The Constantly Evolving Freshman Engineering Course: The Case of the DualShock4 Game Controller to Increase Engagement with Laboratory Exercises for an Introductory Problem Solving Course

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***Abstract*— Universities are now seeing the post-Millennial generation enrolling in freshman engineering courses. These outcome-oriented students engage with the course topics if they can see how the skills being developed can be used outside the classroom. To this end, the authors substituted a contemporary game controller, a PlayStation4 DualShock4 (DS4), for a microcontroller with sensors (Arduino Esplora) that was used in the freshman laboratory exercises to enhance the connection to the "real world" and increase engagement with the course concepts. Using laboratory scores from two consecutive fall semesters at a large, Midwestern university, the authors found the substitution of the DS4 for the Esplora had a significant positive effect on the total scores for the entire semester, as well as positive significant effect on the formalized lab reports.**

Keywords—curriculum development, computer engineering education, first-year experiences, gamification, self-efficacy, engagement, post-Millennial

I. Introduction

Nearly 20 years ago faculty began to recognize their students accessed information, and therefore learning, in a different manner than what they had [1]. Faculty realized it took more to engage the students with learning a programming language and problem-solving than the traditional didactic lecture coupled with laboratory exercises that only included a text editor, the compiler, and the standard I/O. The laboratory exercises had to capture the imagination of those students and the lecture needed to embrace interaction with the students. These redesigned lectures and laboratory exercises targeted the Millennials; those students who had embraced computers from their earliest childhood days. Roll the clock forward and faculty are now seeing the next generation in the classroom, the post-Millennials, also known as Generation Z. While there is still debate on when Generation Z begins, and for that matter, on their name [2], the Pew Research Center defines this group as those born after 1996 [3]. This generation now fills the freshmen engineering courses. These students don't just embrace technology; they are the TRUE "digital natives." While the Millennials had computers in the homes from their earliest memories, Generation Z can't remember a time without being "always on" and "always connected." Their world included high speed data cell phones, Internet in their homes, and computers, whether tablets, smart phones, laptops, or desktops, accessible for all family members. They never had to venture outside to find their friends. They were connected electronically all the time.

Once again the authors found the need to update the freshmen computer engineering course to continue to engage the newest generation with a technology that is relevant to them. In this case, the redesign did not include changing the hands-on laboratory exercises or the classroom experience, but updating the hardware used; moving from an Arduino Esplora which is a microcontroller board with sensors to a DualShock4 (DS4) game controller for a Sony PlayStation4. The authors postulated that introduction of the DS4, a hardware device that is common place and readily found in many homes or down the hall in the residence facilities, would engage freshmen more than the microcontroller (Esplora) that was currently being used in the laboratory exercises. With its printed circuit board (PCB) look, the authors thought the students saw the Esplora as boring as the circuit board controlling the washing machine.

The paper examines the laboratory scores earned over 10 labs in two consecutive fall semesters of a freshman computer engineering course offered at a large, Midwestern university (37,000 enrollment). The first fall semester the students used the Esplora and in the second the DS4 was used. The

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overarching hypothesis is that by using a commonly found game controller in the laboratory exercises, the students will be more engaged with the exercise and will earn higher marks. The paper is organized into eight sections. Section I is the introduction, while section II looks at previous work conducted on learning engagement and self-efficacy. The course is described in section III and the interface developed for the DS4 is outlined in section IV. Section V includes the methodology used and section VI provides the results. Discussion is conducted in section VII and future work is enumerated in section VIII.

II. Literature Review

In 2001 Prensky [1, 4] coined the term "digital native," recognizing that freshmen entering college belonged to a generation that thought and learned differently from the faculty who were employed to teach them. He pointed out that faculty thought and taught linearly, processing one thing completely before moving on to the next while those incoming freshmen multi-tasked their thoughts and actions. Because the two styles were out of sync, the students argued the faculty delivery was boring or out of touch and the faculty thought the students lacked attention span.

What academia was starting to recognize was the technology evolution was having generational effects on information processing and learning styles. And while Prensky [1] didn't realize it, the "digital natives" he described would have yet another generational group surpass it with their technological ingraining. The faculty, most likely part of the Boomer generation (born 1946-64), saw broadcast television evolve in their development years, while Generation X (born 1965-80) grew up as the computer revolution was happening. The Millennials (born 1981-96) to whom the original "digital native" title was given experienced the Internet explosion. But, the post-Millennials/Generation Z (born 1997-present) have had everything previously mentioned in their entire life [3]. The iPhone launched when oldest post-Millennials were 10. Since they were teens they have been "always connected" with mobile devices, WiFi, and high-bandwidth cellular service. Additionally, they have always had access to social media and on-demand entertainment. Being in a conversation with anyone at any time anywhere is normal for them. These are the TRUE "digital natives." And, these are the students filling university freshmen classes.

While the Millennials made universities start thinking about engagement in the classroom [5], Generation Z expects engagement with the topic and the opportunity to develop a skill that can be applied in the after-college world. These outcome-oriented students become engaged with the course topic only if they can see how they can use the information or skills being developed. Their engagement stems from the future use of the information or skills, not the esoteric value of knowledge for knowledge's sake [6-8]. Class content, therefore, needs to include active techniques to let students link their after-college world goals with the class outcomes [9].

Active learning and engagement motivates today's learners by providing the connection to the outcome skill the content develops [6, 9]. While the traditional lecture format focused on content acquisition for the students, content delivery is now relegated to outside of class meeting time. Concept application which includes tying the concept to the after-college world is now the focus. This is the basis of the flipped classroom [10] and hands-on activities. While it may be difficult to flip every lecture period, every time, the goal of any course is to include hands-on learning in at least some portion of the course.

The problem with hands-on activities being used in concept application is that students need to practice the skill multiple times to build self-efficacy before the skill can be used in the after-college world. Self-efficacy measures a person's confidence that he or she can complete an activity in the future which, in turn, has been shown to lead to future success with the task [11, 12]. While there are four primary ways individuals gain self-efficacy, it has been shown that enactive mastery, or personally performing the task, influences the individual's self-efficacy the most [13]. One of the most common ways an engineering student builds self-efficacy is through a well-constructed hands-on laboratory exercises [14]. Further, it is suggested that to learn a skill students should practice it with someone else observing to ensure correctness [15]. Again, in an engineering student's world this is accomplished with teaching assistants guiding the laboratory exercises.

While the hands-on activities can be tied to the after-college world use, there is also another way to engage students. The gamification of the hands-on activity attracts and focuses the students' attention which actively engages the students with the concept. Gamification is using the elements of game design in a non-game context [16]. Examples of gamification that the authors have used in lecture include writing a program to guess the characters in a phrase as "playing Wheel of Fortune" or to generate random numbers as "throwing dice in Yahtzee."

The beauty of using gamification is that most students are familiar with games, even if they are just board games or card games. More likely in Generation Z they have had handheld travel games or used an Xbox or PlayStation4. Even if they don't play themselves, they are familiar with the concept of online games or computer games. Games can grab and focus attention, as well as provide sensory experiences to capture the imagination, which keep the students engaged with the hands-on activity. They also allow students to practice a skill repeatedly in a non-threatening environment until they master that skill [17]. Finally, games contribute to developing critical thinking skills and creativity which directly tie to Bloom's levels of apply, analyze, evaluate, and create [18-20].

The laboratory exercises examined in this paper have been gamified with the introduction of the DS4 controller. The use of the everyday item has students thinking about the computer games they play and how the same controller interacts with them. It stimulates their motivation to understand programming concepts because they are writing some of the same kinds of code that are found in these more complex gaming environments.

III. Course Description

The course was a freshman computer engineering class at a large, Midwestern university. Its focus was on problem-solving using the C programming language. It was a three-credit hour course in which the faculty member met the students in a traditional large classroom setting for two 50-minute time blocks a week. The students additionally attended a smaller, weekly two-hour lab with undergrad teaching assistants. Although the classroom was a large lecture hall, the course was designed for the hands-on laboratory exercises to drive the content covered during lecture periods and active learning was included during the time. Prior to coming to lecture, the students were required to use the online, interactive book to complete readings and interactive assignments from the book company. During the 50-minute lecture periods, the faculty member began by using the documentation camera to define and illustrate the concepts to be covered in an "old-school" manner of handwriting the information down for the students which the students should have already seen from interacting with the online book content. Next, the faculty member switched over to the laptop and demonstrated the concept starting with skeleton code she had already prepared. While completing the code, she continued to reiterate the concepts just covered on paper. Finally, there was a Turn to Your Partner (TTYP) active learning exercise where a different problem with slightly different constraints was given and students were asked to work in pairs to solve the problem. The faculty member then described what will be asked of the students in the weekly lab exercise and explained how what they just covered in lecture will be part of the solution for the week's problem-solving assignment.

Over the course of the 16-week semester there were 10 different laboratory exercises completed in 14 weeks. There was no lab the first week of the semester nor during finals week. The topics covered in each lab are shown in Table I. While every lab was worth 100 points to a student, the way those points were earned varied. In the first four labs all 100 points were available through the submission of a formalized lab report. The formalized report format contained a title page and five sections: problem statement, analysis, design, testing, and comments. The comments section included the answers to any reflection questions. Additionally, the student's code was appended to the end of the lab report. These first four introductory labs were created to help the student become familiar with the hardware device and the C programming language. Many students in the course had not previously programmed and these labs were intended to give everyone equal footing.

Starting with the fifth lab, the formalized lab reports, including code submissions, were worth 80 points. The final 20 points of the total value of 100 were earned from demonstrating working code using a hardware device to one of the undergraduate teaching assistants. The students needed to have all features requested in the laboratory exercise working and be able to explain how their code worked, as well as troubleshoot it if they couldn't get it to work properly in front one of the undergraduate teaching assistants. In addition to the required features, students were given optional challenges that were considered harder to complete because they were not discussed in lecture or the lab period. These additional features could earn the students between 10 and 20 additional points for their demonstration depending upon the week and the difficulty the optional feature posed. It was hoped that by offering additional functionality challenges, students would be motivated to explore ways to solve harder problems without the fear of detracting from their grade if they were not successful in their attempts.

TABLE I. Description of the labs including topics, use of controller, and whether code was demonstrated

Lab Number	Topics	Use of Controller	Code Demonstrated
1	Reading, collecting, plotting data	Y	N
2	Source code, compiling, running	N	N
3	Data types, arithmetic operators	Y	N
4	Intro to functions, reading button pushes	Y	N
5	Intro to conditionals and looping, use of functions	Y	Y
6	Intro to multiple loops, use of functions and conditionals	Y	Y
7	Use of multiple loops, functions, and conditionals	Y	Y
8	Intro to arrays, use of multiple loops, functions, and conditionals	Y	Y
9	Intro to two-dimensional arrays, use of multiple loops, functions, and conditionals	Y	Y
10	Intro to character arrays (strings), use of two-dimensional arrays, multiple loops, functions, and conditionals	Y	Y

The laboratory classroom had 24 Windows desktop computers with Cygwin running on them. The gcc library was installed in Cygwin and the students used Notepad++ for editing their code. In the Fall 2015 semester, the hardware device used was the Esplora which was connected to the desktop machines via USB cable. This hardware device had been used for the previous five years, but being a microcontroller, the Esplora was not readily recognizable by many of the freshmen in the course. Therefore, when it became apparent that the Esploras were going to be a

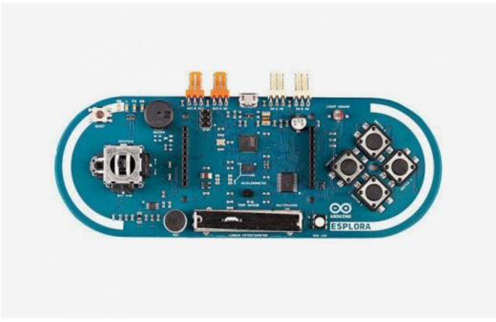

Fig. 1. Arudino Esplora

discontinued Arduino product, one of the authors decided to find a new hardware device that most students in the course could identify with.

Several different platforms were examined before the team settled on the DS4. The alternatives included the Xbox controller which was discarded for not having an accelerometer. For this first revision of the laboratory exercises only the hardware would be changed. The content of the labs would remain the same. Therefore, an accelerometer was a critical sensor. Also, a device that used an Edison board was build and evaluated. However, the price tag of $200 per unit, coupled with not being a commonly found object in a freshman's world, removed it from consideration.

With a capacitive touch pad, motion detection through a three-axis accelerometer and three-axis gyroscope, a lightbar with three colored LEDs, eight buttons, two shoulder buttons, two triggers, two joysticks, on-board sound, and motors in the handles that can vibrate, the DS4s provide multiple inputs/outputs at an affordable cost to the department of $50 per unit. Therefore, in the Fall 2016 semester, the DS4 was introduced in the course one of the authors taught. It was subsequently adopted in all sections of the course.

Fig. 2. PlayStation 4 DualShock4 (DS4)

Further, DS4s are so common place that many students or their roommates already have them as part of their game systems in their residence halls. This makes for easier access outside of the assigned two-hour laboratory period for students to continue their programs or work on additional features. Additionally, the $50 price point makes it less than the cost of a textbook and the authors found many students chose to use or purchase their own as a convenience factor for out of laboratory time use.

To use the new hardware in the laboratory exercises, the authors spent the Summer of 2016 developing the interface for the DS4 and making minor adjustments to the laboratory exercises. They used Bluetooth to pair the DS4 in the Windows environment and the reported output from the human interface device (HID) was available to the Cygwin environment. Designed to be used with vendor defined HIDs, the HIDAPI library [21] was used to communicate with the DS4 and transfer input, output, and feature reports to the operating system. Being new to working with the DS4, the authors had to understand how to use HID report descriptors [22] and to determine the report layout from the DS4 [23]. Additionally, more detail was needed on the accelerometer and gyroscope than what could be found on others' reverse engineering of the DS4. Therefore, when it was determined the Bosch BMI055 sensor module was used in the DS4 [24], the data sheet for the module [25] was referenced to allow the authors to fully understand how the gyroscope and accelerometer data was being reported.

Although the HIDAPI library provided the raw output from the DS4, the data needed to be formatted so it could easily be used in the existing laboratory exercises. Again, the goal was for the topics and the execution of the labs to remain the same with only the hardware device to change. Therefore, an output report was written in C and was formatted to look exactly like the output from the Esplora. The coding was done so that even the flags to display only specific sensor data were coded to be similar to the Esplora flags. While it was assumed the Bluetooth connection would be the primary way to access the DS4 output data, a flag for USB data layout was also included since it was anticipated there would be a time where the controllers might not be fully charged. These times could occur when there are back-to-back labs from 8 a.m. until 8 p.m. in the evening and students didn't pay attention to properly storing the controllers on the charging stations on their desks.

IV. METHODOLOGY

The data used in this paper are the 10 weekly laboratory grades for students enrolled in two consecutive fall semesters of a freshman computer engineering problem-solving course. The authors chose two consecutive fall semesters because this is when the department at the large, Midwestern university sees the largest influx of true first year students in the course. The course lectures are large; averaging between 150 to 250 students in one classroom. While there can be two to three sections of the course each fall, each with 150 to 250 students enrolled, this paper focused on the two sections one of the authors taught. This introductory course is the first course an incoming freshman will have in his/her major. For a majority of the lab sections, the student must be a declared computer engineering major, although there is one lab section that is reserved for other engineering majors who may want to "try before they buy" a computer engineering major.

The data was collected in the Fall 2015 course where the Esplora was used and in the Fall 2016 course where the DS4 was used. All 10 labs were identical except for the controllers and the flags used to ask for specific trigger or button pushes. Those were modified to fit the DS4 controller. For example, requests in the laboratory exercises that needed the up, down, left, right buttons to perform specific functions were renamed to the triangle, x, square, and circle to match the images on the device (See Figs. 1 and 2.) Besides these small differences, both hardware devices had similar sensors and input options including at least one joystick, four buttons, and an accelerometer.

V. RESULTS

A total of 325 students took the course over the two consecutive fall semesters. There were 201 students in Fall 2015 that used the Esplora and 124 students Fall 2016 that used the DS4. As was described in the section III, the course included 10 mandatory lab exercises that were performed over the course of 14 weeks. Some of the lab exercises were two weeks in design because of their complexity. The grade for the first four labs was based solely upon the formalized lab report that included answers to reflection questions and the appended source code. Beginning with lab 5, the students continued to submit a formalized lab report containing reflections, as well as their source code. However, that accounted for only 80% of their grade. The remaining 20% of their grade was earned through demonstration of working code to the undergraduate teaching assistants and scoring of their functionality implementations.

A. Overall Lab Scores

To create an overall lab score, each of the 10 weekly laboratory exercise grades earned by the student were added together and an average calculated. These averages were compared based upon which hardware device was used in the lab. As shown in Table II, the average lab grade for students using the DS4 controller was significantly higher than students using the Esplora board, $F(1, 323) = 11.23$, $p < 0.001$. To ensure this was not an effect of higher attendance in one semester over the other, the effect of attendance on lab grades was also examined with no significant difference in attendance between the two semesters, $(F1, 323) = 0.001$, $p = 0.981$, providing greater credence to our results.

B. Individual Lab Scores

In looking more closely at the individual labs to see where the DS4 had the greatest impact, the difference in average scores for the two groups was considered for each lab. The list of topics covered in each week's lab was previously shown in Table I, while the effects of the hardware devices are reported in Table II.

In four of the weekly labs, students who used the DS4 earned significantly higher grades than those who used the Esploras. In lab 1 students who used the DS4s scored significantly higher on learning to read, collect, and plot data than those who used the Esploras, $F(1, 323) = 24.32$, $p < 0.001$. Likewise, when learning to use data types and arithmetic operators in lab 3, students who used the DS4s earned statistically higher marks than those who used the Esploras, $F(1, 323) = 38.55$, $p < 0.001$. In labs 7 and 8, where concepts that were previously introduced in labs 4, 5, and 6 were reused, students who used the DS4s had significantly higher lab grades than those who used the Esploras, $F(1, 323) = 13.45$, $p < 0.001$) and $F(1, 323) = 14.88$, $p < 0.001$, respectively.

It behooves the authors to consider the individual labs where there was no significant difference between using the Esploras and using the DS4s. First, it would stand to reason that there was no significant difference between the two groups for lab 2, since lab 2 did not use the controller, but was an introduction to how to use the C programming language including what source code is, how to compile, and how to run the compiled code. Therefore, it could be argued that lab 2 should potentially have not been included in the test since there would be no effect of the hardware devices when the devices were not used.

Moving to consider the remaining five labs there is a trend that appears. Labs 4, 5, and 6 introduce concepts that are completely new and relatively complex to students in an introductory computer engineering course. The concept of writing a function instead of using code inline (lab 4), the concept of looping (lab 5), and the use of multiple loops in multiple functions (lab 6) are all new concepts. It seems to make sense that the use of the specific controller does not make a difference in the weekly laboratory scores since the students are focused on learning the unintuitive concepts and the engagement with the game controller has no significant influence on grades. But as discussed above, when labs 7 and 8 reused these same concepts, the students aren't focused on learning the concepts and the engagement with the DS4 does have a significant impact on their grades.

In looking at labs 9 and 10 again we find difficult concepts to master. The introduction of two-dimensional arrays in lab 9 is a difficult concept to master because it also includes the concept of nested loops. While lab 10 sees the reuse of two-dimensional arrays, the introduction of using these for character arrays (strings) is so difficult that it hides the effect of the reused concepts of multiple loops, functions, and conditionals.

TABLE II. EFFECT OF THE CONTROLLER ON LAB SCORES, OVERALL AND BY INDIVIDUAL LAB

Lab Number	Controller	Mean	df	F	Sig.
Overall	Esplora	84.2	323	11.23	0.001
	DS4	90.4			
1	Esplora	80.6	323	24.32	0.001
	DS4	89.9			
2	Esplora	94.0	323	2.83	0.09
	DS4	96.9			
3	Esplora	77.1	323	38.55	0.001
	DS4	89.8			
4	Esplora	89.5	323	0.43	0.51
	DS4	88.1			
5	Esplora	88.6	323	1.33	0.25
	DS4	91.1			
6	Esplora	89.5	323	0.015	0.90
	DS4	90.0			
7	Esplora	83.2	323	13.45	0.001
	DS4	95.4			
8	Esplora	76.0	323	14.88	0.001
	DS4	88.1			
9	Esplora	90.1	323	0.154	0.70
	DS4	91.4			
10	Esplora	76.4	323	2.59	0.11
	DS4	83.8			

C. Lab Reports Only vs. Lab Reports and Demonstrations

The authors wanted to examine whether the DS4 had an effect on the lab scores when what comprised the lab grade differed. An average lab score for the four labs that included only a formalized lab report and code submission was calculated and compared to the average lab score for lab grades that included both a report and working code demonstration. The results are displayed in Table III.

When looking at the effect of the controller on the grades of the four labs that only included the formalized report, the students using the DS4 controllers had significantly higher scores, $F(1, 232) = 22.1$, $p < 0.001$. When considering the effect the DS4 controller had on lab grades for the labs that included a demonstration of fully functional code as well as the formal lab report and documented code, there was also a significant difference $F(1, 323) = 5.58$, $p = 0.02$, though surprisingly this significance was much less in the labs with demonstrations included as compared to those with only reports.

TABLE III. EFFECT OF CONTROLLER ON LAB SCORES BY LAB SUBMISSION TYPE

Lab Submission Type	Controller	Mean	df	F	Sig.
Formal lab report format including code and reflection questions only	Esplora	85.3	323	22.1	0.001
	DS4	91.1			
Formal lab report format including code, reflection questions, and demonstration of working code	Esplora	84.0	323	5.58	0.02
	DS4	90.0			

D. *Lab Reports vs. Demonstrations*

To take an even deeper look at this peculiar phenomenon of the DS4 controller having a more significant effect on the labs that only contained a formalized lab report as compared to the labs that had both a lab report and the demonstration, the individual portions (report vs. demonstration) of the combined labs were examined. The scores for each portion of the lab score were extracted and each portion was normalized to 100% to allow the comparison between the two. For the lab report portion, which was 80% of the weekly lab score, the normalized lab report score was calculated by multiplying the lab report score by 1.25. Likewise, to calculate the normalized demonstration score the weekly demonstration score, which was 20% of the overall score, was multiplied by 5. Once the scores were normalized and compared (Table IV), the DS4 controller had a significantly positive effect on lab report scores, $F(1, 323) = 8.32$, $p = 0.004$, but did not have a significant effect on the demonstration portion of the score.

TABLE IV. EFFECT OF CONTROLLER ON LAB SCORES BY PORTION OF SCORE FOR THOSE LABS HAVING BOTH REPORT AND DEMONSTRATION

Lab Portion	Controller	Mean	df	F	Sig.
Formal lab report portion	Esplora	83.1	323	8.32	0.004
	DS4	89.1			
Demonstration portion	Esplora	95.6	323	0.65	0.422
	DS4	99.5			

VI. DISCUSSION

Overall, the substitution of the DS4 for the Esplora had a significant positive effect on the total lab scores for the entire semester, with no significant differences in attendance between the two semesters. When the labs included the introduction of completely new concepts, many of which are very complex for first time programmers, the controller did not have an effect. However, the DS4 controller had a positive effect on lab grades when the lab requirements included revisiting concepts from previous labs to complete the current lab.

More interesting was the positive significant effect that the DS4 controller had on the formalized report portion of the labs. It was hypothesized that the DS4 controller would have a significant positive impact on the grades for the demonstration portion of the labs; however, that is not true. It appeared that by default the students were interested in the coding portion of the labs no matter what hardware device was used. But, when it came to the formalized write up of what happened in the lab, the DS4 controller appeared to either help the student understand the experiment more completely or engaged them more with the exercise itself to make them do a better job on the formalized write up. This is important because computer engineers tend to be engaged with the coding because they perceive it as fun. However, the write up and documentation is never perceived as being fun. The controller helps with this aspect.

VII. CONCLUSIONS AND FUTURE WORK

The engagement of the next generation of computer engineers is a constantly moving target, as is the development of the introductory problem-solving class. This work has shown that the DS4, a commonly found game controller, has a significant positive effect on students' overall lab scores for the semester. Additionally, it has shown that the DS4 had a significant positive effect on using simple new concepts and the reuse of more complex ones.

Unfortunately, the DS4 did not positively impact any difficult new concepts. Those remained difficult no matter what hardware device was used. This points to an area that needs further work for this introductory course. These results may mean that more time needs to be taken with these complex topics. There are multiple ways that these complex concepts could be reinforced. One would be to devote more time in the lecture portion of the course to the topic, specifically focusing on active learning activities to highlight it. Another option would be to extend the labs that include new, complex topics beyond the current two-week window to allow students more time on task. And, a final option would be to break the complex labs into multiple, smaller, single week labs that build on each other. Results from this data point to this final option as the most valuable. This would allow the student to gain self-efficacy with the new concept and then move on to mastery of that concept in the second or third weekly lab. The same concepts could be covered and the same functionality exacted, but the students would see it in smaller pieces.

The adoption of the DS4 and its weekly laboratory exercises was complete for all freshman computer engineering course sections in the department at the beginning of the Fall 2017 semester. Half of the course sections used the DS4 in the Spring 2017 semester, with the remaining course sections adopted the DS4 for use in the Fall 2017 semester. This does not mean the continual course revisions have stopped. Another revision of the freshman computer engineering course is currently underway as this article is being written. The above changes in handling the complex topics, as well as others, are being considered for incorporation. As with any large institution, changes will be made methodically over time, but always in the best interest of the students.

One of the additional changes being considered is the ability to return output from the code not only to the screen, but to be able to send data back to the DS4 itself. In August of 2016 Sony introduced a wireless dongle to allow the DS4 to be used with PCs or Macs in the Steam digital distribution environment; specifically, to be used as the controller in their online games. Potentially, the addition of the dongle to the equipment used in the laboratory experiments would allow the DS4 to rotate the rotors in the handles, as well as light the LED display. This would mean that a student could include more interactivity with the program being created and add additional engagement with the projects.

This author team is ready to continually update and upgrade the hardware devices, the laboratory exercises, and the lecture activities to meet the needs of the incoming freshmen.

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