Strengthening STEM Laboratory Assessment Using Student-Narrative Portfolios Interwoven with Online Evaluation

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Abstract

The University of Central Florida's (UCF) Department of Electrical and Computer Engineering has developed the ***Electronic Lab Assessments with Tutoring Enhanced Delivery (ELATED)*** laboratory pedagogy using alternating creative portfolios and online formative assessment in the introductory course *Computer Organization and Design*. The ELATED method utilizes a combination of student-driven pedagogical strategies with Vygotskian scaffolding approaches to maximize student performance related to complex concepts. This paper outlines the development process and initial evaluation results from the implementation of the ELATED pedagogy. A total of 183 students participated in ELATED labs in summer and fall 2015. Evidence showed that benefits of ELATED labs include the reduction of voluminous lab reports often deficient due to unimaginative and reused content, motivating learners to engage in professional document authoring through creative expression of a student-structured portfolio, and focusing learner's attention on laboratory procedures likely to appear in the subsequent week's formative assessment. Workload refocusing benefits, such as decreasing Graduate Teaching Assistant (GTA) and faculty grading tasks and reallocating them to content tuning and renewal, as well as targeting individualized scaffolding practices, are also addressed.

Keywords

Computerized Grading, Formative Assessment, Laboratory Assessment, Portfolio, Scaffolding

Introduction

To realize improved learning without increased personnel, we have *researched and evaluated an innovative mapping of GTA expertise* from low-impact grading tasks to new roles, which have an increased impact on student outcomes. Based on trends of what is known regarding how students learn in the era of Internet repositories of assignment solutions, graded weekly lab reports are an indicator of declining pedagogical value [1, 2, 3]. On the other hand, online formative assessments have been documented to exhibit a high degree of correlation with overall student learning [4]. Moreover, documented studies of the benefit of frequent online evaluation at the college-level have indicated a year-over-year summative evaluation increase from 78% to 86% in the case-study of a single course [5]. A recent article by Angus and Watson in 2009 evaluated the extent to which online formative assessments improve learning outcomes and, based on 1,500 observation points, determined that such a provision "robustly leads to higher student learning" [6].

To deliver more rapid and responsive formative assessments in disciplines outside of engineering, *computer-aided testing* to support increasing enrollments and/or learning quality have been well-cited in the literature [7, 8, 9]. Documented experiences often cite numerous benefits, including increased practice and attainment of course outcomes, flexibility of scheduling, and rapid grading response [10, 11]. Thus, in an effort to examine the pedagogical impacts of such approaches, we evaluated the use of alternating creative portfolios and computerized exam questions in an introductory computer engineering course.

In practice, students are first engaged by replacing typically mundane weekly lab reports with free-form portfolios that inventory their learning process during hands-on exercises. Second, during subsequent week's lab session, students complete computer-based evaluations at their PC-equipped lab stations. This is beneficial in that it allows for assessment of the expected learning outcomes from the previous week to be assimilated. Students are afforded opportunities to review their evaluation results with Electronic Lab Assessments (ELA) Tutors. As a consequence of the reduced lab report grading loads, GTAs have extended time available to scaffold and support learners' individual needs. Lastly, students submit monthly formative reports specifying their design, tradeoffs, and test cases according to a precise rubric providing clear expectations and constructive feedback to develop formal documentation skills.

Traditionally, graduate assistants are hired to grade lab weekly reports. However, in ELATED laboratories, lab report graders are reallocated into three new categories of Graduate Scholar Assistants (GSAs):

1) **Lab GTA:** review projects or remedial material, demonstrate the experiments, and clarify grading rubrics,

2) **Question Clone Composer:** develop high quality assessment items based on each lab experiment for computerized delivery,

3) **ELA Tutor:** During office hours, ELA Tutors provide guided content review, answer questions regarding formative assessments, and identify remedial content from open sources.

Preliminary survey feedback from ELATED learners has afforded the following results:

- 76.0% of respondents agreed or strongly agreed that laboratory projects decomposed into iterative phases of ELATED are preferable, and
- 61.9% of respondents agreed or strongly agreed that completion of an online lab assessment every two weeks is preferable to submitting weekly lab reports.

Related Works

A taxonomy of contemporary approaches to assignment of Lab Documentation activities is depicted in Figure 1. Traditionally, weekly lab reports are an integral part of the foundational engineering curriculum. In many conventional curricula, students are required to write a report after each weekly experiment, documenting the lab process. Recent research [1] by Vargas and P. Hanstedt, however, indicates limitations of weekly lab reports, including reduced effectiveness to evaluate students' skills gained from the experiment. For instance, students may become discouraged with weekly reports if they are seen to restrict innovation and creativity. Within the cognitive domain, Bloom (1956) categorizes and orders thinking skills from lower order skills to higher order skills in five levels: knowledge, comprehension, analysis, synthesis, and evaluation. Unfortunately, lab reports can be a less effective assessment method to support active learning due to limited emphasis on the higher domains of cognitive learning outcomes, such as knowledge, synthesis and evaluation [12].

In order to address the issues with conventional weekly lab reports, a method called the Lab Notebook was developed. The objective of the Lab Notebook approach was to facilitate close-knit student interaction with the instructor using frequent feedback to refine the lab report [1]. This iterative method assists students by incrementally improving their analytical thinking and composition skills. Each Lab Notebook consists of two main sections: *data analysis* and *conclusion*, which helped to partition the procedural aspects from the analytical writing task. While this provided some organizational benefit for the grader compared to weekly lab reports, students still had to submit two or three actual technical reports per semester. Nonetheless, this method resulted in increasing the attention toward creativity in the lab [1].

In this paper, a Portfolio is investigated as a creativity-enabling instrument for Lab Documentation. A Portfolio is a type of authentic performance-based assessment that documents students' personal reflection and growth through a collection of artifacts and writings [13]. Research has found that students in an authentic learning environment that emphasizes progress, improvement and the process of learning rather than procedures and grades are more likely to be engaged and motivated in learning [14, 15]. The portfolio instrument utilizes a combination of weekly lab reports, revision processes, and contemplative essays, which provides room to facilitate knowledge synthesis, evaluation and critical thinking skills. The results indicated significant improvements in student attitudes towards learning, understanding of subject content and writing skills [1]. This promising method is explored in other STEM courses within computing curricula, using the ELATED approach herein.

In addition, we used individualized scaffolding practices on the learner's Zone of Proximal Development (ZPD) in the ELATED approach. The ZPD indicates the difference between what a learner can currently do independently, and what the learner can do with assistance [16]. This zone

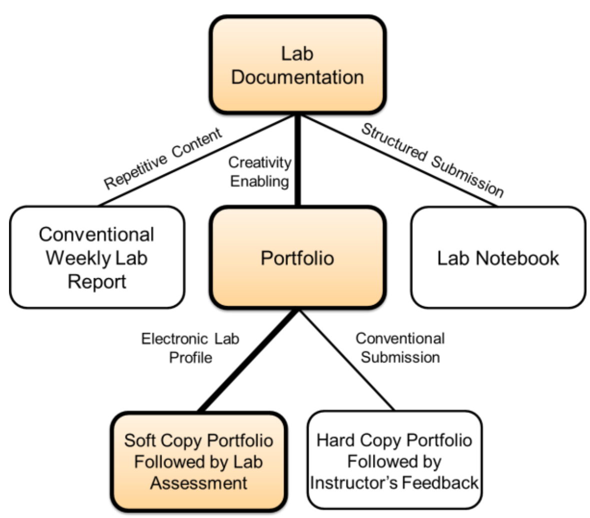


Figure 1: A Taxonomy of Conventional and Emerging Laboratory Documentation Strategies for STEM disciplines.

can be viewed as a bridge between the skills a learner has at the moment and the skills he or she will need to have at a later stage. In the ZPD, a teacher or a more knowledgeable peer works with the learner work on a task that the learner cannot perform independently. The learner is gradually led to attain a goal or solve a problem independently after successful scaffolding [17, 18, 19, 20]. In this project, our goal is to have students, GSAs, and instructors all work together to bring the students from their initial developmental level to gradual independent mastery through online formative assessments and onsite mentoring support from the Content GSAs.

ELATED Method

As mentioned in the introduction, grading weekly lab reports is a both time-consuming and labor-consuming task with a low impact on student achievement. In order to increase student achievement and improve the learning process we have developed and implemented *Electronic Lab Assessments with Tutoring Enhanced Delivery (ELATED).* ELATED converts grading workloads into tutoring gains. Figure 2 illustrates the efficient resource utilization in order to migrate from Conventional lab procedures to ELATED. Expertise becomes focused by recasting fixed laboratory procedures from around weekly reports to become learner-focused. The learner's needs are more fully addressed through targeted mentoring and creativity inspiring portfolios. Instead of formal weekly reports, students submit individualized portfolios via an *Electronic Lab Profile (ELP)* as a first submission. In the subsequent week, a standardized and secured *Electronic Lab Assessment (ELA)* is utilized, which enforces integrity during the laboratory grading process. The ELAs are also efficient due to their use of computerized grading, which frees-up GTA and Grader hours for tutoring and composing ELAs. In a pilot study at UCF, the nominal grading load of a GTA was significantly reduced in the laboratory component of the required undergraduate course, *Computer Organization*. During the Fall 2015 semester, the GTA laboratory load for a total enrollment of 140 students was reduced from 20 hours/week on average having conventional delivery methodology with weekly lab reports, to just 8 hours/week on average using the ELATED methodology. The ELATED GTA workload included

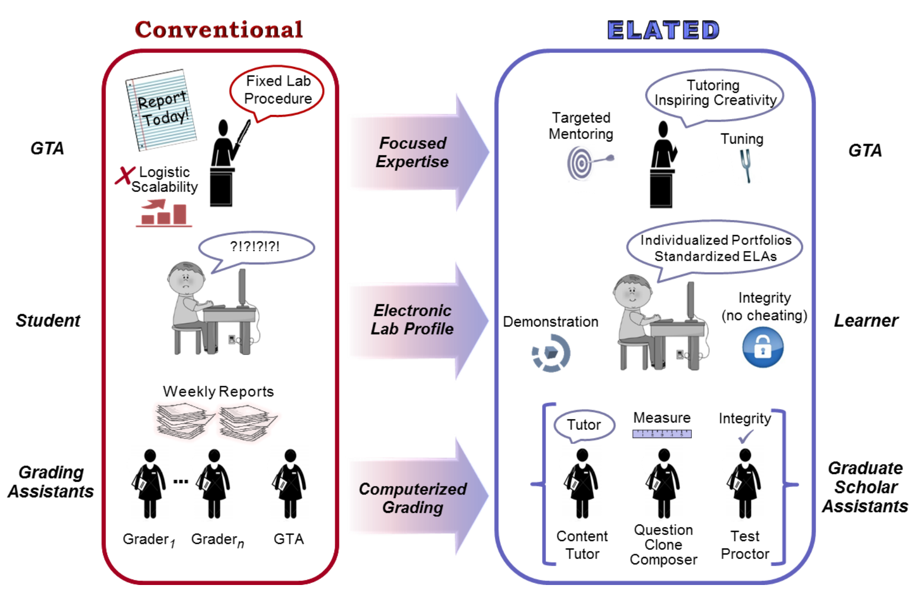


Figure 2: Transforming Conventional Laboratory Delivery using the ELATED Approach.

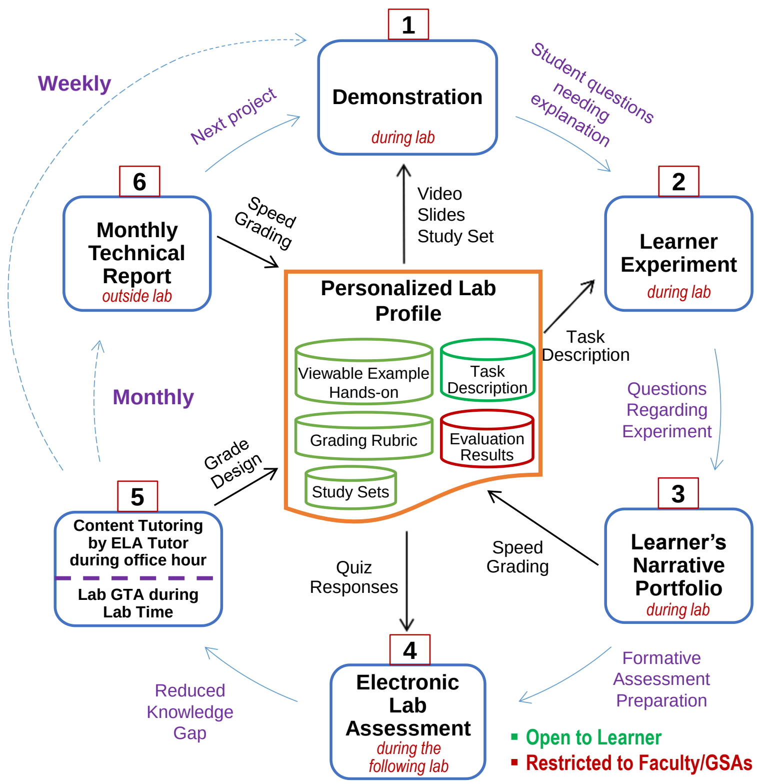


Figure 3: ELATED Operational Flow.

delivering two laboratory sessions each week having duration of three hours per lab, plus eight hours once per month to grade the monthly technical reports submitted by each student.

Figure 3 depicts the ELATED operational flow. It centers on a technology intervention called Electronic Lab Profile (ELP) that structures information exchanged between the learner, GSAs, and GTAs. The pedagogical strategy of the ELATED laboratory encompasses the following 6 elements:

1. **Demonstration:** Instructional content is available in the ELP for students to prepare, prior to arrival at the lab. Lab GTAs design concise experiments to be performed during the lab period. During each lab session, students conduct incremental experiments, which culminate in a complete experiment to be completed within 2 or 3 weeks. During each lab session, learners view instructor-produced or publisher-provided demonstrations or experiment descriptions as desired, read slides/ notes/ textbook/ hyperlinks embedded in the electronic materials, use open Internet resources, solve *Portfolio Problems* and compose narrative portfolios that replace traditional weekly reports.
2. **Learner Experiment:** Students perform the experiment and then clarify questions with *Lab* GTAs during lab.
3. **Learner Portfolio:** As illustrated in Figure 4, there are weekly and monthly activity flows. Each week, students are asked to write a narrative portfolio during the lab session, which is primarily focusing on how they have approached and performed the experiment. It allows their own creative expression regarding how they have completed the tasks that they were

asked to perform. Portfolios then will be graded rapidly after with a 2/1/0 scoring rubric in which 2 means sufficient, 1 means insufficient and 0 indicates no submission.

4. **Electronic Lab Assessment**: Learners complete the online formative assessment at a specific time during the lab time frame, which contains the topics covered during the week prior to each Lab Assessment. *Lab.* GTAs in the lab provide a turnkey service in a secure environment to prevent cheating/ Googling solutions using IP restriction, camera/phone checks, and lockdown browsers. These Electronic Lab Assessments become graded immediately within the LMS, enabling students to see their score.

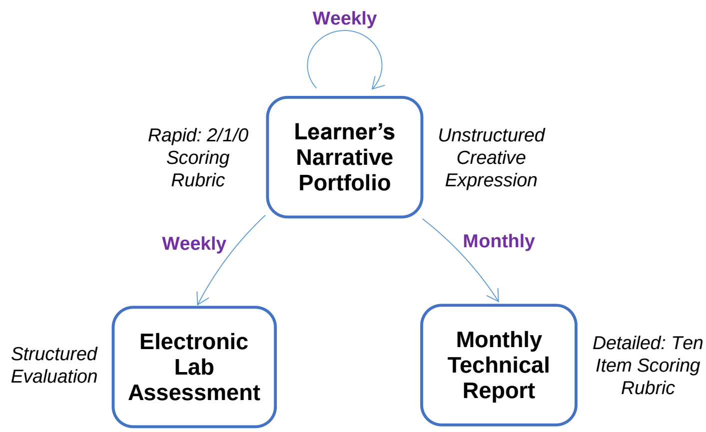


Figure 4: Student-Narrative Portfolios Interwoven with Online Evaluation.

5. **Content Tutoring by ELA Tutor during office hour or LAB GTA during Lab Time:** Learners are obligated to meet with ELA Tutors or Lab GTAs to review their Lab Assessments to learn from any mistakes, prior to the next week's lab session.
6. **Monthly Technical Report:** In completing the entire lab experiment, which consists of individual learning elements whereby students compose a technical report based on the capstone experiment, students learn how to compose technical reports. However, ELATED significantly reduces the overhead effort associated with weekly lab reports, and instead focuses student time more efficiently on learning in more creative ways. The time consuming process of grading weekly lab reports is also reduced. Results provided herein indicate that the ELATED approach can achieve the objective for the student to still acquire skills of writing technical reports.

Developing an Electronic Lab Profile (ELP)

Learner interactions involving the ELP are depicted in Figure 5. The ELP contains the current working model of the Learner's progress, via a web-enabled application. It maintains each experiment's *Task Description* along with historical records and performance information, exchanged between the learner, GSAs, and Lab GTAs, to enable high gain learning. We have developed the ELP as a Canvas *Learning Management System (LMS)* plugin to integrate all information flows needed to realize high gain learning, from task descriptions to computerized testing with GSA-assisted tutoring by the ELA Tutor during office hours or Lab GTA during Lab time, as well as Socratic discussions.

The Lab GTA first selects content to create a Question Prototype. Using the commercially available Respondus converter or publisher content, the Question Prototype is loaded into Canvas. Second, these are grouped by topic and lab to create the required formative assessments, and then cloned by the *Question Clone Composer* GSA. Third, a review session is required whenever students obtain a score below a given threshold, typically a C letter grade. Each remedial experiment has its own description, demonstration, and then a required Lab Assessment

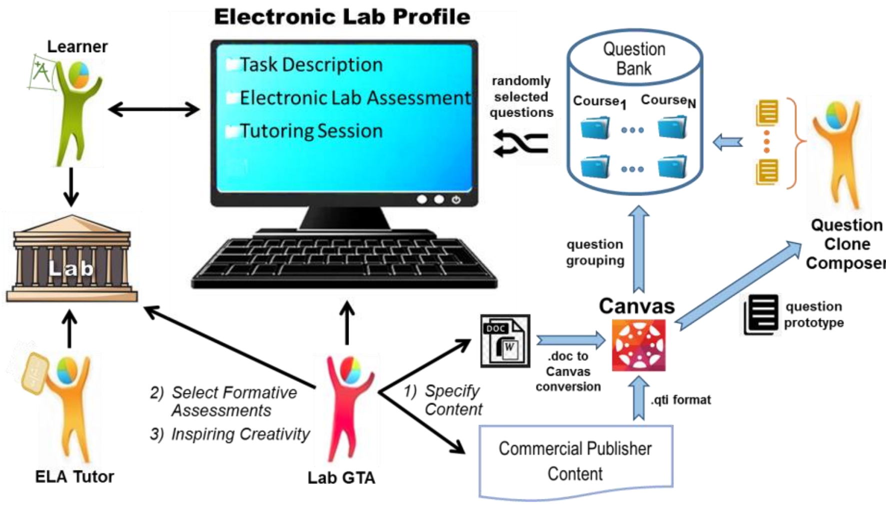


Figure 5: Concept and Operation of an Electronic Lab Profile (ELP).

in the following week. These are already available for all courses that are using ELATED. This solves the issue that GTAs may want to provide or engage Learners with remediation, but may lack office or class time to deliver it [21] and verify successful completion, which is enabled without additional cost or effort via ELATED. A hierarchy of expertise facilitates these roles.

Results

During the spring 2015 semester, we delivered the ELATED approach in the laboratory component of the required undergraduate course, *Computer Organization and Design,* at UCF, and developed weekly projects closely tied to the course lecture modules. With this method students had an opportunity to be creative and use their knowledge by integrating several small

Part I: findMax.asm

The primary goal of today's recitation was for me to write a simple MIPS function that compares two integers and outputs the max of the two to the user. This can be done by a simple MIPS algorithm that performs two syscall 5s to take in integers. ... In some cases, this would be foolish, ... The following MIPS code completes the assignment:

```
#findmax.asm-- Outputs the larger of two input numbers
# $t0 - used to hold the first number.
# $v0 - syscall parameter and return value.
.data
prompt: .asciiz "Please enter two integers to be compared:"

#Output the prompt to the screen
la $a0, prompt
li, $v0, 4
Syscall

# Get first number from user, put into $t0.
li $v0, 5
Syscall
move $t0, $v0
...
```

Figure 6: Sample Student Portfolio.

project components together in order to develop an integrated solution. A sample portfolio example is shown in Figure 6. This sample includes three projects related to the MIPS processor machine code and its design aspects. For instance, the capstone Project 1 entitled, “Quadruplex-Duplex Algebraic Expansion,” was decomposed into weekly elements of addition and subtraction operations during the first week, loops using branches in the second week to construct a multiplication operation, followed by a division operation in the following week. Each subsequent week included a brief ELA consisting of 5 multiple choice questions related to the exact procedure exercised during the preceding week. Some sample ELA questions are shown in Figures 7, 8, and 9. At the end of all learning elements for the capstone project, the students composed a formal technical report, which was compliant with a detailed rubric specifying section headings, contents, and constraints. Sections included: Description of Cover Sheet, Project Description, Program Design, Symbol Table, Learning Coverage, Prototype in C-language, Test Plan of MIPS machine Code, Test Results, and References.

An overview of ELATED laboratory perspective in summer and fall 2015 semesters is listed in Table 1, which shows the quantities of students and statistics of each lab assessment in terms of allotted time, number of questions and number of clones per each question. According to this report, there were 61 and 122 students evenly distributed in two and four sections for summer and fall 2015, respectively. On average, there were 5 questions asked in a 20 minute window for each lab assessment in the summer and fall 2015 semesters. While the lab assessment took around 8.3 minutes for students enrolled in summer 2015, it took on average less than 6.5 minutes to evaluate students.

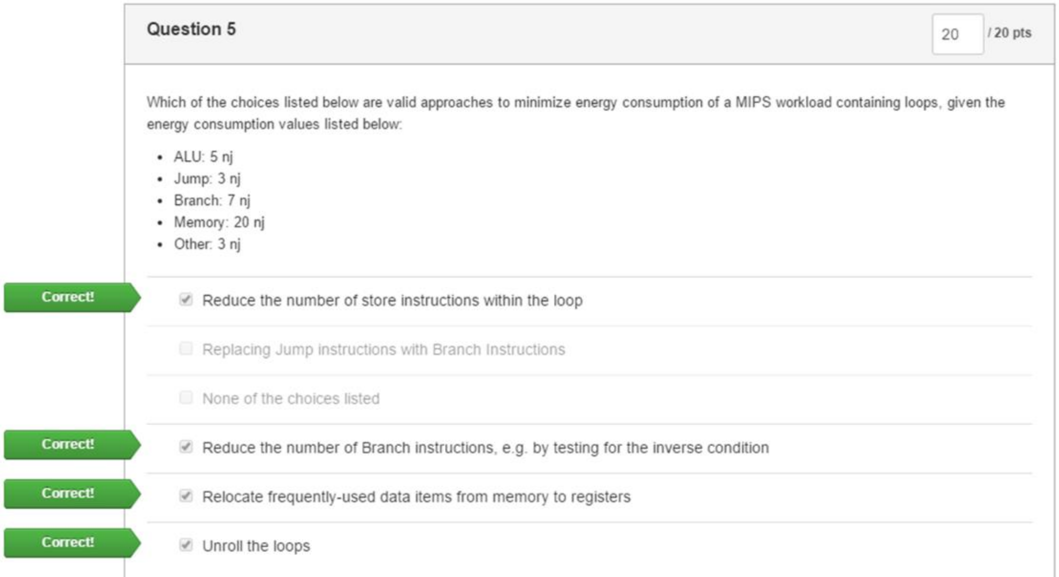
Furthermore, 3 clones were created for each question, on average, to decrease the chance of answering similar questions by multiple students completing the lab assessment questions while seated nearby each other. At the end of the course, students were invited to participate in an optional survey about the ELATED approach. The shown in Figure 10, Figure 11, and Figure 12 include completed survey results from 21 of 63 enrolled students. The results indicate that the majority of the students strongly prefer laboratory procedures and assessments structured with the ELATED approach, as compared to the conventional approach of laboratory delivery. Complementary results are also shown in Figure 13. Figure 13(a) shows quantitative results for two ELAs offered consecutively as the semester progressed. The dotted line indicates that for the earlier ELA there was no clear distinction among students who were able to identify the previous week’s procedures. While the GTAs and faculty member qualitatively perceived the ELAs to

Table 1: An overview of ELATED laboratory perspective

Semester	*Enrollment Numbers*	*Number of Sections*	*Time Allotted per ELA*	*Typical Time per ELA*	*Number of Qs per ELA*	*Number of Clones per Each Question*	*Calculation of Lab Grade*
Summer 2015	61	2	20 min	8.3 min	5	3 on Average	*Code score = 50%* *ELAs score = 35%* *Report and/or Portfolio score = 15%* -------------------------------- *Total = 100%*
Fall 2015	122	4	20 min	6.1 min	5	4 on Average	*Code score = 45%* *ELAs score = 40%* *Report and/or Portfolio score = 15%* -------------------------------- *Total = 100%*

motivate the learners to become more engaged in the laboratory procedures, the green curve quantifies such benefits as 30% and 12% increases in *A*s and *B*s, respectively as well as 18% and 22% decreases in *C*s and *D*s, respectively. Figure 13(b) illustrates the results of administering a content-specific ELA to remediate knowledge gaps evidenced in the Quiz 1 formative assessment, prior to the Exam 1 summative assessment. Despite the small decrease in *A* grades, the number of *B* grades increased by 15% on the technical topics covered.

Figure 7: Sample Electronic Lab Assessment Conceptual Question.



Question 5 20 / 20 pts

Which of the choices listed below are valid approaches to minimize energy consumption of a MIPS workload containing loops, given the energy consumption values listed below:

- ALU: 5 nj
- Jump: 3 nj
- Branch: 7 nj
- Memory: 20 nj
- Other: 3 nj

Correct! ☑ Reduce the number of store instructions within the loop

☐ Replacing Jump instructions with Branch Instructions

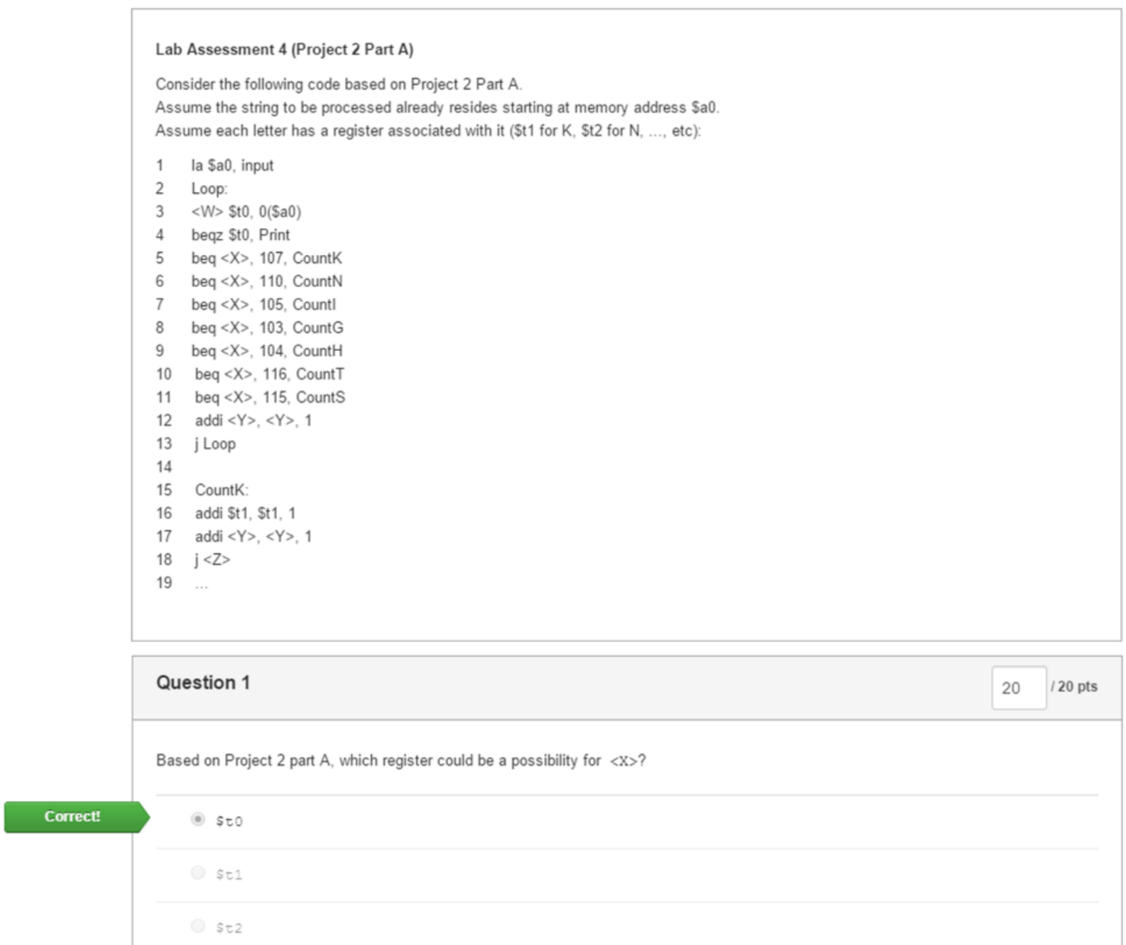
☐ None of the choices listed

Correct! ☑ Reduce the number of Branch instructions, e.g. by testing for the inverse condition

Correct! ☑ Relocate frequently-used data items from memory to registers

Correct! ☑ Unroll the loops

Figure 8: Sample Electronic Lab Assessment Technical Question Based on the Portfolio.



Lab Assessment 4 (Project 2 Part A)

Consider the following code based on Project 2 Part A.
Assume the string to be processed already resides starting at memory address $a0.
Assume each letter has a register associated with it ($t1 for K, $t2 for N, ..., etc):

```
la $a0, input
Loop:
<W> $t0, 0($a0)
beqz $t0, Print
beq <X>, 107, CountK
beq <X>, 110, CountN
beq <X>, 105, CountI
beq <X>, 103, CountG
beq <X>, 104, CountH
beq <X>, 116, CountT
beq <X>, 115, CountS
addi <Y>, <Y>, 1
j Loop

CountK:
addi $t1, $t1, 1
addi <Y>, <Y>, 1
j <Z>
...
```

Question 1 20 / 20 pts

Based on Project 2 part A, which register could be a possibility for <X>?

Correct! ◉ $t0

○ $t1

○ $t2

Figure 9: Sample Electronic Lab Assessment Technical Question Based on the Experiment.

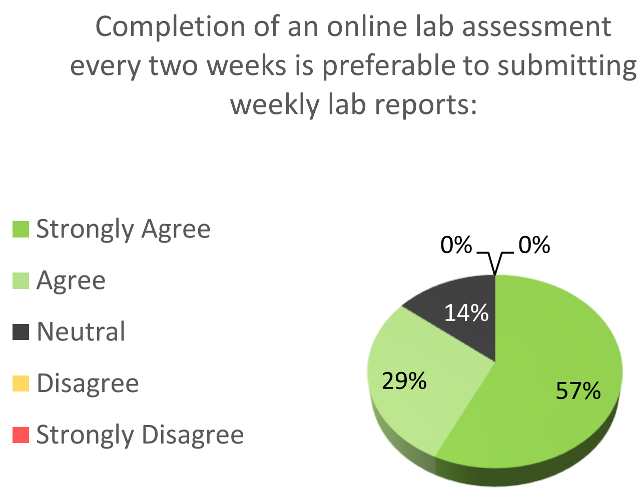


Figure 10: Student Perceptions of incremental Submission of Portfolios Interwoven with Online Formative Assessments.

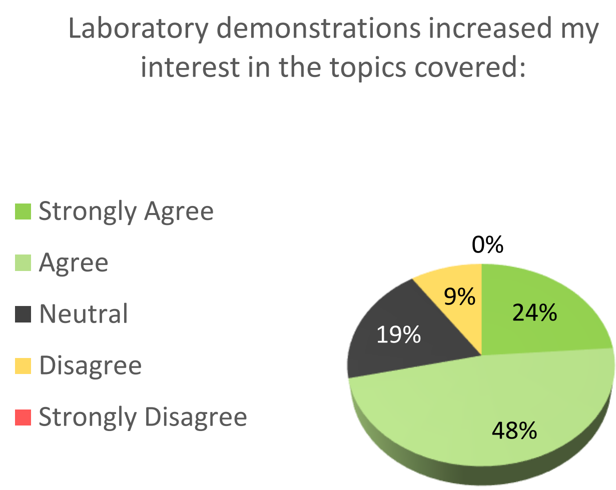


Figure 11: Student Perceptions of Online Formative Assessment Interwoven with Weekly Lab Demonstrations.

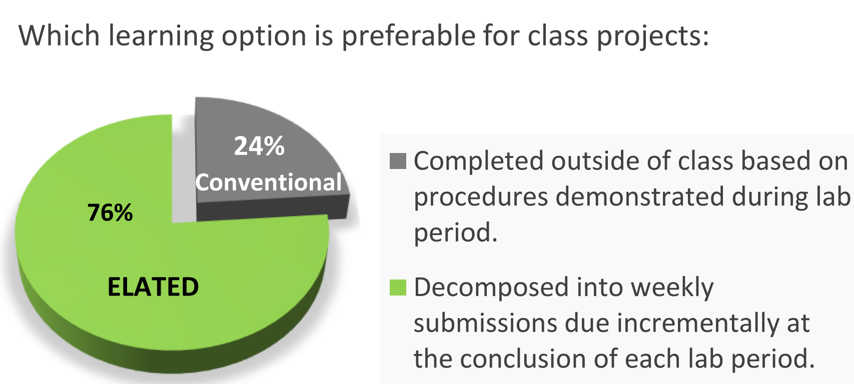


Figure 12: Student Perceptions of Incremental Project Submissions utilized by the ELATED Approach.

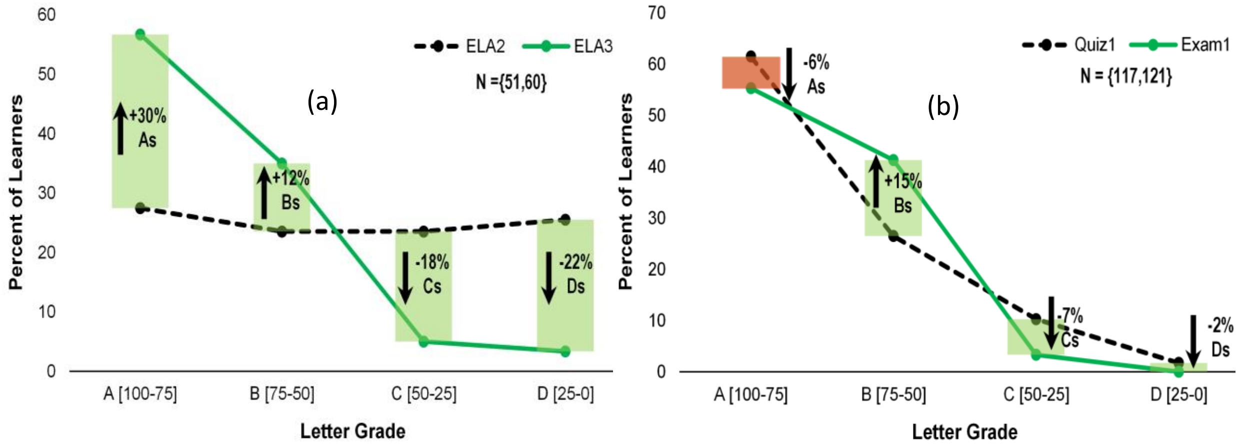


Figure 13: (a) ELAs encourage engagement seen as significantly higher identification of previous week's skills, (b) Improvements seen in Exam 1 are consistent with ELA delivery after Quiz 1.

Monthly Formal Report

As indicated by the rightmost element depicted in Figure 4, the ELATED method retains formal student composition consisting of one traditional laboratory report each month by each student enrolled. The reason to retain these reports is that formal document preparation within STEM disciplines is an essential career-long skill and an accreditation-evaluated expectation. Namely, in order to respond to a professional work solicitation or to compose a technical document submission, students should gain practice with the protocols expected for report organization, contents, and formats. Students are presented with positive examples of report submissions from previous semesters, along with a very detailed rubric, as shown in Figure 14.

- **Professional preparation: [5 points total]**
- **Report Content: [95 points total]**

  1.0 Project Description: ...

  2.0 Program Design: narrative description of how your code operates, and a flowchart with sufficient explanation about the program design for someone else familiar with MIPS to be able replicate your design [20 points]

  3.0 Symbol Table: ...

  4.0 Learning Coverage: provide a meaningful list of at least 5 technical topics learned that you could mention in a job interview. [10 points]

  5.0 Prototype in C-language: ...

  6.0 Test Plan: provide details identifying the inputs chosen to test the program and why these were selected, and justification why they provide adequate test coverage. [10 points]

  7.0 Test Results: ...

  8.0 References: ...

Figure 14: Excerpt of the rubric used with Monthly Formal Reports.

Finally, technical professionalism with respect to Submission Requirements and methods are also encouraged and enforced. The LMS is enabled to allow upload of submissions, so that as each student progresses with the creation of more refined versions of their document, each upload overwrites the previous submission. Only the most recent submission received before the due date/time will be graded, and all deadlines are enforced as hard deadlines (i.e. no late submissions are accepted). Meanwhile, students are explicitly discouraged, via significant deductions to their score, from emailing their document or requesting an unfair advantage of late submission. Students become aware and prepare for these submission procedures enforced at most companies in industry, as well as most graduate schools, and most government agencies, which also uphold such requirements per their legal contracting and acquisition processes. Thus, using the rubric as both a guide and evaluation scoring map, students learn these conventions in the laboratory and gain practice with formal "Project Solicitation"-style Task Definition Documents, without the grading burden of weekly lab reports.

Conclusion

The ELATED laboratory pedagogy improves lab quality through utilizing a combination of student-driven composition strategies with scaffolding approaches. Students are engaged systematically using a phased learning model while their progress is frequently evaluated by the instructor through the detailed formative statistics, throughout the semester. The ELATED laboratory pedagogy also mitigates increasing laboratory grading tasks of GTAs and faculty by refocusing instructor effort on content tuning and renewal, as well as targeting individualized scaffolding practices on the learner's *Zone of Proximal Development (ZPD)* using the ELATED approach. The results of our pilot research have been very encouraging based on using ELATED in *EEL3801: Computer Organization Laboratory* for two semesters. As a result of initial pilot results, other courses, such as *EEL3342: Digital Logic Laboratory*, are under consideration for next course transportability and further research of the effectiveness of the ELATED method. Laboratory innovation is urgently needed for the majority of undergraduate engineering courses toward providing a more effective lab curriculum without adding unnecessary workloads for the instructor. Our research is an endeavor in this regard that renders a significant benefit for laboratory teaching and learning in engineering and related fields.

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References

1. Vargas, S.K. and P. Hanstedt, *Exploring Alternatives in the Teaching of Lab Report Writing: Deepening Student Learning Through a Portfolio Approach.* Double Helix, 2014. **2**.
2. Kohn, A., *The homework myth.* The Atlantic, 2006. **298(4), 124**.
3. Oblinger, D.G. and J.L. Oblinger, *Educating the Net Generation (Boulder, CO: EDUCAUSE, 2005).* Is it age or IT: first steps toward understanding the net generation, 2008.
4. Smith, G., *How does student performance on formative assessments relate to learning assessed by exams?* Journal of College Science Teaching, 2007. **36**(7): p. 28.

5. Lyle, K.B. and N.A. Crawford, *Retrieving essential material at the end of lectures improves performance on statistics exams.* Teaching of Psychology, 2011. **38**(2): p. 94-97.
6. Angus, S.D. and J. Watson, *Does regular online testing enhance student learning in the numerical sciences? Robust evidence from a large data set.* British Journal of Educational Technology, 2009. **40**(2): p. 255-272.
7. Malau-Aduli, B.S., et al., *Using computer-based technology to improve feedback to staff and students on MCQ assessments.* Innovations in Education and Teaching International, 2014. **51**(5): p. 510-522.
8. Moskal, P., R. Caldwell, and T. Ellis, *Evolution of a computer-based testing laboratory.* Innovate: Journal of Online Education, 2009. **5**(6): p. 6.
9. Thelwall, M., *Computer-based assessment: a versatile educational tool.* Computers & Education, 2000. **34**(1): p. 37-49.
10. Gabriel, J., *College Testing Lab: New Name, Upgrades.* UCF Today, Friday, June 24, 2009.
11. *Increasing Student Success: Smaller Classes, Innovative Pedagogy at UCF.* Assoc. of American Colleges and Univ. Newsletter, June/July, 2010.
12. Airasian, P.W., et al., *A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of Educational Objectives.* Anderson LW and Krathwohl DR. New York: Addison Wesley Longmann, 2001.
13. Dick, W., L. Carey, and J.O. Carey, *The systematic design of instruction.* Upper Saddle River, N.J.: Pearson Education, 2015.
14. Palmer, S., et al., *An evaluation of an online student portfolio for the development of engineering graduate attributes.* Computer applications in engineering education, 2011. **19**(3): p. 447-456.
15. Chang, C.-C., et al., *Using e-portfolios to elevate knowledge amassment among university students.* Computers & Education, 2014. **72**: p. 187-195.
16. Vygotsky, L.S., *Interaction between learning and development.* Readings on the development of children, 1978. **23**(3): p. 34-41.
17. Eggen, P. and D. Kauchak, *Educational Psychology.* Prentice-Hall: New Jersey, 1999.
18. McDevitt, T.M. and J.E. Ormrod, *Child development and education*. 2010: Pearson College Division.
19. Wass, R., T. Harland, and A. Mercer, *Scaffolding critical thinking in the zone of proximal development.* Higher Education Research & Development, 2011. **30**(3): p. 317-328.
20. Wass, R. and C. Golding, *Sharpening a tool for teaching: the zone of proximal development.* Teaching in Higher Education, 2014. **19**(6): p. 671-684.
21. Robinson, L. and D.N. Maldonado, *Perceptions about Implementation of Differentiated Instruction.* 2014.

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