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Advancing Engagement and Equity in Asynchronous Online Education

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(Work in Progress Paper)

Abstract

Asynchronous online degree programs offer a flexible and scalable pathway to expanding access to engineering education, particularly for nontraditional learners. However, these programs also raise important challenges in maintaining student engagement, ensuring learning effectiveness, and upholding academic integrity. This paper presents a comparative case study of two sophomore-level engineering courses offered for the first time in a fully asynchronous format during a 10-week summer session. We analyze instructional strategies, student outcomes, and the pedagogical trade-offs involved in transitioning from in-person to asynchronous delivery. While the Digital Logic course demonstrated strong engagement and learning outcomes, the Introduction to Circuits and Electronics course revealed significant barriers tied to motivation, interaction, and content complexity. In addition, we examine fully online master's degree programs delivered on the Coursera platform, which use flexible enrollment models and performance-based admissions to broaden access. These graduate programs highlight innovative approaches to online engineering education but also raise questions about learner preparedness, credential recognition, and program scalability. Finally, we explore the integration of artificial intelligence (AI) tools in asynchronous online platforms, including both their promise for enhancing personalization and the risks they pose to critical thinking and equity. This paper concludes with actionable recommendations for course design, technology use, and institutional policy to support inclusive and effective asynchronous learning.

1. Introduction

Online education, particularly asynchronous programs, has become a popular choice in recent years. Asynchronous learning is different from traditional, in-person learning in that students are not required to attend class at specific times. This freedom makes it especially appealing to learners, who may already have full-time jobs or family commitments. It is important to note, though, that while asynchronous online courses can be just as effective as synchronous ones - where students meet live online, the design of the course and the resources available to students are key to success [1-2]. And, while these programs offer flexibility, they also suffer from challenges such as maintaining student engagement, providing live support, and ensuring that curricula meet industry hands-on skills and needs. This paper focuses on how asynchronous online degree programs can be improved to support students. We explore how thoughtful curriculum design, new teaching strategies, and the integration of AI tools can address some of the challenges faced by students. We also examine how to ensure that these programs are equitable and inclusive, ensuring that all learners, regardless of background, have a fair chance of success.

There is a lot of research on online education for adult learners, covering topics like retention, motivation, and self-esteem [3-4]. However, few studies have specifically focused on the experiences of learners in asynchronous online degree programs. More importantly, even less research has looked at what learners think could improve their online experience in terms of assessments, communication with faculty, and peer interactions [5]. It is critical to understand their unique needs and preferences.

In asynchronous online programs, engaging students require more than just providing course materials. It is about creating learning experiences that keep students interested and motivated. Research suggests that adult learners particularly benefit from active learning strategies that allow them to apply what they are learning in real-world contexts [6]. This could include projects that encourage problem-solving, group activities, or assignments where students tackle current industry challenges. Another way to keep students engaged is by promoting interaction. While it is not possible to have live classes all the time in an asynchronous program, it is still important to find ways for students to connect with each other and connect with the instructor. Discussion boards, peer reviews, and group projects are just a few ways to create a sense of community. These interactions help students feel less isolated and more involved in their coursework, which is crucial in an online environment. Assessments also play a role in engagement. Rather than focusing solely on exams or final papers, it is helpful to have assessments throughout the course that offer opportunities for feedback and improvement. This could include quizzes, self-reflection exercises, or peer feedback sessions. In an asynchronous course, these assessments can provide timely insights into how students are progressing and where they might need extra help.

2. Case Studies - Asynchronous Online Undergraduate Courses

Our Electrical, Computer, and Energy Engineering (ECEE) department offers two core sophomore-level courses: ECEN 2250, Introduction to Circuits and Electronics, and ECEN 2350, Digital Logic. Together, these courses provide foundational knowledge in both analog and digital systems and are core requirements for at least two undergraduate degree programs: Electrical Engineering (EE) and Electrical and Computer Engineering (ECE), as well as minors in Electrical Engineering and Computer Engineering.

ECEN 2250 is a one-semester, 3-credit-hour course that includes take-home, hands-on laboratory homework activities [6]. The course covers basic circuits with RLC components, operational amplifiers, transistors, MOSFETs, and filters. During the Fall and Spring semesters, the course is offered as an in-person, synchronous course with three 50-minutes lectures per week.

ECEN 2350 is also a one-semester, 4-credit-hour course that includes homework assignments, in-class hands-on laboratory activities. The course covers the design and applications of digital logic circuits, including both combinational and sequential logic circuits. It introduces hardware descriptive language (HDL), simulation and synthesis software, and programming of field programmable arrays (FPGAs). During the Fall and Spring semesters, the course is offered as an in-person, synchronous course with three 50-minutes lectures and one 1 hour and 50-minutes laboratory session per week.

Our department and the college have been interested in expanding access to undergraduate students by offering core/foundational undergraduate courses through the hybrid/asynchronous distance learning modality. The authors of this paper planned to launch the two courses as fully asynchronous online courses for the first time during the Summer 2024 semester. Offering these two courses over the summer semester could significantly improve students' ability to stay on track with their degree plans and improve their ability to complete their degrees within 4 years.

During the Summer 2024, the authors of the paper, who taught the same courses as in-person courses during the Fall 2023 semester, offered these courses over a 10-week period through the fully asynchronous, online modality. This condensed a 15-week semester of content into a 10-week semester and converted all the live lectures into recorded lectures that were uploaded to the course Learning Management System (Canvas). Because some of our international students were literally around the world visiting their families during the summer. It was not practical to ship the hands-on lab kits or FPGA development boards to the students. Instead, for ECEN 2250, Introduction to Circuits and Electronics, all the hands-on activities were converted to SPICE simulations using the SIMetrix tool. And, for ECEN 2350, Digital Logic, the simulation and synthesis activities were conducted using AMD (Xilinx) Vivado installed locally on the students' laptops or remotely on the Cloud. Once the students completed the synthesis and implementation of their designs, and downloaded the bitstreams, they were able to upload the bitstreams to LabsLand virtual development board to verify the functionality of their designs.

Only degree-seeking students enrolled in programs at our university could register for these courses.

For ECEN 2250, Introduction to Circuits and Electronics, Summer 2024 course, there was a total of 22 students who completed the course. Four students dropped out for various reasons and 1 student got an incomplete grade and later finished the course in the synchronous in-person modality the following semester. About one third of the students were Electrical Engineering (EE) or Electrical and Computer Engineering (ECE) students, and the rest from other departments who needed the course as an elective, to fulfill a minor in EE or ECE, or to take it from the ECEE department rather than their own department. Other student majors that offer their own introductory circuits courses include aerospace and mechanical engineering. Even though this course was offered asynchronously through recorded lectures, live office hours were held by the instructor and two undergraduate TAs for a total of 10 hours a week. Based on the experiences with this fully asynchronous online summer course, it was our recommendation to NOT offer this particular course again using the same format.

For ECEN 2350, Digital Logic, there was a total of 22 students who successfully completed the course. This course was taught by one instructor - the first author of this paper. Only one student received an F/W grade. There was a mix of students enrolled in this course: seven (7) students majoring in Computer Science, four (4) students majoring in Electrical and Computer Engineering (ECE), four (4) students majoring in Electrical Engineering, one (1) student majoring in Aerospace Engineering Sciences, one (1) student majoring in Engineering Physics, one (1) student double majoring in Electrical Engineering (EE) and Mechanical Engineering (ME), one (1) student majoring in Electrical and Computer Engineering (ECE) and Chemical-Biological Engineering, two (2) students from the Intra-University Transfer (IUT) program, which allows current undergraduate students to change, add, or drop a major and degree program involving two different colleges/schools/programs within CU Boulder. One of the Computer Science students was a full-time student on a different university campus. Even though this course was offered asynchronously through recorded lectures, live office hours were held by the instructor and one graduate TAs for a total of 3 scheduled live office hours per week as well as live appointments based on students' needs. Course assessments encompassed assignments, quizzes, laboratory exercises, and participation in class discussions and reflective posts shared on Canvas.

Based on the successful experiences with the ECEN 2350, Digital Logic, a fully asynchronous online summer course, this course was recommended to be offered again using the same format.

2.1 What worked

In the Summer 2024 offering of ECEN 2250, Introduction to Circuits and Electronics, we used the textbook titled Fundamentals of Electrical Engineering, first edition, by Georgio Rizzoni, which was available online. One textbook chapter was covered each week, and the course outline followed the textbook chapters. The recorded lectures supplemented the textbook. We received very good feedback about the quality of the lectures and the fact that they helped clarify what was presented in the textbook. There were about 2 hours of recorded lectures per chapter, broken into 15-minute segments. The combination was an effective, self-paced, self-study introduction to circuits.

In addition, recitation sections were also recorded. Each week a selection of about 10 problems from the end of the chapter was selected to be reviewed in a lecture. Each short, 2-15 min recitation lecture covered a specific work problem. Ten additional problems, similar to the recitation problems, were assigned as homework. We require each student to complete the problem on paper, make a pdf copy and turn it in. This was graded each week by two undergraduate teaching assistants.

The laboratory activities were specific simulation problems. A series of videos were created as tutorials on the use of the SIMetrix tool assuming a student had never used a simulation before. Each week a simulation problem was assigned for the students to complete and offer an explanation. This 1-page lab report was also graded by the undergraduate teaching assistants.

A few students watched all the videos and completed all the homework assignments and all the simulation hands-on labs. Students would occasionally come to office hours when the faculty was available. These students responded in their evaluations of how valuable the course was for them. This meant these students could complete their full-time summer internships while taking the course, or could be at home supporting their family, while at the same time working toward completing an important curriculum requirement so they could graduate on time. For these students, this online, asynchronous course was a great success.

In the Summer 2024 offering of ECEN 2350, Digital Logic, the textbook was optional. Each week focused on a different digital design topic, with the material building on previous weeks to gradually increase the complexity of the digital circuits. All course materials, including video recordings, additional resources, assignments, and laboratory activities, were available from the beginning of the course, which allowed students to work through them at their own pace. Only the assessments in the Quizzes category were restricted to a specific time window and were administered online. Students were encouraged to collaborate in teams on all other course activities, but quizzes were to be completed individually. For the laboratory activities, students were required to submit a lab report that included: a step-by-step description of their design process, screenshots of simulation results (timing diagrams), details of the synthesized design, and screenshots or videos demonstrating correct functionality on the FPGA virtual development board.

Student feedback for the Summer 2024 offering of ECEN 2350 was overwhelmingly positive. Many students found the lecture slides and videos to be very helpful and effective for learning the material. They also appreciated the instructor's availability, responsiveness, and willingness to help, noting quick replies to emails and consistent support. One student mentioned that the biggest challenge in the online format was ensuring all students had access to the necessary technology on their personal computers.

2.2 What did not work

For most of the students, the ECEN 2250 Summer 2024 course was a disaster. The technical depth of this course was reduced a little from the live source because this summer version had mostly non-ECEE students and because it had to be condensed from 15 weeks of content into 10 weeks. Some of the extended examples of mesh and node circuit analysis were not covered, and AC power analysis related to the power grid and transformers were dropped.

Only a few students reported struggling due to the complexity of the content. By far, the biggest issue was engagement. Those students who never engaged were taking the course because they had to fulfill a requirement, not because they were motivated to gain a strong foundation in circuits. Most students never came to office hours. They completed the assignments and the online mid-term and final, but it was difficult to evaluate if they did so without help from other students or help from an AI such as ChatGPT.

Each of us faculty strongly encouraged each student to meet with us at least once throughout the course in a live Zoom call just to check in. Even though repeated emails and requests were sent out, less than half the registered students actually accepted an invitation. These students generally completed the assignments and scored well on the exams, but we do not believe they benefited from the course other than fulfilling a requirement on their record.

The most important element to the success of a student in this type of group is engagement. If a student was self-motivated, they could take advantage of the content and the flexibility of the schedule to learn at their own pace and complete other activities in their own free time. This is the ideal format for them. However, to be successful, a student must be motivated to devote time and keep up with the program. It is up to them to stay on schedule in order to complete the course on time.

The successful students attended office hours and had regular conversations with the faculty. From anecdotal discussions, we believe these students learned the content and were prepared to go to the next step in their ECEE curriculum. For them, this was an effective method of instruction.

For students who lacked motivation, the asynchronous online format made it possible to do the bare minimum, relying on external resources to complete assignments and exams in order to pass the course and earn credit. As instructors, we felt that the significant effort we invested in designing and delivering the course was not matched by the level of engagement of many students. Based on the overall student response and our limited ability to foster meaningful participation, we decided not to offer ECEN 2250, Introduction to Circuits and Electronics as an asynchronous online course in the future.

2.3 What it takes: Designing High-Engagement Asynchronous Courses

Engagement is critical in asynchronous online courses where the lack of real-time interaction can lead to isolation or detachment. Key factors include:

- **Course Design**: Interactive and scaffolded content such as weekly recitations and laboratory exercises keeps students involved.
- **Opportunities for Interaction**: Virtual synchronous office hours, discussion boards, and group projects help create a sense of community.
- **Instructor Presence**: Frequent and responsive communication from instructors increases motivation and reduces perceived distance.
- **Assessment Variety**: Frequent, formative assessments (quizzes, peer reviews, reflections) help maintain momentum and reinforce learning.

Creating and administering the ECEN 2250 Summer course required approximately 40 hours of work per week, significantly more than is typically expected for a one-semester, 3-credit-hour course delivered in a synchronous, in-person format. Despite the high workload, the substantial effort resulted in a well-developed set of course materials that can be repurposed for other uses. While we do not recommend offering this course again in its current asynchronous online format, we plan to make the content freely available as an online learning resource on YouTube. For motivated students, this can be a highly effective way to learn the material for a core ECEE course.

3. Case Studies - Asynchronous Online Graduate Programs

The University of Colorado Boulder (CU Boulder) offers several fully online master's degree programs on the Coursera platform, including the Master of Science in Electrical Engineering (MS-EE), Master of Science in Data Science (MS-DS), Master of Engineering in Engineering Management (ME-EM), and Master of Science in Computer Science (MS-CS). These programs are designed to expand access to graduate education in engineering and science through innovative, flexible, and scalable delivery models [10].

3.1 Features of the Fully Online Master's Degree Programs

Flexible Learning Structure: CU Boulder's online master's programs follow a modular and flexible structure that lowers traditional barriers to graduate study. Key features include a pay-as-you-go tuition model, continuous enrollment through eight-week sessions year-round, and pre-viewable course content. These design elements have broadened participation, particularly among working professionals and nontraditional learners.

Performance-Based Admissions: A central innovation of the programs is a performance-based admissions pathway, which replaces standardized tests and traditional application materials with demonstrated academic performance in designated gateway courses. While this model has successfully expanded access, it also raises important considerations about learner preparedness and long-term academic success.

Stackable Credentials and Career Alignment: Programs support stackable credentials, which allow students to earn certificates in areas such as artificial intelligence, data science, and sustainability. While this structure promotes career relevance and flexibility, preliminary feedback indicates mixed recognition from employers and concerns about fragmented educational experiences for students who do not pursue full degrees.

3.2 Assessment and Preliminary Results

To evaluate the impact of these programs, a combination of qualitative and quantitative findings was reported in [10]. Learner narratives illustrate how these programs have enabled individuals, many of whom lacked traditional pathways, to pursue graduate education in STEM fields. Enrollment data, demographic trends, and preliminary career outcomes provide insight into the learner population and their trajectories. Benchmarking outcomes against CU Boulder's on-campus programs have been challenging due to differences in learner profiles and delivery formats.

4. AI Integration in Asynchronous Online Learning

The integration of artificial intelligence (AI) tools within asynchronous online learning environments offers promising opportunities to enhance student engagement, personalize learning experiences, and support timely feedback. AI integration can provide automated tutoring, adaptive assessments, and intelligent content recommendations, enabling learners to receive tailored support that addresses individual knowledge gaps and learning preferences. For example, AI chatbots and virtual assistants can offer 24/7 help, answering questions, clarifying concepts, and guiding students through complex material without the constraints of time zones or instructor availability.

In the context of the asynchronous courses discussed, AI tools could help mitigate challenges such as student isolation and lack of motivation by facilitating interactive and responsive learning experiences. Automated analysis of student progress and engagement data can allow instructors to identify at-risk learners earlier and intervene proactively. However, the deployment of AI in online education also raises concerns, including equity of access to technology, the risk of over-reliance on AI-generated solutions that may diminish critical thinking, and privacy considerations related to data collection.

The feedback from our ECEN 2250 and ECEN 2350 courses highlights these challenges, particularly with some students relying on AI tools to complete assignments with minimal engagement. Thus, careful integration of AI should focus on complementing, not replacing, meaningful instructor-student interactions and fostering a supportive learning community.

Combining AI tools with well-designed asynchronous curricula offers a pathway to create more engaging, personalized, and equitable online learning experiences. Further research is needed to evaluate the effectiveness of specific AI tools, develop the best practices for their ethical use, and explore how AI can support both learner autonomy and instructor facilitation in asynchronous settings.

5. Conclusion

This paper has examined the opportunities and challenges inherent in delivering fully asynchronous online courses and degree programs in engineering and science fields. Drawing on case studies from core undergraduate courses and graduate programs at the University of Colorado Boulder, we identified key factors influencing student engagement, learning effectiveness, and equity. While asynchronous formats provide valuable flexibility, particularly for nontraditional learners and working professionals, they also present unique difficulties, including maintaining motivation, fostering interaction, and ensuring access to necessary technologies.

Our experiences with the ECEN 2250 and ECEN 2350 courses illustrate that success in asynchronous learning depends heavily on student motivation and the design of interactive, scaffolded content supported by timely instructor engagement. The contrasting outcomes of these courses underscore the need for continuous adaptation and thoughtful program design. Additionally, CU Boulder's fully online master's degree programs demonstrate innovative approaches to admissions, credentialing, and flexibility that broaden participation but require ongoing assessment to ensure academic quality and career alignment.

AI integration emerges as a critical area for future advancement, with the potential to enhance personalization and scalability of asynchronous education while raising important ethical and practical considerations. Ultimately, creating effective asynchronous programs involves balancing flexibility, engagement, and support to serve a diverse learner population.

6. Policy-Relevant Recommendations

- **Support Performance-Based Admissions with Preparedness Interventions**: Institutions adopting non-traditional admissions models such as performance-based pathways should provide structured academic support and early diagnostics to ensure student readiness and retention.
- **Incentivize Instructor Presence and Engagement:** Funding and workload policies should recognize the significant time commitment required to design and support high-quality asynchronous courses. Faculty compensation models must reflect these demands.
- **Promote Ethical and Equitable Use of AI Tools:** AI integration should be governed by clear institutional policies that prioritize transparency, privacy, and equity. Training for both faculty and students on ethical AI use is essential.
- **Expand Access to Virtual Lab Infrastructure:** Public investment or university-level funding should support scalable, cloud-based simulation and FPGA tools to ensure that all students, regardless of location, can engage with hands-on learning in technical disciplines.
- **Standard Assessment and Quality Metrics Across Modalities:** Asynchronous online programs should not be evaluated in isolation. Development of consistent metrics to benchmark learning outcomes and career trajectories across online, hybrid, and in-person programs is essential.

- **Build Sustainable Feedback Loops with Employers and Students:** Institutional policies should mandate continuous feedback from both learners and industry partners to ensure programs remain aligned with evolving workforce needs and learner expectations.

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