Preliminary Feedback on Learning in Advance Courses to Prepare Engineering Students for Gateway Courses

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Abstract

The University of Alabama is exploring *Learning in Advance* (LIA) courses to introduce engineering students to concepts and correct common misconceptions prior to encountering the complex theories and concepts in three different gateway courses. These gateway courses are circuit analysis, statics, and data-structures/algorithms. The courses were identified based on analysis of institutional data. Data indicated that greater than 90% of UA students who succeed in the three courses went on to complete their undergraduate degree. Yet, each course has individually high rates of failure and/or withdrawals. The objective and intended learning outcomes of each of the three courses is to provide students with knowledge of key concepts that will strengthen the student's critical thinking skills and establish a strong technical foundation. In this work an overview of the LIA courses is provided along with summaries of collected student feedback and the plans for future assessment to track the effectiveness of this intervention to improve student outcomes in the gateway courses.

Keywords

Learning in Advance, Engineering, Gateway Courses

Introduction

The *Learning in Advance* (LIA) courses introduce students to fundamental concepts in a preparatory course before they encounter these concepts in a gateway course that tends to have high rates of failure. The DFW rates (Ds, Fs, and withdraws) from the gateway courses chosen as the focus for this LIA project in were: 15-20% for Circuit Analysis, 25-35% for Statics, and 45-50% for Data Structures (based on 2016 reporting). Preparing students for a specific course is a strong component of many summer bridge programs, thus placing the strategy among evidence-based approaches for improving retention in STEM fields[1,2,3,4] and providing justification for further exploration in this project.

The preparatory courses, ENGR 191, have three sections (001: Data Structures/Algorithms, 002: Circuit Analysis, 003: Statics) to distinguish them from each other. They are one-credit graded courses, eight weeks long, and require instructor permission before students can enroll. An online application was developed so that instructors can make sure students are at the proper place in the curriculum for the preparatory courses. To recruit for these courses flyers are sent to College of Engineering Academic Advisors each semester before course registration begins and emails are sent out to students in the targeted majors.

In ENGR 191-001, *Learning in Advance – Data Structures/Algorithms*, students are preparing for CS 201 by covering concepts important to success in an algorithms class. Topics covered include: order notation, recurrence equations, AVL and red-black trees, binomial heaps, dynamic programming, and graph theory. In ENGR 191-002, *Learning in Advance – Circuit Analysis* students are preparing for ECE 225 by covering basic concepts important to success in circuit analysis. Topics covered include: basic units, Ohms Law, passive sign convention, Kirchhoff's laws, resistor equivalence, current/voltage division, node-voltage and loop-current techniques, source transformations, Thevenin/Norton equivalence, and superposition. In ENGR 191-003, *Learning in Advance - Statics*, students prepare for material related to engineering statics. Topics covered include: unit conversions, coordinate systems, sketching, vectors, vector decomposition, free body diagrams, equilibrium of a particle, dot and cross products, moments, equilibrium of a rigid body.

In three semesters, between Spring 2018 and Spring 2019, a total of 83 students have participated in the three LIA courses. Majorities of the students were Male (71%) and White or Caucasian (66%) (Table 1). Forty percent of the students (22 females + 9 males from underrepresented groups) who participated in the LIA courses were female and/or members of an underrepresented minority group (i.e., African American or Hispanic). The largest number of students were enrolled in ENGR 191-001, prep course for data structures (n=36), followed by ENGR 191-003, prep for statics (n=24), and ENGR 191-002, prep for circuits (n=23).

Strengths of the Preparatory Course

Students enrolled in the LIA courses each semester were asked to participate in a post-course survey to provide feedback by responding to quantitative rating scales as well as open-ended questions that allowed an opportunity for students to share their personal thoughts regarding the LIA course experience. A total of 40 students completed the Post-LIA Course survey for the prep courses offered in Spring 2018 and Fall 2018.

When asked on the post-course survey what the best parts of the LIA course were, students emphasize the value of learning concepts for the subsequent courses, the way instructors explained concepts, and small class size. A few students also appreciated the interactions they had with their instructors and classmates. Following is a sample of some of their comments:

"Being exposed to future material and being in a small class that made me feel more comfortable."
"[Professor] created a very personal and interactive environment allowing our small group of students to work on example problems then help individuals when they struggled with an aspect. Overall it was a great learning environment."
"Instructor took the time to make sure we understood all information and to thoroughly answer questions with detailed demonstration."
"The best thing about this course was the small class size, enabling the students to openly ask questions."
"The teacher was clear, prioritized the class schedule, made sure everyone was on the same page, and I felt like he was more of a mentor than an instructor. He really helped me like the topics we learned."
"The class did not move too fast, but it moved fast enough to cover a decent amount of

material. At first I thought the large amount of quizzes would be overwhelming, but they definitely increased my learning and understanding throughout the course."

Overall, students in Spring 2018 and Fall 2018 felt the LIA courses were useful in preparing them for the next course. The overall mean rating for how useful the LIA course were was 6.2 on a scale from "1-Not at all" to "7-Very Useful." Students rated the effect of the LIA course on their confidence going into the next course at 5.9, indicating it increased their confidence substantially. Students responded similarly to an item asking whether the LIA course was worth their time. The overall mean rating for this item was 6.4. Finally, students felt that they would recommend the LIA courses to other students. The overall rating for how much they would recommend the courses was 6.5.

Students were also asked how the courses could be improved. Students felt the courses could be improved by having more time, adding more assignments, working on applying the concepts, or by making the work even more similar to the assignments in the gateway courses. This feedback is provided to the instruction team to help refine the provided course material and improve the course delivery in an effort to continually improve each iteration.

Gateway Course Experience

The 16 LIA students who have completed these courses thus far have achieved grades of As, Bs, and Cs only, with no Ds or Fs among them. Only one student withdrew from the gateway course, re-registering for it the following semester. While it is too early to draw any conclusions about the effectiveness of this educational intervention in increasing student success in the gateway courses; it is positive to observe that students who have participated are showing success in the gateway courses and strong positive feelings about their LIA participation.

Research Study

In addition to preparing students for the gateway courses, this project is exploring the following research questions*:*
1) To what extent do the embeddedness factors (fit, links, and sacrifice), measured at the start of the LIA experience, predict long-term success and completion of the engineering degree?

2) How do the factors of fit, links, and sacrifice change over time as students participate in the LIA program?

Questionnaire data are being collected from all students who apply to the program along with tracking their outcomes and persistence in the engineering major. Survey instruments have been adapted to assess embeddedness[5,6,7], measuring fit, links, and sacrifice related to being an engineering major. Other characteristics that may be affected by the program components are also being measured such as self-efficacy and professional identification, thus connecting our research to a broader range of student outcome and retention studies[8,9,10]. It is still too early in the project to have data directly relevant to addressing these research questions but our project continues to aggregate the necessary data to analyze these questions by project end.

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Todd Freeborn is an Assistant Professor in Electrical and Computer Engineering (ECE). He regularly teaches courses in circuit analysis, circuit networks, and microcomputers. Through NSF funding, he has coordinated REU Sites for engineering students to explore renewable resources and speech pathology. He is also the coordinator for an NSF S-STEM program to prepare students for gateway courses across different disciplines of engineering to support and retain students in these disciplines.

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Susan Burkett is Professor Emeritus in Electrical and Computer Engineering (ECE). She taught courses in ECE Fundamentals, Circuit Analysis and Integrated Circuit Fabrication. Through NSF funding, she developed courses to prepare STEM undergraduates for research experiences and also coordinated a REU Site on renewable resources. She was also the Campus Director of a NSF Louis Stokes Alliance for Minority Participation grant. She recently finished a term on the Executive Leadership Team of the ASEE Women in Engineering Division. From 2005-2007, she was a program director at NSF in the Division of Undergraduate Education promoting exemplary undergraduate research and educational programs.

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Debra McCallum is a Senior Research Social Scientist and Director of the Institute for Social Science Research. She is a social psychologist interested in evaluations of education and community intervention programs and research on social issues, such as career choices related to STEM fields, social-psychological aspects of health behavior and outcomes, and safety and well-being of children and youth. She has led program evaluation activities for a variety of NSF-funded projects and leads the research study on this project.

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Erika Steele is a Research Associate at the Institute for Social Science Research. She received her M.S. in Cellular and Molecular Biology and PhD in Education from the University of Alabama. She is an education evaluator interested in measurement and assessment of learning, faculty professional development models, and social issues related to health and STEM fields. Erika has co-led program evaluation activities for a variety of NSF-funded projects.

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Sarah Dunlap is a cognitive psychologist and a Research Associate at the Institute for Social Science Research. Her work includes evaluation of a number of projects designed to develop innovative higher education methods in STEM fields, as she is interested in the motivations and experiences of individuals pursuing education and employment in these fields. She is currently the evaluator for this project as well as for a NSF Louis Stokes Alliance for Minority Participation grant.

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Paul Hubner is a Professor in Aerospace Engineering and Mechanics (AEM). He teaches courses in engineering mechanics (statics, dynamics, fluid mechanics) as well as undergraduate core and graduate-level aerospace engineering courses. In addition to this program, he has been a co-PI (Dr. Amy Lang, PI) on a long running NSR REU Site program in fluid mechanics which has hosted over 100 students the past 12 years. In 2017 he was awarded the *Outstanding Commitment to Teaching Award* by the UA Alumni Association.

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Patricia Sobecky

Patricia Sobecky is the Associate Provost for Academic Affairs at the University of Alabama (UA), and is currently serving as the founding Executive Director of the Alabama Water Institute, a new campus research unit. In her role as UA Associate Provost, she leads a number of campus-wide collective network initiatives including the UA STEM Forward Initiative to broaden the participation of individuals from traditionally underserved and/or underrepresented groups in the science, technology, engineering and mathematics fields. She also leads the UA Project Rising Tide Retention and Student Success Initiative.