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Student Performance Improvement from a Student-graded Logbook Exercise

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Abstract

An exercise was designed and implemented for a mid-program design course in order to improve student performance and effectiveness in the use of engineering logbooks in the context of design projects. Over the course of two successive semesters (control), students received instruction and other resources relating to logbooks. In a third successive semester (treatment), students received the same instruction and resources, but additionally a logbook exercise was introduced wherein students assessed the quality of three example logbooks. To compare student performance between control and treatment groups, a random selection of student logbooks were compared and assessed by a team of instructors on four different criteria: 1) general organization and clarity, 2) written communication, 3) self-evaluation and 4) table of contents organization and accuracy. Students from the treatment semester were noticeably more engaged in record keeping and logbook usage throughout their course as compared to either of the control semesters. On aggregate, treatment semester students demonstrated a statistically significant improvement in all four criteria areas and were performing higher in logbook performance earlier in the semester.

Introduction

Engineering logbooks are used for project learning and documentation, and their appropriate use and content has been documented[1–3]. While their value to engineering firms is extremely high, there exists little or no literature on the best practices of developing the skills of maintaining high-quality engineering logbooks. For students, the educational value of a logbook is tied to its quality. For this reason, it is important for students to establish a concept of a good logbook and good habits associated with keeping them. The earlier that students become proficient with documentation via engineering logbooks, the more value they could potentially gain from future courses and other project-based learning experiences. For these reasons, a mid-program mechanical engineering design course at the University of Idaho requires the use of engineering logbooks. The sophomore-level course contains an 8-week team design project in which teams of 3-5 students work both together and independently to produce a working prototype. The prototype involved aspects of mechanical design, circuit design, and basic control software development. Logbooks are required by each student to document coursework and project work such as team meetings, action items, concept sketches and project learning. Logbook performance from students in the class has generally been typical of students in the second year of college study, with students generally being deficient in some areas. More effective logbook performance is desirable to enable better learning in other course content areas as well as to develop stronger documentation skills for life-long learning. Activities wherein students are involved in assessment improve student performance and judgment[4]. Furthermore, judging the correctness of other's answers may develop understanding of the material[5,6], and visualizing abstract ideas significantly improves learning[7]. To this end, an exercise was designed and implemented for this design course in order to improve student performance and effectiveness in the use of engineering logbooks.

Methods

Prior to implementation of the new activity, students in the design course received instruction and documentation each semester regarding logbooks and expectations. These two control semesters, referred to as Control 1 and Control 2, were facilitated by the same instructor. In a third successive semester, students received the same instruction and resources, but additionally a logbook exercise was introduced wherein students assessed the quality of three example logbooks. This third semester, called herein the Treatment semester, was facilitated by the same instructor and a second instructor, but other than the new logbook exercise, the instruction was nominally the same. Demographic information was not collected on the students.

Control Instruction and Logbook Exercise

In all semesters studied, students received two documents with information about engineering logbooks. In the control semesters, these documents were made available online but in the treatment semester, hard copies were made available during the logbook exercise. The first document contained information defining an engineering logbook, explaining the rationale behind keeping a logbook, detailing logbook expectations for the subject course, detailing logbook expectations for industry, and some discussion prompts related to course activities and appropriate logbook use following the activity. For example one entry in the discussion prompts table suggests that if the student just finished a meeting, they should ask themselves whether or not the meeting was productive and why, and that this should be recorded in the student's logbook. The second document was the logbook self-review form used throughout the subject course and in other courses offered by the department. The student is to complete the review form and secure it in their logbook before the logbook is assessed by the instructor or mentor. The form contains prompts to identify several of the student's best logbook entries and to evaluate their logbook documentation in the areas of project management, design development, performance, and organization.

The logbook exercise, first implemented in the treatment semester, consisted of an activity where students assessed the quality of three example logbooks followed by discussion. The sample logbooks were selected by the instructors from logbooks submitted by students during the control semesters. Enough photocopies of the sample logbooks were made so that when students in the course were separated into groups of four or five students, each group could have an example. The sample logbooks were not bound to mimic a real logbook, but were instead stapled in one corner. Three sample logbooks were provided to each group, which were chosen to demonstrate generally good performance, average performance, and poor performance. At the commencement of the exercise, the nature of each example, or even the fact that there were varying levels of quality in the example logbooks was withheld from the students. Students were instructed to assess the three logbooks on the same 4-point scale that the instructors use to assess student performance in the course. A scoring sheet was provided to each group for this purpose. The 4-point scale and scoring sheet are shown in Figs. 1 and 2 respectively.

Score	Attributes
4	Exemplary, insightful, worthy of sharing with entire class
3	Complete, correct, long-term reference value to self
2	Complete, numerous errors, limited reference value to self
1	Incomplete, major errors, no supporting documentation
0	Missing, submitted late, must complete for future portfolio review (if applicable)

Figure 1 – The 4-point scale used by students and instructors for scoring student logbooks and throughout the course.

Logbook #	Pages Numbered?	Entries Dated?	Tabel of Contents	Lecture 1 Notes	Pre-Lab 1 Notes	Lab 1 Notes	Lecture 2 Notes	Assign 1	Self-Evaluation	General Organization & Clarity	Written Communication	Average
1												
2												
3												

Figure 2 – The table provided to students for scoring example logbooks.

Students groups were given fifteen to twenty minutes to complete their assessments, after which, instructors brought the discussion back to a larger group setting, facilitating a discussion wherein students were prompted to share their findings and experience with each logbook. Prompting questions, such as, “Could you find all of the items in Logbook 1?”, “What did you like about the logbook?”, or “What was bad about this logbook?” were asked of the students. These questions were kept rather abstract to motivate the students to explore their own feelings about the usefulness of each example. Students were then asked to rate and rank the performance of example logbooks.

Logbook Assessment and Data Collection

Student logbooks were collected at the end of each semester and stored for evaluation at the end of the study. A random selection of twenty logbooks from each semester were selected for assessment by a team of five instructors. This assessment comprised generally reviewing the logbooks and assessing each in four areas of development on the four-point scale of Fig. 1. The logbooks were individually numbered. To reduce bias, student names on the outside and inside covers of the logbooks were obscured to keep the semester from which the logbook was collected hidden from the reviewer. It was however, not practical to obscure every instance of a student’s name within the logbook or the date from every entry. Evaluators recorded their scores in the areas of table of contents organization and clarity, general organization and clarity, written communication, and self-evaluation using the same 0-4 scale as illustrated in Figure 1.

In addition to logbook evaluation by engineering professors, logbook grades recorded throughout each semester were also considered. These grades were given by a group of peer mentors responsible for helping to administer laboratory activities and grading logbooks. Some mentors participated in the role for multiple semesters and were thus more experienced at assigning logbook grades, but there was additionally some turn-over each semester. Each of the

three or four mid-semester gradings focused both on quality of work (e.g., appropriate content, content clarity, and organization) and on general logbook proficiency (e.g., regular entries, quantity of documentation, and adequate reflection), and to a lesser degree on content correctness. Since the logbook grades were performed by peers rather than experienced engineering professors, lesser emphasis should be placed on these scores than from the formal evaluation of this study. The grades do however allow an important observation; how students' logbook performance changed throughout the semester.

Results

Student Performance Observations

Generally, the students in the treatment semester were engaged in the activity, with some groups taking up to twenty minutes to scrutinize, and evaluate the three sample logbooks. During the following discussion portion of the exercise, students successfully ranked the logbooks in an order consistent with low/med/high quality originally determined by the instructors, with many students able to identify strengths and weaknesses in each example.

Instructor Assessment

Table 1 shows the average evaluator score by criteria area for treatment and control semesters. Also calculated in the table are the mean and standard deviation for all scores in all criteria areas. Among the three populations, there is a statistically significant difference between successive semesters. There is also a statistically significant difference between the treatment semester and the combined control semesters. Students' logbook performance improved in all four criteria areas between control semesters and again as the logbook exercise was implemented. However, more improvement occurred in some areas than others depending on which semesters are compared. Figure 3 shows the mean evaluator score for each content area and semester.

Table 1 – Mean evaluator score and standard deviation. Fleiss's Kappa is given for the four criteria areas.

Average	Semester	Table of Contents	General	Written Communication	Self-Evaluation	All criteria areas
Control 1	Fall 2014	2.00, 1.41	2.47, 0.82	2.43, 0.77	1.63, 1.14	2.133, 1.12
Control 2	Spring 2015	2.89, 0.68	2.68, 0.75	2.55, 0.67	2.09, 1.01	2.53, 0.85
Treatment	Fall 2015	3.31, 0.73	2.91, 0.77	2.74, 0.77	2.42, 1.00	2.845, 0.88
Kappa		0.23	0.11	0.17	0.04	-

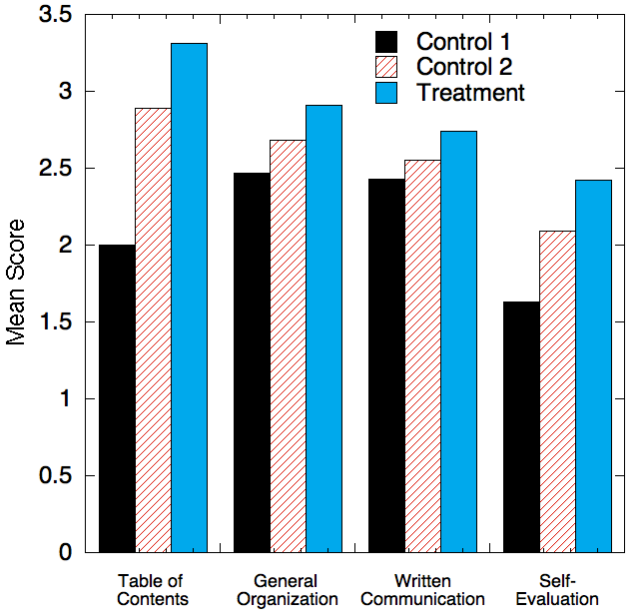

Figure 3 – Mean evaluator score for the four criteria areas.

Evaluator Reliability

Fleiss's Kappa[8] was used as a measure of inter-rater reliability. Kappa values were calculated for each of the four criteria areas used by the evaluators and are displayed in Table 1. Generally, moderate agreement was achieved between the evaluators, with the best agreement achieved for the table of contents organization and accuracy criteria area. Moderate agreement is acceptable, given the simple description and integer scoring imposed on the evaluation exercise.

Mentor Comments

About three weeks after the logbook exercise was administered to the treatment semester students, a logbook check was performed. Mentors graded the logbooks per the established grading rubric on the four-point scale. The course instructors asked the mentors who had served for more than one semester if they thought the logbook exercise made a difference and if they thought the logbooks were of higher quality as a result. Five of the six mentors for the treatment semester had served before and overwhelmingly their response was that the activity made a difference. They said the logbooks were clearer and easier to read, more organized, and that the entries were of generally higher quality than during the previous semester. Those who had served as mentor during both control group semesters felt the treatment semester logbooks were greatly improved over either of the previous two semesters.

Peer Mentor Grading

As mentioned previously, the logbooks were collected for grading periodically throughout the semester by the peer mentors as part of the course grade earned by the students. During the Control 2 semester the logbooks were collected three times. The logbooks were collected four times in the other two semesters. While not a controlled experiment, grades given to the student's logbooks by the course mentors provide some insight into how logbook performance changed throughout the semester. The average grades by semester, in some cases,

normalized to the four-point scale (the four-point scale was adopted between Control 2 and Control 1) are shown in Fig. 4.

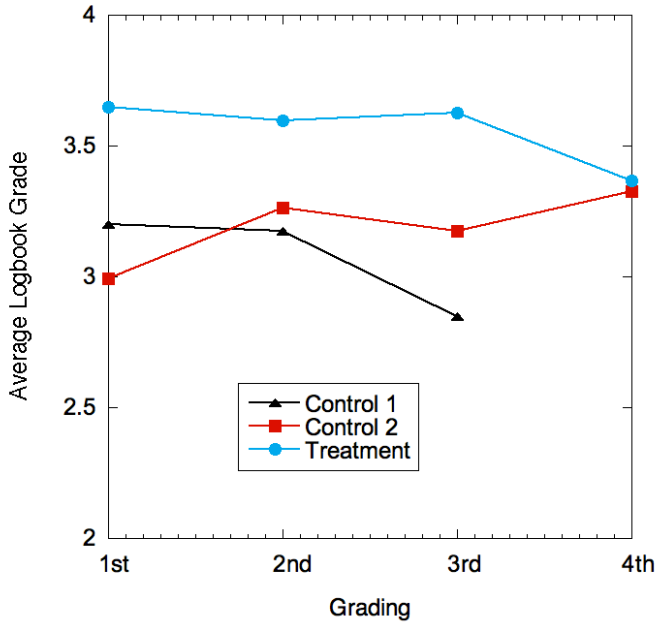

Figure 4 – Average mentor assigned logbook grade from mid-semester logbook checks.

Peer mentor grades were overall highest for the Treatment semester. Control 2 and the Treatment semester maintained nearly steady performance for most of the semester, but then dropped at the final grading. Control 1 maintained nearly steady or slightly improving performance throughout the semester. The standard deviations for the population scores were in all cases between 0.6 and 1.1 points.

Discussion

It is difficult to determine what effect small differences in instruction aside from the logbook exercise had on student logbook performance among the semesters. While there could have been small variations in the exact wording of the instruction, the general content of the lesson was the same and all lessons used identical course materials. Perhaps there are other factors contributing to performance such as the quality of grader feedback, or moving instructor expectation targets leading to students having to "work harder" to achieve results deemed acceptable. Students may have also been more engaged with the printed instructional materials than when they were only available online, but some research suggests that there is no difference in educational efficacy between the two distribution systems.[9] Considering this, it seems reasonable to conclude that there is some natural variation between students from any given semester, but given the statistically significant difference between the treatment semester and the combined non-treatment semesters, the logbook exercise improved performance above this natural variation. We suspect that the improvement in end-of-semester performance as characterized by the instructor evaluation is due to the students' opportunity to experience exemplary and unacceptable logbooks from a reviewer's perspective. This not only gives them a

target, but as Bloom et al.[5] and Sadler and Good[6] point out, can help with their understanding of the concepts and purpose.

The mentor comments after the first logbook grading on the treatment semester combined with the logbook grades shown in Fig. 2 suggest that the logbook exercise brought the performance up very quickly for those students subjected to the exercise. This effect cannot be captured by end-of-semester instructor logbook evaluation alone, since by the time of evaluation, the students had an entire semester's worth of practice and feedback incorporated into their concept of an appropriate logbook. To better capture this effect, and perhaps discover a more important benefit of the logbook exercise, instructor assessment of student logbook performance, should be conducted at intermediate points throughout the semester on treatment and non-treatment semester students with an appropriate analysis.

It also appears from the peer-mentor logbook grading of Fig. 2, that students' performance is dropping somewhat toward the end of the semester. This could be due to the introduction of a team design project in the middle of the semester. This design project, which culminates at the end of the semester, requires a significant amount of attention from the students. Thus, the students may be focusing on the project rather than on maintaining good documentation. Alternatively, the drop could be due to final examinations and other responsibilities placed on students toward the end of the semester. Ultimately though, the logbook exercise appears to improve logbook performance across the four criteria areas and bring students to a higher level more quickly. The exercise also has the added benefit of developing group skills and introducing students to one another early in class.

Conclusions

A student-graded logbook activity was implemented wherein students grade the performance of sample logbooks prepared by instructors. In the activity, students use the same four-point scale that is used for grading the course. The activity improves student logbook performance when introduced early in the course. This higher level of performance is maintained for most of the semester, but may be influenced by outside factors such as class projects or final exams in other courses. Evaluator scores show statistically significant differences between logbook scores from students having participated in the activity and those that did not when evaluated at the end of the semester. This suggests that lasting learning and performance improvement can be achieved through this targeted activity above what is achievable with the combination of simple instructional handouts and lecture.

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