A Workshop for Electricity Access Educators

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***Abstract*—This paper summarizes and describes the discussions, outcomes, and survey results from a first-of-its-kind workshop that focused on electricity access education at the undergraduate engineering level in the United States. In this context, "electricity access" refers to the provision of electricity in under-resourced settings, usually in developing countries or under-served communities. The two-day workshop convened 24 university educators, industry and non-profit practitioners, government stakeholders, and students with the goal of expanding and enhancing the state of electricity access education in the United States. The workshop held targeted panel sessions on methods and best practices of incorporating electricity access themes into the classroom, student projects, undergraduate research, as well as a practitioner panel. Surveys of perceptions of the state of energy access education were conducted during the workshop. The surveys and discussion show a perceived opportunity to expand electricity access education at universities in the United States and the need for additional course materials, textbooks, and references.**

***Index Terms*—electricity access, engineering education, global engineering, workshop**

I. Introduction

Humanitarian engineering (HE), also known as "global engineering" and "development engineering" among other names, has been described as "the artful drawing on science to direct the resources of nature to meet the basic needs of mankind, with preference toward the poor and marginalized" [1]. There are many positive outcomes associated with engineering students engaging with HE at the undergraduate level. Research shows engaging with HE in curricular, extra-curricular, and co-curricular activities can motivate students to study engineering and improve student persistence [2]. The effect is especially pronounced for women and minorities underrepresented in engineering [2]. However, student participation in HE activities varies unevenly by engineering discipline. It is common for HE activities to focus on what have been traditionally considered to be civil and mechanical engineering domains such as improving access to clean water and building schools and medical clinics. Students studying electrical engineering, however, may find fewer avenues to engage with HE. Research shows that electrical engineering students are less likely to see the connection between their discipline and serving humanity than students in other engineering disciplines [3].

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Electricity access is an emerging field with HE roots. Hereafter, "electricity access" refers to the provision of electricity in under-resourced settings, usually in developing countries or under-served communities. Worldwide, over 700 million people lack access to the electricity grid [4]. This form of energy poverty disproportionately afflicts people living in at-risk communities in developing countries [5]. There is an opportunity for electrical engineering students to deeply engage in electricity access HE activities. However, the number of faculty active in this area is relatively small, and there is no venue, professional association, or infrastructure dedicated to serving this group of educators. This stifles community building, academic exchange and discourse, opportunities for collaboration, and visibility within the field of electrical engineering as a whole.

As a step in changing this reality, an Electricity Access Educators (EAE) Workshop was held in June of 2022. The workshop was funded by a grant (# EEC-2202428/2202882) from the National Science Foundation. The overall goal of the workshop was to expand and enhance the state of energy access education at the undergraduate level in the United States. Other objectives of the workshop included: inventory the state of undergraduate engineering education on electricity access (who is teaching it, what is being taught, where it is being taught, how it is being taught); share best practices in curricular, co-curricular, and extra-curricular activities; identify gaps and barriers to enhancing and expanding engineering education in electricity access; connect educators with stakeholder groups, including those from industry and non-governmental organizations; learn from field practitioners what skills and experiences students need to be competitive, impactful, and successful in pursuing a career in electricity access.

This paper provides a summary of the workshop and results of the associated surveys of the participants. To the authors' knowledge, no similar workshop dedicated to electricity access education at the undergraduate level has been held in the United States. The descriptions, results, and summaries are useful to administrators, educators, engineering education researchers, and those considering similar workshops in the United States or elsewhere.

The remainder of the paper is arranged as follows. The workshop is described in detail in Section 2. Section 3 provides a summary of the discussion at the workshop, including rele-

vant survey results. Conclusions and next steps are provided in Section 4.

II. Workshop Description

The workshop was held June 24-25, 2022 in Minneapolis, Minnesota in the United States. The dates and location were selected to co-locate the workshop with American Society for Engineering Education (ASEE) Conference & Exposition, which began June 26.

The ASEE Conference & Exposition is a major annual event that attracts thousands of engineering educators from the United States and elsewhere. The workshop was organized as a primarily in-person event. However, several participants were unable to attend in person and so remote accommodations were made for approximately half of the sessions. The following sub-sections provide additional details about the participants, format, and agenda of the workshop.

A. Participants

A total of 24 people (including the four organizers) participated in the workshop. Of these, 18 people participated in-person, and six participated remotely. Care was taken to have representation from a wide range of academic institutions, as well as in the gender, region, career stage, and previous experience teaching energy access of the participants. Most, but not all, participants were existing contacts of the organizers. Those attending the workshop represented a blend of experience in electricity access and humanitarian engineering, ranging from no experience to decades of experience. A summary of the participants by academic institution type is provided in Table I. In this Table, "PUI" and "TCU" refers to "Predominately Undergraduate Institution" and "Tribal College/University" as defined by the National Science Foundation; R1 and R2 refer to "Very high research activity" and "High research activity" according to the Carnegie classification. In addition, there was one participant from an international university (Universidad de Chile).

TABLE I
Academic Institutions

Name	Description
Bucknell University	PUI
Cal. Poly Humboldt	PUI
Lispcomb University	PUI
Navajo Inst. of Tech.	TCU, PUI
Ohio State University	R1
Rochester Inst. of Tech.	R2
Seattle University	PUI
Tennessee Tech. University	R2
Texas Christian University	R2
University of Colorado	R1
University of Minnesota	R1
University of St. Thomas	PUI
Villanova University	R2

The non-academic institutions represented are shown in Table II. There was an additional attendee observer from the National Science Foundation at the workshop.

TABLE II
Non-Academic Institutions

Name	Description
AGSOL	For-Profit
BEMI	For-Profit
Engineering for Change	Large Non-Profit
EarthSpark Intl.	For Profit
KiloWatts for Humanity	Small Non-Profit
NRECA International	Large Non-Profit

B. Format

The workshop was designed to provide a mixture of panel sessions, keynote speeches, opportunities for discussion, networking interaction, and reflection. Notably, all workshop attendees participated as panelist or keynote speaker in at least one session.

C. Agenda

Participants were surveyed before the workshop to express their interest in possible session themes. The resulting programs for each day of the workshop are found in Table III and Table IV. The sessions in bold were also offered virtually to remote participants. The panels featured three to five panelists. Each panelist gave a presentation, and 10-20 minutes was reserved for questions at the end of each session. The practitioner panel on Day 2 featured five non-academic panelists from for- and non-profit organizations based in the United States, Latin America, and Africa. At the conclusion of each day, a de-brief session was held to summarize the day's events and allow for additional discussion on points of interest.

TABLE III
Workshop Day 1 Agenda

Time	ID	Session Title
8:30-9:00	1A	Welcome Remarks
9:00-10:15	1B	Orientation, Goals, Introductions, Survey
10:15-10:30		Morning Refreshment Break
10:30-11:30	1C	Keynote: Approaches to Humanitarian Engineering to Maximize Pedagogical Benefits
11:30-12:30	1D	**Panel: Teaching Energy Access in the Undergraduate Curriculum Part 1**
12:30-13:15		Networking Lunch Break
13:15-14:00	1E	**Panel: Teaching Energy Access in the Undergraduate Curriculum Part 2**
14:00-15:45	1F	Panel: Preparing and Including Undergraduates in Energy Access Research
15:45-16:00		Afternoon Refreshment Break
16:00-17:00	1G	Day 1 De-Brief
17:30-		Networking Dinner (optional)

D. Surveys

Participants were given two surveys. The first was given during the workshop. This survey asked the participants to respond to several prompts regarding their perceptions of the state of electricity access education at the undergraduate level in the United States. The second survey was given after the workshop with the goal of assessing the success

TABLE IV
WORKSHOP DAY 2 AGENDA

Time	ID	Session Title
8:30-10:00	2A	**Panel: Impactful Student Projects Part 1**
10:00-10:30		Morning Refreshment Break
10:30-12:00	2B	**Panel: Impactful Student Projects Part 2**
12:00-13:00		Lunch Break with Presentation
13:00-14:30	2C	**Practitioner Panel**
14:30-15:00	2D	Keynote: Long-Term Impact of Humanitarian Engineering Projects on
		Views of Diversity, Equity, and Inclusion
15:00-15:15		Afternoon Refreshment Break
15:15-16:00	2E	**Motivating Students to Learn about Energy Access**
16:00-16:30	2F	Day 2 De-Brief
16:30-16:45	2G	Closing Remarks

of the workshop. Both surveys were offered online and were anonymous. Participation in the surveys was optional.

The in-workshop survey was targeted at engineering educators, but all workshop participants were eligible to respond. A QR code with link to the survey was shown to the in-person participants during a break on the first day of the workshop. As such, only in-person participants were able to respond. There were eight respondents to the survey. Although this is a modest sample size, the survey can still provide meaningful insight because, to our knowledge, it is the first time these questions have been asked to a group of electricity access educators. In interpreting the results, the demographics of the respondents must be kept in mind: these are primarily engineering educators with at least enough interest in electricity access to participate in the workshop. It should not be confused with engineering educators at large.

III. WORKSHOP DISCUSSION AND SURVEY SUMMARY

Several themes emerged throughout the the workshop sessions and were documented by dedicated note takers. The most prominent themes that emerged were the state of electricity access education; opportunities to improve student recruitment and retention; barriers to expanding and enhancing electricity access education; and ethical considerations surrounding electricity access projects. The general sentiment of the discussion of these topics are provided in this section. Of course it was not possible to capture all perspectives on these themes and some nuance may have been lost in the note-taking process. Still, there was apparent general agreement on the main discussion outcomes. Survey results related to each theme are provided in the following where relevant. Note that all surveys questions had an option of "No Opinion/Prefer Not to Answer", which has been omitted from figures of the survey results for the purposes of clarity.

A. State of Electricity Access Education

An objective of the workshop was to better understand the state of electricity access education in the United States. The sessions on teaching electricity access in the classroom, student projects, and undergraduate research, as well as the responses to several survey questions provided insight into this theme.

In general, the workshop uncovered that the primary mode that electricity access themes are introduced to students is within the curriculum. This includes courses, independent studies, and capstone projects. Undergraduate research or extra-curricular activities such as student club projects also introduced electricity access themes, but to lesser extent than curricular instruction. Few courses are dedicated solely to electricity access. Instead, it was more common for electricity access themes to be introduced into global engineering (humanitarian engineering) courses. Even if such courses are not offered, a common strategy used by the educators was to introduce electricity access themes in more traditional courses on electric power engineering, thermodynamics, introduction to engineering/design, and sustainable engineering, among others. A common and agreed upon best practice was to use project-based learning when introducing electricity access themes. Examples include having students design solar lanterns, or power supplies for air filters in areas prone to wildfires.

The general sentiment of the educators was that the overall quality and quantity of electricity access education in the United States needs improvement. This was supported by the survey responses, as shown in Fig. 1 and Fig. 2.

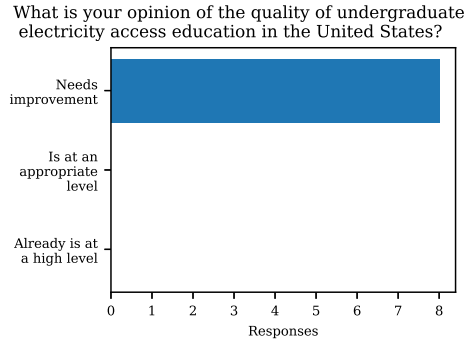

Fig. 1. Survey responses to the question "What is your opinion of the quality of undergraduate electricity access education in the United States?".

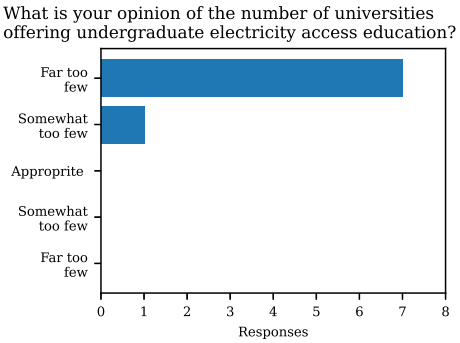

Fig. 2. Survey responses to the question "What is your opinion of the quantity (number of universities) offering undergraduate electricity access education opportunities in the United States?".

The need for improvement was also reflected in survey questions asking about how well students were prepared to either enter the workforce in the global engineering field or to pursue an advanced degree in the area, as shown in Fig. 3 and Fig 4, respectively.

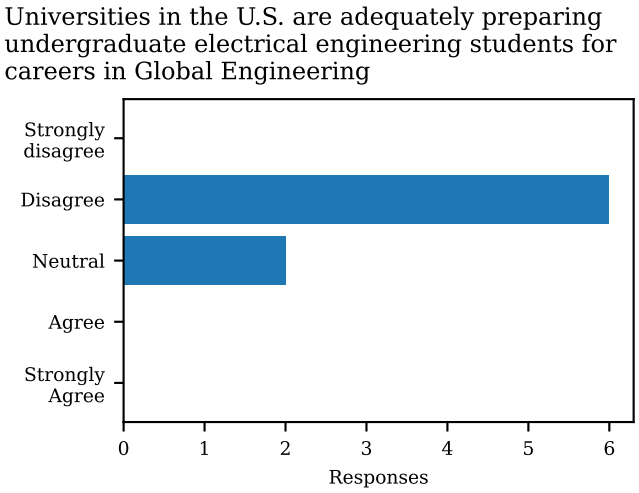

Fig. 3. Survey responses to the prompt: "Universities in the U.S. are adequately preparing undergraduate electrical engineering students for careers in Global Engineering".

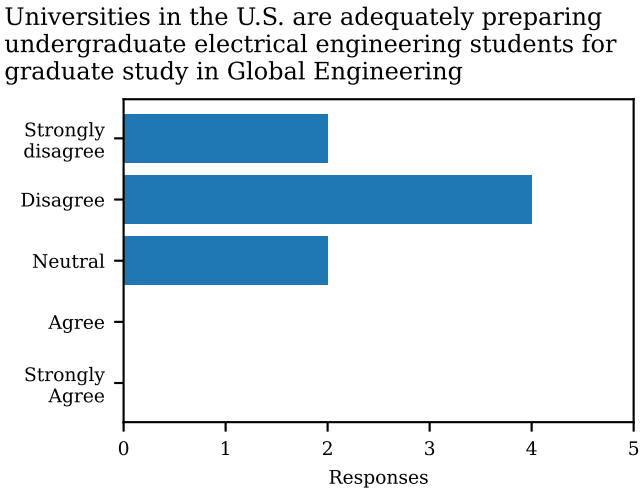

Fig. 4. Survey responses to the prompt "Universities in the U.S. are adequately preparing undergraduate electrical engineering students for graduate study in Global Engineering".

When asked about how improvements should be prioritized, the participants felt that education at the undergraduate level and within the curriculum should be prioritized (see Fig. 5 and Fig. 6) over graduate education and co-/extra-curricular and research activities.

B. Recruitment and Retention

The participants saw the potential of using electricity access themes to reach students and to motivate them to

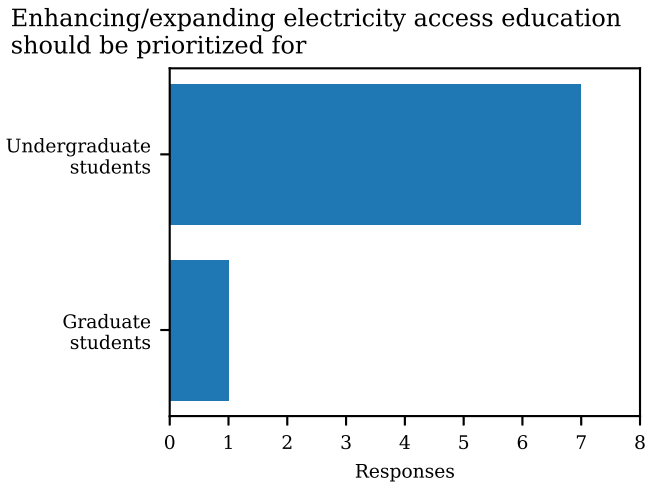

Fig. 5. Survey responses to the prompt "Enhancing/expanding electricity access education should be prioritized for".

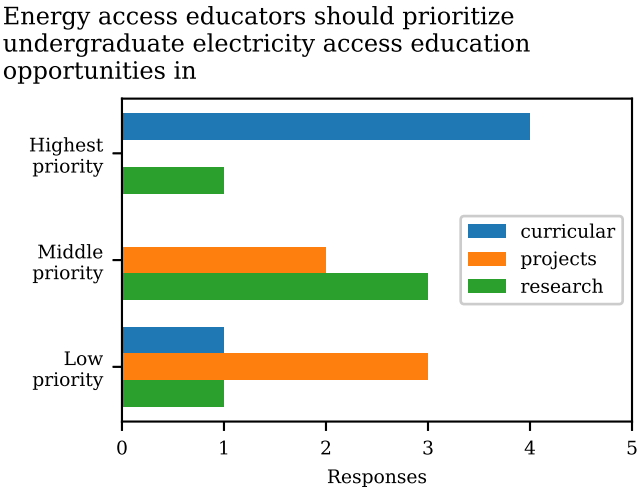

Fig. 6. Survey responses to the prompt "Energy access educators should prioritize enhancing/expanding undergraduate electricity access education opportunities in".

study engineering in general and electrical engineering more specifically (see Fig. 7). A common reason for this was the belief that electricity access frames the discipline of electrical engineering in a way that is socially relevant. The educators felt that electricity access themes would resonate particularly well with students that experienced energy poverty firsthand, and in women that may be more drawn to engineering disciplines whose connection to improving society is obvious. This viewpoint was shared by students at workshop as well.

However, the challenge of reaching students early enough—middle school and high school—to influence their pursuit of an electrical engineering degree was an acknowledged barrier. Participants also suggested that underrepresented communities were less aware of career opportunities in the power industry. The potential for incorporating electricity access themes to improve recruitment and retention in electric power engineering

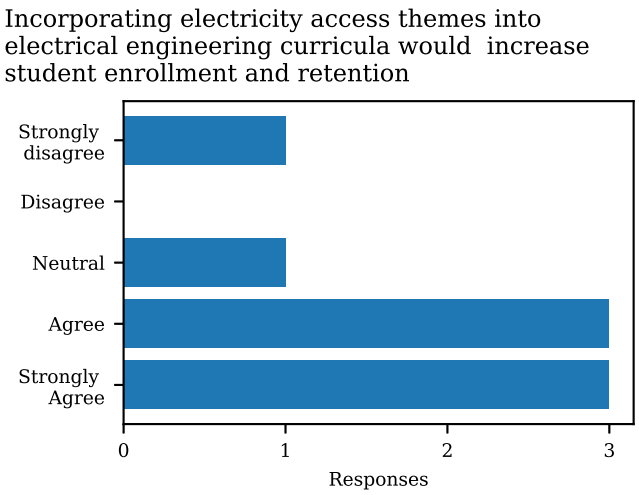

Fig. 7. Survey responses to the prompt "Incorporating electricity access themes into electrical engineering curricula would increase student enrollment and retention".

courses was seen by almost all survey respondents as being particularly promising (see Fig. 8).

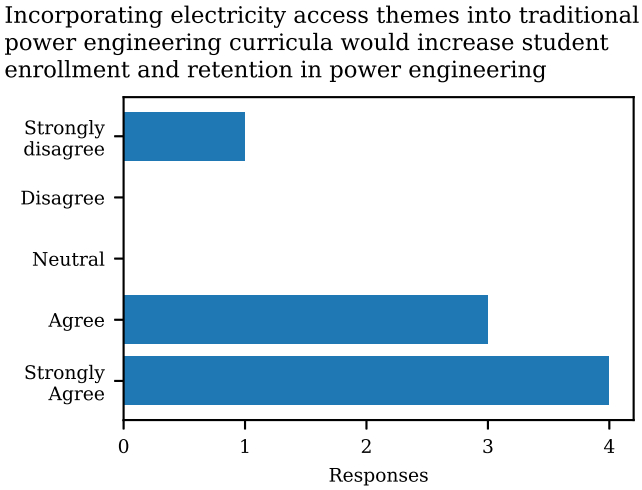

Fig. 8. Survey responses to the prompt "Incorporating electricity access themes into traditional power engineering curricula would increase student enrollment and retention in power engineering".

C. Barriers to Expanding/Enhancing Electricity Access Education

Much of the discussion at the workshop was around barriers to expanding or enhancing electricity access education. The barriers discussed pertained to institutional support, access to education materials, funding, and need for closer ties with industry.

1) Challenges with Institutional Support: There was a general agreement that administration and leadership at the educator's university acknowledged, supported, and in some cases encouraged electricity access education activities for faculty (see Fig. 9). However, it was voiced that faculty hiring decisions often prioritize a candidate's potential for research funding over humanitarian impact and teaching ability. This may decrease the number of faculty with a background in electricity access.

Most felt that electricity access was aligned with their departmental objectives or learning outcomes (see Fig. 10). However, some felt that their faculty colleagues at their institutions were less supportive. A perception is that, to these colleagues, electricity access is "nice to do" but it is not rigorous or true engineering. This sentiment is often expressed by engineering faculty with regard to global engineering more generally [6]. Perhaps reflecting this is the perception that it remains difficult to publish research, even very high quality research, in journals traditionally valued by faculty. Although, it was acknowledged, that this is beginning to change. Survey responses were more mixed on whether electricity access education is adequately supported by awards, conferences, publications, networking opportunities offered by professional associations such as IEEE (see Fig. 11).

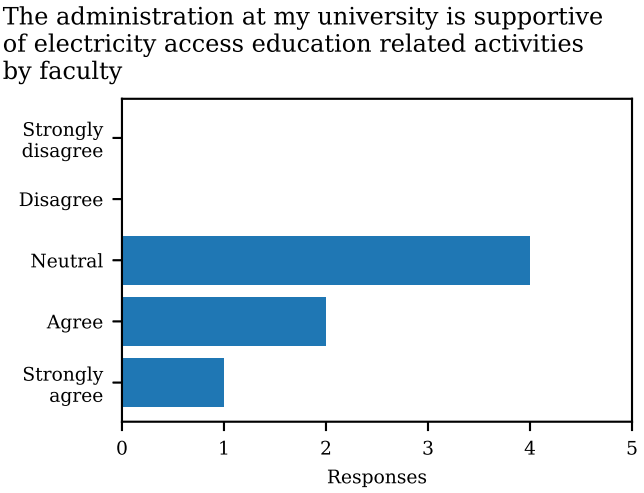

Fig. 9. Survey responses to the prompt "The administration at my university is supportive of electricity access education related activities by faculty(e.g. through tenure/promotion decisions, resources, visibility and recognition, etc.)".

2) Unavailability of Educational Materials: Another barrier identified by the educators was a lack of educational materials—textbooks, lecture materials, videos, and project and homework assignments—that focus on electricity access (see Fig. 12). Exacerbating this is that teaching global engineering and electricity access is felt to be more challenging than technical courses, because there is a social and often cross-cultural component that should be included. Faculty may be less trained in these areas, and it is difficult to find materials that cover in sufficient detail the technical and non-technical aspects of electricity access. This makes the need for resources that include these components even more salient. Two books that educators had used that do offer a blend of technical and non-technical aspects were identified [5], [7]

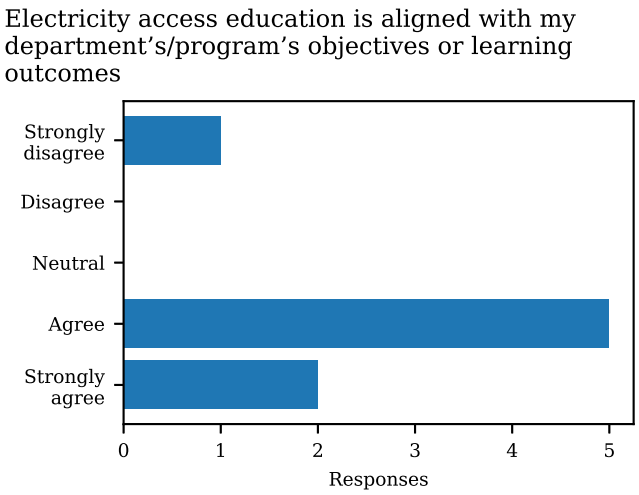

Fig. 10. Survey responses to the prompt "Electricity access education is aligned with my department's/program's objectives or learning outcomes".

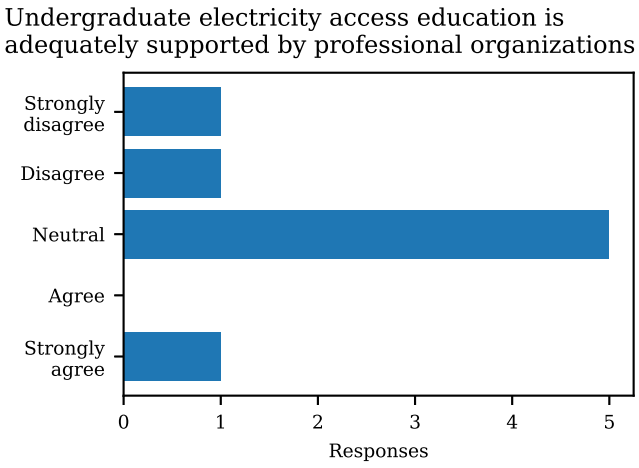

Fig. 11. Survey responses to the prompt "Undergraduate electricity access education is adequately supported by professional organizations for example through specific awards, peer-reviewed journals, conferences and workshops, networking opportunities, etc.".

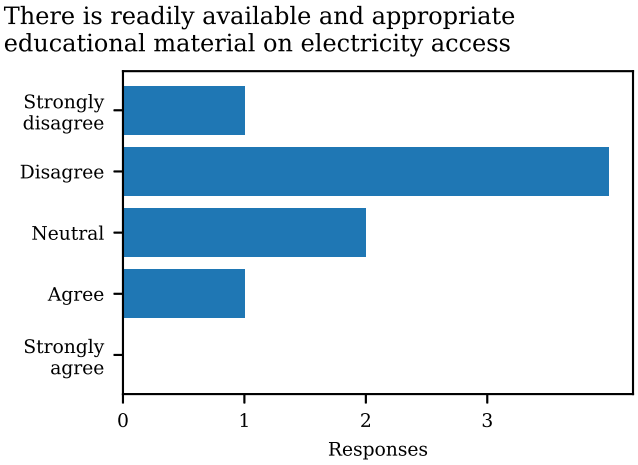

Fig. 12. Survey responses to the prompt "There presently exists readily available and appropriate educational material (lecture notes, videos, laboratory exercises, projects, question banks, textbooks) on electricity access".

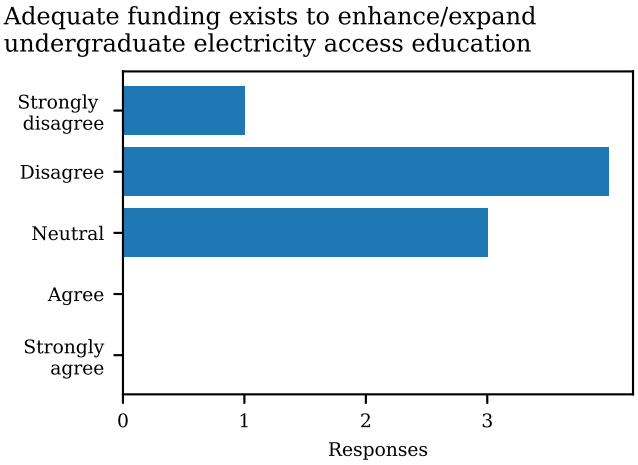

Fig. 13. Survey responses to the prompt "Adequate funding exists through extra-mural sources (government agencies, private foundations, etc.) to enhance/expand undergraduate electricity access education".

3) Inadequate Funding: Adequate funding was also identified as barrier, specifically for extra-curricular projects. Most felt that there was inadequate extra-mural funding available to improve electricity access education (see Fig. 13). There were additional concerns about how universities manage donations for these projects, and whether the sometimes sizable overhead costs would be taken.

4) Lack of Industry Collaboration: Lastly, the participants noted that the connection between industry—those that might hire students—and educators could be strengthened. Although many universities have relationships with organizations involved in electricity access, this is done in an individual, ad hoc basis. There is no strong representative industry voice that can help guide curriculum, learning outcomes or provide crucial insight into workforce quantity or preparedness needs. The lack of reliable electricity access workforce demand numbers is a barrier to enhancing and expanding electricity access education. Pointing toward the demand for engineers skilled in this area would make convincing colleagues, administration, and funders that enhancing and expanding electricity access curriculum is worthwhile.

D. Ethical Considerations

Throughout the workshop, several ethical questions and discussions arose. The educators discussed ways to limit risk to communities from student projects; how to prepare students for projects, especially those abroad; the role of students on projects; and best practices for working with communities.

The educators saw the potential for electricity access projects to indeed be harmful to or extractive from the very

TABLE V
POST-WORKSHOP RATING QUESTIONS AND RESPONSES

Name	Excellent	Good	Neutral/ No Opinion	Fair	Poor
Overall, how would you rate the workshop?	8	4	0	0	0
Rate the organization of the workshop.	9	3	0	0	0
Rate the networking opportunities at the workshop.	5	5	1	0	0
Rate the overall quality of sessions at the workshop.	7	3	1	0	0

TABLE VI
POST-WORKSHOP LIKERT SCALE QUESTIONS AND RESPONSES

Name	Strongly Agree	Disagree	Neutral/ No Opinion	Disagree	Strongly Disagree
I was given the opportunity to expression my viewpoints and opinions at the workshop.	7	4	0	0	0
I learned practical strategies to expand/enhance undergraduate electricity access education at the workshop	4	4	3	0	0
The workshop's sessions concerned relevant topics that I was interested in.	8	3	0	0	0
The workshop identified and discussed gaps and barriers to expanding/enhancing electricity access education.	6	5	0	0	0
The workshop improved my understanding of what skills and experiences students need to be competitive in pursuing career or graduate study in electricity access.	4	4	2	1	0

communities they are intended to serve. Several best practices were shared to reduce this risk. One strategy identified by the educators was to rely on in-class, rather than in-field, experiences and projects to teach electricity access. In this way, there is no risk to actual communities. The educators cautioned, however, that if the in-class projects only focus on technical aspects, then the students may perceive that the non-technical considerations—the social, cultural, economic—are less important. This experience can perpetuate this belief as the students become professionals.

There were also discussion about how to best prepare students for projects that do impact communities. Some discussion centered on the concept of empathy in engineering [8], and the thought that educators must actively encourage and promote empathy to engineering students. The educators discussed how to prepare students for projects that take place abroad. A best practice identified is to have a one-credit course that covers socio-cultural exchange as well as safety. It was also noted that safety and liability concerns can prevent students from having more authentic experiences in the communities they are involved in, such as sleeping overnight in the community. It was also discussed that while there is some research showing the benefits to students involved in these projects, there is scant research on what the impact is on the communities.

There were myriad viewpoints on the role of students on projects that affect actual communities. Some advocated that the goal of undergraduate participation in global engineering projects should be exposure, rather than application. The actual engineering and community engagement tasks should be done by professionals or advanced graduate students. Similarly, some educators suggested that a "learning service" over a "service learning" mindset should be taken for in-community projects, which frames the students' roles as learners/observers rather than "doers" or "saviors" [9]. These approaches necessitate partnering with established, reputable, and perhaps local organizations that regularly perform electricity access work.

When working with actual communities, discussion of best practices centered around building longstanding relationships with the communities, and allowing them to act as authentic partners on the project. Some questioned what role universities should have in development work, since universities tend to prioritize educational experiences for their students over community needs and development outcomes. Again, this perspective highlights a model in which an experienced, established external organization whose mission aligns with the developmental needs of the community leads the project, with the students engaged primarily in learning and observing.

E. Post-Workshop Survey

An evaluative post-workshop survey was administered following the workshop. The results are summarized in Table V and Table VI. The results show that the workshop was highly rated in terms of its overall quality, session quality, organization, and networking opportunities. When asked about their interest in participating in a similar workshop in the future, 73 percent indicated that they had "strong interest" in doing so and 27 percent indicated that they were "somewhat interested".

The responses to the post-survey Likert scale questions is shown in Table VI. Here again the responses show that the workshop was successful in accomplishing its aims.

In addition to these questions, participants were given the opportunity to provide open-ended feedback as to what they liked about the workshop and what could have been improved. The respondents welcomed the diversity of the participants and perspectives, the range of topics covered, and meeting like-minded colleagues. The respondents also suggested allocating

more time to open discussion and ideation around topics of interest.

IV. Conclusions

A two-day workshop was held with the goal of enhancing and expanding electricity access education at the undergraduate level in the United States. The workshop brought together 24 educators, industry and non-profit practitioners, students and other stakeholders. The workshop featured panel sessions on curricular, extra/co-curricular, and research activities.

Discussions and surveys captured participant perceptions on the state of electricity access education, opportunities for student recruitment and retention, barriers for enhancement and expansion, and ethical concerns. Overall, the participants saw a need to improve the quality of and number of universities offering electricity access education in the United States. The participants saw great potential for using electricity access to attracting and retaining students in electrical engineering. The barriers identified included lack of support or acknowledgement of the value of electricity access education from faculty peers; lack of educational materials; inadequate funding; and absence of an electricity access workforce advocate to provide input on curriculum design and workforce forecasts.

Several recommendations can be made based on the workshop's discussion and survey results. First, a wider, more formal study of the state of electricity education is needed. Second, there is clear value that participating in the workshop is perceived to be valuable by the participants, and future workshops should be offered. Third, there is a clear need for materials to make it easier for interested faculty to teach electricity access. Fourth, a closer, more formalized relationship with academia and industry should be explored.

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