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Board 247: ECE-WisCom: Enhancing Student Performance and Persistence through a Wisdom Community

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ECE-WisCom: Enhancing Student Performance and Persistence through a Wisdom Community

Abstract

The idea of contributing to a better and more inclusive academic environment for minority Electrical and Computer Engineering (ECE) students lies in recognizing their value and significant role at New Mexico State University (NMSU), a Hispanic-Serving Institution (HSI). The Wisdom Community (WisCom) framework among ECE students and faculty proposed in this work is an academic research project funded through the National Science Foundation (NSF) HSI program. The innovative component consists of the development of an online mixed-reality (MR) ECE-WisCom platform, which is accomplished through an interdisciplinary approach involving the fields of engineering, education, computer science, and sociology. The MR environment serves as a place to support core WisCom activities online, linking together both physical and online learning spaces. Through iterative human-centered design, the project includes a participatory design process focusing on the ECE student community. The MR also includes pedagogical virtual companions that students can rely on for different purposes such as increasing interactions, finding resources, identifying peer/faculty mentors, and improving their learning skills. The use and impact of the ECE-WisCom is evaluated through a mixed-methods approach. The collection and analysis of data include surveys, network interactions, journaling, interviews, observations, and focus groups. The analysis considers student community formation, identity development, and academic performance as well as participant intersectionalities. Overall, the ECE-WisCom seeks to improve the college experience of engineering students by supporting their learning process and socialization, a couple of skills relevant and with lifelong impact in college and beyond.

Background

Recent studies show that, while 58% of White students persist in earning a STEM degree, the percentage of Latinx students who persist is only 43% [1]. This NSF-funded project takes place at New Mexico State University (NMSU), a Land-Grant and Space Grant Hispanic-Serving Institution (HSI) that enrolls a large Latinx and multicultural student population including 58% Latinos, 27% whites, 5% nonresident aliens, 3% African Americans, and 2% American Indians [2]. In particular, Electrical and Computer Engineering (ECE) students are student populations that need to grow, as ECE students represent only 2% of the total NMSU student population [3] despite the importance of this field in our modern society. This project is a work in progress whose research goal is to develop and evaluate iteratively an online mixed-reality (MR) wisdom community (ECE-WisCom) to support resilience in ECE students.

The proposed educational and research program envisions serving and retaining a diverse pool of students beyond the traditional Engineering profile, such as women, non-traditional students, LGBTQ, non-native English speaking, first-generation, international, veterans, and low-income students [4, 5]. These characteristics intersect with the multiple identities each student has. For example, the experiences of a Latina student living in a border region from a low-income area differs from a White male student from Colorado from an upper socioeconomic class, despite both pursuing the same Engineering degree at NMSU. The project aims to reach those vulnerable and at-risk students who may drop out due to feeling that they do not belong, are not welcome in the Engineering community, are ill-prepared for success, have personal responsibilities that interfere with their study time, or other factors.

Need for an equitable ECE-WisCom in NMSU's ECE program

In a survey given to 16 NMSU students, 32% responded that they did not feel part of their degree program's community, and 100% said that it would be helpful to their professional growth to connect with faculty and students online beyond coursework. Lack of sense of belonging coupled with the challenging and time-consuming nature of ECE-domain problems leads to drop-out. Current instructional models require that when students need help solving engineering problems, they most likely have to wait for the availability of their instructor. However, students often need immediate support and guidance to simultaneously cope with multiple academic obligations. Due to COVID-19, many students are learning online and most report feelings of isolation and detachment while learning separate from a brick-and-mortar campus. A frequent criticism of this modality of learning is that some teachers do not yet know how to teach well online [6]. Even on brick-and-mortar campuses, numerous students report a sense of isolation, especially those who are minoritized. A related issue is that faculty members are commonly detached from most students other than those that they advise [7,8] and they rarely form solid bonds or a shared knowledge base with students. This lack of access to support exacerbates the isolation of minorities. The fact that many students have effectively learned how to collaborate and learn online paves the road for online learning communities.

The WisCom framework

Given the problems described above, to address a better integration of key elements in ECE students' education and socialization, our team of electrical engineers, computer scientists, and educators is iteratively developing and evaluating an MR wisdom community (ECE-WisCom) to support resilience in ECE students where human and virtual pedagogical companions interacting with each other can facilitate the development of the ECE-WisCom. We are posing three hypotheses as follows:

(i) the diverse knowledge, experiences, and perspectives of a multidisciplinary group of faculty and students will enhance student's sense of belonging in a learning community, identity development, and academic performance,

(ii) the ECE-WisCom will encourage faculty to become naturally involved in pedagogical efforts tailored to a broad student body with particular needs,

(iii) this framework will foster a variety of co-mentoring relationships and thereby increase communication and social networking within the ECE department and with the broader ECE community.

The Wisdom Communities (WisComs) Framework for distance learning generates growth of the learning community in online programs [9]. Each learner has unique knowledge, needs, experiences, culture, and expectations that, when shared, can broaden others' perspectives and knowledge bases while they benefit from those others [10]. Learners with diverse levels of competence learn from one another and their instructors. In a WisCom, learners collaboratively follow an inquiry cycle of learning challenges, exploration of possibilities and resources, continuous reflection, negotiation among fellow participants, and preservation of their new-found knowledge.

We are applying this framework to generate a learning community among ECE students and instructors [10]. Research shows that individuals in a shared academic community often interact through social media beyond their courses and become colleagues as they build their careers. To remediate the lack of belonging that our Latinx ECE students feel, sociocultural learning theories have been proposed which frame the design, development, implementation, and evaluation of our ECE-WisCom that will support the inclusion of our Latinx students [10]. Sociocultural perspectives on learning emphasize that learners develop and learn by transforming their understandings through socially shared activities. The environment will facilitate learners with diverse levels of competence learning from one another and their instructors. In online WisComs students use technologies to communicate with one another and with instructors synchronously and asynchronously - an approach that has been called "distributed co-mentoring" [11, pp. 8-9]. Learner support is also critical in a WisCom, since student retention, motivation, professional identity formation, academic achievement, satisfaction, engagement, and success all hinge on students knowing that they belong and are supported [12]. For this reason, a WisCom provides access to interactive activities and services intended to support and facilitate the learning process of each student. Learners in a WisCom collaboratively follow an inquiry cycle of learning challenges, exploration of possibilities and resources, continuous reflection, negotiation among fellow participants, and preservation of their new-found knowledge in artifacts. To cultivate ECE wisdom, our WisCom will incorporate wisdom, community, communication, technology, co-mentoring, learner support, collaborative problem-solving, and, ultimately, transformative learning, all online. Research studies provide evidence that online learning communities increase comfort, communication, and collaboration among students and instructors [13, 14, 15]. Our ECE-WisCom will use pedagogical agents to intentionally bond students and faculty socially and support each other as co-mentors. Our project aims at constructing an MR Learning Management System (LMS) around a WisCom for ECE students, where these complementary benefits will coexist and be promoted not only by participants but also by virtual agents, allowing students and faculty to collaboratively face the academic challenges encountered in STEM throughout their studies and across their degree program. What follows is an example of students interacting by using a mixed-reality platform.

Students' day (or night) at the ECE mixed reality (MR) communal space

An imagined student's experience in the WisCom follows: After dinner and putting her kids down for bed, Santana starts to work on tomorrow's circuit design homework. As usual, Santana logs in to the ECE department's MR student space, also known as the CROSNO student lounge, from home, (see Figure 1). After logging in, she quickly sees there are a few students up on campus late tonight, quite a few more are remotely logged in from home. Around the tables scattered around the room, students are diligently working while others are eating dinner and laughing about a mishap in one of their lectures earlier that day.

Santana moves her avatar to approach Angel, the virtual proctor for the room. She tells Angel over the text chat that she's hoping to work on her circuits assignment and asks if anyone else is doing the same. Angel quickly provides some links to some online discussions students have been having on Canvas about the assignment. Angel then indicates that a few students are also currently working on the assignment. He ushers Santana over to a nearby table where two other students are currently sitting. Santana immediately recognizes Eduardo, another sophomore also in circuit design, doubtless he is also working on tomorrow's assignment. He is sitting with Clarissa, a senior, whom Santana has met once before. Eduardo, like Santana, is logged in from home, and Clarissa is actually sitting in the room on campus. Santana moves her avatar to sit down at the table, her webcam video appearing on the dedicated proxy machine on the table next to Eduardo. Noticing her sitting down, Clarissa waves at Santana on the proxy. Eduardo also says "hi" from his desk in his dorm.

As it turns out, Eduardo has already worked through the first couple of problems and has been getting help from Clarissa. Santana asks if they mind if she joins in, and before long they are quickly working through assigned problems. They talk the problems out among themselves, reference the online discussion, and even answer a few questions there. When they get to the last problem, Eduardo and Santana are stumped. Clarissa suggests that they move to the shared whiteboard a few feet away (see Figure 1, below). Eduardo and Santana move their avatars to a virtual whiteboard, and thus their webcam video feeds appear on the physical board in the room. Clarissa goes over and starts working at the digital whiteboard waving at Santana and Eduardo in their new location. Eduardo throws a screenshot of the circuit up on the board. Clarissa then starts sketching over the circuit, prompting the two sophomores to solve for the current across particular legs of the circuit using Ohm's Law. Before long, they finished the assignment. They wind down for the night chatting about their other projects, games they have been playing, and how Santana's kids are doing at school. Finally, after bidding the other two goodnight, Santana logs off and goes to bed.

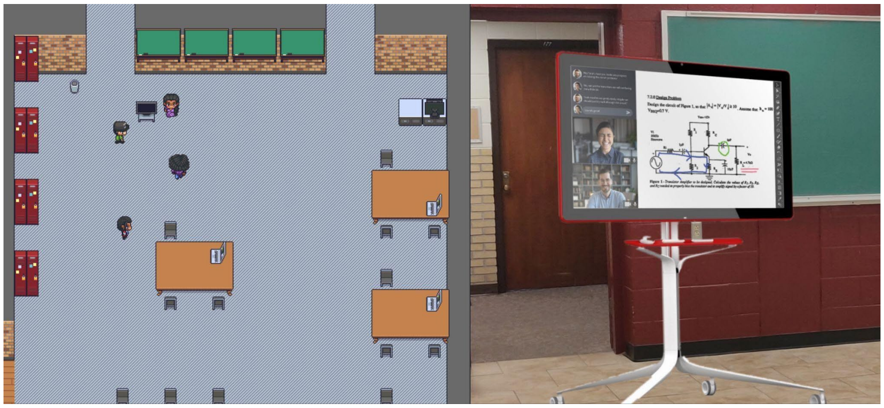

Figure 1. The MR student space (ECE-WisCom, left) will serve as a place for students and faculty both on campus and online to meet, hangout, and work. Online students will appear as virtual avatars and can inhabit various proxy machines around the room to talk with people physically in the space. Within the space, virtual agents will work to facilitate communal activities such as impromptu synchronous student co-mentoring and asynchronous online discussions. Devices such as shared digital whiteboards (right), will serve as places where both in-person and remote students can come together to work collaboratively.

Research methodology

To accomplish a successful model, the research team proposed a paradigm using educational design and development research [16]. This cycle, which is graphically depicted in Figure 2, will be repeated every three years. Given the areas of expertise of the project team, along with the diverse ECE student body and the need to reduce educational inequalities by providing underrepresented students with the opportunity to excel in STEM programs, three main research objectives are proposed:

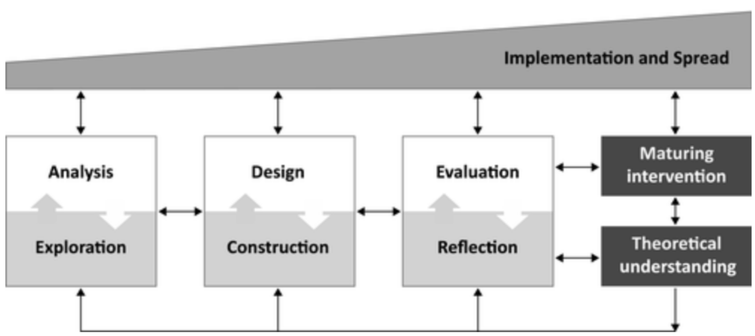

Figure 2. A model for conducting design and development research in education [16].

Research objective 1: The mixed reality ECE-WisCom platform - an online media environment to serve as a place for shared learning and co-mentoring

Our first objective is to establish an MR environment to serve as a place to support core WisCom activities online. Our initial aim is for the mixed reality environment to link together both physical and online learning spaces to afford students who are both remote and on campus to engage in social learning and mentoring activities together. This MR environment is the foundation upon which we will conduct our other activities, including deploying pedagogical companions, data collection, and evaluation. Our goal is to design a holistic media environment to foster shared learning activities critical to ECE students' success. Our hope is for students to be able to inhabit this space and transform it into a place that supports their communal learning activities [17]. The success of the research objective is based on three activities including a participatory design process of the MR platform, developing and deploying the platform, and linking existing learning media spaces.

Participatory design process

We engage in iterative human-centered design [18,19], starting with a participatory design process [20] particularly focusing on the ECE student community at NMSU. Participatory design as a methodology focuses on engaging stakeholders in the design process of innovative technologies. Our aim through the participatory design process is not only to develop needs and requirements for the planned MR platform, but also to develop stakeholders, including students, staff, and instructors, ownership in the design and resulting media place and community.

We have recruited a cohort of representative student participants to take part in a series of participatory design sessions along with other stakeholders, e.g. instructors. During these sessions, we facilitate participants engaging in several participatory design activities such as discussing their lived experiences as ECE students, lo-fi prototyping of mixed reality designs[21], and live-action role-playing WisCom learning experiences mediated by lo-fi mixed reality designs [22].

Through these participatory design activities, we derive an understanding of the needs and requirements of the ECE learning community. We then build on the design concepts developed in the participatory design sessions and our understanding of the needs and requirements of the ECE learners to develop and deploy the ECE-WisCom MR platform.

Developing and deploying the ECE-WisCom MR platform

Our next goal is to build on the findings of the participatory design process to develop and deploy the mixed reality platform. While many of the exact design choices we plan to make are dependent on the outcome of the participatory design process, we will potentially incorporate existing technologies to help support WisCom learning activities.

First, we are considering the use of the open-source project WorkAdventure [23] as the foundational environment for building our MR platform. WorkAdventure provides a 16-bit role-playing video game-style environment in which participants can control custom avatars not only to explore virtual environments but to interact with participants through real-time communication modalities such as streaming video and audio and text chat. WorkAdventure provides us with a customizable environment with the necessary features for supporting online students in interacting with one another. The platform also contains the necessary tools for collecting data about participant engagement such as how often and with whom students interact on the platform.

Beyond the online environment provided by WorkAdventure, we plan to augment a physical learning environment on campus used by ECE students. Our initial ideas about this augmentation include the incorporation of technologies such as collaborative whiteboards or tablets in the learning space. These devices will serve as windows or social proxies [24] in the virtual environment of WorkAdventure through which physically present and online community members could be aware of and collaborate. Again, our goal through this approach is to work to build community among a student population that is often not able to be present in person due to the cultural, social, and economic realities of their lives.

Linking existing LMS systems

The Canvas [25] LMS is used at NMSU to supply functionality such as digital assignment submissions and forums. However, students and instructors often informally communicate through other communication platforms such as Microsoft Teams or Discord [26] for text chat, audio, and video communications. Many instructors are relying on platforms such as Zoom [27] as online media spaces to meet for class.

While we plan to create a new media environment to support building community among students, both on campus and online, we acknowledge that the space needs to exist in this rich, already established media environment. To that end, we are taking an approach that seeks to curate and link these existing media platforms with the MR WisCom platform to create a coherent online place readily usable by students.

For example, we are linking course discussion boards and chat servers into the MR ECE-WisCom platform, with these spaces accessible through embedded representations in the virtual environment. We are doing this by creating custom interactive tools such as chatbots, web applications embedded into WorkAdventure, and modules embedded into Canvas. These tools will allow for the integration of the companions (Research Objective 2) and foster ECE-WisCom activities such as communication, organizing co-mentoring, and engaging students in the collaborative inquiry cycle across all of the existing online media spaces that ECE students already engage in as part of their participation in classes. We note though that these potential integrations and designs will likely evolve based on the outcomes of the planned participatory design process.

Research objective 2: Develop pedagogical companions to interact with participants

The second objective is to develop culturally relevant pedagogical virtual companions that will be implemented as a WorkAdventure avatar to impersonate approachable faculty and students for interacting with ECE-WisCom participants (see one potential avatar to the right). The objective behind these interactions will be to scaffold critical thinking and identity as ECE students. We consider the ECE-WisCom goals to ascertain what students need (individually) to be able to achieve those goals. Then, the companions can find (diversified) resources, i.e., relevant literature or student/faculty co-mentors, to remedy weaknesses and support learners' strengths that lead to goal achievement.

Figure 3: Potential student and agent avatars meeting in the mixed-reality platform.

The companions are being designed to ask, as a first interaction with the student participants, a set of multiple-choice questions, e.g., “What are you working on right now?”, “What concepts do you think you might need help understanding with that?”, "Who, if anyone, are you currently working with on this?". This first interaction results in a dataset that represents a coarse model, i.e., an informative representation of the student’s current strengths and weaknesses, as well as social networks. The initial interaction enables the creation of a suite of relevant learning resources and human talent residing in the ECE-WisCom LMS, which is of importance for the students, in particular, and the ECE members (students/faculty) in general. Once the dataset has been substantially populated, outcomes will be used to identify common characteristics and areas of expertise among students. Also, student and faculty interactions can inform social and co-mentoring relationships that may support the student's academic needs. Ultimately, the companion's main objective is to facilitate interactions, i.e., social/professional networking, that otherwise will never happen when students are facing classes in isolation, remotely, and/or asynchronous.

Through this technical research component, our team is creating informative models of students’ skills, knowledge, networking, and progression through the collaborative learning process. The research challenge behind this task is how to obtain and use relevant student-specific information to model cognitive and social spirit. Towards this goal, we decided to adopt the concept of machine learning-inspired modeling, as used in artificial intelligence (AI), to collect participant data relevant to enabling a virtual agent representative of the MR ECE-WisCom participants. The agent, however, will have an overall understanding of the participants' social network, academic strengths, and general areas for potential growth. This information allows the LMS to recommend resources to students, based on their inquiries and other metadata (e.g., grades) within the virtual platform and to scaffold their learning processes [28].

Research objective 3: Methodology behind the project evaluation

The third objective is to use a mixed-methods approach to evaluate the efficacy of the ECE-WisCom MR platform. This will result in a thorough analysis of the attributes of the ECE-WisCom platform that attract faculty participation and have the largest effects on ECE students' performance. The analysis considers student community formation, identity development, and academic performance all the while considering participant intersectionalities. Institutional IRB was granted for performing the data collection and publication of research outcomes.

Quantitative evaluation

The purpose of the quantitative evaluation will be to assess if and how participation in the MR ECE-WisCom platform affects three student outcomes: community formation, engineering identity development, and academic performance. We will also conduct inferential network analyses to model the probabilities of interaction patterns on the platform. The variables and analytical strategies necessary to perform this analysis are outlined below.

Independent and control variables

We will collect user metadata and analytics to track various features of platform use and how these uses change on a user-by-user basis over time. Specifically, we will track, for each user and at any given time while the platform is in use, the total and mean number of minutes spent (1) logging into the platform, (2) interacting with the companion up to that point in time, (3) interacting with student and professor users, and (4) using platform learning resources. These measures will function as our primary independent variables. Control variables will include academic and sociodemographic variables. For instance, for both student and professor users, we will collect information on age, sex, race-ethnicity, and previous experience with online learning technologies. For students, we will also gather data on academic standing, number of registered credit hours, resident vs. commuter status, and student level. For professors/instructors, we will track faculty rank, teaching load, total student enrollment across classes, and the number of online vs. on-campus courses being taught. Similar approaches performed by the researcher in charge of the online survey construction and implementation can be found in [29, 30].

Outcome variables

We will use social network analysis (SNA) to measure community development [31]. We will collect longitudinal measures for several network characteristics. We will characterize the platform user interactions as a dynamic weighted network—specifically, as a series of weighted adjacency matrices. We will treat the students, professors, and companions as a set of vertices and the interactions between them as a series of edges, where the edges are weighted by the mean duration of each dyadic interaction. We will construct these adjacency matrices at equal time intervals throughout the study; thus, there will be a matrix per time point. We will then measure how several network characteristics change over time. We will focus on network measures that proxy for community development among platform users: e.g., an increase in the number and/or strength of platform interactions and the emergence of user groups with similar interaction profiles. These profiles will be identified using community detection methods, such as modularity maximization and stochastic blockmodels [32].

By *identity development*, we mean learners' coming to see themselves as engineers and using that new sense of self to guide their sense-making and actions. The development of group identity is important to the equitable functioning of a WisCom: a sense of shared identity is critical to the future of newcomers in the community, and key to the concept of legitimate peripheral participation [10]. We will use text-analytic methods to measure the extent to which a student formulates an engineering identity throughout the study. Students will be asked to maintain an electronic diary [33] where they will be periodically asked to write about their class experiences, college peer relationships, and future ambitions. At each point when data are collected, we will use word embedding models and each student's diary entries to measure the extent to which the student uses engineering to discursively frame their experiences, relationships, and future ambitions.

Finally, we will have two measures of academic performance: the mean grade (on a 0-100 scale) across all letter-grade courses for the student during the semester in which the measurement takes place and the mean grade (again on a 0-100 scale) across all ECE courses taken by the student up to that point in time.

Quantitative analysis

Multivariate longitudinal statistical analysis of the quantitative data will be carried out in the R statistical computing environment [34]. To assess any intersectional effects of student characteristics on our four outcome variables, we will use a series of interaction terms to model how sociodemographic qualities such as gender and race-ethnicity might have differential effects on community formation, identity development, and academic performance as a function of one another—for example, if any gender differences are bigger or smaller for difference racial-ethnic groups.

The analysis outlined above is an individual-level analysis specific to each student—i.e., the students are the units of observation. We will also leverage the interactional data we will get from students using the platform to conduct inferential network analyses where the interactional network itself will be treated as the outcome variable. More specifically, we will construct dyadic regression models to predict the probability that we will observe an interaction between any two students at any given point in time. It might be, for example, that an interaction between two students will be more likely if the two students are both at the same level (e.g., freshman, sophomore, junior, or senior). This would be a *homophily effect*. Or it could be that interaction between any two students is more likely if they share interactions with the same alters, that is, the same other participants on the platform. This would be a *transitivity effect*. Dyadic regression models will be able to tease apart these possible effects.

Qualitative evaluation

The qualitative component of the study will consist of a set of interviews, observations, and focus groups. All three aforementioned activities will include students and professors involved in the use of companions and participants of the ECE-WisCom addressing student community development, academic performance, and identity development. Intersectionality factors from student participants will also be considered.

Interviews, observations, and focus Groups

i) During the three-year cycle, a set of interviews will address the experience of students with online learning in terms of student's academic performance including strategies and motivation to learn, relationships with peers, and interaction with professors. Professors' interviews will include their experience with online teaching, gaps, and improvements to better serve students at an HSI. Students and professors will also address their expectations with the interface in terms of navigation, communication, access, and resources as established by Gunawardena and her colleagues in [10]. ii) For the second approach, observations will be carried out as well. Observations will record participants' ease of use and course interface design in terms of their needs, skills, and expectations. Synchronous meetings, peer collaboration, as well as professional community development will also be documented. And iii) Two focus groups will be conducted by the end of each spring term. Participants will discuss as a community the benefits of being part of an online MR ECE-WisCom including aspects such as teamwork and collaboration, mentoring, support, and transformative learning.

Qualitative analysis

Both interviews and focus groups' information will be transcribed verbatim following the unitization of data, which will generate transcripts. The interview data will be analyzed using a content analysis process [35]. Two researchers from the research team will listen to and read the interviews and focus group transcripts multiple times to gain insight into the participants' use of the platform and collaboration in the ECEWisCom, which might help reinforce their professional community development, identity development, and academic performance. Dedoose, a software that helps analyze qualitative data, will support researchers in identifying and classifying units of data. Having these data units yields the coding phase. In this stage, initial themes and categories emerge within each transcript including the observation records, which are later re-defined in comparing this initial categorization with the remainder of the transcripts. Patterns might be noted as the analysis process evolves, setting a group of established themes and categories, which will help answer the research question(s).

Current status

In the Fall 2023 semester, the ECE student recruitment process started along with conversations among the faculty and graduate research assistants from Engineering and Computer Science about the components needed to create the MR platform. Selected ECE students were invited to participate in a couple of sessions to provide feedback on the design of the MR platform. In the Spring 2024 semester, three participatory design sessions were performed, with a subset of ten of the recruited cohort of student participants. The subset has been selected purposefully to ensure that a diverse representation of the whole cohort's demographics and educational experiences are represented. During these participatory design sessions, the researchers gathered data about the participants' current learning experiences and the needs and requirements of the WisCom mixed reality platform through activities like storyboarding, focus group discussions, building low-fidelity prototypes, and role-playing scenarios. Participants were compensated $40 in Amazon gift cards for each of the two-hour participatory design sessions they participated in. Also, at the beginning of the 2024 Spring semester, ECE students attended meetings. The design, development, and evaluation team, and graduate students working on the project met each other, learned more details about the program and following phases, and started gaining rapport and getting to know each other. During one of the initial meetings those attending ate pizza and played board games.

Challenges encountered

Student recruitment has been slower than expected despite sending invitation flyers through the ECE listserv and organizing pizza events where students usually gather to hang out and do homework. The criteria to participate in the program may discourage some students from applying because NSF requests that students must be citizens or residents to be able to receive federal financial support through this grant. Due to the geographical location of NMSU, close to the border, the institution enrolls many students from Mexico who do not meet this criterion. The leadership team had bi-weekly meetings throughout the Fall 2023 and Spring 2024 semesters. In these meetings, usually, three to four graduate research assistants also participate. The PI realized that better coordination is needed to make sure that graduate research assistants are engaged and working towards the goals of this project.

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