Implementation and Evaluation of a Second Language Acquisition–Based Programming Course

Dr. Christina Frederick, Embry-Riddle Aeronautical University - Daytona Beach

Dr. Frederick is currently a Professor and Graduate Program Coordinator in the Human Factors and Systems Department at Embry-Riddle Aeronautical University in Daytona Beach, Florida. Dr. Frederick received her Ph.D. in 1991 from the University of Rochester with a major in Psychological Development. She previously taught at the University of Rochester, Southern Utah University and the University of Central Florida. In 2000, Dr. Frederick joined the Human Factors and Systems Department at Embry-Riddle, where her work focused on applied motivation and human factors issues in aviation/aerospace. Dr. Frederick also served in various roles in University administration between 2004-2012, including Vice President for Academics and Research. Dr. Frederick's current research interests examine how individual differences interact with technology to enhance educational engagement and performance. Dr. Frederick is the author of more than 50 research publications, 4 book chapters and over 60 regional, national and international conference presentations on a wide range of topics in human factors and psychology. She is active in a number of professional associations, and is a Consultant for Psi Chi, the National Honor Society in Psychology.

Dr. Lulu Sun, Embry-Riddle Aeronautical University - Daytona Beach

Lulu Sun is an associate professor in the Engineering Fundamentals Department at Embry-Riddle Aeronautical University, where she has taught since 2006. She received her B.S. degree in Mechanical Engineering from Harbin Engineering University (China), in 1999, and her Ph.D. degree in Mechanical Engineering from University of California, Riverside, in 2006. Before joining Embry-riddle, she worked in the consulting firm of Arup at Los Angeles office as a fire engineer. Her research interests include second language acquisition in programming languages, and online course design She is a professional member of the Society of Fire Protection Engineers, and a member of the American Society for Engineering Education.

Prof. Caroline Liron, Embry-Riddle Aeronautical University - Daytona Beach

Caroline Liron is an Assistant Professor in the Engineering Fundamentals Department, at Embry-Riddle Aeronautical University (ERAU), where she has been teaching since 2005. She obtained her bachelor's in Aeronautics and Space from EPF, Ecole d'Ingénieur (France), and her M.S. in Aerospace Engineering from ERAU. She currently teaches Introduction to Programming for Engineers. She is involved in developing and maintaining the hybrid version of that class, and researching improvements methods to teach programming to incoming freshmen using new technologies. She also researches means to incorporate more engineering mathematics and physics into the programming course.

Dr. Matthew A. Verleger, Embry-Riddle Aeronautical University - Daytona Beach

Matthew Verleger is an Assistant Professor of Engineering Fundamentals at Embry-Riddle Aeronautical University in Daytona Beach, Florida. His research interests are focused on using action research methodologies to develop immediate, measurable improvements in classroom instruction and the use of Model-Eliciting Activities (MEAs) in teaching students about engineering problem solving. Dr. Verleger is an active member of ASEE. He also serves as the developer and site manager for the Model-Eliciting Activities Learning System (MEALearning.com), a site designed for implementing, managing, and researching MEAs in large classes.

Rachel Marie Cunningham, Embry-Riddle Aeronautical University - Daytona Beach

Graduate Research Assistant at ERAU with an interest in design and creative thinking.

Miss Paula Sanjuan Espejo, Embry-Riddle Aeronautical University - Daytona Beach

I am an UG Aerospace Engineering student at Embry-Riddle Aeronautical University, Daytona Beach. I am from Spain and I am currently working on the SLA-aBLE project, the Implementation and Evaluation of Second Language Acquisition applied to programming courses.

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Abstract

This paper describes initial findings of an NSF funded project under the Research Initiation Grant in Engineering Education (RIGEE) program. The RIGEE program is a multidisciplinary program focused on developing innovative, implementing and assessing innovative programs that enhance engineering education. The project applied theory and methods of second language acquisition (SLA) to teach an introductory programming course in engineering. The project is a two year long project implemented in multiple sections of an introductory programming class at a technological university, and assessed throughout implementation. It included a component whereby student assistants participated in project development and implementation, and were mentored by project leads. The current presentation presents the results of the fall 2015 assessment of learning effectiveness in the course, and compares SLA course sections to non-SLA sections. Objective and subjective measures of effectiveness were collected and analyzed.

Introduction

At Universities throughout the world, students in engineering, computer science and other majors are required to learn a programming language. In the U.S., only 2% of students in high school and college learn a programming language[1]. However, programming knowledge is so important to the workplace of the 21st century, both within and outside the technology sector, that some leaders are calling for widespread implementation of programming courses beginning in elementary schools and continuing through college[1]. For engineering and computer science students, a programming course is commonly taken in the first year of college as a required course in the curriculum. Many languages are taught at this level, including C, JAVA, and Matlab. All are effective for teaching basic elements of programming, such as syntax, structure and problem solving[2-5]. While the initial exposure to computer programming comes in a lower level requirement, students still typically find that learning a programming language is difficult. For many students, learning a programming language is a complex task, containing logical reasoning, syntax and problem solving skills that are unfamiliar. Although difficult, acquisition of a programming language is critical to the development of basic skills, such as problem solving and use of logic, that transfer to courses throughout engineering and STEM-based curricula[2,5].

Learning a programming language is similar in many ways to learning a second language[6]. Both have unique vocabulary, syntax and punctuation. As well, some programming languages, like some foreign languages, have unique alphabets the learner must acquire in order to obtain proficiency [6-10]. For students, focusing on the common elements between foreign language and programming language acquisition can provide them with a familiar framework to understand programming. For educators who teach programming, understanding the commonalities between these forms of language acquisition offers a multitude of well-tested teaching techniques that can be applied across domains [11].

The present research implemented a second language acquisition (SLA) approach to teach an introductory computer programming course at the college level. New materials and teaching techniques were implemented in specified course sections and then learning effectiveness was compared between SLA-based sections and non-SLA-based sections of the same course with the same instructors. All students in the programming course learned MATLAB, a commonly taught programming language, and all sections were taught in a blended learning (hybrid) learning format [12-14]. In second language acquisition, teaching techniques vary as a function of learner proficiency. Proficiency levels are typically characterized as progressing through five stages from preproduction to advanced fluency. Throughout the SLA sections, self-paced videos were developed for the students, consistent with and supplementing in-class instructional strategies. As well, peer supportive techniques, such as 'think, pair, share' and moderated discussion boards, were used throughout the projects in SLA course sections[12-15]. Table 1 below presents the stages of language proficiency and presents a comparison of teaching techniques applied at each stage in both SLA and non-SLA based class sections [15].

Table 1. A comparison of Non-SLA-based and SLA-based Teaching Techniques

	Preproduction (minimal compre-hension)	**Early Production (limited compre-hension)**	**Speech Emergence (increased compre-hension)**	**Intermediate Fluency (very good compre-hension)**	**Advanced Fluency**
Non-SLA Based Strategies	Few pictures and visuals. Some topics are not well explained. Not enough self-testing questions in the screencasts.	There are multiple choice questions but no simple programs. Facebook is used but there is no group discussion.	Students begin reading and writing in their programming language by solving different engineering problems.	Give students more challenging problems to synthetize what they have learned.	Open-ended engineering project to challenge their understand-ing and expand their knowledge.
Teaching Strategies in SLA-aBLe	Use pictures and visuals; speak slowly and use simple and shorter words to draw connection between SLA	Reinforce learning by asking students to produce simple programs in addition to	Emphasize tiered questions and ask students to do a "think, pair, share" to process the new concepts.	Emphasize compare and contrast different concepts. Allow students to explain their problem	Project presentation opportunity will be offered to students to enhance their

	and programming languages; Reinforce learning by giving more self- testing questions without adding in pressure.	the multiple choice questions; use Facebook to encourage group discussion.		solving process.	understand-ing.
Specific SLA-based in-class exercises	Show me… Circle the… Where is the…	Yes/No questions Either/Or questions Use 1-2 word answers Use lists and labels	Ask why and how questions Ask students to explain using phrase or short sentence answers	Use 'What would happen if…' questions Use 'Why do you think' questions	Use 'decide if' exercises Have student 'retell' in his/her own words

Problem Statement

Computer programming is often a required course that is taught in the first year of the engineering curriculum, and it has been found to be a difficult course for college students[11]. This project tested the hypothesis that the use of second language acquisition techniques would improve engagement and enhance the learning experience of engineering students taking an introductory programming course.

The Current Project

The current project applied second language acquisition techniques to teaching and introductory programming language using MATLAB. The project was titled SLA-aBLe, which refers to the use of a SLA approach within a blend learning (BL) environment. Three instructors taught EGR 115, an Introduction to Programming course using both SLA (3 classes) and non-SLA (4 classes) materials. Each instructor had one section of each class type, with one instructor teaching two non-SLA format classes. In order to help control for instructor differences in teaching, all instructors were trained in the SLA strategies, used the same videos, coordinated their syllabi to cover the same topics and attended regular team meetings to verify progress. The SLA sections used 6 innovative, self-paced videos to facilitate student learning in 4 topics, as well as integrating techniques into classroom teaching that have been shown to be effective in second language acquisition. These cognitive techniques included focusing on a continuum of learning from preproduction to advanced fluency (see Table 2 above). As students progressed across the continuum, they were exposed to materials in different ways specific to their fluency level. In the pre-production phase, for example, learning was accompanied by visual representations and moderated online discussions. Special videos were created to build stage one and two fluency. The videos focused on four important topics: data types, input and output, conditional statements, and loops. Each video provided definitions, examples and quiz questions to reinforce correct learning. The videos were designed to be self-paced so that students could view them as many times as they wished until comprehension occurred. An online mediated discussion was also created to help support early production skills. Students were required to post questions and comments to the discussion, which were responded to by two female research assistants, one undergraduate student and one graduate student. At the intermediate level a 'think, pair, share' technique was used during labs. Intermediate fluency was accomplished through homework and advanced fluency was achieved by an open-ended project at the end of the semester. To facilitate learning at the intermediate and advanced levels, students were given guided exercises during labs that they then finished on their own. The course culminated in an individual project chosen by the student that used knowledge gained throughout the semester. Students were also given the chance to present their projects to the class to show their competence and level of comprehension of the material. Students in the non-SLA sections of the course also used the blended learning environment, but they did not have access to the SLA-aBLe videos, nor did the instructors use SLA-based teaching techniques in those sections.

Method

This paper presents the results of the SLA-aBLe project from the first semester of implementation in fall 2015. Seven sections of EGR 115 were studied with 3 sections using SLA-aBLe techniques and 4 sections taught in the existing blended learning format. A total of 20 students participated in the fall 2015 data collection, 11 in SLA-aBLe sections of the class and 9 in non-SLA sections. Demographic information was collected about the class participants at the beginning of the semester. In addition, two measures were used to assess student perceptions of the class and materials. The first measure, the Intrinsic Motivation Inventory, assessed student motivation across five dimensions, interest/enjoyment, perceived competence, effort, felt pressure and tension, and perceived choice. The IMI has been validated for use with college student populations [17]. The second measured used in the study was the NASA TLX, a well-established measure of self-assessed workload, validated by researchers at NASA[18]. The TLX measures six workload dimensions: mental demand, physical demand, temporal demand, performance, effort and frustration [18]. The IMI and TLX were administered six times across the semester; at the beginning of the class, after each of the four learning videos and at the end of the course. In addition, grades for each EGR 115 section were collected at the end of the semester and participation in the discussion board was also tracked. The following research questions are addressed in the present paper:

1. Did students in the SLA-aBLe classes show differences in perceived motivation and workload as compared to students in Non-SLA classes? This question was assessed using

t-tests with section type as the independent variable and the IMI and TLX variables entered as dependent variables. For all tests, significance level was set at p=.05 or less. For the workload variables, two-tailed *t*-tests were used to explore whether or not group differences occurred for those variables with no assumption made about the direction of the difference. For the motivation variables, one-tailed *t*-tests were used, based on the hypothesis that for these variables means would be higher in the SLA-aBLe sections of the class than in the non-SLA sections of the class, with the exception of the frustration variables, for which non-SLA students would experience higher frustration than SLA-aBLe students.

2. Did grades differ between students in the SLA-aBLe classes and students in non-SLA classes? It was hypothesized that students in the SLA-aBLe classes would do better in the class due to the additional learning elements and specialized teaching techniques they experienced. This analysis was conducted using a chi-square analysis.

3. What was the level of student involvement in the discussion boards used in the SLA-aBLe class sections? This information is presented in frequency counts across the first 5 weeks of the class for the SLA-aBLe sections of the class. The results presented are preliminary and continued data analyses will be conducted in the next several months.

Results

<u>Question1:</u> <u>Did students in the SLA-aBLe classes show differences in perceived motivation and workload as compared to students in Non-SLA classes?</u>

<u>Differences in Perceived Workload</u>. For the t-tests run to examine differences in perceived workload at the beginning and end of the semester, and after SLA students viewed the specialized videos for their sections, there was only one statistically significant mean difference in perceived workload found across the six survey administrations. After viewing the input/output materials, students in the SLA-aBLe sections reported significantly lower frustration than students in the non-SLA sections. Overall, however, students in the SLA-aBLe sections did not experience the specialized content as any more or less workload intensive than the non-SLA sections. Even though means across SLA and non SLA course sections did appear to differ on a number of the other workload variables, none of these reached statistical significance. These results are presented in Table 2 below.

Table 2
Means for Workload Variables across Administration Periods

		Administration Period					
		Week 1 of Course	Data Types Video	Input/ Output Video	Conditional Statements Video	Loops Video	End of Course
Workload Variables	Class Section Means						
Mental Demand	SLA Non-SLA	10.52 10.19	12.12 13.52	11.08 13.57	12.92 13.00	14.15 13.24	16.78 16.82
Physical Demand	SLA Non-SLA	6.00 5.38	5.96 7.29	6.67 6.43	6.17 5.62	7.19 6.53	8.44 12.45
Temporal Demand	SLA Non-SLA	10.64 8.38	11.44 11.90	8.25 11.21	10.67 10.92	10.38 11.94	17.33 16.18
Performance Demands	SLA Non-SLA	7.33 7.78	7.04 8.95	8.83 5.43	7.42 7.23	8.50 9.00	5.56 8.55
Effort	SLA Non-SLA	11.91 11.32	12.60 13.38	11.50 14.36	13.12 13.33	14.31 13.41	16.78 17.00
Frustration	SLA Non-SLA	8.45 8.32	8.44 11.52	8.42 13.00*	7.67 11.77	12.56 11.47	14.11 14.82
Motivation Variables							
Enjoyment	SLA Non-SLA	4.61 4.31	4.77 4.02*	4.82 4.41	4.64 4.49	4.23 4.01	4.27 3.90
Importance	SLA Non-SLA	5.23 4.73	5.42 4.98	5.72 5.23	5.62 5.12	5.65 5.02	5.98 5.78
Pressure-Tension	SLA Non-SLA	3.04 2.74	2.78 3.62*	2.71 3.69	2.40 3.32	3.95 3.19	4.30 4.62
Competence	SLA Non-SLA	4.76 4.98	5.05 4.20*	4.94 4.81	4.94 5.03	4.40 4.09	4.70 4.37
Usefulness	SLA Non-SLA	5.20 4.89	5.72 4.65**	5.85 4.93*	5.85 5.62	5.41 5.07	4.85 4.61

* *p*<05
** *p*<.01

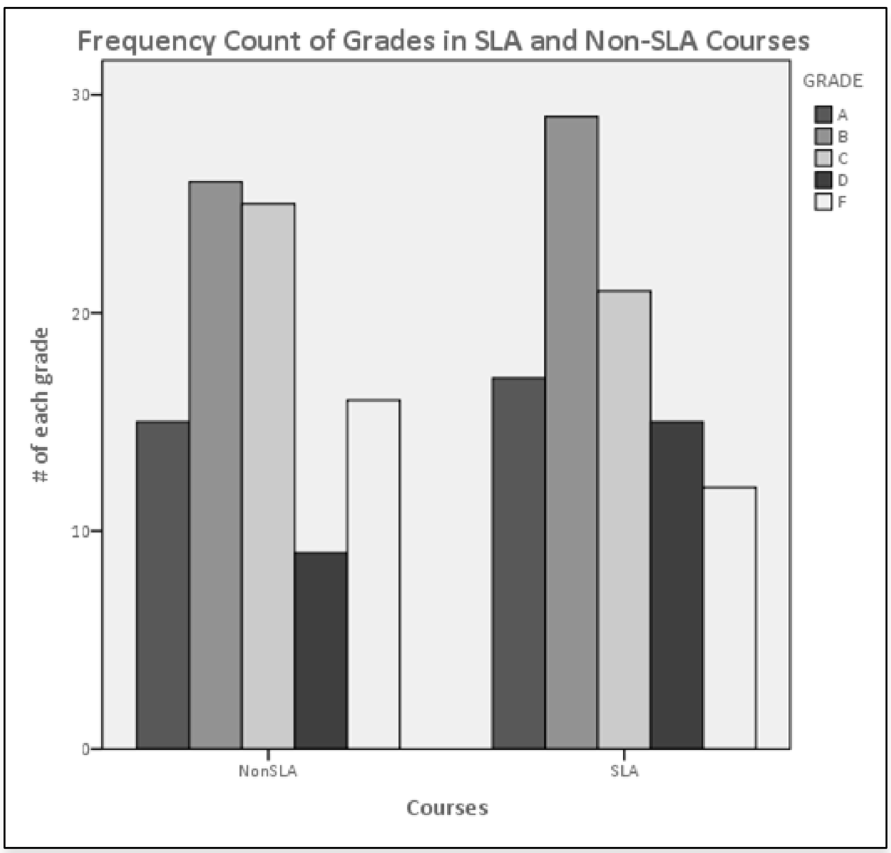
Differences in Motivation. Motivational differences were found between students in SLA-aBLe course sections and students in non-SLA sections. After viewing the data types' materials, students in the SLA-aBLe section reported significantly higher levels of enjoyment, competence, and usefulness for class information than students in non-SLA sections. In addition, students in the SLA-aBLe sections reported significantly lower levels of frustration than the non-SLA students after the ‘data types’ information was presented. After viewing the specialized input/output materials, students in the SLA-aBLe sections also reported significantly higher levels of usefulness for those materials than students in the non-SLA sections. These results are also presented in Table 2 above.

Question 2: Did grade in the course differ between SLA-aBLe students compared to students in the non-SLA class sections?

A chi-square test of independence showed no significant relationship between the course section and final grade, ($X^2(4) = 2.660$. $p = .616$). Students in the SLAaBLe sections did not achieve higher grades in the class than students in the non-SLAaBLe sections. Table 3 presents a graph of this information.

Table 3

Comparison of students' final grades in the SLAaBLe and non-SLAaBLe sections for Fall 2015



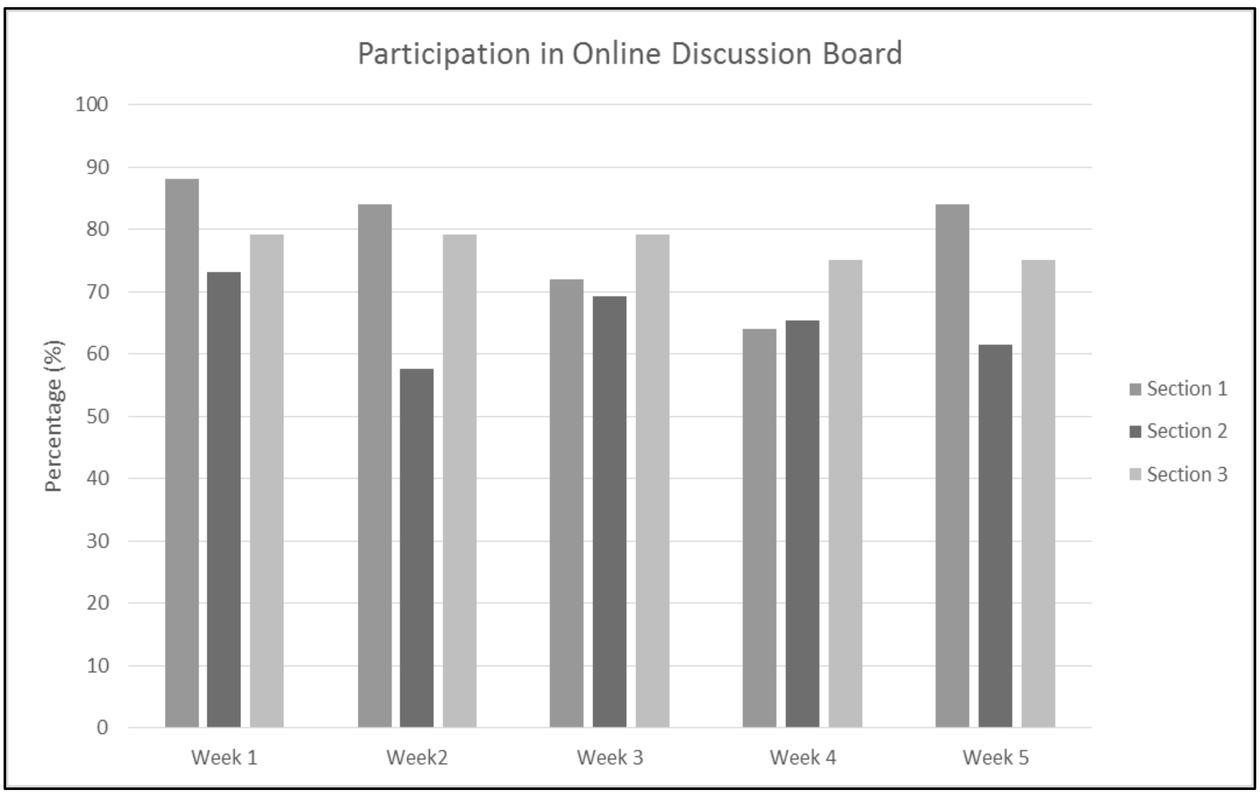
While these results from fall 2015 do not show significant differences, students in the SLA-aBLe sections did receive more A's and B's and fewer F's in the class than did non-SLA section students. This trend will be interesting to observe in future semesters.

Question 3: What was the level of student involvement in the discussion boards used in the SLA-aBLe class sections?

In the SLA-aBLe sections of the class, students were required to participate in the Discussion Board a minimum number of times in order to receive a grade. The participation grade contributed 3% to a student's overall course grade, so while it was a small piece of the overall course grade, it added class points that through minimal effort, 100% of students could achieve. Table 4 shows the percentage of students in each SLAaBLe section who participated in online discussion boards across the first five weeks of the course. The students in the non-SLA sections of the class were not required to participate in the discussion board.

Table 4

Percentage of student participation in each of the three SLAaBLe EGR115 sections for Fall 2015



A secondary analysis was conducted related to Discussion Board Participation for one SLA-aBLe section of the course. Of interest was the percentage of students who posted to the Discussion Board beyond the course requirement. It would be reasonable to conclude that students posting beyond the requirements would find the discussion board useful for their learning, although that conclusion is at this time circumstantial only. In this section, in week 1, 10 of 19 students who posted did so beyond the requirement. In week 2, 14 of 15 students posted above the minimum requirement. In week 3, 6 of 18 students posted above the minimum. In week 4, 4 of 17 students posted above the minimum and in week 5, 4 of 16 students posted above the minimum requirement.

Two pieces of information are interesting about the pattern of postings. First, is that even though posting was required and added to the students' final grade with minimal effort, some students did not use the discussion board. On the other hand, the preliminary analysis of one SLA-aBLe section did show that of those students posting, a substantial number posted beyond the requirement. This percentage did decline across the five week period, but perhaps that was indicative of developing competence in the students, who then did not need to ask as many questions of the student assistants.

Discussion

The SLA-aBle Project was first implemented in the fall of 2015. Results from the data collected during this first semester were presented in this paper. The project will be ongoing for three more semesters, culminating in 2017. The purpose of the project is to implement second language acquisition learning techniques in an introductory computer programming course. The goal of the project is to learn how application of these techniques can facilitate student engagement in the class and enhance student learning.

The paper presented preliminary analysis of the first semester of implementation. Results are promising, but not conclusive at this time. The first research question addressed the topic of learner motivation and workload. Although no significant mean differences across the semester were shown related to workload, some interesting trends were shown. First, across the semester at all administration periods except two (week 1 and after the loops video) the mean scores for perceived frustration were lower in SLA-aBLe section students than for students in non-SLA sections of the course. Additionally, at the end of the course, the perceived physical demand of the course was perceived to be lower overall in SLA-aBLe students than for non-SLA students. This information was presented in Table 2. While these differences were not statistically significant, they are interesting and may be important. The smaller sample size for this data collection may have precluded the difference reaching statistical significance. In further semesters, researchers will examine the data to determine if the same trends are replicated.

Some motivational differences were also shown between SLA-aBLe students and non-SLA students. Motivational differences favoring the SLA-aBLe students were shown after students viewed the data types' materials and the input/output materials for four weeks. Specifically SLA-aBLe students reported finding the specialized materials they used as valuable, and for the data types' week, they also reported higher enjoyment and competence and lower pressure. No differences were shown during the pre-test, during the presentation of conditional statements or loops, or at the end of the course.

The second research question examined final grades in the class and compared grades in SLA-aBLe sections of the course with grades in non-SLA sections. Although there were no significant differences across the two forms of instruction, trends were promising. The grades distributions showed that students in the SLA-aBLe sections of the course received more ‘A’ and ‘B’ grades than students in the non-SLA sections. These results should be viewed cautiously and researchers will continue to examine end of course grades as one measure of learning effectiveness.

The third research question of interest in this paper was the discussion board participation. The discussion board is a collaborative learning experience where students can post questions, to which research assistants or other class members will respond. It is student focused, accessible outside of class time, and provides a collaborative learning environment. It also provides a lesser degree of self-consciousness for student. A student who feels anxious or uncomfortable asking questions in class may feel more comfortable posting on the discussion board. When usage of the discussion board was examined, results were interesting. Although a minimum amount of posting was required for students in the SLA-aBLe sections in return for the equivalent of a homework grade, across the first five weeks of the semester, participation did not reach 100%. The highest posting rate achieved was 88% in one class section in the first week of class. The lowest rate was exhibited in the second week of the semester in one section and was approximately 67%. It is not clear why students chose not to avail themselves of the discussion board to a greater extent. It is possible that students did not have meaningful questions or comments to post, were too novice to even know the type of questions they wanted to ask, were still too self-conscious to post, or perhaps just did not have time to post. In future semesters, researchers will explore this issue in greater depth.

Overall, the SLA-aBLe project was first implemented in fall 2015. Analysis of data is ongoing to understand which of the techniques integrated into the programming class were effective. In spring of 2016, seven more sections of EGR 115 are being evaluated (3 SLA-aBLe sections and 4 non-SLA sections) with the same instructors as taught in fall 2015. Based on feedback from instructors after fall 2015, small changes have been made to the SLA-aBLe sections. First, the instructors are exhibiting more consistency in using the ‘think, pair, share’ technique. It will be implemented in lab sessions and done using a 5 minute time limit, so that students will report on their outcomes and receive feedback. Second, participation in the discussion board is being recommended, but it will no longer count as a course grade. After the fall semester, students reported that they sometimes didn’t know enough about the class topics to post meaningfully, and that postings often became repetitive for the same topic. The change to recommended versus required postings allows students to post questions more freely and of more relevance to their learning. The instructors are also now more familiar with the SLA-aBLe format and materials, allowing them to utilize them more effectively.

As information from two semesters is analyzed over the summer, it will allow for better conclusions to be drawn from the SLA-aBLe Project. Researchers will examine and discuss numerous points of data to recommend project modifications that can be implemented and analyzed in the final year of the project. It is hoped that at the end of the project, materials deemed effective for student learning and engagement will be made widely available, so that instructors across the world can use them in introductory programming classes.

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