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The Student Educational Experience with Electronic Laboratory Notebooks (Work in Progress)

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Monica Okon, a current graduate student in biomedical engineering at Ohio State University, became interested in engineering education when starting as a graduate teaching associate (GTA) for the Engineering Education Department at Ohio State University. She has had the opportunity to teach the Fundamentals in Engineering laboratory component for the standard courses as well as served as a lead GTA for this department for two years. She is currently a lead GTA in the Department of Biomedical Engineering where she helped pilot the electronic lab notebooks in junior level labs.

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Work in Progress: The Student Educational Experience with Electronic Laboratory Notebooks

Introduction

Graduates from ABET accredited programs are expected to demonstrate an ability to communicate effectively [ABET 2016]. Engineers need to document and report their technical ideas, designs, and solutions in a clear and succinct manner and to a variety of audiences. One way for students to gain and practice documentation and technical communication skills in a practical setting is through the experiential courses throughout the curriculum (i.e. laboratory courses).

Given the increasing presence of social media as well as other methods of electronic communication, computer mediated activities provide an opportunity to educate students in a familiar setting. Electronic documentation is also gaining popularity in research laboratories and industries, as well as in the medical and other professional fields, all in which biomedical engineers are likely to seek employment [Guerrero 2016; Rubacha 2011]. For this reason, we have recently (autumn 2016) transitioned the biomedical engineering laboratory courses from paper-based laboratory notebooks to electronic-based laboratory notebooks (ELNs). This work in progress describes the implementation of ELNs into the laboratory courses. We are also in the process of surveying students regarding perceived impacts the electronic platform has had on their own motivation, documentation, and technical communication skills, compared to the paper-based notebooks completed in a previous offering of the same courses (academic year 2015-2016).

Methods

Our biomedical engineering (BME) department offers six undergraduate domain laboratory courses, of which BME majors are required to complete three during their junior and/or senior years. Students most recently enrolled in domain labs during the 2016-2017 academic year were required to keep electronic-based lab notebooks (LabArchives Classroom Edition). Before the start of each lab course, students were provided a link to create their ELN account that was pre-loaded with a daily lab notebook template created by the authors (Figure 1). The student ELNs were also pre-loaded with laboratory notebook requirements (Figure 2) and associated grading rubric, daily graduate teaching assistant formative feedback forms, and an example notebook page template with guidelines for each section.

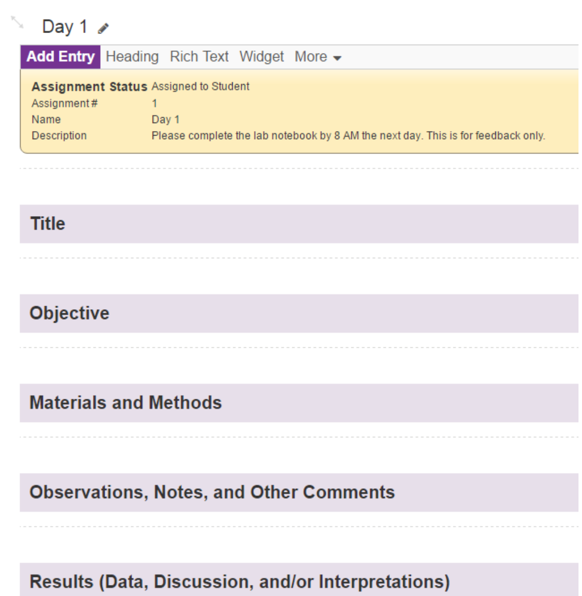

Fig. 1: Electronic lab notebook

During each laboratory session, every student was required to bring their own electronic device (laptop, tablet, smartphone, etc.) and document her or his laboratory experiences. Between sessions, graduate teaching assistants remotely accessed each student's notebook to provide formative electronic feedback. Students were then permitted to correct any identified deficiencies, and were expected to demonstrate improvements in their notebook keeping during subsequent lab sessions. Notebooks were submitted for summative rubric assessment at the end of the laboratory course.

Lab Notebook Requirements

Metrics	Requirements
Electronic	All lab notes are kept and organized electronically
Uploads	All uploads have good resolution and details are easily distinguishable.
Daily Submissions	Each lab day is recorded on a separate notebook page and **completed by 8 AM** the next day for feedback from your GTA.
Data	All collected raw data is included, and any additional plots, tables, and figures are uploaded before final submission
Clarity	Notebook clearly explains when, how, and what was done.
Mistakes	Notebook is free of spelling and grammatical errors
Organized	Includes the following: • Table of contents • Descriptive, informative title of experiment • Experimental objective at the top each page • Includes date and signature
Informative	• All collected data and information is recorded • Descriptive observations are included • Explanation of methodology is detailed such that experiments could be easily repeated

Fig 2: Student electronic notebook requirements.

This work in progress further seeks to gain understanding on how BME students perceive the impacts of electronic-based notebooks on their laboratory motivation, documentation and technical communication skills. We are currently analyzing preliminary results from an anonymous online survey (Qualtrics) administered to all current junior and senior-level BME students who were enrolled in one or more domain laboratory courses during the 2015-2016 academic year when paper-based notebooks were required, and/or during 2016-2017 academic year when ELNs were introduced. The survey responses placed the students into one of two sub-categories, those who 1) had completed at least one domain lab course using paper-based notebooks and at least one domain lab course using electronic-based notebook keeping methods; and 2) had completed domain lab course(s) with electronic-based notebook keeping methods only. The survey (Table 1) prompted a series of Likert-scale (#1-10) and open ended questions (#11-13), intended to measure the perceived effects ELNs had on students' perception on their abilities to document and communicate effectively. Questions used in this survey were adapted from assessment survey sample questions provided by The Ohio State University Center for the Advancement of Teaching (UCAT).

Table 1: Survey questions aimed at measuring the student-perceived effects of ELNs.

The use of electronic lab notebook (Likert-scale)…
1) enhanced my ability to be well organized in my record keeping.
2) enhanced my ability to document lab procedures and other information to meet my instructor's expectations.
3) enhanced my ability to store data collected in lab.
4) enhanced my ability to share data with others.
5) allowed me to be more time-efficient in notebook keeping compared to notebook keeping on paper.
6) rubrics helped me gauge my notebook keeping strengths and weaknesses.
7) allowed me to incorporate the feedback I received from the graduate teaching assistants.
8) enhanced my ability to communicate effectively.
9) helped me acquire techniques, skills and/or modern engineering tools necessary for engineering practices.
10) enhanced my learning the lab course.
Open Ended Questions:
11) What knowledge and skills did the electronic lab notebook help you acquire?
12) What aspects of the ELN motivated you to or prevented you from devoting your efforts to the experiments?

Results and Discussion

Examples of submitted paper-based and electronic lab notebooks are shown in Figures 3 and 4, respectively. It was observed by instructors and teaching assistants that the ELN format allowed students to record more thorough and complete documentation of their laboratory experiments compared to paper-based notebooks. Particularly, students regularly included attachments of raw and analyzed data files and pictures and/or videos of their experiments, compared to hand-drawn sketches in the paper-based format. It was also noted that documentation in the electronic format increased students' efforts in notebook keeping even outside the designated laboratory time, thereby increasing the quality and quantity of information documented.

Preliminary survey results (n=32) indicated the majority of students agreed or strongly agreed with all ten Likert-scale survey questions presented in Table 1. Most notably, 84.4% of students agreed or strongly agreed that the formative assessment rubrics helped them to gauge their notebook keeping strengths and weaknesses (question #6) and 87.5% of students believed the use of ELNs allowed them to incorporate the feedback received from graduate teaching assistants (question #7). High percentages of surveyed students also agreed the ELNs helped them be more organized (75%) and enhanced their documentation skills (72%) and ability to store the data collected in lab (69%), as per questions 1, 2 and 3, respectively.

Some challenges were experienced during the ELN implementation process, including a short learning curve for first-time ELN users. Also, students were required to bring their own device to lab to complete the ELNs, which added clutter to benchtop space during experimentation and sometimes served as a temptation for student distraction. Additionally, we are seeking opportunities to integrate the ELN with our university's learning management system to promote a more streamlined feedback and grading process. Overall, we are encouraged by our transition to ELNs and will continue their use in future biomedical engineering laboratory courses.

Conclusions

This work in progress describes how ELNs have been incorporated into upper-level biomedical engineering lab courses. We have found that most students prefer ELNs over paper-based notebooks. Through continued efforts to analyze student survey responses, we aim to identify what factor(s) of the ELNs may influence this preference, as well as gain further insight into the use of ELNs as a medium for teaching documentation and effective communication skills.

References

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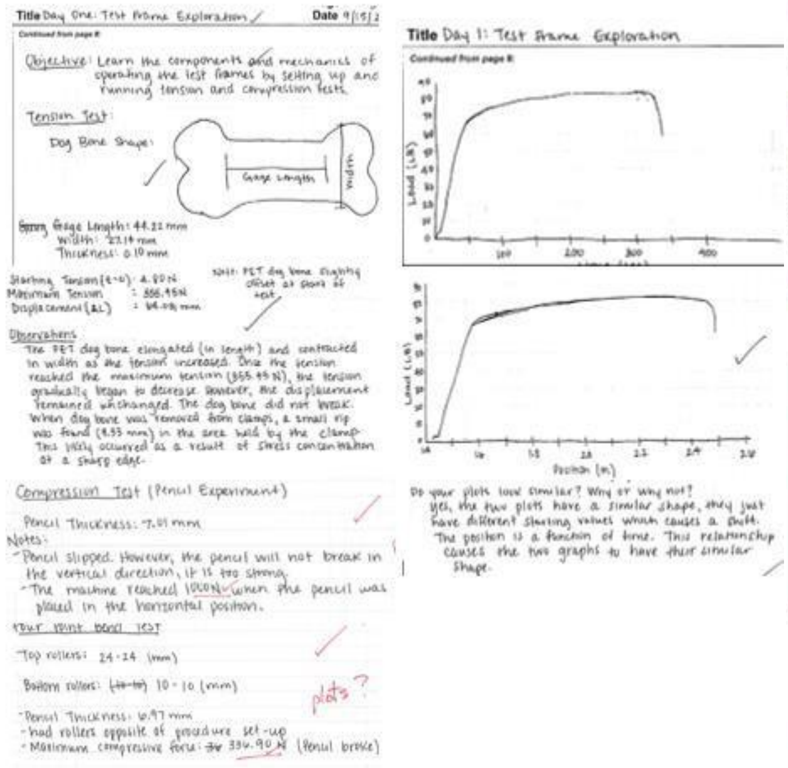

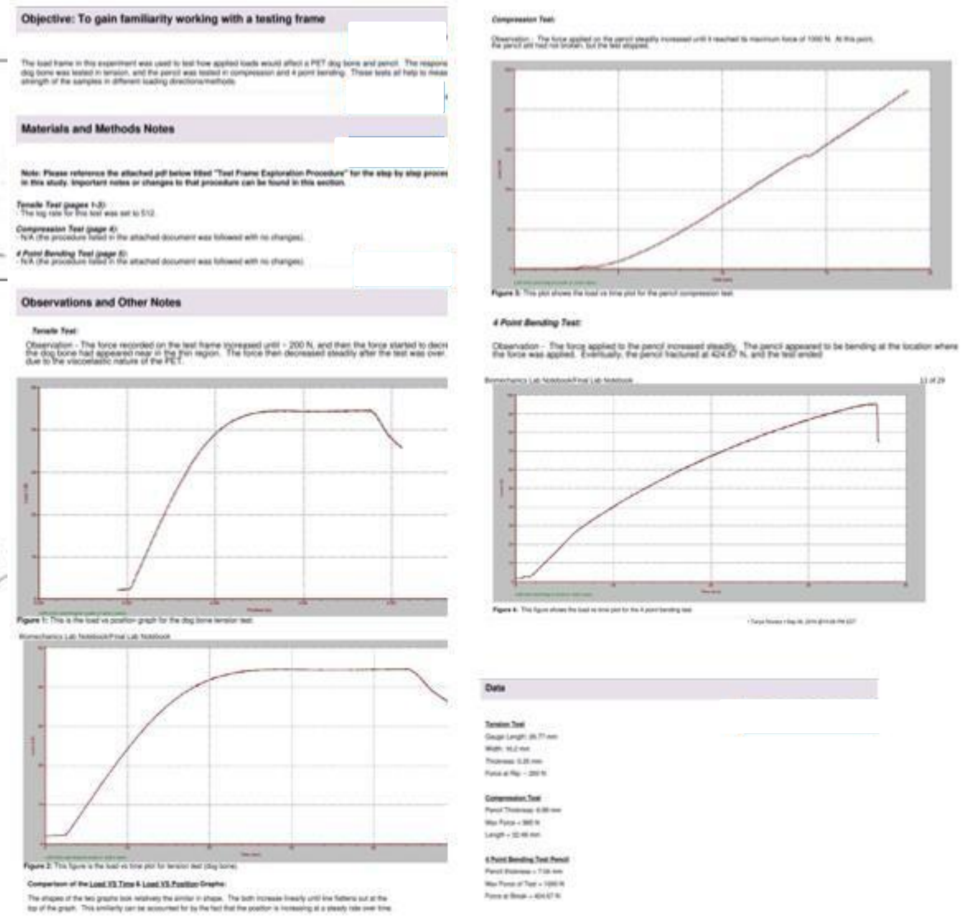

Fig 3: Paper lab notebook entry example.
Fig 4 (right): ELN entry example