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How Co-Design Enhances Learning Outcomes for Engineering Learners with Disabilities: A Study with the Blind and Low-Vision Community

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Abstract

Co-design is an important approach for engaging communities as equal partners with power to define design directions and make design decisions at every stage. This approach has proven valuable for disability inclusion by centering lived experiences with disability in accessible design endeavors. Furthermore, co-design has been adopted in engineering education research, from developing science museum activities with students to supporting engineering faculty professional development. Our recent research explored the co-design of an accessible engineering education tool through a community partnership with a nonprofit that serves the blind and low-vision (BLV) community in Northern California. Eight BLV community members collaborated with researchers at Stanford University, over 2.5 years, to co-design the first accessible electronic circuit simulator for BLV learners. BLV participants made core design decisions, including proposing multimodal features and a new tutorial, to iteratively shape the tool's design. The research findings demonstrated how co-design ensures equitable power allocation among all co-designers – BLV participants and researchers alike – while fostering an authentic, inclusive design environment.

This paper extends those findings by investigating how co-designing the engineering education tool with BLV participants impacted their learning outcomes using the tool. Participant data were collected through surveys and observation notes of participants' tool interactions. The data were analyzed using a grounded theory building approach and examined through the lenses of Bloom's Taxonomy and Fink's Taxonomy of Significant Learning. The findings reveal multiple cognitive, metacognitive, and affective learning outcomes in participants' tool experiences. Notably, several outcomes directly resulted from design decisions made by BLV participants during the co-design process. Thus, the impact of these decisions extended beyond accessibility objectives to support learning using the tool. Consequently, this work demonstrates that engaging community members with disabilities as co-designers of engineering education tools can enhance their learning outcomes across cognitive, metacognitive, and affective domains.

1 Introduction

Participatory design methods that engage communities deliver several benefits to those involved. Community-engaged design prepares students with important skillsets for increasingly complex careers, including developing a deeper understanding, a stronger sense of agency, and a new mode of engagement with real needs beyond course materials [1], [2]. Moreover, educators in diverse fields have begun to redesign curricula in collaboration with their students, ensuring that students are included as equal partners in dialogue. Such participatory approaches help eliminate power imbalances, foster more profound connections between students, communities, and educators, and "cultivate a culture of permanent research transfer into and with society" [2].

Co-design is one such participatory approach that expands on traditional design-thinking to bring end-users and designers equally to the decision-making space [3]. Promoting the idea of "making with, not for," co-design elevates users to the role of a full designer, ultimately prioritizing lived experience and what communities may need for their own contexts [4]. Thus, co-design fosters more equitable and inclusive interactions between research, practice, and lived experiences [5]. Engineering as a discipline directly interfaces with community, as it is intended to meet the needs of society. To facilitate engagement with communities, co-design and similar participatory design approaches have been increasingly adopted in engineering education curricula. Engineering educators have delivered project-based classes where students work with representative co-designers from the user group they design for. Chien and Liu evaluated the experiences of K-12 students with an engineering design curriculum centered on participatory design, and the results demonstrated higher levels of design ability and critical thinking [6]. This community-engaged approach has similarly been applied to engineering education for sustainable development [7].

However, the engineering curriculum itself can also be further improved through co-design involving students and educators. For example, Trenchard and Lombardo devised a new pedagogical practice, providing their undergraduate engineering students with more curricular agency through awarding credit for student-devised projects with the Engineers Without Borders USA organization [8]. This approach led to iterative and productive curricular co-creation, engaging students directly in real-world settings and leading to increasingly refined and more comprehensive deliverables, aligned with the intended learning outcomes.

Co-design can also be adopted to engage community members with disabilities in efforts for disability inclusion. Benz et al. collaborated with participants with lived experiences with disability to co-design improved telehealth practices while emphasizing accessibility and considering practicality [5]. Additionally, Winters et al., through a nonprofit partnership, co-designed accessible science education simulators with blind and low-vision students, as the latter iterated through the entire design process, made decisions regarding the simulator prototype construction, and evaluated outcomes, noting the need for improved sonification techniques to support accessible STEM education experiences [9]. Thus, if implemented thoughtfully, co-design can be a valuable approach for embedding accessibility throughout the design process.

This study's primary contribution is an evaluation of how engaging community members with disabilities as co-designers of an engineering education tool impacts their learning outcomes. Situated at the intersection of co-design, accessibility, and engineering education research, this study focuses on the experiences of blind and low-vision (BLV) participants who co-designed an accessible engineering education tool during a 2.5-year long community engagement program. **Section 2** introduces practitioner-centric educational taxonomies, namely Bloom's and Fink's taxonomies, which were adopted to evaluate BLV participants' learning outcomes using the co-designed engineering education tool. **Section 3** presents this study's authors' and broader contributors' positionalities. **Section 4** provides an overview of the community engagement program, its curriculum, and the co-designed engineering education tool. **Section 5** describes the research methods adopted in order to collect and inductively analyze qualitative and video data. In **Section 6**, findings pertaining to the BLV participants' diverse cognitive, affective, and metacognitive learning outcomes are presented and organized in line with different principles of Bloom's and Fink's taxonomies. These findings are further discussed in **Section 7** to clearly evaluate the impact of co-design on the participants' learning outcomes. Limitations and future directions are presented, then **Section 8** concludes this work. Finally, certain acronyms appear frequently throughout this work. The acronym BLV stands for "Blind or Low-Vision," and the acronym ECE stands for "Electrical and Computer Engineering."

2 Literature Review

This study utilized two educational taxonomies, Bloom's taxonomy and Fink's Significant Learning Outcomes, to evaluate BLV participants' learning outcomes using the co-designed tool and during the co-design process [10], [11]. These frameworks were selected as they are widely adopted by educators and practitioners, promoting high-quality learning objectives and outcomes across diverse fields, including engineering education [12], [13].

2.1 An Overview of Bloom's Taxonomy

Bloom's Taxonomy is a hierarchical framework that defines a learner's cognitive process as their ability to "remember, understand, apply, analyze, evaluate, and create" [14]. These categories are hierarchical; a student would be expected to become familiarized with the core knowledge of a subject before comprehending, applying, and utilizing it in increasingly sophisticated contexts and ways. An effective curriculum design would enable students to achieve the most advanced forms of integrated learning according to Bloom's hierarchy: evaluation and creation.

Bloom's taxonomy has been used by educators to guide, define, and evaluate multiple dimensions of engineering education, including curriculum design and assessment strategies. A study that introduced revised educational material aligned with Bloom's taxonomy to an undergraduate fluid mechanics course noted better student performance on tasks at higher cognitive levels [15]. Another study analyzed the impact of utilizing Bloom's taxonomy to align in-class assessment approaches with ABET requirements; results indicated easier and more accurate assessments [16].

2.2 An Overview of Fink's Significant Learning Outcomes

Fink's Taxonomy of Significant Learning Outcomes does not rely on hierarchical strategies of learning, but rather six interactive categories that could occur concurrently [11]. Fink defined the six learning outcomes as: foundational knowledge, application, integration, human dimension, caring, and learning how to learn. Despite some overlap with Bloom's taxonomy, Fink's non-hierarchical structure acknowledges affective learning outcomes through students' diverse and unique experiences with the course content.

Fink's taxonomy has been adopted in engineering education research as well. One project adopted Fink's taxonomy to evaluate the impact of integrated project-based learning on students, identifying improved cognitive and affective experiences [13]. Another study evaluated a holistic, culminating assessment model in a biomedical engineering course using Fink's taxonomy to assess for certain learning objectives in broader contexts, rather than focusing solely on cognitive processes [17].

Table 1 presents a summary of Bloom's and Fink's taxonomies to assist the reader with interpreting the evidence presented in **Section 6**. Expanding on prior studies' use of these taxonomies, the current study adopts these taxonomies in a participatory co-design setting, involving the learners themselves in improving their own learning experiences, which are evaluated with Bloom's and Fink's principles.

Table 1. Summary of Bloom's and Fink's taxonomies' structure, list of learning categories, and learning focus.

	Bloom's Taxonomy	Fink's Significant Learning Outcomes
Structure	Hierarchical	Interactive
List of Learning Categories	Remember, understand, apply, analyze, evaluate, and create.	Foundational knowledge, application, integration, human dimension, caring, and learning how to learn.
Learning Focus	Primarily cognitive	Both cognitive and affective

3 Positionality

This study emerged from a larger research project focused on improving the accessibility of ECE education for BLV learners. The larger project was designed and conducted through collaborative efforts among sighted, blind, and low-vision researchers, students, and community members in Northern California. The scholarly contributions of all collaborators are fully documented through the citations of their co-authored publications, which are referenced in this work.

The authors team for the current study comprises three sighted researchers and collaborators from the aforementioned larger project. The first author is an engineering graduate student researcher in Electrical Engineering, the second an undergraduate researcher in Design, and the third an engineering faculty member in Mechanical Engineering. The three authors bring complementary skillsets across interdisciplinary areas, including accessible user experience design, human-computer interaction, circuit design pedagogy, mixed-methods research, community-based research, and engineering education research. The first author established a community partnership with a nonprofit to engage the BLV community in Northern California with the larger research project. The second and third authors have also worked closely with the BLV community across several studies over the past three years.

4 Community Engagement Program Overview

The first author established a community partnership with LightHouse for the Blind and Visually Impaired in San Francisco, a nonprofit in Northern California that serves the BLV community. The partnership was built gradually through consistent communication and collaborative efforts over multiple months, culminating in the drafting of a Memorandum of Understanding document to delineate the scope of the co-design process [18].

4.1 The Research on Accessible Design (RAD) Program

In collaboration with LightHouse in San Francisco, the Research on Accessible Design (RAD) program was developed, welcoming eight BLV community members as co-designers, six of whom were blind and two of whom had low vision, relying on magnification or residual vision. The BLV participants had diverse prior experiences with design and engineering but shared a common interest in improving the accessibility of engineering education for BLV learners. The objectives of the RAD program were two-fold. The first was to iteratively co-design an accessible engineering education tool, with BLV participants making key design decisions throughout the design process. The second was to evaluate the BLV participants' learning outcomes using the co-designed tool. RAD consisted of two in-person program iterations, RAD 1.0 (2023) and RAD 2.0 (2024). Further program and curricular details are provided in [18]. Participants were fairly compensated for their involvement with RAD 1.0 and RAD 2.0.

4.2 The RAD Curriculum

The RAD 1.0 and 2.0 program iterations were intentionally designed to promote the aforementioned principles of Bloom's taxonomy. Participants used the co-designed engineering education tool to complete different Electrical and Computer Engineering (ECE) activities at different levels of Bloom's hierarchy. For instance, participants were introduced to different ECE concepts and electronic components, in line with Bloom's "remember" and "understand categories." They were asked to execute certain circuit designs, aligning with Bloom's "apply" category. The activities culminated in questions about predicted trends and circuit behavior, which participants should be able to answer by building intuition, in relation to Bloom's "analyze" category. As participants were confronted with errors, they had to "evaluate" and debug their work. Finally, some participants were driven by curiosities beyond the provided activities, so they ventured on their own, "creating" new circuit designs to find answers for their arising questions.

Moreover, the RAD curricular design touched upon several affective elements of Fink's significant learning outcomes. By engaging the BLV participants as co-designers of the accessible engineering education tool, RAD programming created space for the participants to learn about others' lived experiences with disability and STEM education. This approach aligned with Fink's "human dimension." Some RAD activities were grounded in real-life examples, such as fixing a broken circuit in an electric heater in time for the cold winter. This allowed for the "integration" of technical and real-life concepts and experiences. Finally, the RAD program offered participants opportunities to voice feedback, make design decisions, and work with fellow BLV participants. This brought a "caring" dimension to tackle the significant inaccessibility of ECE.

4.3 Brief Overview of the Co-Designed Accessible Engineering Education Tool

IncluSim is an educational electronic circuit simulator that is accessible for BLV learners in introductory ECE education. The tool design was informed by extensive needfinding with the BLV community, including an autoethnographic study, and the tool was iteratively co-designed during the RAD program with BLV and sighted researchers, students, and community partners [18], [19]. During RAD 1.0, BLV participants used a preliminary tool prototype, developed by BLV and sighted researchers, as foundations for co-design.

The participants made three core changes to the tool between RAD 1.0 and 2.0: reducing the physical tool size, adding color contrast in the hardware and software interfaces, and including a tutorial on the tool functionalities and usability with a digital screen reader, which converts text to speech and can navigate grid-based interfaces. **Figure 1** shows the tool's multimodal hardware-digital interface in RAD 2.0, using which a BLV learner can design, simulate, and debug circuit designs. The tool features are discussed in detail in [20].

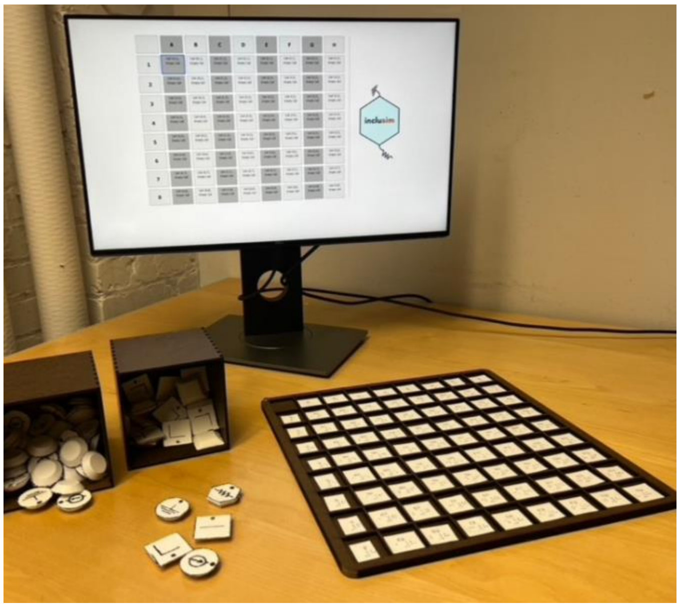

Figure 1. The tool's hardware components (tactile tiles and tactile grid board) and digital component (computer app) on display.

To design a circuit, the learner places tactile tiles on a tactile hardware grid board to create a modular circuit design. Each tile has a color-contrasted tactile schematic of a specific electronic component (e.g., resistor). The hardware grid board has color-contrasted braille labels and print coordinates of the different grid cells. Next, the learner transfers their hardware circuit design into an identical digital grid interface using their keyboard and a digital screen reader. Once the circuit design is saved digitally, the learner runs a simulation profile using keyboard shortcuts and reviews accessible, text-based simulation results, including errors, warnings, and resulting values. Such real-time simulation feedback allows the learner to evaluate their own work iteratively and debug as needed using the tactile tiles and the digital simulator.

5 Methods

5.1 Data Collection Methods

Data were collected through post-program surveys including open-ended questions, ethnography, and more than 700 minutes of video recordings of BLV participants' interactions and experiences with the co-designed tool. Participants' RAD activity workbooks were also collected as artifacts. All participant data were anonymized, per the study's IRB-approved research protocol.

5.2 Data Analysis Methods

Qualitative survey data were coded inductively, as a grounded theory building approach was adopted [21]. A round of focused coding followed to cluster codes into groupings of relevant themes. Example themes included "collaboration," "emotions," and "learning outcomes," with supporting data having emerged from analyzing the BLV participants' collected data. Two researchers completed the coding process, merging their codebooks and resolving any arising conflicts. To further improve the research quality, researchers cross-referenced qualitative survey data with ethnography notes and video data as a data triangulation method [22].

6 Findings

This section showcases how participants, using IncluSim during the RAD program, achieved diverse cognitive, affective, and metacognitive principles and learning outcomes promoted by Bloom's and Fink's taxonomies. Based on the analysis results, some data served as evidence for multiple principles of both taxonomies simultaneously. Consequently, the following sections present evidence for several cross-taxonomy principles at a time. Bloom's taxonomy principles are prefaced by (B) and Fink's by (F). Participants are anonymously referred to as **P[number]**, and their presented data are prefaced with (1.0) or (2.0) depending on the RAD program iteration during which the data was collected. Moreover, several co-design decisions that participants made directly impacted their learning experiences, and they are also discussed below.

6.1 Evidence for (B) Remembering and (F) Foundational Knowledge

Generally, participants first constructed their circuit designs using the hardware components, then they input their designs into the digital simulator. Several participants brought up the importance of the tool hardware components as a memory aid. **P2** (1.0) shared that the hardware *"provided [them] a way to check [their] work so [they] wouldn't have to totally rely on [their] memory."* **P6** (2.0) similarly stated, *"... Without the visual representation, [simulation] would be much harder because it would entail reading and memorizing the board, circuit, and values."*

The preliminary simulator tool prototype used during RAD 1.0 incorporated purely tactile embossing (braille, schematics, etc.) on white paper. During the co-design reflection session of RAD 1.0, a low-vision participant, **P1**, shared that "*since [she] hasn't had experience with braille, [she] didn't have the tactile sensitivity to distinguish the small dots. It would've helped to have higher contrast between the dots and the blocks' background*." In fact, P1 ended up leaving an entire section of the simulation activity incomplete, as she spent considerable time trying to identify the tiles and remember the electronic components that they represented. Therefore, the BLV participants made a collective co-design decision to introduce color contrast to the tool hardware resources. Consequently, tactile embossing was marked with a black color on a white background in the improved tool hardware design. A comparative video analysis of **P1**'s experiences using the tool's tactile tiles during RAD 1.0 and RAD 2.0 demonstrated a complete change in **P1**'s approach. While she asked for the researcher's help in identifying the single-color schematics and labels on the original tool tiles during RAD 1.0, **P1** repeatedly and efficiently remembered the schematics of different electronic components during RAD 2.0, relying on the color contrast as a low-vision learner.

6.2 Evidence for (B) Understanding, (B) Applying, and (F) Application

In their survey responses and while thinking aloud during the in-person activities, participants noted their ability to spatially understand and reason about their circuit designs using the grid-based hardware layout as well as the digital simulator interface. This allowed researchers to track the participants' thought processes, as participants defined components, explained relationships, and justified next steps. Participants also applied their acquired ECE knowledge in completing different ECE tasks, such as debugging. **P7** (1.0) shared that *"having the physical representation helped… [them] visualize the way that the circuit looked and… how the different components connected with each other. It's the equivalent of a sighted individual having a visual representation of the circuit that they could look at to picture how the components fit together."* In fact, **P7** (1.0) *"did not know how the physical board would enable [them] to work with the digital simulation tool [at the beginning]. [They] thought that the physical board may not have been necessary. After beginning to work with the tools, [they] began to understand the value of having the physical representation of the circuit."* **P1** (1.0) added that she *"[realized] the importance of spatial awareness for the activity, which added to [her] growing understanding of the material."* She (2.0) also felt she *"needed a physical iteration to complement the digital [medium], in order to understand the circuit pathway more clearly.*" Not only did the hardware and software media support **P1** (1.0) in applying the ECE concepts she learned to design a circuit according to given requirements, they also *"helped with understanding the formula [she] had to solve."*

During RAD 1.0, several BLV participants noted the learning curve that accompanied the use of the simulator tool prototype. **P7** and **P4** (1.0) noted that the *"tool itself had a learning curve."* **P3** (1.0) needed to understand how to interact with *"the grid… the [tutorial] dialog… and [shortcuts],"* especially when using a screen reader to navigate the digital simulator interface. Therefore, another co-design decision was made to improve the learning curve by introducing a tutorial. As a result, the improved tool, IncluSim, that BLV participants used in RAD 2.0 included a tutorial that provided detailed guidance on the main functionalities of the simulator tool, interfacing with the digital simulator using a screen reader, interacting with the hardware and digital tool components, in addition to a complete tutorial activity on designing, simulating, and debugging an example circuit design. Reflecting on the tutorial feature, participants shared that they became more familiar, comfortable, and prepared to apply what the tutorial had taught them. **P6** (2.0) noted that the tutorial "*[tutorial] training… helped tremendously with being prepared…*," as he learned the "*shortcuts, tool's controls and functions, [and] interaction with the tutorial*." Similarly, **P1** (2.0) shared, "*Having the warnings and errors with advice [in the tutorial] also made a huge difference, making me feel like I was being set up for success. Like a good tutorial should, it prepared me ahead of time and taught me what to do, so I was ready for the in-person segment*."

6.3 Evidence for (B) Analyzing and (B) Evaluating

Participants expanded on their experiences with iteratively constructing, simulating, and debugging circuit designs. **P5** (1.0) relied on the simulation outputs to *"identify where the errors were and… resolve most of them."* Similarly, **P1** (1.0) found it *"affirming"* to simulate her circuit and *"learn what [she] did wrong and why."* As for **P7** (1.0), they appreciated the *"instant feedback"* of the digital simulator on their circuit design. In fact, participants dealt with a variety of errors and had to, consequently, devise different debugging strategies. While **P1** (1.0) realized she had built a series circuit and needed to break it up into two parallel branches, **P2** (1.0) noticed their error was a simple misplaced wire tile. As the final parts of the circuit design activity asked participants to test the impact of different resistance values, **P1** (2.0) stated that *"it felt very quick and easy to test current flow"* as a result. She also relied on *"the tool [to] confirm [her mathematical] calculations or tell [her] otherwise,"* drawing connections between theoretical calculations and simulation results for verification.

6.4 Evidence for (B) Creating and (F) Application

While several participants designed circuits that met the activity requirements and resulted in correct simulation outputs, some participants were creative in the shapes their circuits took and the connections between their components. For instance, **P7** (1.0) designed a "circular" circuit while **P1** (2.0) designed a "straight-line" circuit, using two ground nodes at either end to "close" the circuit. In her post-program survey response, **P1** (2.0) shared that she *"gained enough confidence to make [her] curious and want to experiment and learn from replicating or building bigger circuits."* She also appreciated *"the ability to build and experiment without wasting materials,"* referring to the modular and iterative nature of IncluSim.

6.5 Evidence for (F) Human Dimension and (F) Caring

The RAD program kept participants engaged as active co-designers throughout the process. **P1** (2.0) reflected on *"being seen and heard"* throughout the co-design process during the RAD program. **P3** (1.0) shared, *"It's promising to see the potential and progress being made to make electrical engineering accessible."* **P6** (2.0) stated that the experience *"increased [their] ownership and stake in the success of the tool to make circuit design and learning more accessible."* Thus, participants' engagement with IncluSim entailed a strong belief in the broader importance and impact of making ECE education more accessible.

7 Discussion

The prior section presented evidence from different participants' experiences, during RAD 1.0 and 2.0, aligning learning outcomes using IncluSim with Bloom's and Fink's taxonomies, covering diverse cognitive, affective, and metacognitive learning principles. Moreover, the researchers' taxonomy-congruent, intentional planning that had gone into designing the RAD activities for IncluSim, as discussed in **Section 4**, was consistent with the data analysis results that arose as evidence for the taxonomies' learning outcomes in the participants' experiences.

7.1 How Does Co-Design Impact Learning Outcomes?

The RAD curricular design, which was closely modeled by researchers after different principles of Bloom's and Fink's taxonomies, achieved its intended cognitive, metacognitive, and affective learning outcomes, as evidenced by the various findings presented in **Section 6**. This illustrates that the curriculum played a core role in successfully delivering the core ECE objectives according to the learning aims originally planned for by the researchers.

Of note are resulting learning outcomes that were *unintentional*. These were traced back to co-design decisions that BLV participants made – introducing (1) color contrast, and (2) a comprehensive tutorial. Not only did these co-design decisions result in more inclusive learning experiences for a broader range of learners, but they also enhanced existing learning experiences. As discussed in **Section 6.1**, the use of color contrast created a much more accessible learning process for low-vision participants, and it also allowed them to remember components by their colored schematics, supporting their cognitive learning process, in line with Bloom's foundational category, "Remember," and Fink's "Foundational Knowledge." Similarly, the tool facilitated the learning experience for many of the BLV participants who found the simulation process to be overwhelming by integrating a co-designed tutorial. Using the tutorial, as described in **Section 6.2**, the participants understood the different simulation stages and applied their learnings to create, analyze, and debug new circuit designs, in line with Bloom's metacognitive categories, such as "Create." Had the participants not made this co-design decision, the simulator tool would still feature a steep learning curve on different fronts (hardware usage, simulator functionalities, and screen reader compatibility). Finally, participants reported affective learning experiences, including a sense of fulfilling personal contributions to improving the accessibility of ECE education for broader and diverse groups of learners.

The cognitive and affective learning outcomes identified in this study align with those of prior engineering education research projects which also drew on Bloom's and Fink's taxonomies [13], [15], [16], [17] – from improved performance on cognitive tasks to positive emotional experiences. This study expands the scope of previous research by adopting Bloom's and Fink's taxonomy in a novel context: to demonstrate how the co-design of an accessible engineering education tool for learners with disabilities impacts the co-designers' learning outcomes. The role of co-design evolved beyond solely ensuring accessibility to also entail enhancements to the learning experiences of the BLV participants. These learning experience improvements were advocated for by the BLV participants themselves as co-designers with design decision-making power.

7.2 Limitations and Future Work

The RAD program hosted eight BLV participants, each of whom had diverse and rich lived experiences. That being said, the sample size was relatively small, and future work can include valuable perspectives from more community members, including deafblind learners. In addition, the RAD programming spread over more than two years, and it engaged community members directly in precise ECE activities in a workshop-like setting. Future work could explore more frequent engagement (e.g., once a week) and invite community members to engage in classroom settings. Such work could unveil the potential impact of co-design in facilitating mixed-ability collaboration and learning experiences.

8 Conclusion

Engaging community members with disabilities as co-designers of educational affordances supports the development of accessible curricula and technology and amplifies the lived experiences and preferences of the broader community. This results in creating disability-inclusive educational environments and experiences for learners of all abilities. This work expanded the evaluation of co-design in engineering education research to consider the impact of co-design on the co-designers' learning outcomes. Engaging blind and low-vision (BLV) community members as co-designers of an accessible engineering education tool, this study demonstrated that co-design not only promoted and centered accessible design principles based on lived experiences among the community members, but it also enhanced the BLV participants' learning experiences in line with principles promoted by Bloom's and Fink's educational taxonomies. Future work can expand this study to consider the impact of co-design in diverse and mixed-ability educational settings.

References:

[1] D. S. Hurwitz *et al.*, “Influence of Collaborative Curriculum Design on Educational Beliefs, Communities of Practitioners, and Classroom Practice in Transportation Engineering Education,” *J. Prof. Issues Eng. Educ. Pract.*, vol. 140, no. 3, p. 04013020, Jul. 2014, doi: 10.1061/(ASCE)EI.1943-5541.0000196.

[2] V. Varney and L. Brendel, “Enabling Engineering Responsibility: Challenge-Based Learning and Co-creation in Engineering Education,” in *Open Science in Engineering*, vol. 763, M. E. Auer, R. Langmann, and T. Tsiatsos, Eds., in Lecture Notes in Networks and Systems, vol. 763. , Cham: Springer Nature Switzerland, 2023, pp. 1033–1042. doi: 10.1007/978-3-031-42467-0_95.

[3] C. Sutton-Long, K. S. Aagard, Z. Howard, and V. Tassone, “Co-Design for Community Inclusion,” Huddle, Australia, 2016.

[4] K. A. McKercher, *Doing Co-design for Real: Mindsets, Methods and Movements*, 1st ed. Beyond Sticky Notes, 2020.

[5] C. Benz *et al.*, “Community-based participatory-research through co-design: supporting collaboration from all sides of disability,” *Res Involv Engagem*, vol. 10, no. 1, p. 47, May 2024, doi: 10.1186/s40900-024-00573-3.

[6] Y.-H. Chien and C.-Y. Liu, “Participatory design curriculum promotes engineering design, critical thinking, and creativity for students from kindergarten to 12th grade.,” *Psychology of Aesthetics, Creativity, and the Arts*, vol. 19, no. 5, pp. 988–999, Oct. 2025, doi: 10.1037/aca0000652.

[7] J. Goggins and M. Hajdukiewicz, “The Role of Community-Engaged Learning in Engineering Education for Sustainable Development,” *Sustainability*, vol. 14, no. 13, p. 8208, Jul. 2022, doi: 10.3390/su14138208.

[8] N. Trenchard and C. Lombardo, “A New Framework for Student-Led Cocurricular Design Projects,” in *2020 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual On line: ASEE Conferences, Jun. 2020, p. 34025. doi: 10.18260/1-2--34025.

[9] R. M. Winters, E. L. Harden, and E. B. Moore, “Co-Designing Accessible Science Education Simulations with Blind and Visually-Impaired Teens,” in *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility*, Virtual Event Greece: ACM, Oct. 2020, pp. 1–4. doi: 10.1145/3373625.3418025.

[10] D. R. Krathwohl, “A Revision of Bloom’s Taxonomy: An Overview,” *Theory Into Practice*, vol. 41, no. 4, pp. 212–218, Nov. 2002, doi: 10.1207/s15430421tip4104_2.

[11] L. D. Fink, *Creating significant learning experiences: an integrated approach to designing college courses*, Revised and Updated. San Francisco: Jossey-Bass, 2013.

[12] R. M. Felder and R. Brent, “The ABC’s of engineering education: ABET, Bloom’s taxonomy, cooperative learning, and so on,” presented at the 2004 American Society for Engineering Education Annual Conference & Exposition, Vancouver, BC, Canada, 2004.

[13] R. M. Paul, Y. Jazayeri, L. Behjat, and M. Potter, “Design of an Integrated Project-Based Learning Curriculum: Analysis Through Fink’s Taxonomy of Significant Learning,” *IEEE Trans. Educ.*, vol. 66, no. 5, pp. 457–467, Oct. 2023, doi: 10.1109/TE.2023.3307974.

[14] L. W. Anderson and D. R. Krathwohl, Eds., *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom’s Taxonomy of Educational Objectives*, Complete ed., [Nachdr.]. New York: Longman, 2001.

[15] P. Charoenphol and A. Bandyopadhyay, "A Comparative Study on the Role of Bloom's Taxonomy-based Assignments and Project-based Learning on Student Performance in an Undergraduate Fluid Mechanics Course," in *2024 ASEE Annual Conference & Exposition Proceedings*, Portland, Oregon: ASEE Conferences, Jun. 2024, p. 46427. doi: 10.18260/1-2--46427.

[16] K. Gosselin and N. Okamoto, "Improving Instruction and Assessment via Bloom's Taxonomy and Descriptive Rubrics," in *2018 ASEE Annual Conference & Exposition Proceedings*, Salt Lake City, Utah: ASEE Conferences, Jun. 2018, p. 30630. doi: 10.18260/1-2--30630.

[17] E. Dosmar and B. A. Nguyen, "Applying the Framework of Fink's Taxonomy to the Design of a Holistic Culminating Assessment of Student Learning in Biomedical Engineering," in *2021 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual Conference: ASEE Conferences, Jul. 2021, p. 36695. doi: 10.18260/1-2--36695.

[18] A. Mouallem, T. Rogando, S. Dougherty, M. Mendez Pons, and S. Sheppard, "'Nothing About Us, Without Us': Co-Designing an Accessible Engineering Education Tool with the Blind and Low Vision (BLV) Community," in *2025 ASEE Annual Conference & Exposition Proceedings*, Montreal, Quebec, Canada: ASEE Conferences, Jun. 2025, p. 55321. doi: 10.18260/1-2--55321.

[19] T. Kulkarni, G. S.-H. Kim, and A. Mouallem, "A Case for Improving the Accessibility of Electrical and Computer Engineering Education – Starting with a Blind Student's Autoethnography," in *The 25th International ACM SIGACCESS Conference on Computers and Accessibility*, New York NY USA: ACM, Oct. 2023, pp. 1–8. doi: 10.1145/3597638.3614551.

[20] A. Mouallem *et al.*, "IncluSim: An Accessible Educational Electronic Circuit Simulator for Blind and Low-Vision Learners," in *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems*, Yokohama Japan: ACM, Apr. 2025, pp. 1–18. doi: 10.1145/3706598.3713437.

[21] K. Charmaz, "The grounded theory method: An explication and interpretation," in *Contemporary field research: A book of readings*, Boston: Little Brown and Company, 1983, pp. 109–126.

[22] A. Tashakkori and C. Teddlie, "The Past and Future of Mixed Methods Research: From Data Triangulation to Mixed Model Designs," in *Handbook of Mixed Methods in Social and Behavioral Research*, Sage Publications, 2003, pp. 671–701.