Faculty and Stakeholder Perspectives from a Workshop on Electricity Access Education

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Abstract

Electricity access refers to the provision of electricity to populations that do not have access to the electrical grid, usually in under-resourced settings. Over 700 million people do not have access to electricity. Interest, investment, and activity in this sub-field of Humanitarian Engineering has grown considerably over the last 15 years. Yet, there is very little coverage of this topic in U.S. universities. This critical challenge can motivate students to pursue electrical engineering studies and inspire engineering students to engage with curricular and extra-curricular activities related to electricity access, making it a pivotal area for educational focus. In 2022 and 2023, the National Science Foundation sponsored two workshops with the goal of identifying approaches to enhance and expand electricity access education at the undergraduate engineering level in the U.S., primarily within the electrical engineering discipline. In this paper, we summarize and synthesize the insightful discussion from the second workshop, supplemented by results from in-workshop polling of the participants. We identify perceptions of the state of electricity access education in the U.S., and identify needs and barriers for improving related curricular and extra-curricular activities. Finally, we propose a road map of activities for further discussion.

Key words: Electricity access, engineering education, educators, humanitarian engineering

Introduction

Humanitarian Engineering (HE) considers the application of engineering to improve the lives of people in vulnerable or under-resourced settings. A wide range of academic institutions in the U.S. offer programs dedicated to HE [1, 2, 3, 4, 5, 6, 7]. These programs allow students to earn minors, certificates, or concentrations in HE. There are compelling reasons for universities to offer HE opportunities to students. There is evidence that HE programs tend to attract more women and a more racially and ethnically diverse student population [2, 8, 9, 10, 11]. Additionally, research shows that introducing HE projects and themes into courses can improve student retention [12]. It follows that a viable strategy for broadening participation in engineering could be to incorporate HE themes and engagement opportunities into the traditional engineering programs.

The linkage between engineering and serving humanity varies unevenly by discipline. In a study of 1900 undergraduate students, 73% of Civil and Environmental Engineering (CEE) majors agreed or strongly agreed that “helping others is a central message in my discipline”, the most of any engineering discipline [13]. However, only 45% of electrical engineering students agreed or strongly agreed with the same statement. It may not be coincidental that CEE has double the representation of female students (28.3%) when compared to Electrical Engineering (14.4%) [14]. Further, in our experience, extra-curricular opportunities to engage with HE projects, for example through student clubs, are often rooted in the civil and mechanical engineering disciplines. For example, many Engineers without Borders student chapter projects focus on water access and building construction. While electrical engineering students may participate in these experiences, not seeing their discipline reflected in the projects may limit the appeal. In short, there is at least the perception that electrical engineering students do not engage with HE themes as often in their coursework or in extra-curricular ways as their peers in other engineering disciplines. This may discourage broader participation and negatively affect retention in electrical engineering. Clearly, additional research is needed to better understand the relationship between HE engagement and retention and recruitment within different engineering disciplines. Such a study is beyond the scope of this paper.

Instead, we focus on electrical engineering faculty and other stakeholders that have already embraced HE, explicitly within the sub-field of Electricity Access (EA). EA refers to providing electricity access to populations that are not served by the electric grid, most often–but not always–in rural settings in developing countries. Worldwide, over 700 million people do not have access to electricity, including approximately 100,000 people on Tribal lands within the U.S [15]. The topic of EA and, more generally, energy access has attracted global attention. Notably, energy access is enshrined as one of the 17 United Nations Sustainable Development Goals (SDGs) [15].

In 2022 and 2023, the National Science Foundation sponsored two workshops that each convened approximately 30 faculty and other stakeholders on the topic of EA education at the undergraduate engineering level. The primary goal of the workshops was to identify ways to expand and enhance EA education. In this paper, we summarize and synthesize the discussions and themes that emerged from the second workshop. We further propose a road map for future activities in this area.

Workshop Overview

Detailed descriptions of the 2022 and 2023 workshops are found in [16, 17]. While the purpose of this paper is to synthesize the discussions and themes emerging from the second workshop, it is important to provide a summary overview of the workshop for the context. The workshop was funded by a National Science Foundation grant from the Division of Engineering Education and Centers. The 2023 workshop was held on October 10-11, 2023 in Villanova, Pennsylvania.

There were a total of 40 participants. Although most were electrical engineering faculty members, there were also mechanical engineering, chemical engineering, and civil engineering faculty, industry stakeholders (non-profit and for-profit), and students present. A total of 25 educational institutions and 11 industry, non-profit, or government organizations were represented. Most, but not all, of the participants were recruited by direct invitation by the workshop organizers. An open solicitation was made to relevant faculty email lists and posted on LinkedIn. A small number of participants had attended the previous workshop in 2022. There was broad representation from universities, including R1, R2, Primarily Undergraduate, public, and private. One tribal college

Table 1: Workshop Schedule Day 1

Topic	Duration (min)
Welcome Remarks	15
Workshop Orientation	30
Introductions, Motivations, Aspirations	30
Keynote: Integrating Electricity Access and Sustainable Business	75
Discussion Overview	15
Discussion #1a: Enhancing the Classroom Experience	45
Discussion #1b: Enhancing the Classroom Experience	60
Student Panel	30
Discussion #2a: Implementing Sustainable, Ethical, and Beneficial Projects	45
Discussion #2b: Implementing Sustainable, Ethical, and Beneficial Projects	45
Day 1 De-Brief	15

Table 2: Workshop Schedule Day 2

Topic	Duration (min)
Panel: Engineering Education Perspectives on Energy Access	60
Discussion #3a: Breaking Barriers and Building Opportunities	45
Discussion #3b: Breaking Barriers and Building Opportunities	30
Practitioner Panel	60
Discussion: Priorities and Recommendations	90
Discussion: Sustaining Our Community	90

was represented. Most participants, including all the faculty, were from U.S. institutions.

The agenda for the workshop was informed by experience and feedback from the previous year's workshop. The agenda featured three discussion areas that emerged from the first workshop: enhancing the classroom experience; implementing sustainable, ethical, and beneficial projects; and barriers and opportunities. An overview of the sessions for Day 1 and Day 2 are shown in Table 1 and Table 2, respectively. Note that refreshment breaks and meals are not shown in these tables.

The bulk of the interactive discussion occurred during the "Discussion" sessions. These sessions were split into two sub-sessions, "a" and "b", with a break in between. The "a" sessions began with two or three brief five-minute presentations that introduced the topic and provided thought-provoking examples, followed by ample time for structured small group discussion. The "b" sessions allowed for unstructured small group discussion followed by large group discussion. To further stimulate discussion, polls were conducted throughout the workshop using the Mentimeter audience response system [18]. The afternoon of the second day featured targeted discussions on priorities, recommendations, and ways to continue building a community of EA educators and stakeholders.

Methodology

The goals of this paper are to summarize and synthesize the discussion from the workshop, leading to a coherent road map for future action. We have drawn from detailed discussion notes and results from the in-workshop polls. The polls used a variety of question structures, including multiple choice, open text, ranking, and Likert scales. The polls were generally used as a companion to the discussion. They stimulated engagement and provided another mechanism for the participants to express their viewpoints. Still, effort was taken to limit bias. This included making the polls anonymous and optional, and not dynamically displaying responses.

After the workshop, the responses to open-text polls were first cleaned to correct spelling and to parse text when multiple responses were included in the same response to a prompt. We then reviewed the responses, identified common themes, and grouped the responses thematically.

We stress that the polls were not intended to be research instruments and their results should not be interpreted to be representative of EA educators and stakeholder groups at large. The workshop participants were largely drawn from a body of educators with an expressed interest and/or past experience in EA education at some level, with a few exceptions. This almost surely adds biases to the results in some way. Still, these are educators and stakeholders with the best knowledge of EA education and their viewpoints are extremely valuable.

Perceptions of the State of Electricity Access Education

At the beginning of the workshop, we explored perceptions of the present state of EA education in the U.S. in terms of quantity and quality. Overall, the participants saw the need and opportunity to expand EA education at the undergraduate level in the U.S., as shown in Table 3. The perceived quality of EA education presently offered is inadequate, with most participants indicating that U.S. universities are not adequately preparing electrical engineering students for careers in Global Engineering (used in the workshop as a synonym for Humanitarian Engineering) or for graduate studies in Global Engineering (Table 4 and Table 5). Although it is perhaps not surprising that a group of EA educators and stakeholders would see a need to expand EA education, it is more surprising that they also felt that the quality of EA education is low. The opinions about the quantity and quality of EA are largely unchanged from the previous year's workshop [16].

Table 3: Responses to the prompt "What is your opinion of the quantity (number of universities) offering undergraduate electricity access education opportunities in the U.S.? " (N = 30)

Far too few	Somewhat too few	Appropriate	Somewhat too many	Far too many	No opinion
47%	27%	0%	0%	0%	27%

Table 4: Responses to the prompt "What is your opinion of the quality of undergraduate electricity access education in the U.S.? " (N = 32)

Needs improvement	Is at an appropriate level	Already is at a high level	No opinion
84%	3%	0%	13%

Table 5: Poll responses to preparation of EE students in careers and graduate study in Global Engineering (N=30 and N=29, respectively)

Prompt	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Universities in the U.S. are adequately preparing undergraduate EE students for **careers** in Global Engineering	30%	53%	13%	3%	0 %
Universities in the U.S. are adequately preparing undergraduate EE students for **graduate study** in Global Engineering	41%	17%	34%	7%	0%

Clearly, the participants felt there is much work to be done to enhance and expand EA education. But how should this effort be prioritized? A large majority of the participants felt that undergraduate education should be prioritized, as shown in Table 6. Again, this is consistent with the previous year's workshop.

Table 6: Responses to the prompt "Enhancing/expanding electricity access education should be prioritized for " (N = 30)

Undergraduate students	Graduate students	Unsure
77%	13%	10%

Three general areas of engaging students in EA were discussed: through courses (or modules within courses), extra-curricular activities (e.g. through student clubs like Engineers without Borders), and in undergraduate research. The workshop participants ranked these three areas, with results in Table 7. Somewhat over half of the participants felt that efforts to enhance/expand EA education within courses should be given the highest priority. Note that EA courses may include an in-community project component. This is followed by extra-curricular activities, which 43% ranked as the highest priority. Enhancing and expanding undergraduate research opportunities was generally seen as the lowest priority, with just 7% ranking it as the highest priority and 60% ranking it as the lowest priority.

Table 7: Responses to the prompt "Rank these areas according to how educators should prioritize their efforts in enhancing/expanding undergraduate electricity access education" (Extra-Curricular, Research: N = 30; Courses: N =31)

Rank	Courses	Extra-Curricular Projects	Research
1 (Highest priority)	52%	43%	7%
2	32%	33%	33%
3 (Lowest priority)	16%	23%	60%

Overall, the perceptions of EA education in terms of quantity and quality remained consistent with the previous year's workshop. The workshop participants broadly saw a need to improve how EA education is taught and to expand the number of universities teaching it, especially within the curriculum at the undergraduate level.

Enhancing the Classroom Experience

The workshop allocated considerable time to discuss the curricular teaching of EA. Here, curricular teaching includes courses, capstone projects, and independent studies with a focus on the classroom experience (as opposed to in-community experiences). Here, we adopted a broad interpretation of curricular teaching, applying it to courses solely dedicated to EA and those where EA concepts may be introduced. For example, a fundamental course like Electrical Circuits could be considered if an EA concept could be introduced within it.

The participants acknowledged that, as a new field within electrical engineering, faculty have not converged on a generally accepted set of learning outcomes related to EA. In other words, each faculty member may teach and focus on different aspects of EA. To facilitate deeper discussion, the participants were asked to list the three most important concepts about EA that should be taught to students. A range of topics were identified by the participants. The responses were grouped by theme and are provided in Table 8, along with the number of responses clustered within each theme, and examples of specific responses.

Table 8: Responses to the prompt "What are the three most important concepts about electricity access that should be taught to students" grouped by thematic area

Theme	Responses	Examples
Contextual understanding	19	empathy, needs assessment, cultural understanding
Technological aspects	13	appropriate technology, energy use estimation, renewable energy, life cycle analysis
Professional skills	12	systems thinking, perseverance, patience, interdisciplinarity, community based design
Human development	10	need for electricity access, humanitarian impact
Business and economic aspects	10	business models, project cost
Sustainability	8	UN Sustainable Development Goals
Community engagement	7	community engagement
Political and legal aspects	5	identifying decision makers

The most commonly-expressed concept that should be taught was contextual understanding of the community to be engaged. This was expressed in different ways, with needs assessment and empathy being the most common. A broad range of technical concepts were also identified as being important. These included appropriate technology, life cycle analysis, and several aspects of energy system design including renewable energy technology selection, energy use estimation, resource assessment, and component sizing. Twelve responses were related to professional or general engineering skills and mindsets, such as systems thinking, inter-disciplinarity, community based design, and persistence and patience. Another common theme was human development. That is, understanding the importance of electricity access to development and recognizing the humanitarian impact of electricity access projects. The business and economic aspects of EA were also identified as important to teach. Several respondents felt that the business models that underpin most EA should be taught, reflecting an orientation that EA is not strictly a charitable endeavor. The other thematic areas identified were sustainability, in particular how EA relates to the United Nations' Sustainable Development Goals; community engagement; and the political and legal aspects of electricity access.

It is notable that the non-technical responses far outweigh the technical. Also of note is the overlap of many of the non-technical themes were those likely covered in a more general HE course. This suggests that EA themes could be embedded within HE courses.

It is easy to see how even the non-technical concepts of EA could map to existing electrical engineering program outcomes. For example, many of the professional skills, business and economic considerations, and sustainability are often found in program outcomes. Adding insight to this, the participants were asked if EA education aligned with program outcomes. As shown in row A of Table 9, 44% agreed or strongly agreed that they did compared to 29% that felt they did not.

Table 9: Responses to Likert scale questions (A: N = 27, B: N = 30, C: N = 29, D: N = 26, E: N = 32)

Prompt	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
A. EA education is aligned with my program's educational outcomes	22%	7%	26%	7%	37%
B. There presently exists readily available and appropriate EA educational material	20%	33%	33%	10%	3%
C. Adequate funding exists through extra-mural sources (govt. agencies, foundations, etc.) to enhance/ expand undergraduate EA education	24%	28%	24%	21%	3%
D. My university's administration is supportive of electricity access activities by faculty (tenure/rank decisions, resources, recognition, etc.)	12%	15%	38%	23%	12%
E. Incorporating a "hands-on" project in a community is essential to teaching EA	3%	13%	28%	22%	34%

Participants also discussed what would enhance their teaching of EA. Again, the focus remained on the classroom experience. This was explored from two perspectives. The first discussion focused on what would improve teaching of EA; the second discussion focused on barriers. Naturally, some of the responses to both overlapped as removing a barrier could lead to improved teaching. However, the participants typically offered ideas of what would improve their teaching that were specific and tactical, whereas the barriers identified tended to be external or more general.

Considering first what would improve teaching, the lack of readily-available teaching materials such as slides, case studies, and syllabi, was voiced by many participants. This was explicitly explored in a separate poll question whose results are in Table 9, row B. Only 13% agreed or strongly agreed that there were materials that are readily available. The companion poll to the discussion on improving classroom teaching identified other themes, as shown in Table 10. After the need for materials, the second most common theme was the desire for additional training in EA, field experience in EA projects, and deeper engagement from EA practitioners–for example to provide guest lectures or practical design advice. Other themes were related to resources, including funding and access to software; and assistance in identifying and implementing successful EA projects.

Table 10: Responses to the prompt "What would improve your teaching of electricity access?" grouped by thematic area

Theme	Responses	Examples
Course materials	17	case studies, syllabus
Training and experience	7	best practices, input from professionals, field experience
Resources	4	financial (for projects), software
Projects	4	identifying partners/locations

The discussion on barriers uncovered several themes, as well as strategies to overcome the barriers. The companion poll to this discussion is found in Table 11. Foremost among the barriers were curricular constraints. Many participants felt that their curriculum does not allow much, or any, flexibility where a course on EA could be included. Even within existing courses, not necessarily those with a EA or HE focus, participants struggled with finding time to include EA content.

Table 11: Responses to the prompt "What are the barriers preventing you from teaching energy/electricity access or teaching it more" grouped by thematic area

Theme	Responses	Examples
Curriculum	13	time in class, space in curriculum
Funding/Resources	8	university investment in EA
Student interest	6	need to demonstrate sustained enrollment
Experience/Training	6	EA not within area of expertise
Department resistance	6	negative perception of EA among colleagues, no incentives to teach EA,
Time	5	course development
Access to materials	4	slides, examples, lab experiments
Projects	4	access to communities, appropriate scope
None	3	

Another common barrier was funding. Although the individual responses tended to focus on university funding, a separate poll on extra-mural funding opportunities was posed, with results in Table 9, row C. Here, less than one quarter of the responses indicated agreement/strong agreement that adequate funding exists for EA education. Several participants suggested that student interest in or awareness of EA as being a barrier. This was most often in the context of ensuring there were enough students enrolled to justify offering a dedicated EA course.

Lively discussion centered on the resistance faculty have encountered or would expect to encounter at the departmental level to teaching EA. Many professed that faculty HE work of any kind remains stigmatized. There is a perception that it is not valued or not viewed as rigorous as other subjects, in particular by older and senior faculty. Other barriers identified included lacking time to develop courses and those related to EA projects such as community and partner identification and finding a project with an appropriate scope.

It is also interesting to consider what was not mentioned as a barrier. Notably, a lack of higher administration support was not seen as a barrier. This was further explored through a separate poll question, as seen in Table 9, row D. Although there is some variation in opinion, 27% felt their administration did not support EA activity by faculty, while 38% were neutral.

The participants shared many strategies to overcome the barriers. Offering EA first as an experimental course can help gauge and grow student interest and allow the faculty to explore the material without the department committing as many resources to it. Additionally, rather than teaching a course devoted to EA, certain EA topics can be introduced into traditional engineering courses, by considering examples and applications relevant to EA. For example, rather than having students design a lighting circuit for an automobile, have them design a lighting circuit for an off-grid school. This approach also allows non-technical constraints and considerations to be introduced to students, as is done in [19]. Participants felt it important to emphasize the relevance of EA concepts by mapping them to course learning objectives to combat the perception by students that it is extraneous or being taught to “check a box”.

Electricity Access Projects

HE education often couples classroom learning with project-based, experiential learning. Here, projects generally referred to as in-community experiences, either locally or abroad, for students. These may be offered within the curriculum or as an extra-curricular activity. The topic of EA projects elicited strong discussion and opinions at the workshop.

One discussion thread was the importance of projects to EA education. There were varied opinions expressed, and a poll showed that 56% of the participants felt it was essential that projects be incorporated into EA education, as seen in Table 9, row E.

If a project is essential to EA education, then how should these projects be formulated? Slightly over half of the participants felt that projects should be incorporated into a curricular activity, including into a course, capstone design project, independent study, or practicum, as shown in Table 12. Twenty eight percent felt that projects should be incorporated as part of an extra-curricular activity such as through a student club. Nineteen percent were unsure.

Table 12: Responses to the prompt “Projects are best done as a...” (N = 32)

Curricular Activity	Extra-Curricular Activity	Unsure
53%	28%	19%

Then there is the question of what should the goals of an EA project be? The discussion here uncovered a tension: should EA projects prioritize outcomes for the students or for the community? A project conceptualized to prioritize learning would likely manifest itself differently than one focused on community impact. This tension has been identified for HE more generally [20]. The opinions on this topic at the workshop varied, which is reflected in the results of the companion poll, as shown in Table 13. We see that themes related to learning as well as impact were both commonly identified as characteristics of successful projects. The participants felt that there are ways to devise a project so that student and community outcomes can be generally aligned, and identified practices to do so.

Table 13: Responses to the prompt "What are characteristics of a successful hands on, in-community project" grouped by thematic area

Theme	Responses	Example
Learning and Development	16	students learn, mentorship, mutual learning, change in perspective
Sustainability and impact	15	adoption by community, self-sustaining, reliable, mutually beneficial
Community engagement and collaboration	15	community-led, long-term partnership,
Communication	8	cross-communication
Ethics and Safety	4	right motivation, no harm to community

One approach is to partner with a reputable, experienced, and preferably local organization, for example a solar installer or development organization, to implement the project. This can de-risk the project and improve the quality of work. Students can then be involved at different levels from simply observing the project to active participation under the mentorship and guidance from trained professionals. Elevating the role of the community from simply project beneficiary to active contributor and leader was an approach for keeping the project focus on the community, building local capacity, allowing the students to be engaged at a level deemed appropriate by the community, and avoiding issues of White Saviorism [21].

Comprehensive student preparation was viewed as a way to improve the impact of a project and enhance student learning. This includes technical training, but also cultural training, for example how to avoid stereotypes and a "deficit" mindset. The preparation can include student-to-student mentorship (for longer-term projects) and mentorship from partner organizations. Lastly, the participants felt that EA projects should be long-lasting and not build dependency. A general mindset of "be *part* of the solution, not *the* solution" was suggested.

The participants discussed barriers to projects more generally. The companion poll results are found in Table 14. Some of the barriers—time, curricular constraints, and resources—are the same as those to teaching EA more generally, as detailed in the previous Section. However, the discussion did highlight how challenging it can be to identify, build and maintain relationships with communities and partner organizations for projects. Participants highlighted the additional workload in arranging projects. A faculty may be required to secure IRB approval, engage with study abroad offices, navigate travel arrangements, risk management, and be involved with fundraising efforts.

The timeline of a project was also discussed as a barrier. A timeline that neatly maps to the

Table 14: Responses to the prompt “What is the biggest barrier in engaging students in a community energy/electricity access project” grouped by thematic area

Theme	Responses	Examples
Communities	7	partners, locations, maintaining community focus
Time	5	preparation
Curricular	4	semester length, credit, more than an assignment
Experience	4	practical knowledge
Context	4	language, cultural awareness
Interest	3	student interest
Resources	3	funding
Project management	3	planning, scope, leadership

academic calendar, be it semester or quarter, often does not match the natural cadence of the project. Even during the summer, there can be a narrow window of time when students can be in the community. This is a well known challenge of HE projects more generally [20].

Several participants found that offering multi-year projects alleviated the time pressure. In this approach, the project is divided into phases. Each student cohort considers only one phase of the project. This then naturally requires a longer view of the project and partnership with the community, which is generally viewed as positive. Although, this approach is not without challenges. Continuity can be challenging, and students may be more motivated to work on a new project when compared to a project that they have inherited. A separate poll asked participants on whether projects should last multiple years. A large majority (90%) supported this approach.

Road Map

In this section, we outline a road map for significantly expanding and enhancing electricity access education. Reflecting the views of the workshop participants, the road map prioritizes in-class and projects within the undergraduate electrical engineering curriculum.

Develop electricity access course materials: lack of access to appropriate and readily-available course materials such as lecture slides, case studies, and syllabi is the greatest single barrier to expanding EA education. A first step is to raise awareness of materials such as [22]. Existing materials on topics such as sustainability, community engagement, and contextual engineering [23] can be adapted for EA. A range of materials should be developed for both standalone EA courses and for traditional electrical engineering courses. Materials for the traditional courses can be short modules that apply or illustrate how electrical engineering concepts may be applied to the EA domain.

Connect and articulate electricity access education with program outcomes: overcome resistance to EA education within existing departments by connecting and articulating how electricity access themes map to course learning objects, program educational objectives, and ABET student outcomes. All developed course materials should map to generally accepted course outcomes to promote their widespread use and facilitate their introduction into traditional electrical engineering courses.

Support professional development of faculty: lack of faculty and instructors experienced in EA is a bottleneck to wider EA education. Offering workshops, meetings, and other in-person and virtual opportunities for faculty and graduate students to learn about electricity access theory, practice, and pedagogy can alleviate the bottleneck. Faculty and instructors should be trained on how to use the EA course materials and how to develop their own. A viable strategy would be to integrate these gatherings with existing conferences on related subjects such as engineering education or humanitarian engineering.

Improve how EA projects benefit communities and students: continue to discuss, identify, evaluate, and share best practices for EA projects, with an emphasis on improving sustainability of projects, student learning, and reducing risk to the community and students. Developing a generally accepted standard or code of conduct that clearly articulates best practices could enhance overall quality of projects and encourage more faculty to engage in EA. Learning from other disciplines on how they structure their HE projects can accelerate this process.

Expand research on EA education: identify and probe literature gaps at the intersection of engineering education and electricity access. This can include surveying the state of electricity access more broadly, understanding student and faculty perspectives and motivations, studying how HE benefits and impact on students vary between and within engineering disciplines, and evaluating practices for in-class EA education and projects.

Grow the community of electricity access educators and stakeholders: all of these actions benefit from a vibrant and connected community of EA educators and other stakeholders. To nurture and grow this community, develop infrastructure such as LinkedIn groups, email lists, and file repositories to facilitate networking, discourse, support, material sharing, and mentorship among educators and stakeholders. Hold regular virtual and in-person opportunities for community building. Formalizing this community within a professional association such as ASEE or IEEE may help provide infrastructure, credibility, and a professional identity.

Conclusions

A two-day workshop focused on expanding and enhancing electricity access education at the undergraduate level in the U.S. was held in October 2023. A variety of opinions, perspectives, and ideas were expressed during this workshop, which are summarized and synthesized in this paper. Consistent with a previous workshop, the participants felt that EA education in its present state is too limited and of inadequate quality. Workshop participants felt that EA education in the classroom would be improved with access to course materials and focused instructor training. Barriers to expanding EA education included curricular constraints, funding and resources, resistance at the departmental level, and sustained student interest. The participants generally felt that integrating projects was essential to EA education, but had a variety of opinions on how to balance student outcomes with community outcomes. Barriers to projects included finding and developing connections with communities and partners, the time requirements of arranging the projects, and aligning the projects with the academic calendar.

An outline of a road map was proposed which consisted of developing course materials;

connecting EA education with relevant educational outcomes; supporting the professional development of faculty; improving projects; expanding education research; and growing the community of electricity access stakeholders.

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