guidebooks are:

1. How to set up and align a vise in the VF-2 table
2. How to troubleshoot and clear a Tool Changer error.
3. How to troubleshoot and clear a Low Lube error.

The student assignment guidebooks are:

1. How to set the coordinate offsets and jog the axes.
2. How to cut a flat face on a work piece.
3. How to clean and shut down the machine.

These guidebooks can be seen and accessed by navigating to a URL[16] on any web browser. Figure 1 shows two screen shots from the “How to set the coordinate offsets and jog the axes” guidebook. Each step in the guides can have text, photos, links, and a variety of formats for highlighting tasks and posting warnings or other notices to the user.

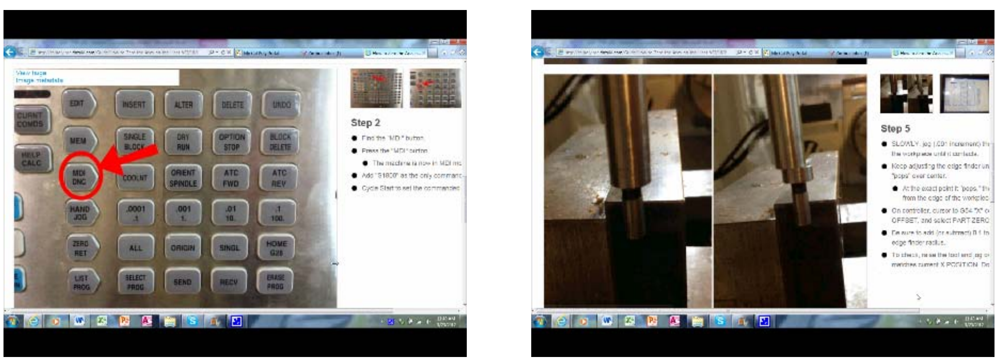

Figure 1 Screen Shots from On-line Guidebook Wiki

Figure 2 shows a still image from an embedded Youtube video from the same guidebook on setting coordinate axes. The guides can be used to integrate video clips with the step-by-step instructions.

Figure 2 Still Image from Embedded Youtube Guidebook Video

Although the guides can be accessed through any web browser, a special application is available for viewing the guides on several devices, including Apple's iPad. The iPad allows the user to move from step to step, view video clips or images, and zoom and focus on key tasks, all using touchscreen manipulation. Since the on-line guide is actually a wiki, the user is also able to propose changes. With the iPad's camera utility, the user can record new content as well and propose a visual update to the guide. A guidebook administrator (e.g., school technician) is defined to approve such changes.

The impact of making these guidebooks available was assessed by asking current students to complete real-time course tasks using the guidebooks rather than face-to-face instructor assistance. As an initial assessment, approximately 10 students (from IME 335 and IME 352) were run through assigned lab tasks using the guides. These students were asked to create a flat face on their workpieces, set coordinate offsets, and clean/shut down the machine. All of the students had received prior basic training on the machine setup and operation. In addition, one student was directed to complete the maintenance task of troubleshooting/correcting the machine's Tool Changer error. Student and instructor feedback was collected from the experiences.

Results

Students who used the online wiki guidebooks created by the pilot development group clearly enjoyed the experience of using the guides to complete lab tasks. In all cases but one, the students were able to successfully complete the assigned tasks without instructor assistance. In the one instance that an instructor was called for assistance, the instructor was able to make a simple change to the guidebook and add content so that future students would be able to resolve the issue by themselves. Student comments after using the guidebooks on the provided iPad2 tablet included:

- "It was really easy to follow"
- "I like the step-by-step interface and the iPad environment. Everybody loves to work on the iPad."

- "The guidebook worked great. I was able to finish the part on my own."
- "It was a good reminder for things I'd seen before but couldn't necessarily remember every step."

In the case of the student completing the maintenance task, the task itself proved more complex than the guidebook initially presented. The process revealed a couple of different ways that a technician could go wrong by simply following the guide. The guide was then updated to allow for various contingencies during the maintenance process. It became clear that complex tasks require practice and repetition if they are to be documented in a step-by-step procedure.

The IME 335/352 course instructor also gave very positive feedback on the use of the guidebooks by the students. The instructor confirmed that students did in fact complete their tasks successfully on their own. It was estimated that the instructor would have had to provide approximately 20 minutes of guidance for each such task. The instructor also confirmed that the students seemed to really enjoy the experience of using the guidebooks on the iPad. Although a device manual was available, students appreciated the ease and rich media of the on-line guidebooks. Further, most of the tasks they were assigned to complete were not well described in the existing device printed manual but rather represented specific course requirements and local lab policies.

Although these preliminary results are limited, they do show the promise of such a system for providing students with the guidance they need to perform basic lab tasks on their own. Regardless of the technical documentation available at a device, the ability to see video demonstrations and to follow along step-by-step through a task at one's own pace provides for an effective and enjoyable experience in completing the lab task. The creation of the on-line wikis shows great promise as well for student technicians who must complete more complex tasks. Finally, having such guides available to students also appears to have the potential for freeing up considerable instructor time that would otherwise be spent repeating individual instructions.

The pilot student group was found to be readily capable of creating effective guidebooks with some instructor and technician assistance. Although most simple activities were easily documented for the guides, some of the more complex tasks required some iterations to establish an effective guidebook. If the guides are to be eventually created using student groups in a technical writing course, significant instructor and/or technician assistance will have to be committed.

Conclusions

The technology now exists for educators to easily create rich media content recordings to serve as guides to student laboratory activities. A set of pilot on-line guidebooks was created for one device and several lab tasks in the College of Engineering at a large public university. The guidebooks demonstrate step-by-step actions using photos, text, and video. The lab tasks to be completed include both course assigned tasks and regular equipment maintenance tasks, though both types would typically be completed by current college students.

Initial results show that the on-line wiki guidebooks can work well for providing an enjoyable environment for students to successfully complete these lab tasks without assistance from an instructor or other technician. Specifically, the study found that:

- Students could easily follow the guidebooks and complete the tasks successfully.
- Students enjoyed the experience of following the step-by-step guides on their own.
- The course instructor saved considerable time by having the on-line guides available at the site of the equipment.
- Although students can create and add to the guidebooks themselves, it is important to have administrative oversight as well as updated guide iterations, especially for complex tasks.

Acknowledgements

Funding for this project has been generously provided by Solar Turbines, Boeing, Pacific Gas, & Electric, SAIL Ventures, and the Cal Poly IME Department. Dozuki Software has also donated the use of their online wiki creation environment for use on the pilot project and for ENGL 149 technical writing students in creating content for the engineering labs at Cal Poly.

References

1. Parry, M., "Killing the Lecture with Technology," *The Chronicle of Higher Education*, Aug 17, 2010.
2. Chapman, P., "Report Calls for Distance Learning to Improve College Access and Efficiency in California," *The Chronicle of Higher Education*, Oct 29, 2010.
3. Keller, J. and M. Parry, "U. of California Considers Online Classes, or Even Degrees," *The Chronicle of Higher Education*, May 9, 2010
4. Grose, T.K., "Day of Reckoning," Prism, February 2010, pp. 22-27.
5. Parry, M., "Mass Video Courses May Free Up Professors for More Personalized Teaching," *The Chronicle of Higher Education*, Aug. 8, 2010.
6. Boroughs, D., "Millions Log In," Prism, Jan 2009, pp. 29-33.
7. Reasons, S.G., Valadares, K., and M. Slavkin, "Questioning the Hybrid Model: Student Outcomes in Different Course Formats," *Journal of Asynchronous Learning Networks*, Vol. 9, Issue 1, March 2005.
8. Boettcher, J.V., & Conrad, R.M., *The Online Teaching Survival Guide: Simple and Practical Pedagogical Tips*, Jossey-Bass, 2010.
9. Bourne, J., Harris, D., and F. Mayadas, "Online Engineering Education: Learning Anywhere, Anytime," *Journal of Engineering Education*, Jan 2005, pp. 131-146.
10. Foertsch, J., Moses, G., Strikwerda, J., and M. Litzkow, "Reversing the Lecture/Homework Paradigm Using eTEACH® Web-based Streaming Video Software," *J. of Engineering Education*, July 2002, pp. 267-274.
11. Bergmann, J. and A. Sams, "Remixing Chemistry Class," *Learning and Leading with Technology*, International Society for Technology in Education, Dec/Jan 2008-09, pp. 22-27, http://www.learningandleading-digital.com/learning_leading/200812/.
12. Schaffhauser, D., "The Vod Couple," THE Journal, Aug. 1, 2009, http://thejournal.com/Articles/2009/08/09/Vodcasting.aspx?Page=1
13. Pink, D.H., "Think Tank: Flip-thinking - the new buzz word sweeping the US," *The Telegraph* (UK), De. 14, 2010, http://www.telegraph.co.uk/finance/businessclub/7996379/Daniel-Pinks-Think-Tank-Flip-thinking-the-new-buzz-word-sweeping-the-US.html.
14. Waldorf, Daniel and Liz Schlemer, "The Inside-Out Classroom: A Win-Win-Win Strategy for Teaching with Technology," *Computers in Education Journal*, January-March, 2012.

15. Walter, Deborah, "Audio-Visual Lab Tutorials to Develop Independent Learners," *Proceedings of the ASEE Annual Conference and Exposition*, Vancouver June 26-29, 2011.
16. Dozuki guidebook custom web link for institution, http://CalPolyIME.Dozuki.com/.

Biographical Information

Dr. Dan Waldorf, Professor in Industrial and Manufacturing Engineering, joined the Cal Poly faculty in 1998 after two years in Chicago as a Quality/Manufacturing Engineer at ATF, Inc., a supplier of specialty cold-formed and machined components for automotive applications. At ATF he implemented process control technologies, taught and instituted quality control systems, and designed experiments in a traditional manufacturing environment. He received his Ph.D. in industrial engineering in 1996 from the University of Illinois at Urbana-Champaign, where, as a graduate student, he taught quality and applied statistics and researched machining models for monitoring and control. At Cal Poly, Dr. Waldorf has taught and developed courses in manufacturing process design, computer-aided manufacturing, tool engineering, quality engineering, and reliability. He has participated in numerous activities related to the improvement of teaching methods, teaching assessment, and curriculum design. He is currently the faculty advisor for Society of Manufacturing Engineers (SME). His research interests are in metal cutting process modeling, tool wear, cutting tool design, and engineering education.