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Engagement in Practice: Building Inclusive and Just Pathways to a Clean Energy Economy through Youth Education of Clean Energy

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Introduction

The International Energy Agency predicts that growth in the clean energy industry could create thirty million jobs around the world in a range of industries, from construction, engineering, manufacturing, etc. by 2030 [1]. However, as clean energy job opportunities increase, the gap between available jobs and qualified workers grows. Education in the U.S. does not emphasize the clean energy or environmentally friendly behavior, so many students do not see these jobs as a potential career path or even know they exist.

Education plays a critical role in helping the United Nations reach its Sustainable Development Goals (SDGs) [2]. Environmental education begins with giving children access and opportunities to build a relationship with nature, learn about environmental issues and the need for clean energy, develop important skills for the clean energy workforce, and inform them of the jobs and career paths in clean energy [3]. The early introduction of these ideals and opportunities will ensure that students have the interest and ability to participate in the clean energy industry.

Not all students have access to education about the environment and clean energy issues. Students from a low socio-economic status (SES) have the least exposure to clean energy, the industry's growing job opportunities, and the skills to become qualified applicants for those jobs [4]. If a school does not prioritize exposure to environmental issues and clean energy technology, their students will be less likely to pursue a career in the field compared to schools that had the resources to include environmental education in their curriculum.

Alabama does not have environmental education requirement in its public schools, leaving many students without access or exposure to the skills or job opportunities available in the clean energy industry [5]. In 2021, the state established the STEM Council to address the shortcomings, and clean energy needs to be emphasized [6]. Outside of the classroom, rural communities are wary of unfamiliar businesses, and clean energy jobs might not gain the same traction as some parts of the country [7]. As such, many of the Alabamian youth are disadvantaged in clean energy and energy efficiency, and workforce development. An important contribution of this research is that we address recent interest in developing youth education programs for an inclusive and just transition to clean energy.

While clean energy education can provide tools to students to grow and explore interests in related academic and career pathways, we lack conceptual models and empirical research on how students shape and grow their interests, attitudes, and knowledge of the clean energy economy based on their learning and interactions with mentors and peers. To fill this theoretical and practical gap, we present a research-based practice implemented in Alabama; the Alabama Energy Transformation Initiative (AETI) developed energy science and management training for secondary and higher education and explored its potential to build inclusive and just pathways to a clean energy economy. In this research, we address the following research questions.

- How does the hands-on, real-world, and problem-based energy education approach affect students' perception and disposition towards STEM and specifically the area of energy?

- How does the interaction with mentors influence student mentees' perception toward scientists/engineers and energy issues?

Project Description

The collaborative team for the initiative included The University of Alabama (UA) Engineering and Political Science Departments, Energy Alabama (a nonprofit organization), the Alabama Industrial Assessment Center (AIAC), and local majority-minority high schools. Most of the UA participants are underrepresented minority (URM) students in STEM.

Student recruiting strategy

To meet the project objective of increasing the underrepresented minority students in STEM engaged in these high impact experiences, intentional marketing and participant recruitment was used. Strategies included engaging students already a part of other URM in STEM programs such as the Louis Stokes Alliance for Minority Participation (LSAMP), as well as participants in an on-campus program for men of color called BRIDGE. These communities not only acted as ready populations to recruit from but were also asked to share the experience with their peers, further enlarging the recruitment efforts. Additionally, a review of all STEM and/or racial/ethnic minority-centered student organizations was conducted, and information was shared with those officer groups to share with their respective students. This snowball method of recruitment was successful in reaching a large audience to recruit from while avoiding mass emails that can feel less personalized. The recruitment for the program spanned just over a month in 2022, from late July to early August, and resulted in a strong group of applicants for the program.

Clean Energy Instruction and Mentorship Training for College Mentors

In partnership with a local non-profit, Energy Alabama, the project aimed to educate up to 50 high school students at two majority-minority schools with peer mentoring by college students. Mentor students met with the Education Manager and Director of Energy Alabama to align on

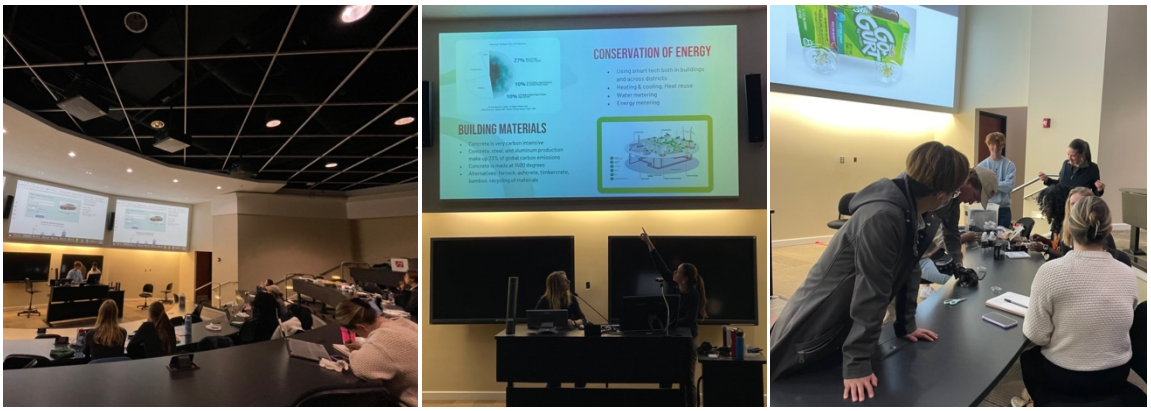


Figure 1. Mentors mock presenting course material and hands-on activities for peer feedback

energy education topics. After being introduced to the educational and program topics, mentor students were divided into the following five groups: 1) Why Care About Energy; 2) Energy Conservation and Efficiency; 3) Renewable Energy; 4) Building Science; and 5) Electric Transportation. Each group created presentations that included both an educational lecture section and interactive, age-appropriate activities relating to the educational contents. These presentations also incorporated objectives from the Environmental Science portion of the Alabama Course of Study. After submitting initial drafts to Energy Alabama for review in October of 2022, the mentor students revised their presentation contents and gave mock presentations in January for peer review and final revisions, as depicted in Figure 1. The mock presentations also allowed for cross training between groups, as having mentor students able to present any of the five topics increases scheduling flexibility.

Provision of Clean Energy Education at Partner High Schools

Beginning in late February 2023, mentor students will present in groups of two to three at two local majority-minority high schools during their general and Advanced Placement environmental science classes. The clean energy education will be taught in five class sessions over one or two weeks in each school, and college mentors will serve as a lead instructor teaching subject matter, demonstrating hands-on activities that they prepared, and interacting and assisting with mentee students during in-class activity time. The high school students reached will be evaluated for educational content retention to assess the effectiveness of the Energy in Action outreach.

Supplementary Seminars and Field Trips

Clean energy cuts across multiple issues from sustainable development to energy justice, and thus clean energy education should take a comprehensive approach in empowering students and igniting their entrepreneurial vision. In doing so, we have organized the Clean Energy Seminars (in person and virtual) by inviting speakers from industry, governments, and academia in science, and technology. The program format allowed for anyone at UA or outside the organization to attend. We also organized Sustainable Energy Field Trips with businesses that have adopted sustainable energy practices. For example, we visited the Mercedes-Benz of Birmingham, AL manufacturing plant to tour their new electric vehicle line.

Research Methods

Research Design

This research examines to what extent the provision of clean energy education influences both participating student mentors' and mentees' interests in STEM and energy literacy composed of knowledge, attitudes, and behaviors toward clean energy. For college mentors, pre- and post-program surveys and interviews will be conducted to measure their perceptions of clean energy. Since we recruited only 10 college mentors, the sample size is too small to conduct any

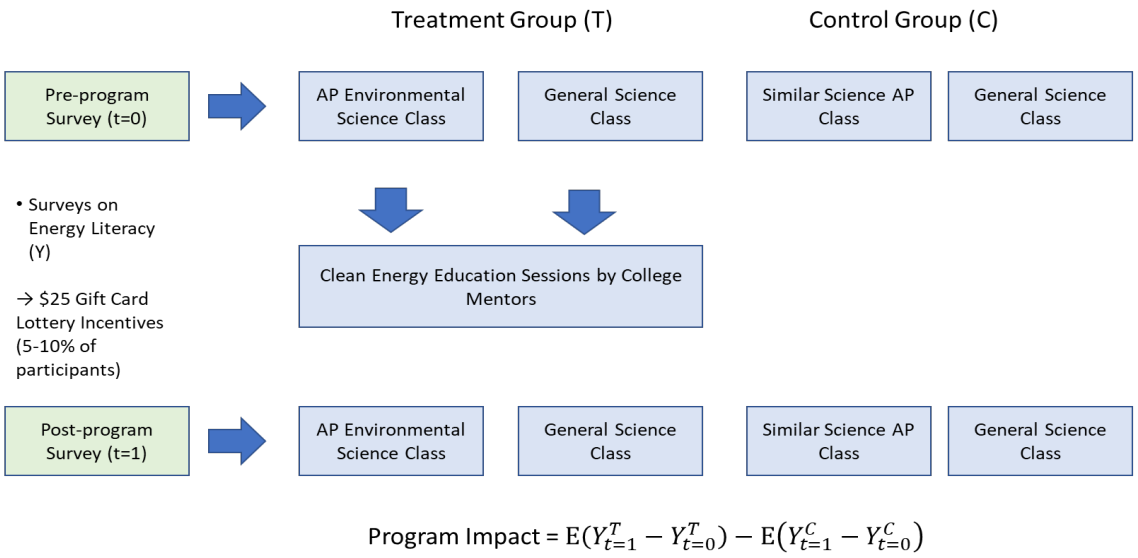


Figure 2 Evaluation Design for Clean Energy Education Program on High School Students

meaningful statistical analysis. Therefore, qualitative data from interviews will be primary data to understand their energy literacy.

For high school mentees, pre- and post-program surveys will be conducted with those students taking the energy education sessions (treatment group), with a control group taking the same surveys for a comparative analysis. Since the energy education sessions will be incorporated into a part of the environmental science class, we will recruit control group students from similar science classes in the same school. The overall approach to assessing the program impacts on High School students is described in Figure 2.

Sample Characteristics

Table 1 summarizes demographic information of 10 college student mentors in our sample. Ethnic group categories not represented by our mentor student group is not shown in the table. Mentor students' majors included chemical, environmental, and mechanical engineering, and finance. College freshman to senior students participated in our program as mentors.

Table 1. Mentor Student Demographic

	Black	Hispanic	White
Female	1	1	5
Male	1	0	2

Our high school mentee student sample is drawn from two majority-minority high schools from Tuscaloosa County (School A) and Hale County (School B, located in Black Belt) districts respectively, approximately 60 and 25 students from each school for the program participation. While the recruitment is still in process, and we do not collect an individual student's demographic information, our sample most likely to include Black, economically disadvantaged students who are disproportionately suffering from low funding, high student-teacher ratios, and

low outcomes in STEM education. Table 2 provides overall socio-economic and educational conditions of these schools in comparison with Alabama and National average.

Table 2. A Comparison of Participating High Schools with State and National Averages

	School A (in Tuscaloosa County)	School B (in Hale County)	Alabama Average	National Average
# of Students in School	1,314	383	544 (K-12)	514 (K-12)
School Budget (2021)	$7,088,345	DISTRICT: $8,267,799 (could not find stat for individual school)	Alabama education budget is $7.7billion for 2022	National education budget is $666.9 billion
Gender Composition	645 male, 669 female	194 male, 189 female	N/A	N/A
Racial/ethnic Compositions of Students	39.4% White, 55.5% Black, 5.1% Other	50% White, 48.2% Black, 1.8% Other	58% White, 32.4% Black 9.6% Other	45.8% White, 15% Black, 28% Hispanic, 5.4% Asian
Cost Per Student	$5,394	$10,298	$10,100	$13,185
Student-Teacher Ratio	18.77	24.7	15.7	15.3
College/Career Readiness	65.45%	98.80%	76%	64%
Students Classified as "Economically Disadvantaged"	43.65%	59.40%	47.70%	N/A
Science Proficiency	32.31%	19.77%	37.31%	N/A

Note: Information drawn from National Center for Education Statistics (NCES). Accessed on February 10, 2023 at https://nces.ed.gov/Programs/Edge/ACSDashboard/0101680.

Both schools have a significant population classified as “economically disadvantaged.” 60% of the School B (in Hale County) student population falls into this category, and, while relatively better, 43% of School A (Tuscaloosa County) also comes from a low socio-economic status. The schools’ budgets are significantly lower than the national average - School B spends $3,000 less per student than the national average of $13,185, and School A spends less than half the national amount, averaging $5,394 per student. This lack of funding extends to a lack of teachers. Both schools have higher student-teacher ratios than both the state and national averages. Without a

sufficient workforce, students' academic proficiencies drop significantly. Only 32% of students at School A are proficient in science, and School B is even lower, with only 19% of students reaching proficiency. Furthermore, these schools have Black student populations significantly higher than the state and national averages. 55.5% of the School A and 48.2% of the School B student bodies are Black, while Alabama's student population is 32.4% Black and the nation's is 15%.

Measurement of Energy Literacy

To measure energy literacy of high school students in both treatment and control groups, we use an energy literacy survey developed for high school seniors and graduates by the National Energy Foundation (NEF) [8]. The survey questionnaire is composed of questions measuring a respondent's knowledge of energy issues and concepts, behaviors related to energy consumption and efficiency, and attitudes related to energy.

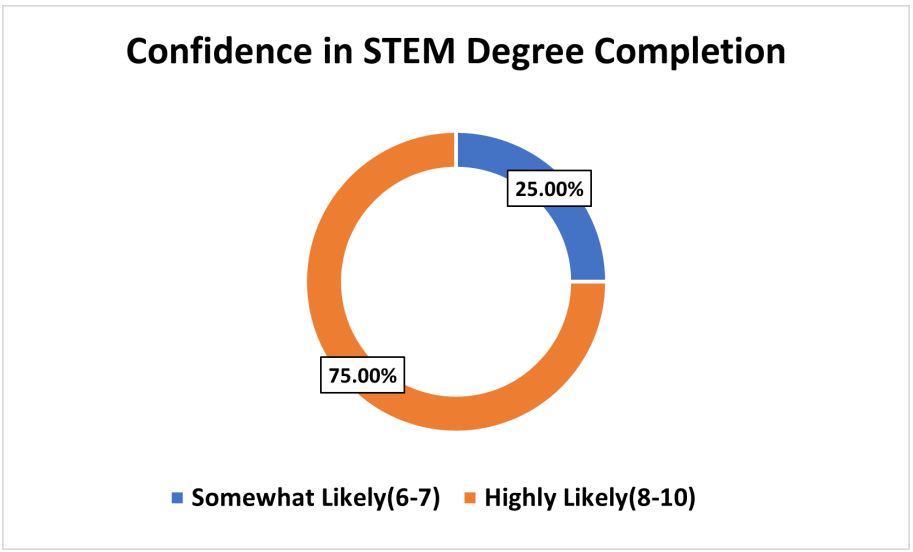
To measure energy literacy of college mentors, for which group a survey is not a valid instrument, we conduct a semi-structured interview asking modified questions from the NEF survey, with open-ended questions to elaborate their answers.

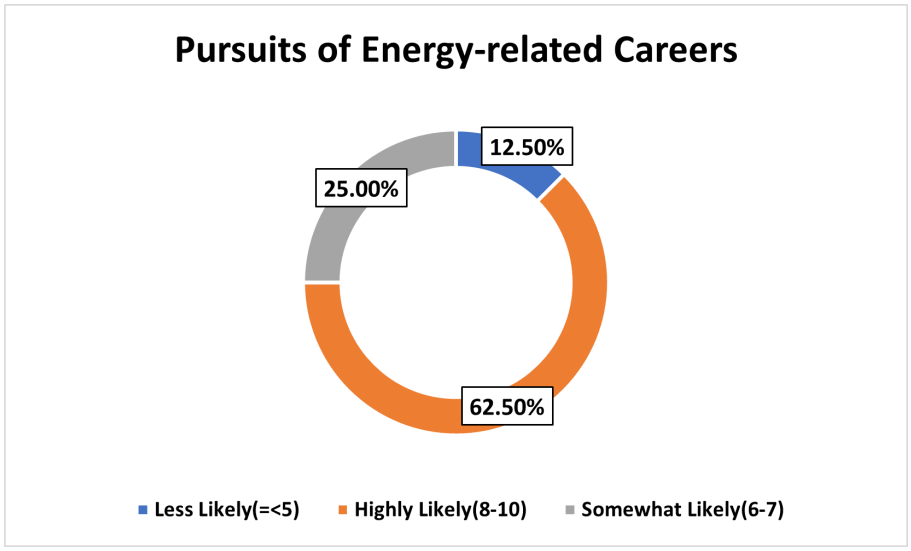
Preliminary Results from Mentors' Interview and Discussion

Via surveys and interviews, we will evaluate high school students' technical understanding, analyze how hands-on, real-world, and problem-based education affects their perception and disposition toward STEM and energy, and gauge their interest in continuing to pursue energy and STEM education and career. Since this project is still in implementation, with the high school education outreach scheduled to be implemented between March and April 2023, surveys toward high school student participants have not been conducted yet. The only data collected at this stage is pre-program survey and interview on college mentors about their perception and disposition toward energy.

The pre-program survey and interview of college mentors included open-ended questions that asked college mentors to describe their academic goals, career aspirations, and their personal understanding of clean energy. The **Error! Reference source not found.** provides a preliminary result on 8 students' responses on their likelihood of completing their declared STEM degrees (top left), pursuing energy-related careers (top right), and discussing clean energy issues with their peers (bottom), in 0 to10 response scale. These students showed their passion for their declared STEM degrees and clean energy awareness as most college respondents showed high likelihood in those questions.

Their interviews also display these interests, illustrated by one student who said, "I think it's really important to find clean solutions to some of our energy problems…and make that a





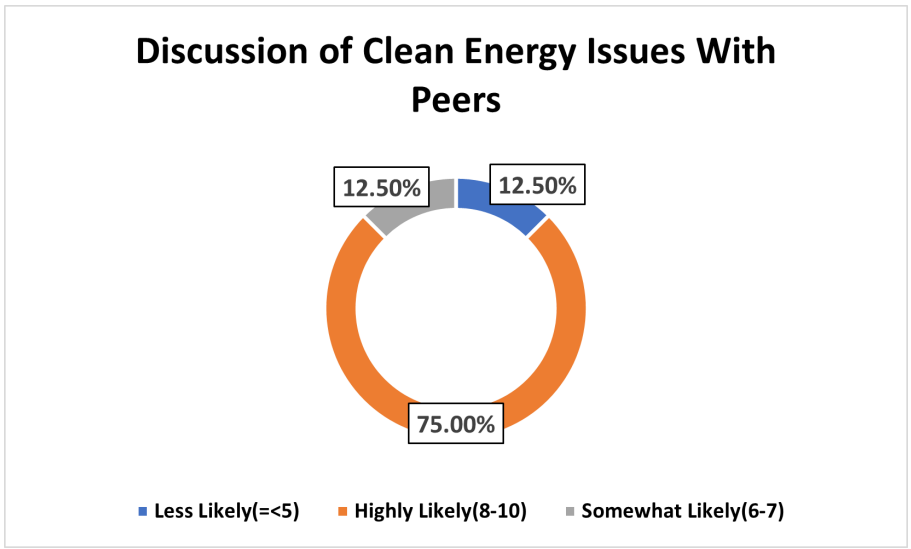


Figure 3. Pre-program surveys on college mentors' disposition toward STEM and clean energy

priority when considering energy solutions and also for human impacts with pollution." (Female Freshman in Mechanical Engineering). Emphasizing the importance, another student remarked that "clean energy is beneficial and it's a great way for us to keep our environment how it is" (Female Sophomore in Civil Engineering).

Participating high school mentees will benefit greatly from the advice, guidance, and examples set by the college mentors, ultimately encouraging these high schoolers to pursue a degree and career path that they may not have considered before. The goals these mentors have can introduce new careers, another student explains, showing them that pursuing clean energy is "an opportunity to learn a lot, just as a young engineer and as a young student in a STEM major. There's a lot happening in the world right now, moving towards clean energy…Learning about clean energy and learning about how these things can impact the world as a whole really gives us an opportunity to apply these to our future careers, and help those things in that direction" (Senior in Chemical Engineering).

Another mentor highlights these many opportunities when they say they "want to pursue a career in energy resources in some way, hopefully, solar, wind or water…I'm also really passionate about pursuing a career in green architecture and going into the planning and design process of that" (Female Junior in Environmental Engineering). Whether these mentees pursue a degree in STEM or not, the relationships they will build with these environmentally-minded mentors will bleed into other aspects of their life. As one student says, "... after graduation I would like to focus my career goals on sustainable development in rural communities both domestically and abroad. I envision a combination of field work, creativity, design and management…as well as implementing sustainability policy to develop human condition goals and also sustainable goals at the same time," values that will promote clean energy and environmental awareness both in and out of the STEM field (Female Freshman in Environmental Engineering).

Conclusions, limitations, and future work

Energy and climate change issues in Alabama are related to the equity issue as the state is home to one of the highest household energy burdens and industrial energy use in the nation. Education and outreach are our main levers for supporting underserved and underrepresented groups. Education plays a crucial role by teaching young students about environmental issues, developing skills for the clean energy workforce, and informing them of career paths in the field, but Alabama is one example of a state with no environmental education requirement. Not all students have equal access to environmental education, and those from low socio-economic status have the least exposure to the field. The Alabama Energy Transformation Initiative (AETI) is a research-based practice aimed at addressing the gap in understanding how students shape and grow their interests, attitudes, and knowledge of the clean energy economy through learning and interaction with mentors and peers. AETI provides energy science and management training to secondary and higher education students in Alabama and aims to build inclusive and just

pathways to a clean energy economy for Alabamian youth. This Engagement-in-Practice paper present the preliminary data before interventions at partner high schools. A full analysis will be conducted after the high school program, and report results regarding the effects of hands-on, real-world, and problem-based energy education on students' perception and disposition towards STEM and specifically the area of energy, as well as the influence of interaction with mentors on students' perception towards scientists/engineers and energy issues.

Acknowledgment

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