Student Perceptions of Learning Models in First-Year Programming Courses

Dr. David M. Feinauer, P.E., Virginia Military Institute

Dr. Feinauer is an Associate Professor of Electrical and Computer Engineering at Virginia Military Institute. His scholarly work spans a number of areas related to engineering education, including the first-year engineering experience, incorporating innovation and entrepreneurship practice in the engineering classroom, and P-12 engineering outreach. Additionally, he has research experience in the areas of automation and control theory, system identification, machine learning, and energy resilience fundamentals. His work has been published through the American Society for Engineering Education (ASEE) and the Institute for Electrical and Electronics Engineering (IEEE); he is an active member of both organizations. He holds a PhD and BS in Electrical Engineering from the University of Kentucky.

Runna Alghazo, Prince Mohammad Bin Fahd University, Saudi Arabia

Runna Al Ghazo is an educational researcher and rehabilitation counselor. She received her Ph.D. in rehabilitation from Southern Illinois University-Carbondale (USA). Her areas of interest include psychological and systemic variables that may contribute to students' academic success in Higher Education, educational technology, curriculum and instruction, leadership, and technical writing pedagogy.

Dr. Jaafar M. Alghazo, Virginia Military Institute

Dr. Jaafar Alghazo is an Associate Professor in Electrical and Computer Engineering at the Virginia Military Institute. He graduated from Southern Illinois University with a Ph.D in Engineering Science/Computer Engineering in 2004 and M.Sc. in Electrical and Computer Engineering in 2000 from the same university. He worked at the American University in Dubai, the University of Central Florida, and Prince Mohammad Bin Fahd University before joining the Virginia Military Institute as a Tenure Track faculty member. His research interests are in Machine Learning and Artificial Intelligence in addition to Engineering Education.

Dr. Sherif Abdelhamid, Virginia Military Institute

Sherif E. Abdelhamid serves as an Assistant Professor at the Computer and Information Sciences Department, Virginia Military Institute (VMI). Before joining VMI, he was an Assistant Professor at the College of Computing and Information Technology (AAST - Smart Village Campus, Egypt). He was also an Infrastructure Software Engineer at the Center for Open Science in Virginia, USA. He obtained his Ph.D. and M.Sc. degrees in Computer Science from Virginia Tech and M.Sc. and B.Sc. degrees in Computer Science from AAST - Alexandria Campus, Egypt. Dr. Abdelhamid's research interests are in high-performance services-based computing solutions, novel digital educational technologies, and tools for the social network analysis of complex systems. More specifically, his research focuses on designing and building software systems and services (science-as-service) that enable students and domain experts from various fields to easily access and interact with various learning resources and perform data analyses and simulations to study large-scale biological information socio-technical (BIST) complex systems.

Prof. James C. Squire, P.E., Virginia Military Institute

James Squire is the Jamison-Payne Professor of Electrical Engineering at the Virginia Military Institute. Dr. Squire received a B.S. from the United States Military Academy and his Ph.D. from the Massachusetts Institute of Technology. He was awarded a

Student Perceptions of Learning Models in First-Year Programming Courses

Abstract

This paper explores student perceptions of the flipped and traditional classroom modalities in two concurrent programming courses among first-year ECE students at a Senior Military College. The course in C programming operated in a flipped classroom style building off of the C Programming zyBook. The second course was a traditional lecture/lab course focused on problem-solving using MATLAB and it was built off a workbook. Students reported high enjoyment of both courses with slightly higher enjoyment of the traditional modality. However, students reported a sense of increased opportunity to ask questions and interact in the flipped classroom course while also expressing a sense that participation in the flipped classroom course helped reduce their dependency on the instructor for learning—a result that may suggest further exploration of flipped classroom pedagogies in transitional and introductory courses. Further study is needed to explore these dimensions and the contributing factors that led to the perceptions shared by the students.

Keywords: Flipped Classroom, Interactive Textbook, Courseware, C Programming, MATLAB Programming

I. Introduction

The Gen Z students that we teach today have had much experience using electronic devices and technology in their education. The first cohort of Gen Alpha is expected in university classrooms around 2028. Generation Z describes those born from ~1997–2009, and Generation Alpha refers to people born in or after 2010. The Gen Alpha student will be one who is truly a "digital native"—they will not have known a world without pervasive touchscreen devices. Colleges and Universities must be ready for possible changes in the learning methodologies required to meet this new generation. Use of computing devices in primary and secondary education has grown tremendously through the use of one-to-one (1:1) device or technology programs. A 2017 report [13] found that more than 50% of K-12 teachers taught in 1:1 classroom environments and a meta-analysis of 15 years of research studies [14] reported increased student engagement and persistence in 1:1 classrooms and suggested the result may have been linked to increased use of student-centered pedagogies in 1:1 classrooms. At Virginia Military Institute (VMI), first year students have expressed surprise at the prevalence of chalk boards and the lack of technology in many classrooms; the authors feel this is also linked to the growing prevalence of 1:1 device programs.

One typical course structure when teaching programming involves the use of a lecture followed by a lab in which students can practice what they learned. Traditional teaching methods that have produced educated, innovative engineers for generations involve interactions that are predominantly instructor-designed and instructor prompted. Nowadays, many online interactive books support the flipped learning model where readings, presentations, and short exercises are assigned to students to be completed on their own time while reserving class time for hands-on, active engagement, problem-solving sessions, or "labs". Interactive books also incorporate software development environments and testing platforms that allow students to iteratively develop and test programs, receiving instant feedback on their work. The concept of the flipped classroom dates back to the early 1980s. At that point, technology was not widespread so flipping the classroom meant completing readings at home and concentrating on practical problems and examples during class time. With the development of technology, the definition and implementation of the flipped classroom have evolved. Having the students complete readings, watch videos, or engage with interactive books and exercises outside of class time creates opportunities for student-driven interactions and student-driven learning pathways during instructor-supervised class time.

At VMI, first-year electrical and computer engineering (ECE) students are taught C Programming using a zyBooks interactive text under a flipped classroom learning model. The first-year ECE students complete a separate introductory course in MATLAB that is structured to include in-class lectures followed by a workbook-supported lab and problem-solving period. In this study, we analyzed the students' perception of the flipped versus traditional classroom models in a programming course. The same students take the two courses concurrently, creating an opportunity to capture their perceptions and explore comparisons with a survey at the end of the semester. It should be mentioned that in addition to adjusting to college from a variety of cultural and high school backgrounds, the students surveyed are members of a Corps of Cadets and they are all adjusting to the regimented expectations of a military lifestyle.

The motivation for this work is the exploration of pedagogical methods for enhancing the learning experience for students, especially for the newer generation of learners; Generation Z and Generation Alpha. Lessons learned were abstracted from the student perceptions and instructor experience and recommendations regarding the relevancy and perception of the techniques for today's students are discussed. The insight that Generation Z offers is critical for preparing the education models that will be vital for the success of Generation Alpha.

Section 2 of the paper details recent pedagogical literature about teaching modalities and provides some examples of the types of lessons used in the two programming courses experienced by the students. Section 3 details the methodology for the study, while section 4 presents the survey results with a discussion of their meaning. Section 5 concludes the paper and presents opportunities for future work.

II. Background

Comparison of the flipped classroom to a traditional classroom has been extensively researched. In [1], the authors examine the effect of the flipped classroom model on student learning outcomes taking into account variables such as study duration, student grade level, subject area, and publication type. The authors looked through seventeen databases to find literature (55 papers and 115 experimental effect size comparisons) regarding cognitive student learning outcomes published from 2000–2016. They reported a statistically significant effect size (g =

0.193; $p < .001$; with a 95% confidence interval of 0.113–0.274) that shows a learning outcome advantage to the flipped classroom model. In [2], the authors examined the effects of the flipped classroom model in a Master's course at a university in the Netherlands, teaching half of the course using the traditional method and half using the flipped classroom model. The primary positive of the flipped classroom discussed by the students was the experience of peer-learning that accompanied the flipped classroom activities. In [3], the authors transformed an applied physics course for doctoral and master's students into an online flipped classroom. Their results indicated that there was not a statistically significant difference in the mean performance between the traditional and flipped online class. However, they noticed that the flipped online version led to a larger spread in student performance. In [4], the authors examined the flipped classroom model in a university biology course and its effect on aspects of the student learning experience. They further studied the identification of the course design associated with student engagement, motivation, and confidence. The authors reported positive results in support of the flipped classroom model and its effect on enhancing student's learning outcomes and experience. In [5], the authors conducted a study to in a high school-level chemistry course in Iraqi schools. They assessed the effect of flipped classroom model on motivation, creative thinking, and achievement. After holistically exploring student preference, teacher preference, learning flexibility, teaching aid effectiveness, working environment, and student participation, they recommended shifting to the flipped classroom model in Iraqi secondary schools.

In [6], the authors performed a meta-analysis (33,768 students in 198 papers) of the effect of the flipped classroom on student's performance compared with the traditional classroom model across all education levels and disciplines. Their findings indicate a moderate positive effect of the flipped classroom model on the performance of students. They also report that the flipped classroom model was favored irrespective of the discipline. Overall, their finding indicates that the flipped classroom model has the strength of providing structured active learning and problem-solving. In [7], the authors conducted a meta-analysis (37 papers, 40 effect sizes) on the effect of flipped mathematics K-12 classrooms on student achievement, reporting an overall statistical significance effect in favor of the flipped classroom model. In [8], the authors analyzed the results of 58 papers from 54 quantitative studies published from 2007–2020, exploring the influence of the flipped classroom model on students' academic achievement. The authors report a statistical significance in favor of the flipped classroom on student achievement. In [9], the authors summarized the trends of blended learning represented in 22 recent publications on student perceptions of learning models in higher education. They reported favoring the flipped/blended classroom model in higher education and concluded with the encouragement to progressively increase this model in Malaysian Higher education institutions over time. In [10], the authors propose the use of the Jigsaw collaborative teaching practice which involves instructor-supervised learning for teaching circuit analysis for first-year university students. They enhanced the process by grouping students according to their personality rather than at random, noticing a significant improvement in students' assessment scores by up to 20%. They also report that the perception of the student is that the learning process is more enjoyable to them and the authors suggest that Generation Z and Generation Alpha suffer from a shorter attention span and thus require modified teaching methods. Studies [11-13] suggest that Generation Z and Generation Alpha require or will require innovative teaching and learning methodologies.

Considering the ability of novel learning modalities to meet the learning needs of the newer generations is important. Examining the meta analyses described above paints a picture of the flipped classroom as a means for improving student engagement, motivation, confidence, and opportunities for peer-to-peer learning. At all grade-levels, in many disciplines, the results also tend to show learning outcome advantages, although this was not universally true in all contexts.

The two courses examined in this paper are C Programming (a flipped classroom introductory programming course) and Computer Tools (a traditional introductory problem-solving using MATLAB course). Both courses contain lessons and activities which are similar in nature, but explored through different pedagogies. In the C-Programming course an interactive zyBook is used. In the zyBook, students are assigned "Participation and Challenge" interactive activities that are usually completed prior to coming to the class, with longer lab assignments completed during a 50 minute class period. Participation activities includes 100s of multiple choice questions, animations, and other augmentations to the typical reading material. Challenge activities are programming tasks that can be tested in-line in the textbook and involve writing a few lines of code, providing instant feedback and visibility of correct solutions. Lab activities are completed in a web-based programming shell that allows the students to check their work and receive instant feedback. The exercises typically take 1-2 class periods for completion and provide more in-depth practice for the topic being studied. When completing a lab, students work in develop mode initially in order to test their understanding and ensure that they are completing the lab correctly by checking it against public test cases, and then they move to submit mode when they are prepared to have their assignment checked against private test cases for grading. A list of topics covered in the text and course is available by exploring the table of contents at https://www.zybooks.com/catalog/programming-in-c/ .

In Computer Tools, ECE fall-semester first-year students learn MATLAB programming and circuit simulation. The course meets twice a week for 1.25 hours each meeting. Classes use a traditional format of ~10 minutes of in-class lecture followed by ~20 minutes of in-class problem solving, repeating in cycles throughout the period. Students are kept motivated by knowing that they must hand in the results of their in-class work at the end of class for a participation grade. In addition, out-of-class homework packets that involve longer or extended problem-solving tasks are assigned every two weeks, and there are summative midterm and final examinations. Because of the flipped classroom experience in the C programming course, the instructor has given students the option to flip this arrangement, pre-completing the reading and in-class assignments on their own before class, enabling them to work on the larger, more-involved homework problem sets during class time. In practice, fewer than 5% of students take advantage of this option. See https://www.jimsquire.com/teaching/ee120/ee120.htm for a detailed listing of readings and assignments students are given at the start of the semester to enable this option.

III. Methodology

ECE students at Virginia Military Institute complete an introductory course in C Programming and an introductory problem solving and computer tools course using MATLAB during the first semester of their freshman year. Both courses are three credit hours and meet 150 minutes per week. The C Programming course is taught in a flipped classroom format and the Computer Tools course is delivered in a more traditional classroom modality.

In the fall of 2022, first-year ECE students were given a survey about their experiences in both courses. The same survey was given to sophomore ECE students, who persisted in the program and complete the aforementioned course sequence one year prior, asking them to reflect on their first-year experience. A quantitative analysis of the Likert scale survey questions and a discussion of themes present in the student responses are detailed in the next section.

IV. Results and Discussion

Resulting from 24 responses from students who began their university studies in the fall of 2021 and fall of 2022, figure 1 shows a picture of the student experience with respect to using technology for learning. For the survey responses, *rarely* was defined as the use of a digital device for learning less than 1 day per week. *Sometimes* was defined as use 1-2 days per week, *often* was defined as usage 3-4 days per week, and *always* represented usage 5 or more days per week. Figure 1 shows that as the students progressed through school, their use of technology for learning greatly increased. By the time the students reached the high school classroom, approximately 83% of them used technology for school work daily, and the minimum usage reported by any student was 1-2 days per week. These results support the motivating assumption that current and future university students are "digital natives", and consideration of this when designing a university course (and classroom) is important.

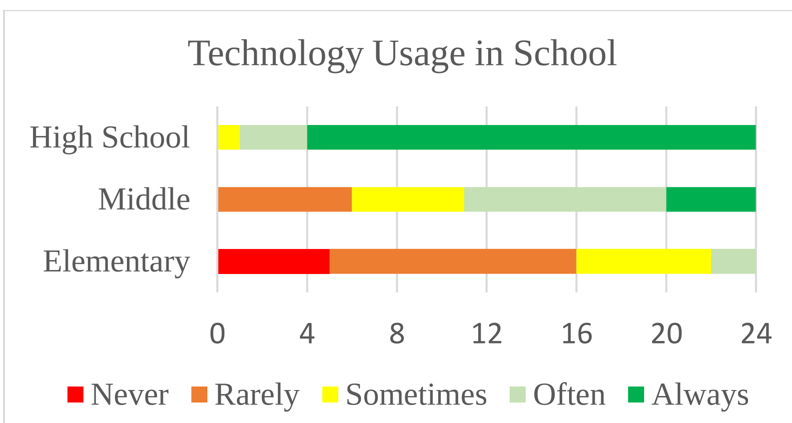

Figure 1 – Reported frequency of use of technology for learning during primary and secondary school. Results from N=12 freshman and N=12 ECE sophomores surveyed.

The summary in Table 1 details the student responses to ten Likert scale questions regarding the flipped classroom. Twelve first-year ECE students concurrently enrolled in a C programming and MATLAB problem-solving course completed the survey during the final week of classes in the fall, their responses are in the "Fresh." column. Twelve students who persisted in the ECE program were asked to reflect on their freshman experiences and their responses were collected one year after they completed the concurrent programming courses, and are reported in the "Soph." column. The strongest results from the student survey relate to interaction and engagement in the flipped classroom course (bolded **blue** text). Both cohorts agreed or strongly agreed that the flipped classroom model did not limit their interaction with the instructor and that it provided them with increased opportunities to ask questions. Despite these increased opportunities for interaction, the students also reported that the flipped classroom was not more engaging than the traditional classroom (bolded **red** text).

Table 1 - Results for survey questions about flipped and traditional classroom learning in introductory programming courses for first-semester ECE students. N=12 freshman (Fresh.) were surveyed at the end of their fall courses and N=12 sophomores (Soph.) were surveyed one year after completing the freshman courses.

Question	% Agree or Strongly Agree		% Neutral		% Disagree or Strongly Disagree	
	Soph.	Fresh.	Soph.	Fresh.	Soph.	Fresh.
With the flipped classroom model, I feel more prepared for my exams.	42	25	17	50	42	25
I wish more instructors would use the flipped classroom model.	17	33	42	42	42	25
The flipped classroom model gives me more opportunity to ask more questions inside the classroom.	**67**	**42**	8	42	25	17
The flipped classroom matches my learning style.	8	25	75	25	17	50
I would not recommend the flipped classroom to a friend.	8	42	50	25	42	33
Flipped classroom learning has reduced my dependency on the instructor.	**42**	**42**	33	50	25	8
The Flipped classroom is more engaging than traditional instruction.	8	25	25	33	**67**	**42**
More lecture should be incorporated into the flipped classroom course.	25	50	50	25	25	25
The flipped classroom model did not limit my interaction with the instructor.	**58**	**58**	8	25	33	17
I wish less lecture time were incorporated in the traditional classroom.	17	17	50	58	33	25

Another interesting result was that 42% of both cohorts reported that flipped classroom instruction resulted in reduced dependency on the instructor for learning (bold **green** text). This theme should be explored further and may serve as an indicator of the value of timing the use of a flipped classroom modality in first-year courses to support students in transition to college.

Table 2 shows self-reported student enjoyment of each programming course. For both cohorts, 67% of the respondents reported that they slightly enjoyed or greatly enjoyed studying C programming in a flipped classroom modality. For both cohorts, more students reported enjoyment of studying MATLAB programming and problem solving in a traditional learning modality. When examining each individual's response regarding both modalities, a total of 4 students (out of 24) indicated greater enjoyment of the flipped course, with 11 (out of 24) indicating greater enjoyment of the traditional classroom. It is also interesting to note that the responses from the sophomores were more polarized than those from the freshman. It would be interesting to explore this in the future to see whether that is attributed to the dynamics of the cohort or a result of the additional year of courses and university experience between their experience with the flipped course and the time of their reflection.

Table 2 - Results for Likert scale survey question regarding self-reported student enjoyment of the study of programming in a flipped (C) and traditional (MATLAB) classroom during the first semester of the freshman year. N=12 freshman and N=12 sophomores were surveyed.

Result	Soph.	Fresh.
% Positive Enjoyment of Study in Traditional Course	75%	84%
% Positive Enjoyment of Study in Flipped Course	67%	67%
N Enjoyment of Traditional Course Greater Than Flipped	7	4
N Enjoyment of Flipped Course Greater Than Traditional	3	1

V. Conclusion

Most students reported enjoyment of their study of programming in both the traditional and flipped classroom. Counter to many of the findings from studies on this topic, the students at VMI indicated a greater preference for traditional instruction over the flipped classroom model. As student enjoyment should not be the only metric or justification for the adoption of teaching pedagogy, it is important to note that the students reported improved opportunities to ask questions and they did not find the flipped classroom modality limiting their instructor interaction. However, the students did not describe the flipped classroom as more engaging than the traditional classroom. There is an opportunity to explore the students' definitions of "engaging" in the future. Other variables that could be added to the study to gain insight into students' preferences include the challenges of first-semester students at a Senior Military College, the instructors' preferred methods of teaching, or instructor personality. Additionally, future surveys could use additional questions to explore which dimensions of each course led to the students' sense of engagement.

An additional dimension worth exploring is that 42% of the respondents agreed or strongly agreed that the flipped classroom reduced their dependency on the instructor for learning. The contribution of the flipped classroom modality to the development of a student's self-efficacy beliefs and its usefulness in helping students transition from high school to college or university classrooms could be quite interesting. Future studies should include qualitative results whether through interviews with students and instructors or other well-defined qualitative research methods. Free response questions were included in this study, but the student responses were very terse and did not lend to this type of analysis.

As students from Generation Alpha enter the university around 2028, much effort is needed to study the learning needs of that generation and how the teaching pedagogies could be modified for the incoming generation. Generation is only one variable of many to consider when attuning teaching and learning pedagogies to an audience. However, it is the opinion of the authors that modifying the current pedagogies for generation Alpha can add value to their educational experience and lead to graduating more well-rounded independent graduates.

VI. References

[1] Cheng, L., Ritzhaupt, A. D., & Antonenko, P. (2019). Effects of the flipped classroom instructional strategy on students' learning outcomes: A meta-analysis. *Educational Technology Research and Development*, *67*(4), 793-824.

[2] Goedhart, N. S., Blignaut-van Westrhenen, N., Moser, C., & Zweekhorst, M. B. M. (2019). The flipped classroom: supporting a diverse group of students in their learning. *Learning Environments Research*, *22*(2), 297-310.

[3] Stöhr, C., Demazière, C., & Adawi, T. (2020). The polarizing effect of the online flipped classroom. *Computers & Education*, *147*, 103789.

[4] Awidi, I. T., & Paynter, M. (2019). The impact of a flipped classroom approach on student learning experience. *Computers & Education*, *128*, 269-283.

[5] Mohammed, H. J., & Daham, H. A. (2021). Analytic hierarchy process for evaluating flipped classroom learning. *Computers, Materials & Continua*, *66*(3), 2229-2239.

[6] Strelan, P., Osborn, A., & Palmer, E. (2020). The flipped classroom: A meta-analysis of effects on student performance across disciplines and education levels. *Educational Research Review*, *30*, 100314.

[7] Güler, M., Kokoç, M., & Önder Bütüner, S. (2022). Does a flipped classroom model work in mathematics education? A meta-analysis. *Education and Information Technologies*, 1-23.

[8] Kazu, İ. Y., & Yalçın, C. K. (2022). A Meta-Analysis Study on the Effectiveness of Flipped Classroom Learning on Students' Academic Achievement. *E-International Journal of Educational Research*, *13*(1).

[9] Soon Tan, C., Zakuan, N., & Ismail Abd Aziz, M. (2022). Recent trends of blended learning and flipped classroom in Malaysia. *Arab World English Journal (AWEJ) 2nd Special Issue on Covid*, *19*.

[10] Reba, P., Susithra, N., Deepa, M., & Santhanamari, G. (2022). Effective Teaching of Electric Circuit Analysis through Jigsaw Cooperative Learning Method. *Journal of Engineering Education Transformations*, *36*(1).

[11] Nguyen, N. N. (2022). Research on factors affecting smart choices regarding to a good place to study: A case of young students. *Central European Management Journal*, *30*(4), 444-449.

[12] Körtesi, P., Simonka, Z., Szabo, Z. K., Guncaga, J., & Neag, R. (2022). Challenging Examples of the Wise Use of Computer Tools for the Sustainability of Knowledge and Developing Active and Innovative Methods in STEAM and Mathematics Education. *Sustainability*, *14*(20), 12991.

[13] Staff, Edtech. "More Than 50 Percent of Teachers Report 1:1 Computing." EdTech. Feb. 1, 2017. [Online]. https://edtechmagazine.com/k12/article/2017/02/more-50-percent-teachers-report-11-computing [Accessed on Apr. 25, 2021].

[14] L. Doran and B. Herald. "1-to-1 laptop initiatives boost student scores, study finds." Education Week, vol. 35, no. 31, p. 11. May 2016.