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Enhancing the Equity and Inclusivity of Engineering Education for Diverse Learners through an Innovative Instructional Design, Delivery, and Evaluation: International Students in Focus

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Abstract

In the United States, 64.9% of all engineering master's and 59.0% of all engineering doctoral degrees are awarded to international students [1]. These international students bring significant cultural and economic value to engineering education programs but face unique social, cultural, and academic challenges [27]. Therefore, we need to create more inclusive engineering education environments to enable international engineering students to overcome these challenges and to foster diverse perspectives among the engineering learning community. One way of moving towards more inclusive engineering education environments is to incorporate innovative lessons into engineering courses and curricula that consider effective instructional design principles.

This paper presents the processes of designing and delivering an innovative instructional lesson to reach more diverse students to enhance the inclusivity and equity for international engineering graduate students. To this end, I developed, delivered, and evaluated instructional lesson on the topic "Traffic Signals Coordination along the Street" that engaged diverse engineering graduate students, domestic and international. The lesson contributes to addressing disparities in efforts (between domestic and international students) in navigating cultural differences, thus improving equity and inclusivity in engineering education. I developed this pilot lesson as part of an assignment in a graduate class where we were challenged to design and deliver innovative instructional lessons. Using this opportunity, I considered instructional design elements and modified Bloom's Taxonomy of cognitive learning theory [2] to create effective instruction that adds to the efforts to address equity and inclusivity in engineering education.

The Analyze, Design, Develop, Implement, and Evaluate (ADDIE) instructional design model [9] was used to frame the design of the lesson: identify needs, learners' characteristics and task analysis, delivery modalities, design of active learning strategies, and continuous assessment techniques. This paper shares the procedures I followed to design, deliver, and evaluate this more inclusive and equitable lesson for domestic and international students. In addition, two reviewer groups composed of four graduate students and three instructors conducted a summative evaluation of the delivered lesson. The feedback from the reviewers suggests that the lesson could help enhance the inclusivity and equity of education for international graduate students in engineering education.

Keywords: Instructional design, inclusive lessons, diverse learners, international graduate students, higher education

Introduction & background

Higher education institutions in the United States regularly enroll domestic and international students [18]. These domestic and international students have diverse backgrounds, cultures, and identities. Additionally, these student groups are from different education systems; hence, they have various educational backgrounds, professional opportunities, and experiences. Education in the United States is not homogenous. There is a range of educational opportunities available to United States students, with some students from more affluent parents having ample opportunities and higher quality education. Students from low-income and minority students are concentrated in the least funded schools with varying opportunities even within districts [11]. For domestic students, despite the diversity in their states, the diversity in their education is less likely to be as high because all are exposed to a similar education system, the United States education system. However, for international students, the difference is more significant across two fronts. First, the education systems differ globally—the significant difference between the United States education system and their home countries. Second, continentally/regionally-- large difference among the education systems of home-countries or regions international students are from [13], [30]. Despite these differences in education exposure, prior scholars' findings show that these student groups are generally exposed to similar engineering education, predominantly the United States education systems, for instance, ABET Standards [39], norms [39], cultures [38], and approaches [38]. These could diminish the equity of education and learning experience between domestic and international students, for instance, in the efforts to adapt to the American higher education system's norms, cultures, and expectations [30].

One of the reasons that international students have wanted to come to United States universities is to prepare for careers, either in the United States or in their home country [13]. In addition, studies show that the United States universities add skills and experiences that make international students better candidates for jobs and help them compete on a global scale [10], [17]. Many international students in the United States are from China, India, Saudi Arabia, Japan, and South Korea enrolled in Science, Technology, Engineering, and Mathematics (STEM) disciplines [13]. The diversity in countries of origin of international students means that these students were from different education systems, cultures, and identities. At times, this makes them face diverse challenges such as difficulty adapting to the host country's culture, loss of social support, language barriers, anxiety, and difficulty adjusting to academic expectations [35].

Beyond challenges, the diversity among international students, their experiences, and the engineering education systems they were exposed to can also be an asset for engineering education [12], [37]. The diversity in their background may add to the diversity in thinking, innovation, and perspectives in engineering education. The unique challenges that these diverse international students encounter may also be a source of research topics for the engineering community. Thus, enhancing the equity and inclusivity of international students may lead to more just and broadened engineering education.

Equitable engineering education also enhances students' sense of belonging to their engineering discipline, college, university, and engineering community. In education institutions, a sense of belonging is a fundamental need for international learners to belong and feel valued as members of the engineering community [20]. For the engineering community (faculty, advisors, administrators, and staff), understanding the experiences that contribute to international students' sense of belonging is essential as a sense of belonging has a positive impact on the students' academic integration and persistence in programs [20], [21], [32]. However, a recent study [29] reports that fewer facilitators of a sense of belonging exist within STEM doctoral program environments than in non-STEM programs. In addition, [15] indicates doctoral engineering students' sense of belonging is relatively lower than non-engineering doctoral students' and suggests that international students' sense of belonging status can impact the course and program level enrollment and persistence.

Instructional design framework: ADDIE

The analysis, design, development, implementation, and evaluation (ADDIE) instructional framework is used to design, develop, and evaluate effective instruction for a diverse student group [9], [26]. In addition, instruction designer scholars and training developers use the ADDIE framework to describe iterative instruction design tasks and design a process-based approach to learning contents [7], [8], [9], [28]. In particular, ADDIE is an instructional design system that considers the principles and procedures by which instructional materials, training, learning lessons, and the whole system can be developed consistently and reliably [24], [25], [26].

The ADDIE instructional framework consists of five phases that define the development of instructional materials that can be applied to teaching practices across disciplines [26]. These five iterative phases help practitioners and subject-matter experts systematically design instructions [9], [26], [31]:

- Analyzing a learning situation
- Designing objectives and principles to address the needs in learning situations
- Developing instruction materials to meet the needs
- Implementing the learning resources in learning situations; and
- Evaluating how the designed instruction materials addressed instructional needs [8], [9], 26].

The ADDIE instructional framework emphasizes designing instruction through conducting the need assessment on the learners' characteristics to meet learning outcomes. Morrison [26] and [9] have explored the importance of instructional design in promoting an inclusive learning environment. In addition, effective instruction design helps the learning be more efficient, effective, and less difficult for all student groups. Recent studies [26], [30] indicate that effective instructional design will meet the needs of diverse students, that the designed material will be attractive, and that well-organized instruction fosters critical thinking and deep understanding.

The instructional design makes a difference in improving the overall learning process by considering students' learning experiences and needs. Thus, it is an effort to bridge the gap between instructional content and diverse students' engagement and comprehension. In addition, the design of effective instruction and delivery approaches can create opportunities for instruction intervention to facilitate the understanding of the newly designed instructional goals and objectives. This helps instruction designers and subject matter experts design instructional material comprehensively by incorporating creativity skills during the instructional material development phase. Likewise, developing an effective instructional design for diverse learners helps to disseminate learning content by adjusting pedagogies [multimodal instructional strategies] that result in efficient, effective, and appealing learning situations [26]. In doing so, the instruction designer masters the needs and characteristics of diverse learners that would be an input for instruction designers and course experts to include diverse perspectives for all student groups: international and domestic, contributing to an equitable learning experience. Moreover, adopting effective instructional design and delivery can help further to innovate the teaching-learning process in engineering learning environments. This happens by considering how the diverse learning background of international and domestic graduate students can be handled for education equity and inclusivity goals in engineering education.

Designing effective instruction for engineering education students

Designing effective instructional materials for the engineering community takes various approaches. This includes effective instruction delivery and developing effective materials by which curricular designers create high-quality learning for diverse student groups [26]. While designing instructional material for diverse engineering groups, the designer considers learners' identities [26]. Evidence-based established instructional models help in developing more engaging and inclusive lessons. An effective instructional design of course contents, delivery, and assessment can help engineering education become more inclusive and equitable for diverse learners. Effective instruction design encourages the lesson designer to identify content, topics, objectives, and learning tasks for various student groups. Well-designed instruction could help international graduate engineering students highlight their assets, overcome some of their unique challenges, and gain skills, knowledge, and experiences [4], [26].

Purpose: This paper aims to share an experience of designing more engaging instructional lessons to address the equity and inclusivity of engineering education for international engineering graduate students. To this effect, it addresses the following research question:

1. How can engineering educators design and develop more engaging instructional lessons to enhance the equity and inclusivity of engineering education for international engineering graduate students?

Positionality statements

I, the author of this paper, am a second-year, international Ph.D. student studying Engineering Education Systems and Design at Arizona State University. I earned my undergraduate engineering degree at Hawassa University, and Master's degree at Arba Minch University, both in Ethiopia. While studying my doctoral degree in the United States, I have been exposed to students and faculty from diverse backgrounds, domestic and international. While I am open and eager to learn diverse perspectives from the diverse engineering community, I am also observing and experiencing some differences between the United States education system and the education system from my home country. Previously, I had a teaching experience of four years in public higher education [a university] in my home country. While I was teaching students from diverse ethnic, religions, regions, and linguistic and cultural backgrounds, I was curious how the university and engineering educators provide equitable engineering education for all. As an engineering educator, I tried to design the contents of the courses I taught by considering the diverse needs and backgrounds of the students to provide them equitable learning for all. When I became a doctoral student myself in the United States, where the diversity of students became even larger and more complex, I am experiencing and recognizing the importance of considering students' diverse backgrounds and needs to provide an equitable learning experience. Part of my research interest is focused on exploring how different initiatives might be designed to ensure education equity for all students. My learning experience in the United States inspired me to extend what I previously started to work on and share with the larger engineering community.

Instruction design and methods

The pilot instructional design was conducted on thirteen graduate students majoring in Ph.D. in Engineering Education Systems and Design (EESD). While designing the instructional lesson, I used the Analysis, Design, Development, Implement, and Evaluation (ADDIE) instructional design model to make an effective instructional design lesson [26]. I conducted a need analysis to identify the performance gap in the analysis phase: the discrepancies between the desired and actual performances [26]. In the design phase, I explored how to integrate learning experiences and learning materials [8], [26]. In the development stage, I focused on creating and developing learning materials/experiences [8]. During the implementation stage of the designed pilot lesson, the delivery of the designed learning materials, contents, learning tasks and experiences, and assessments were conducted [33], [34]. The quality and effectiveness of the designed instructional materials were conducted during the formative/continuous evaluation phase, intentionally making evaluation a part of every design stage activity [23], [26]. Finally, as a part of the summative evaluation, two reviewer teams, graduate students, and course instructors reviewed the lesson materials and their delivery and provided feedback.

Context

I extended the EGR 598 Topic: Innovation and Design of Engineering Academic Settings course project conducted during the 2021 Spring semester to address educational equity and inclusivity for diverse engineering student groups. The pilot instructional materials were designed for graduate engineering students. I followed the procedures to identify the instructional topic and need analysis:

Step 1: I brainstormed ideas to identify the needs in teaching and learning in engineering education for diverse graduate student groups. Chatting turn by turn with engineering students: both international and domestic students, I shared their thoughts concerning the needs in teaching and learning in the zoom breakout room. With students, I discussed the challenges and benefits of designing effective instruction for diverse student groups in a teaching and learning environment with both international and domestic students. After identifying the needs, and instructional topic, I decided to develop an inclusive lesson for international graduate students. Then, I shared these ideas to be a base for the lesson topic with classmates.

Step 2: I provided a pitch speech on a selected topic, "Traffic Signals Coordination along the Street," to my peers in the class. At this stage, I received feedback from classmates and course professors.

Step 3: I then designed a video lesson that aligned with the selected topic and incorporated the feedback from step 2. This included preparing the lesson by considering diverse pedagogies of engagement and essential elements of the instructional design.

Step 4: Then, I went through a summative review process of the designed lesson. Two groups conducted the review and received feedback from four graduate students and three subject matter course instructors— and recorded positive and constructive feedback/ideas for improvement. Feedback at this stage revolved around the significance of the selected topic and the action plans to improve it.

Results: Designing effective instruction for engineering education students

To design an effective instructional lesson, previous scholars' findings and instructional design framework were explored. In addition, by considering the EGR 598 Topic: Innovation and Design of Engineering Academic Settings course's project goals, which involved adapting to the new education culture in the learning classroom, I employed eight comprehensive and interrelated procedures to design an effective instruction lesson: a) analyzing the needs of target audiences, which means identifying the problems that we are dealing with, b) conducting learners' characteristics analysis, c) setting instructional goals, d) task analysis and content sequencing, e) designing instructional objectives, f) designing instructional strategies and assessments, g) developing instructional materials, and h) evaluating instruments [9], [26] as shown on Figure 1.

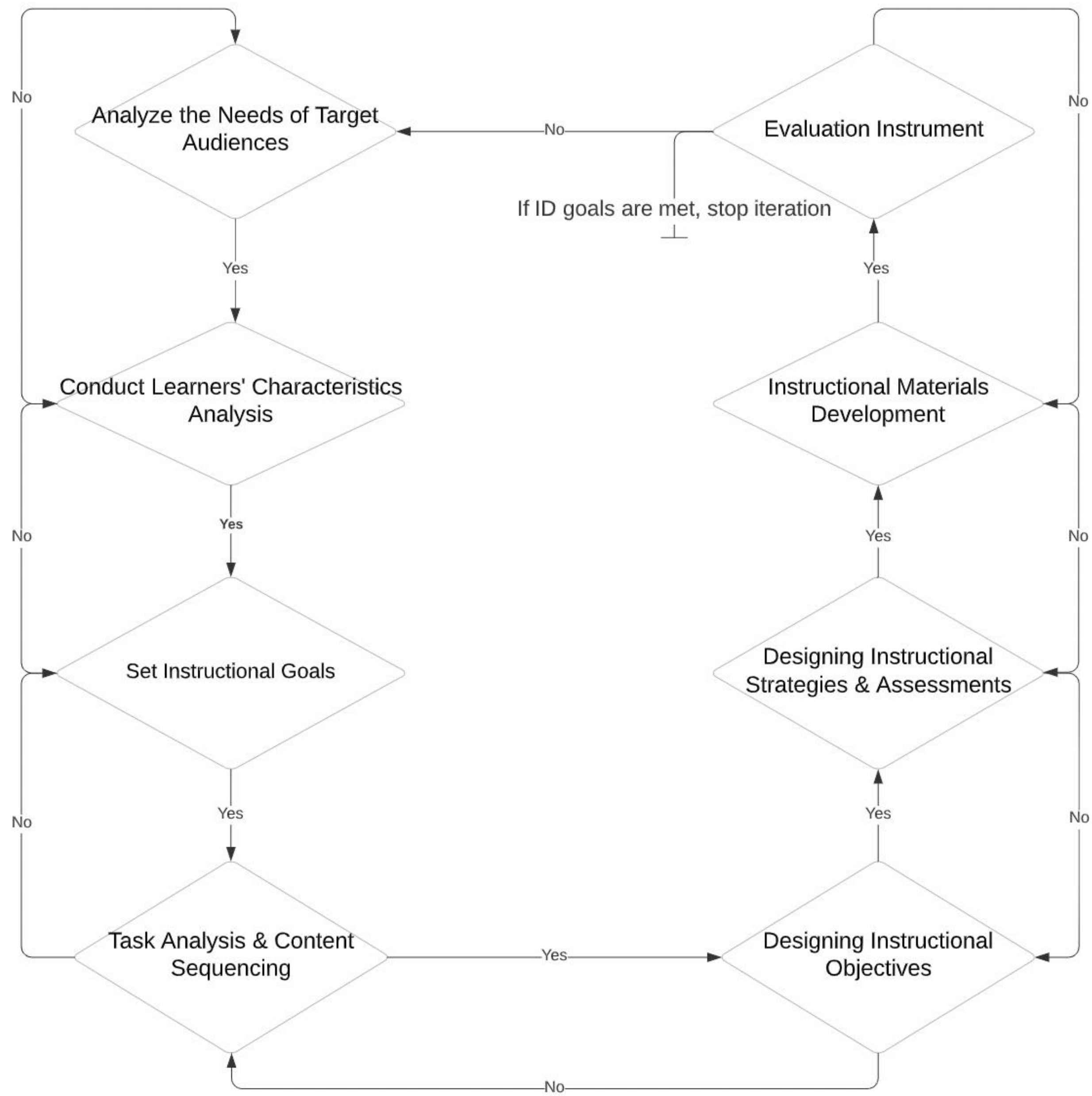

Figure 1: Hypothesized comprehensive and interrelated procedures to design effective instruction lesson

The topic of the designed lesson was *Traffic Signals Coordination along the Street,* and the comprehensive and interrelated procedures used for instructional design elements were incorporated in ADDIE instructional design phases. In the following sections, I summarized the hypothesized comprehensive and complementary instructional design procedures through ADDIE instructional design model phases [26]:

A) **Analysis**: I identified two instructional design elements during the analysis phase. First, I conducted a need assessment to conceptualize and identify the need to set instructional goals [26]. Second, I analyzed tasks and target learners' characteristics. The general learner's characteristics include gender, age, ethnicity, educational level, and international/domestic makeup of students [9]. In addition, I identified students' prerequisite knowledge and skills: whether all learners have an engineering knowledge background and if they majored in engineering disciplines. Analyzing such learners' characteristics was critical in designing and delivering more engaging and inclusive lessons for learners of diverse identities. Finally, in the task analysis stage, by identifying the content structure of the lesson and domain of learning, I analyzed what knowledge and procedures were needed to deliver subject contents and analyze the instructional contexts [26], [33], [34].

Table 1

Task analysis of pilot lesson: traffic signals coordination along the street

Task Analysis	
Topic	Traffic signals coordination along the street
Goal	Traffic engineering students will demonstrate how to provide continuous traffic flow along with a series of signal intersection

1 Traffic Signal Coordination
- 1.1 Introduction to traffic signal coordination
- 1.2 Types of signal coordination
- 1.3 Important terms/elements of signal coordination
  - 1.3.1 Signal intersection
  - 1.3.2 Traffic signal
  - 1.3.3 Signal timings
  - 1.3.4 Corridor
  - 1.3.5 Traffic vehicles

2 Importance of Signal Coordination on Traffic Flow Parameters
- 2.1 Intersection capacity
- 2.2 Traffic congestion
- 2.3 Traffic flow operations and directions
- 2.4 Traffic flow

3 Traffic Signals Coordination Approaches
- 3.1 Simultaneous approach
- 3.2 Simple progressive approach
- 3.3 Flexible progressive approach

A) **Design**: during the design stage, I developed instructional objectives, assessments, and instructional strategies. According to Morrison et al. [26], the instructional objectives provide two essential functions for the instructional designer. First, it helps the instruction designer select and organizes instructional activities and resources to facilitate effective learning. Second, instructional objectives provide a framework for evaluating students' learning, for instance, measuring students' achievement with assessment items. In doing so, I identified the objective domain of the task analysis as a cognitive learning domain that emphasizes intellectual aspects of learning [2], [3]. Based on the task analysis result, I developed three instructional objectives that the learners would need to achieve to master the contents as described in appendix table 1. While designing instructional objectives, I considered action verbs with subject-content structure, level of achievement, and performance conditions [26].

Design of instructional assessment: While developing assessment instruments, I considered a sequence of subject content and the types of instructional objectives [26]. Then, I identified assessment techniques aligned with the knowledge stated in instructional objectives as described in appendix table 1 [9], [26].

Design of instructional strategies: In designing instructional strategy, I identified different instructional strategies that help the learners integrate the existing knowledge into the new knowledge and scaffold their learning to master the skills and knowledge specified in the objectives. To demonstrate effective design, I considered two essential elements. First, the initial presentation to provide an outline of information/contents associated with stated goals and identify the methods of instruction of lesson contents about each objective. Second, I considered the generative strategy to describe the instructional strategies that would enable learners to practice lesson competencies [26].

In addition, descriptions of how the learners would receive feedback on the practice activity and what kinds of feedback would be provided to learners were included. Following this, I designed active (student-centered) instruction. In doing so, I used active learning methods such as individual attempts, pair work, small group work, and brainstorming to further discussions of the lesson materials. I continued to monitor students' understanding throughout the lesson via diverse continuous assessment strategies, e.g., observing students' performance and quick questions. Finally, I checked the attainment of the lesson objectives by checking students' understanding throughout the lesson before transitioning to the next part, as well as through overall lesson assessments, a short quiz, asking questions, and objective-checking with the students [9], [26]. These processes are further indicated in appendix table 2.

B) **Development:** I created and assembled the subject contents developed in the design and development phases. During the pilot lesson, I prepared instruction material, put the lesson-related technical pattern words using videos to present the instruction contents, and directed learners' attention as per instruction contents design and instructional strategies [26]. In doing so, I produced the recorded video: the delivery of the developed lesson for diverse engineering students.

C) **Implementation:** The designed lesson was implemented and delivered to the students in the implementation phase. After the delivery, the effectiveness of the developed lesson was evaluated by target learners and instructors, the subject-matter experts [14].

D) **Evaluate:** I conducted formative evaluation and revision from the early need analysis stage to the final stage of the instructional materials development [26]. Four assigned graduate students and three instructors conducted the review process. During this pilot instructional design, the procedures followed to provide a summative lesson evaluation are presented below.

Step 1: Four EESD graduate students were assigned to review the developed instructional materials (the recorded video).
Step 2: During the review, all reviewers noted:

- What aspects of the lesson's content structure were found to clarify the topic?
- What aspects of the lesson needed improvement to bolster learners' understanding?
- The overall assessment of the asynchronous instruction in the video lesson?

Step 3: All reviewers individually reflected on the effectiveness of the designed video lesson, provided feedback in the form of a voice thread, and posted comments.

Step 4: All reviewers had an open discussion about the components of an effective instructional lesson.

Step 5: One reviewer from the reviewers' team was assigned to recap feedback to all classroom students.

Table 2
Demographic identity of reviewer teams -- graduate students

No	Reviewers (pseudonyms)	Major	Year in program	Gender	Reviewer identity
1	Olivia	Ph.D. in Engineering Education Systems and Design	4th	Female	US resident student /domestic student
2	Alexander		2nd	Male	International student
3	Victoria		3rd	Female	US resident/ domestic student
4	Jackson		3rd	Male	International student

The graduate engineering students conducted a summative evaluation to evaluate the relevance and comprehensiveness of instructional material development and delivery [26], [9]. They provided detailed feedback on the organization of the contents, setting introduction, designed instructional objectives, students understanding of checkpoints, active teaching, learning strategies, multimodal learning, assessment techniques, and presentation skills.

Table 3
Demographic identity of reviewer teams-course instructors

No	Reviewers (pseudonyms)	Roles	Gender	Department
1	Dr. William	Faculty	Male	Engineering Education Systems and Design

2	Dr. Michael	Faculty	Male	Engineering Education Systems and Design
3	Levi	Teaching assistant	Male	Engineering Education Systems and Design

Similar to the evaluation conducted by the student group, instructor-evaluators composed of two-course faculty and a graduate teaching assistant reviewed the developed material and its delivery. On behalf of the faculty reviewer team, one of these team members provided summative feedback on the recorded video lesson.

Generally, as subject-structure contents of pilot lessons situated in the cognitive learning domain, I used the cognitive learning theory throughout the design of instruction to include essential instructional design elements and provide concrete information [2], [3], [26]. In addition, the cognitive domain of learning was used to identify, understand and analyze the information covered and formulate a new understanding by integrating pre-existing knowledge, skills, and experiences [5], [6]. In doing so, I applied cognitive perspective learning throughout all elements of effective instructional design. Formative evaluation and revision processes were conducted. The two reviewer teams, graduate students, and course instructors provided summative evaluation and feedback to further improve the lesson's design.

Some of the common positive feedback provided by students and instructors were:

- Addition of lesson objectives and how it was framed with videos
- Great introduction and clear objectives
- Before transitioning to the next lesson topic, suitable interactive activities with students helped review and reflect on the lesson.
- The concise lesson content and absence of ambiguity in the delivery
- A great definition of concepts and great transitions through the lesson
- Good use of visual diagrams and video clips that helped to visualize and contextualize the actual environment (to correlate the theoretical knowledge with a video showing real-world practical applications) that also engage and see the application of signal coordination on the roadway
- Great efforts in checking students' understanding throughout the lesson before transitioning to the next part (use of formative evaluation)
- Starting the lesson by communicating with lesson objectives and a preview of lesson contents
- Clear delivery of the lesson using diagrams to concretize abstract contents and tie them to real-life situations
- Using different media for the content presentation: auditory/lecture, visual/videos, diagrams, and pictures
- The presentation is supported by examples from different world countries and s ample examples taken from Ethiopia and the United States, which helps learners see and understand various methods to apply the same engineering concepts and skills across different global countries.

Constructive feedback includes:

- Inconsistent voice; in a few places the use of fast voice, and low in others
- The need to improve or have animation in power point presentation
- The need to show classroom tasks in turn rather than showing two activities on the same page
- The comments to build-in more engaging activities and video savviness to aspects of the lesson that are fun for students.

Future work and limitation

Effective instruction design for diverse student groups in engineering education is one of the initiatives designed by scholars to include education equity and inclusivity in teaching and learning environments. This project study was conducted during the Covid-19 pandemic of the 2021 Spring semester. Thus, the interactions with learners while identifying the needs, design, and delivery were over Zoom technology. Furthermore, the covid-19 pandemic limited the interactions between students and instruction designers. Thus, the involvement of students in design was limited. Yet, the researcher made all efforts possible to enhance the inclusion of students in the designed instruction by including student groups, as indicated by the two international students and two domestic students. In addition, they served as reviewers and provided feedback. In the future, the researchers will extend the study on the topic by including the input from learners in different aspects of lesson design.

Discussions and implications

During this pilot instructional design, an active approach to designing and delivering more engaging and inclusive lessons was implemented. While designing interactive and inclusive instruction for engineering learners, I introduced cognitive learning theory in all instructional design phases and incorporated practical examples from the real-world [3], [26]. The pilot lesson, a concrete example of how to design and deliver effective instruction for diverse engineering students, was developed by analyzing four fundamental instruction design components: a) For whom was the instruction to be developed? b) What do you want the learners to learn? c) How are the subject contents best learned? d) How do the instructors determine the extent to which learning is achieved?, which aligns with previous instruction design in academic settings [6], [26]. The ADDIE instructional model phases were used to structure instructional materials development and help with systematic instructional design [26]. Relying on scholarly and professional literature in the needs analysis, setting instruction goals and objectives, and designing and evaluation phases helped to focus and refine my efforts to develop more engaging and inclusive instructional content and learning experiences.

The pilot lesson was developed innovatively through instructional need analysis to instructional materials development to deliver effective instruction by engaging diverse student groups in engineering education. In addition, in the instruction design stages, I focused on engaging the diverse student groups with lesson contents, among each other, and with instructors in innovative ways. I designed instruction by integrating multiple instructional methods, for instance, multimedia: audio/lecture, pictures/diagrams, labels as well as videos, which reveal the innovative teaching and learning strategies in engineering education. The continuous assessment techniques were consisting multiple choices, pair discussions, and home-based application writing assignments. Half of the graduate students were an international student group who reflected on how the designed lesson included them during the delivery of the lesson, as evidenced through their feedback. This signals the effectiveness of the designed lesson in enhancing the inclusivity and equity for all students, domestic and international, and has potential effects on the quality of learning among diverse learner groups.

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Appendix

Table 1
Instructional assessments design of pilot lesson: traffic signals coordination along the street

Instructional objectives (IO)	Type of instructional objectives*	Type of assessment	Sample assessment items
IO 1: Using provided instructional material of the lesson, at least 12 out of 13 students will define the traffic signal coordination	Fact/recall	Constructed response test: short answer item	1. Define traffic signal coordination. 2. The traffic control device that helps to regulate and operate vehicles along different directions is a(n) _______.
IO 2: Using the provided instructional material, the learner will explore the importance of signal coordination, and enumerate at least three advantages of signal coordination	Fact/concepts	Objective tests: multiple-choice item	1. The following is/are the benefit/s of signal coordination, which one? a. Reduced traffic congestion b. Improved traffic flow c. Increased intersection capacity d. All of the above
IO 3: Given designed instructional material, the learner will design signal coordination along the street with simple progressive approach within 45 minutes	Procedure	Constructed response test: problem-solving questions	1. Using a simple progressive approach, describe the major steps you would use to design signal coordination. 2. In your locality, identify the common types of signal coordination (Simple, Simultaneous**,** Flexible), and write a one-paragraph summary report analyzing why (e.g., advantages) that particular type of signal coordination is preferred.

Note: * = All three instructional objectives of the learning lesson fell in the cognitive learning domain. Based on content categories, it is classified as either*, fact, concept, principles, and rules, procedures, interpersonal, or attitude* [26], which helps to determine the level of learning, instructional strategies, and assessment types.

Table 2
Design of instruction and instructional strategies of pilot lesson: traffic signals coordination along the street

Instructional objective 1: Using the provided instructional material, at least 12 out of 13 students will define traffic signal coordination. *Fact/recall**
Initial presentation: First, ask if students have any background knowledge about traffic signal coordination. Then, present the definition of traffic signal coordination and types of traffic signal (pedestrian traffic signal, fixed time traffic signal, and actuated traffic signal). Do this by integrating audio/lecture, video, diagrams, and elaborative questions. Third, present the definition of essential elements of signal coordination.
Generative strategy: Ask learners to develop a mnemonic representation of types of traffic signals and important signal coordination terms that help them remember and recall. The learner receives detailed feedback on the students-generated mnemonic descriptions of the traffic signal types and essential terms of signal coordination through the course's canvas webpage.
Instructional objective 2: Using the provided instructional material, learners will explore the importance of traffic signal coordination, and enumerate at least three advantages of signal coordination. *Fact/concepts**
Initial presentation: Explore the importance of traffic signal coordination in the context of traffic flow parameters (e.g., traffic flow, intersection capacity, traffic density, travel time, etc.) through benefit comparison table show, audio, lecture, and demonstration videos. Identify and present the advantages and disadvantages of signal coordination by organizing students into pair or small group discussions. Throughout the lesson, check if some or all students are struggling to understand, or mastering lesson objectives (continuous assessment).
Generative strategy: Ask the learners to list the similarities and differences between traffic signal types. Ask the students to list the advantages of signal coordination and organize them into small groups for discussions. The learners receive detailed feedback supported with a resource link attached to the course's canvas. Also, provide feedback directly in the classroom by acknowledging and appreciating learners' efforts: the strengths and areas for improvement.
Instructional objective 3: Given the designed instructional material, the learner will design signal coordination along the street with a simple progressive approach within 45 minutes. *Procedure**

Initial presentation:	Explore traffic signal coordination approaches and identify the best signal synchronization approach in optimizing the benefits of signal coordination through comparison table shows, audio lecture, video, integrative, and organization strategies. Highlight each approach's characteristics that reflect common features (e.g., how each approach is used to design signal coordination) in different signal coordination approaches. Describe step-by-step procedures of how to design signal coordination with a simple progressive approach. Use illustrative examples of signal coordination by simple progressive approach to explore the errors and challenges through demonstration and practice.
Generative strategy:	Ask the learners to list the procedures of how to make signal coordination with a simple progressive approach. Encourage students to practice and design signal coordination for existing geometric and existing traffic conditions. Ask the learners to identify their procedural errors and challenges. Provide the learners with detailed feedback directly in the classroom and keep the detailed feedback on the course canvas as well. Encourage students' self-reflection, asking questions, and identifying areas they are succeeding on and areas that need more work.

Note: * = All three instructional objectives of the learning lesson fell in the cognitive learning domain. Based on content categories, it is classified as either, *fact, concept, principles, and rules, procedures, interpersonal, or attitude* [26], which helps to determine the level of learning, instructional strategies, and assessment types.