The Future of
Engineering Education
2024 Annual Conference & Exposition

Oregon Convention Center
Portland, OR . June 23 - 26, 2024

ASEE

Paper ID #42284

Visual Voices in Computing: Exploring Photovoice in Computer Science Education for Underrepresented Groups

Miss Disha Patel, Florida International University

Disha Patel is a computer science Ph.D. Candidate in the School of Computing and Information Sciences (SCIS) at Florida International University. Her research interests include using the photovoice method to investigate how underrepresented students perceive they can be best supported through navigation of the computer science field.

Mrs. Monique S. Ross, The Ohio State University

Monique Ross earned a doctoral degree in Engineering Education from Purdue University. She has a Bachelor's degree in Computer Engineering from Elizabethtown College, a Master's degree in Computer Science and Software Engineering from Auburn University

Visual Voices in Computing: Exploring Photovoice in Computer Science Education for Underrepresented Groups

Abstract

Photovoice, a participatory action research method, aims to enable participants to document and reflect on their group's strengths and concerns, fosters critical dialogue and knowledge-sharing through the images captured, and reach changemakers. While widely utilized in the fields of medicine, social sciences, and education, its application in engineering education is relatively new and underexplored within the domain of computer science education. This position paper aims to present a comprehensive account of a pilot study that introduces photovoice to computer science students, showcasing the method's merits and contributions.

The study investigates the strengths of photovoice in comprehending the perspectives of underrepresented groups in computing guided by emancipatory research in which participation is elicited not just from a sample population. Rather, it is used as an analytical perspective because participants actively engage in co-constructing knowledge with researchers. Over a two-week period, six participants representing minoritized backgrounds based on race, gender, or sexuality, enrolled full-time in a U.S.-based computer science program and engaged in photovoice as part of a Research Experience for Undergraduates (REU). The objective was to capture their experiences and challenges during their initial REU participation. Participants were guided by the following prompts:

- What are your experiences and some of the challenges you may face participating in an REU?

- How has your participation in this program changed your view on computer science/computing?

- How has your participation in this program affected your life?

This paper will outline the implementation of photovoice with this group of participants, detailing how research facilitators adapted and executed the method's steps, the obstacles confronted during the process, and the inherent value derived from the study's outcomes. Themes that emerged and were defined from discussion exercises with participants are the following: 'lost and found,' signifying moments of uncertainty and discovery; 'lack of community,' highlighting feelings of isolation; 'not surface level,' underscoring the depth and complexity of the issues discussed; and 'community,' reflecting participants' desire for, or efforts toward, building a sense of belonging within the research program. These themes serve as integral components of our

investigation into the impact of photovoice on understanding the perspectives of underrepresented groups in computing.

Keywords: Photovoice, computer science, underrepresentation, student perception

1 Introduction

This paper extends the application of photovoice to the field of computer science, specifically examining the experiences of participants in a Research Experience for Undergraduates (REU) program at a U.S.-based university. The study follows six participants enrolled full-time in a computer science program, gathering for a two-week on-site REU in the Midwest. The participants, comprising three women, two men, and one non-binary individual, represent diverse educational levels and ethnic backgrounds. As the group engages in photovoice, this paper explores their experiences, providing a unique lens into the challenges within the realm of computer science education.

Photovoice, a method of participatory action research, empowers participants to document and reflect on their community's strengths and concerns through imagery, fostering critical dialogue and knowledge-sharing [1]. While popularly utilized in medicine, social sciences, and education, its application in engineering education [2–5] and computer science education [6–8] is relatively new and underexplored. This position paper aims to bridge this gap by presenting a comprehensive account of a pilot study that introduces photovoice to computer science students, showcasing the method's merits and contributions. It will outline implementation and adaptation of the method's steps, obstacles faced during its duration, the value derived from the emergent themes from visual artifacts developed from participants, and the holistic value derived from active participation throughout the process. This paper aims to explore how the deeper insights gained from photovoice can enhance various aspects of computer science programs, departments, organizations with focused intentionality, thereby contributing to the retention and expansion of participation among underrepresented minority populations within the discipline at large. NSF [9] defines underrepresented minorities as "races or ethnicities whose representation in STEM employment and S&E education is smaller than their representation in the U.S. population. This includes Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives."

2 Literature Review

One common means of using photographs for research, photovoice, is a method of participatory research in which study participants are also researchers - there exists co-construction of knowledge between official researchers and participants. The concept of photovoice as a tool for participatory research was first introduced by Wang and Burris in 1997, before photo and video sharing social media platforms were developed. The three main goals of photovoice as described by Wang and Burris (1997) are as follows:

1. "to enable people to record and reflect their community's strengths and concerns,

2. to promote critical dialogue and knowledge about important community issues through large and small group discussion of photographs, and

3. to reach policymakers." (p.397) [1]

Wang and Burr (1997) have highlighted several benefits to implementing photovoice as a research method. Some of these benefits include being able to identify and assess the needs and strengths of participants in a community; sustain participation of the vulnerable, in the context of our study minoritized, populations in a community; amplify the voices of participants to reach other community members and push for change [1]. The possibility of such positive outcomes has been investigated in relation to women [10–12], disadvantaged groups [13, 14], and largely within the professional medicine community [15–17]. Yang has used photovoice, along with portrait photography and photojournalism, to study whether participatory photography can help socio-economically disadvantaged adults develop agency towards pursuing higher education [14]. Budig at al. have used photovoice to bring together residents of a low-income community in Spain, public health practitioners from the area, and university-based researchers to understand residents' perceptions of the local food environment existing in the community and communicate the needs of the community to local policymakers [13]. In previous studies, researchers have hosted discussion groups in which participants came together to review the photographs, get to know each other, and in turn begin to build some form of community [13, 14, 18, 19]. Such community-building and strengthening efforts in computer science education that may also benefit from implementation of the photovoice method include classrooms, hackathons, student organizations, etc.

A number of studies within engineering education adopted/modified elements of photovoice such as opting for individual interviews with participants in place of group discussions, or choosing to implement thematic coding as a process removed from the participants, etc. [3, 4, 20–26]. Most recently photovoice has been seen in engineering education through a study conducted by Parnell Jr, et. al (2023) in a paper titled "Engineering While Black: Exploring the Experiences of Black University of Florida Undergraduate Engineering Students Using Photovoice." Researchers explored how the "racial climate in the United States was impacting the experiences of Black undergraduate engineering students' (p.2) at a Predominantly White Institution (PWI) campus. They found six themes emerging from their participants' experiences: finding comfort, building community, fitting in, experiencing frustration, overcoming imposter syndrome, and valuing mentorship [2].

No studies were identified within the United States where all goals of photovoice (listed above) were implemented. One study, conducted in Scotland, was found in which researchers were using photovoice to study the transition journey of transfer students transitioning from 2-year college degrees to the School of Computing at a university [7]. Perez has proposed that the community should consider conducting a study that uses photovoice to understand the experiences of youth and their families in integrating computing into their learning schedule [8]. The limited exposure of photovoice in the field of computer science is noteworthy as it underscores the potential value of detailed studies like these in informing others seeking to introduce diverse qualitative approaches into traditionally quantitative environments.

This paper has loosely adhered to the tenets of emancipatory research,a multifaceted concept encompassing various critical theories. Some of its aims, as delineated by El-Amin and Brion-Meisels in their editorial piece "Emancipatory inquiry in educational research: models and methods for transformational learning," [27] have been considered. The first objective involves "

redefining who is the researcher and who is researched" (p.1). This paper addresses this objective by seeking to involve participants beyond merely serving as subjects of study, rather co-creators of knowledge. Participants have been asked to work alongside researchers to develop meaning from the images they have taken through their engagement as subjects of the study. Their involvement has also helped address the second objective of "shifting whose forms of knowledge are valued and centralized" (p.1). This paper places the outcomes of how participants describe their experiences at the forefront, rather than the researchers individual interpretations. The third objective is "being attentive and responsive to social power, privilege, and intersectional oppression" (p.1). The participants in this study comprise a distinctive cohort, each identifying with at least one minoritized group within the field of CS, with some aligning with multiple minoritized identities, placing them at various intersections (see Table 1).

3 Context

This study follows the experiences of six participants enrolled full-time in a U.S.-based computer science program, who gathered at a PWI in the Midwest to engage in a REU. The program lasted for two-weeks and was on-site, allowing students to interact daily for the duration. Each student was flown into the Midwest, assisted with moving into dormitories, and provided funds for meals on campus. The REU experience starkly contrasted with their regular campus experiences; most attendees hailed from universities with predominantly commuter student populations and were transitioning to dormitory living. Among the participants, four were enrolled in a minority-serving institution (MSI) and two in a historically Black college or university (HBCU), now finding themselves at a large PWI.

Table 1 outlines each participant's education level, gender, racial, and ethnic background as provided by them. Three participants identified as women, two men, and one non-binary. Three participants were in their senior year of undergrad, one junior, and two freshmen. In terms of race/ethnicity, one participant identified as Black, one as Black/Hispanic, three as White/Hispanic, and one identified as Latina.

Year	Gender	Race/Ethnicity
Senior	Non-binary	White/Hispanic
Senior	Woman	Latina
Freshman	Man	Black
Junior	Woman	White/Hispanic
Freshman	Man	Black/Hispanic
Senior	Woman	White/Hispanic

Table 1: Participants' education level, gender, racial, and ethnic background

4 Positionality Statement

The primary author of this paper is a PhD candidate of South Asian Canadian/American background, raised in an immigrant family. Having obtained her computer science degree from a minority-serving institution, she shares a commonality with numerous participants in this study.

The author recognizes that her personal background and shared experiences with the participants contribute to a nuanced understanding of the findings. Additionally, she meets participants at multiple crossroads of similarity including gender, academic interests, and experiences as a first-generation immigrant. These crossroads of similarity have influenced the design of the study as she aims to advocate to hear the voices of minoritized groups in the Western world. Therefore, she has chosen a participatory action research method, recognizing its potential to empower participants and amplify their voices within the research process. She takes her personal experiences in these realms into consideration while also drawing her own interpretations of photographs and captions, and themes holistically.

5   Method - Phased approach

Photovoice is a method known for its adaptability and flexibility, offering a structured framework for implementation. Numerous guides are available to assist facilitators in dissecting this multifaceted approach into manageable steps [28–30]. In order to incorporate the photovoice activity into the REU we adopted approaches found in such guides and tailored them to complement the struture of the REU. For example timelines were modified to match duration of the REU, and ice breakers used in the REU were replaced any ice breakers mentioned in the guides. Participants were asked to take photos on their phones instead of being provided with disposable cameras as some guides suggested. In order to make discussions more interactive photos were printed and grouped into categories on a large table.

Prior to the initial session, students were given the opportunity to acquaint themselves by engaging in an icebreaker activity on the first day of the REU. During this introductory session, students were asked to create a life map and present it to the group, with graduate mentors also actively participating in this engaging activity. The life map activity is one in which participants are asked to create a visual representation outlining the major milestones in their lives to share with the group.

5.1   Phase 1

The first official session served as an introduction to the concept of photovoice. Students were provided with comprehensive instructions outlining the structure of the activity to unfold over a two-week period. Their initial task involved the submission of five photos (each having its own unique title, and a caption no longer than a few sentences) within two days, each relevant to the provided prompt. Sample submissions were provided, and a step-by-step guide to the activity was presented. For precise details, refer to Appendix 1, which contains the exact written instructions provided to the students. The following prompt was presented to participants: "Spend time this week capturing at least five photos that you feel best capture your experiences and some of the challenges you may face participating in an REU for the first time". The following guiding questions were also given to help them:

1. What are your experiences and some of the challenges you may face participating in an REU?

2. How has your participation in this program changed your view on computer

science/computing?

3. How has your participation in this program affected your life?

5.2   Phase 2

The subsequent session was dedicated to individual presentations, where each student showcased their captured images. These photographs delved into the students' experiences adapting to the new campus environment, including aspects such as local cuisine and extracurricular activities outside of REU commitments. While the initial photos were insightful for REU stakeholders organizing the event, they were not in alignment with the initial purpose and prompts provided to participants. To address this, we (the researchers) pivoted the current working sessions to revisit instructions, and highlight examples that qualified for the study in the group setting. Participants were instructed to return later in the day with new or adjusted photos, titles, and descriptions that better conformed to the overarching theme of the photovoice activity. They were subsequently asked to present each photo to the group using the "SHOWeD" method [31]. This method comprises a set of questions designed as a guide for describing the photos. The questions are as follows:

1. What do you See?

2. What is really Happening?

3. How does it relate to Our lives?

4. Why does this situation, concern, or strength exist?

5. What can we Do about it?

5.3   Phase 3

In the third session, after having time to alter their submissions, students convened around a table, each photo printed on a separate piece of paper alongside its title and caption (e.g., see Firgure 1). The group collectively spent time organizing the photos into common themes (see Findings). Students took on the dual responsibility of not only grouping the photos but also determining how to categorize and define each theme through an iterative process of discussing photos one by one and determining which they found related to one another. An inductive approach was employed for coding the photographs - it involves interpreting data and identifying emerging themes [32] participants considered which words would arise repeatedly to develop emerging theme names from the grouped photos, rather than trying to fit the photos into predetermined categories.

5.4   Phase 4

At the end, one participant assumed the responsibility of collaborating with fellow students to present their exhibition of photos to the facilitators of the REU. Each participant ultimately selected two images as their final submission. These selected images were compiled and showcased on a dedicated website.

6 Findings

This section of the paper will focus on presenting descriptions of what each theme represented along with a selection of photos from each theme. Due to the nature of this paper arguing for the the use of the method, we will not be providing an in-depth recounting of the analytical approach. Participants collaborated to organize photos into four major emerging themes- "lost and found", "lack of community", "not surface level", and "community". They worked through many iterations of groupings as they discussed their diverse interpretations of them. Discussions around specific photographs along with the photographer allowed others to gain a deeper understanding of one's experiences.

Additionally, it's worth noting that the photos and captions are presented with the correcspnding figure and reflect participants' experiences within the REU program and in their pursuit of a computer science degree. These themes provide a deeper understanding of how these experiences can represent their encounters in computing at large.

6.1 Lost and Found

Figure 1 is an example of the theme "Lost and Found", which captures participants' sentiments of feeling lost, particularly when attempting new tasks, and the subsequent discovery of resources to alleviate such sentiment. Participants expressed how they overcame and were transformed through persistence to moments of triumph when treading uncharted territory. They described how they were able to move through their often initial feelings of disorientation. Participant's relationships between experiencing newness of environment and tasks in the REU to their experiences of solving programming problems, successful debugging, and other computing tasks.

Figure 1: **Eventually**
This image reflects how this building is a maze and how my computer science career is full of unexpected turns. Some of the turns will not always get me the results that I want, but they lead me to my final destination. This REU is one of the many turns in my computer science career. It has positively pushed me to consider what aspect of computer science I want to focus on when I pursue my PhD.

6.2 Lack of Community

A profound sentiment echoed in the study was the struggle associated with the quest of finding community and belongingness. The theme encompasses the desire to explore new opportunities while grappling with a sense of not belonging to the dominant population. It delves into the complex process of learning to assert oneself in a space where the absence of a supportive community intensifies the challenges, and navigating the establishment of community for oneself to satisfy their need for belonging in the academic realm. This theme is presented in figure 2 and figure 3.

Figure 2: **Corners**
Throughout the first two days of the REU, my friend and I found ourselves drawn to the comfort of corners in this unfamiliar environment. We have slowly grown more comfortable taking up space and have moved away from corners. This is applicable to my participation in computer science; I started knowing no one and nothing, keeping to myself and staying out of the way. As I continue to grow within this field, I am expanding my network and taking up more space.

Figure 3: **Brother**
Not my first time being in a male-dominated "field". I was unbothered in the gym full of men. Which is kind of in a way how I've come to be/ feel in the computing world. As the REU continued, I was reminded of how different my life was at this moment compared to my life before. I have learned a lot, and essentially changed my outlook career-wise and life-wise.

6.3 Not Surface Level

The theme "Not Surface Level" highlights participants' journeys in pushing beyond their initial reservations when tackling challenges. Participants in the study shared their experiences of

breaking down complex issues into manageable components, highlighting the importance of delving beneath the surface to gain a deeper understanding of computing concepts and gain more insight into the subject matter. Figure 4 is an image that was highlighted during discussions with participants and categorized within this theme.

Figure 4: **The Stacks**
When coming to [REU location], I was hoping to run into a friend I made while abroad. She is still abroad, so she shared about her favorite place on campus. This is "the stacks". It holds tons of information within all its books; it might be overwhelming when looking at it all from afar. But if you look at a single book, it feels a lot more manageable. It's similar to looking at the field of computing: if we look at 'computer science' as a whole, it is overwhelming how broad the field is. But once you narrow it down, it is a lot less intimidating.

6.4 Community

The study emphasized the significance of community in various aspects of an individual's lives. Beyond the academic spheres, finding a supportive community was of great importance for participants. This theme encompassed creating a space for open conversations about life and challenges outside the realm of computer science. It also highlighted the value of programs connecting individuals, fostering collaborative problem-solving, and providing the support needed to navigate unfamiliar experiences, both personally and professionally. Figure 5 and figure 6 encapsulate the essence of this theme.
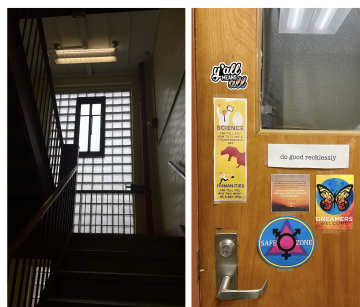

Figure 5: **[Engineering] lab I and II**
These two pictures talk about my experience in the [Engineering] building. The one on the left relates to how I feel every time I enter the building: kind of lost and confused whereas the one on the right tries to stress the importance of safe spaces for students. This duality can easily translate to my experience majoring in Computer Science.

Figure 6: **Roses are red, Violets are blue. I'm trying to figure out whatever this is, how about you?**
Some research topics can be confusing, but this program helped me understand how to conduct research and read scholarly data. When you feel lost, it is always good to find a team member to help you understand. Just like my peers helped me understand this photo.

7 Discussion

In this discussion section, we delve into the approach and findings of the study as a means to represent how photovoice has the means to confirm and enhance our understanding of the experience of underrepresented minorities in computing. In her paper, ""Learning from small numbers" of underrepresented students' stories: Discussing a method to learn about institutional structure through narrative," Alice Pawley argues that "rich personal narratives that demonstrate the complexity of underrepresented students' lives from a small number of participants will be more effective in prompting engineering education leaders to think of new ways to address institutional issues that affect underrepresented students' academic success" (p.10). [33] Although the scope of this study has been limited by a small participant pool and short duration, its qualitative nature offers valuable insight into CS students' experiences by utilizing visual mediums and fostering rich critical dialogue. Participants have seized the opportunity to convey their emotions, and stories through visuals, recognizing the impact of this mode of expression.

The study presented in this paper is one of a unique population in which a small number of participants were able to gather for a short duration of time in one physical location. While this experience did not take place during a regular school semester, the participants were encouraged to reflect on their experiences in a CS degree in a holistic manner. The findings represent some of their feelings and attitudes towards their degree, and what they may seek or value towards completion of their degree. Figure 3 is a prime example that addresses the similar isolating feeling women may experiences when trying to work out at the gym and in a classroom where they may be one of very few or no other women in their CS program or classes. AS recent as this year, McNeely and Frehill (2024) published a journal article presenting statistical evidence that, despite exponential growth in the computing field, efforts toward diversity, equity, and inclusion in obtaining CS degrees have not kept pace [34]. In short, women and other minoritized

populations remain underrepresented in computng. As such, the authors stress the importance of comprehending the affective constructs, dynamics, relations, and outcomes associated with disparities in representation and participation, urging a broader examination of societal stratification processes (McNeely, p.13). This understanding is crucial for improving conditions to retain and expand participation. Methods such as photovoice enable researchers to gain that deeper insight into the emotions, relationships, and experiences outlined by McNeely and Frehill.

Additionally, photo artifacts played a pivotal role as a starting point for conversations and a means of reflecting on emotions, providing participants with insights into how their cohort peers were navigating their own experiences both during the REU and beyond. In their paper "Talking about pictures: A case for photo elicitation", Harper (2002) states,

> There is the need, described in all qualitative methods books, of bridging gaps between the worlds of the researcher and the researched. Photo elicitation may overcome the difficulties posed by in-depth interviewing because it is anchored in an image that is understood, at least in part, by both parties. If the interview has been successful, the understanding has increased through the interview process. (p.20) [35]

As observed in this study, photovoice proved to be a valuable tool in stimulating discussion within the "classroom" setting, where all participants actively engaged in sharing diverse interpretations of images and experiences, as well as in dissecting the emergent themes until a consensus was established within the group. These discussions surrounding an image also bridged gaps for researchers in understanding emotions that participants may be attempting to express through the activity.

The inherent value derived from the study's outcomes lies in the potential insights that could significantly enhance the REU program for future iterations. The study suggests several avenues for improvement that organizers can consider moving forward. Firstly, emphasizing more opportunities for collaboration and engagement is crucial, as many studies highlight the high value placed on community by the participants. For example, Kargarmoakhar et al found that convening of communities of practice (in computing for undergraduates) with intentionality was "was enough to impact their experiences and act as a tool to make the field of computing more inclusive" (p.10) [36]. Participants in this study also highlighted that it was during these collaborative sessions that they felt the most engaged and interactive throughout the REU. Creating spaces and activities that foster collaboration can contribute to a stronger sense of community among REU participants, and in turn have the potential to help retain and broaden participation in the field. Fostering a sense of belonging within a community has long been recognized as a key objective for REUs, as evidenced by previous research [37–39]. Integration of methodologies like photovoice can further facilitate the achievement of this goal.

Secondly, establishing a knowledge and resource bank for participants, accessible both during and beyond the two-week duration of the program, can serve as a valuable resource for ongoing learning and professional development. Lastly, acknowledging and carefully considering the physical location of the REU, along with recognizing participants' experiences within those spaces, can further enhance the overall experience and effectiveness of the program.

For future work, it would be beneficial to incorporate more frequent check-in sessions between

the researcher and participants to facilitate discussions and ensure alignment on the study's goals. This approach would necessitate providing additional opportunities for students to capture new photos and present them to the group. Implementing multiple iterations of sessions where participants collaboratively group photographs could enhance the overall value for the group, offering them increased insights and considerations for subsequent photo-taking endeavors.

8   Conclusion

In conclusion, this pilot study introduces photovoice as a valuable method for understanding the experiences and challenges of underrepresented groups in computer science education. By employing a participatory approach, participants actively engaged in co-constructing knowledge with researchers, shedding light on their perspectives through a visual exhibition of their experiences. Participants were provided opportunities to both reflect and present their photographs individually, and collaborate to co-construct four emergent themes of "lost and found," "lack of community," "not surface level," and "community." These themes served as powerful points of connection, fostering a sense of shared experience among participants.

This study contributes to groundwork for future research that explores the use of photovoice as a transformative method for understanding and amplifying diverse voices within computing. It highlights the potential of this method in fostering community, identifying resources, and addressing various challenges encountered by participants. As we continue to explore the possibilities of photovoice, we unlock new avenues for enhancing inclusivity, dialogue, and support within computer science education.

References

[1] C. Wang and M. A. Burris, "Photovoice: Concept, Methodology, and Use for Participatory Needs Assessment," *Health Education and Behavior*, vol. 24, no. 3, pp. 369–387, 7 1997. [Online]. Available: https://journals.sagepub.com/doi/10.1177/109019819702400309

[2] D. R. Parnell, J. Wilson, K. T. Hicklin, and J. A. Magruder Waisome, "Engineering While Black: Exploring the Experiences of Black University of Florida Undergraduate Engineering Students Using Photovoice," in *ASEE Annual Conference and Exposition, Conference Proceedings*.   American Society for Engineering Education, 6 2023.

[3] J. Wawire, B. McGowan, L. S. Benjamin, K. Schaefer, and J. Henderson, "Work-in-Progress: Balancing It All: Using Photovoice to Visualize Second-Year Engineering Student Experiences," 8 2022. [Online]. Available: www.slayte.com

[4] S. J. Bork and J. L. Mondisa, "Work in Progress: Using Photovoice to Examine the Mental Health Experiences of Engineering Graduate Students During COVID-19," *ASEE Annual Conference and Exposition, Conference Proceedings*, 7 2021.

[5] L. Bosman and K. Shirey, "Using Bio-Inspired Design and STEAM to Teach the Entrepreneurial Mindset to Engineers," 8 2022. [Online]. Available: www.slayte.com

[6] D. Meharg, A. Varey, and S. Cairncross, "A journey that motivates: Exploring the Associate Students Transition Framework," *Proceedings - Frontiers in Education Conference, FIE*, vol. 2021-October, 2021.

[7] D. Meharg, S. Cairncross, and A. Varey, ""so far back, I'm anonymous": Exploring student identity using photovoice," *Proceedings - Frontiers in Education Conference, FIE*, vol. 2018-October, 3 2019.

[8] M. Perez, "Participatory design for stem learning environments with youth & families," in *Proceedings of the 20th Annual ACM Interaction Design and Children Conference*, ser. IDC '21.   New York, NY, USA: Association for Computing Machinery, 2021, p. 631–632. [Online]. Available: https://doi.org/10.1145/3459990.3463400

[9] "Nsf 23-601: Research experiences for undergraduates — nsf - national science foundation." [Online]. Available: https://new.nsf.gov/funding/opportunities/research-experiences-undergraduates-reu/nsf23-601/solicitation

[10] J. Rocha, "Snapshots of everyday affirmations captured through critical race photovoice: Seven women's strategies to deploy asset-based resources during their college transition," *Equity & Excellence in Education*, vol. 56, pp. 221–239, 4 2023.

[11] D. Macdonald, K. Peacock, A. Dew, K. R. Fisher, and K. M. Boydell, "Photovoice as a platform for empowerment of women with disability," *SSM - Qualitative Research in Health*, vol. 2, 2022.

[12] R. Moletsane, "Using photovoice to enhance young women's participation in addressing gender-based violence in higher education," *Comparative Education*, vol. 59, pp. 239–258, 4 2023.

[13] K. Budig, J. Diez, P. Conde, M. Sastre, M. Hernán, and M. Franco, "Photovoice and empowerment: Evaluating the transformative potential of a participatory action research project," *BMC Public Health*, vol. 18, pp. 1–9, 4 2018. [Online]. Available: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-018-5335-7

[14] K. H. Yang, "Participatory photography: can it help adult learners develop agency?" *http://dx.doi.org/10.1080/02601370.2013.852143*, vol. 33, no. 2, pp. 233–249, 2014. [Online]. Available: https://www.tandfonline.com/doi/abs/10.1080/02601370.2013.852143

[15] S. N. Balbale, M. A. Morris, and S. L. LaVela, "Using photovoice to explore patient perceptions of patient-centered care in the veterans affairs health care system," *The patient*, vol. 7, pp. 187–195, 2014. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/24452963/

[16] P. Lindhout, T. Teunissen, and G. Reniers, "What about Using Photovoice for Health and Safety?" *International Journal of Environmental Research and Public Health*, vol. 18, no. 22, 11 2021. [Online]. Available: /pmc/articles/PMC8620590/ /pmc/articles/PMC8620590/?report=abstract https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8620590/

[17] C. Catalani and M. Minkler, "Photovoice: A review of the literature in health and public health," *Health Education and Behavior*, vol. 37, no. 3, pp. 424–451, 6 2010.

[18] L. Andonian, "Community Participation of People with Mental Health Issues within an Urban Environment," *Occupational Therapy in Mental Health*, vol. 26, no. 4, pp. 401–417, 2010. [Online]. Available: https://www.tandfonline.com/action/journalInformation?journalCode=womh20

[19] N. Haque and B. Eng, "(No Title)," *Global Health Promotion*, vol. 18, no. 1, pp. 16–19, 2011. [Online]. Available: http://www.sagepub.co.uk/journalsPermissions.navDOI:10.1177/1757975910393165http://ghp.sagepub.com

[20] S. T. Tripathy, K. Chandra, and D. Reichlen, "Participatory Action Research (PAR) as Formative Assessment of a STEM Summer Bridge Program," *ASEE Annual Conference and Exposition, Conference Proceedings*, vol. 2020-June, 6 2020.

[21] S. T. Tripathy, K. Chandra, H.-Y. Hsu, Y. Li, and D. Reichlen, "Engaging Women Engineering Undergraduates as Peer Facilitators in Participatory Action Research Focus Groups," 7 2021.

[22] D. Feil-Seifer, M. Parker, and A. Kirn, "Examining Faculty and Graduate Student Attitudes on Stress and Mental Health," 8 2022. [Online]. Available: www.slayte.com

[23] J. G. Liang, R. Evans, and S. E. Kulesza, "We are Thriving! Undergraduate Women in Engineering Student Project Teams," *ASEE Annual Conference and Exposition, Conference Proceedings*, 6 2019.

[24] K. Redmond, G. Panther, M. Asadollahipajouh, R. Evans, S. Kulesza, , and G. Liang, "We are thriving: Increasing the number of women in engineering," *2022 ASEE Annual Conference & Exposition*, 2022. [Online]. Available: https://par.nsf.gov/biblio/10398298

[25] K. Shirey and L. Bosman, "Using bio-inspired design and steam to teach the entrepreneurial mindset to engineers," in *2022 ASEE Annual Conference & Exposition*, no. 10.18260/1-2–40832. Minneapolis, MN: ASEE Conferences, August 2022, https://peer.asee.org/40832.

[26] C. A. Turpen, J. Radoff, K. Adkins, S. Raj, B. Keeron, Z. Rahman, and H. Sangha, "Partnering with undergraduate engineering students to unearth cultural practices within a science, technology, and society (sts) program," in *2022 ASEE Annual Conference & Exposition*, no. 10.18260/1-2–41600. Minneapolis, MN: ASEE Conferences, August 2022, https://peer.asee.org/41600.

[27] A. El-Amin and G. Brion-Meisels, "Editorial: Emancipatory inquiry in educational research: models and methods for transformational learning," *Frontiers in Education*, vol. 9, 2024. [Online]. Available: https://www.frontiersin.org/articles/10.3389/feduc.2024.1396662

[28] V. Apaza and P. DeSantis, "Facilitator's Toolkit for a Photovoice Project."

[29] SALaMA, "Photovoice Faciliatation Guide," 9 2021. [Online]. Available: https://bpb-us-w2.wpmucdn.com/sites.wustl.edu/dist/f/2918/files/2022/06/Photovoice-Facilitation-Guide-1-resize-3-1.pdf

[30] Rutgers, "Photovoice Facilitator's guide." [Online]. Available: https://rutgers.international/wp-content/uploads/2021/09/Photovoice-Facilitators-guide.pdf

[31] R. Shaffer and B. Shaffer, "Beyond the dispensary," *AMREF*, 1984.

[32] J. Saldana and M. Omasta, *Qualitative Research - Analyzing Life - Second Edition*. Sage, 2022.

[33] A. L. Pawley, "Learning from small numbers of underrepresented students' stories: Discussing a method to learn about institutional structure through narrative," *ASEE Annual Conference and Exposition, Conference Proceedings*, 2013.

[34] C. L. McNeely and L. M. Frehill, "A differentiated diversity: Demographic patterns and contextual delineations in u.s. computing," *Computing in Science & Engineering*, pp. 1–16, 2024.

[35] D. Harper, "Talking about pictures: A case for photo elicitation," *Visual Studies*, vol. 17, no. 1, pp. 13–26, 1 2002. [Online]. Available: https://www.tandfonline.com/action/journalInformation?journalCode=rvst20

[36] M. Kargarmoakhar, M. Ross, Z. Hazari, S. Secules, M. A. Weiss, M. Georgiopoulos, K. Christensen, and T. Solis, "The Impact of a Community of Practice Scholarship Program on Students' Computing Identity," *ACM Transactions on Computing Education*, 9 2021. [Online]. Available: https://dl.acm.org/doi/10.1145/3623615

[37] M. Ross, E. Litzler, and J. Lopez, "Meeting students where they are: A virtual computer science education research (cser) experience for undergraduates (reu)," in *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*, ser. SIGCSE '21. New York, NY, USA: Association for Computing Machinery, 2021, p. 309–314. [Online]. Available: https://doi.org/10.1145/3408877.3432547

[38] B. Jelen, J. Dunbar, S. Monsey, O. K. Richards, and K. A. Siek, "Utilizing the affinity research group model in a summer research experience for undergraduates program," in *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, ser. SIGCSE '19. New York, NY, USA: Association for Computing Machinery, 2019, p. 990–996. [Online]. Available: https://doi.org/10.1145/3287324.3287501

[39] "Nsf 23-601: Research experiences for undergraduates — nsf - national science foundation." [Online]. Available: https://new.nsf.gov/funding/opportunities/research-experiences-undergraduates-reu/nsf23-601/solicitation

Appendix 1

Photo-Voice Project Instructions

Photovoice is a participatory action research method in which researchers aim to accomplish three main goals:

1. To enable people to record and reflect their community's strengths and concerns.
2. To promote critical dialogue and knowledge about important issues through large and small group discussions of photographs.
3. To reach policymakers.

Considering many of us may identify with one or more minority groups, and that this may be our first REU experience, we have the unique opportunity to capture our experiences and struggles during our time here through the practice of photovoice for the next two weeks.

Step 1: Take five photos.

Photo Prompt: Spend time this week capturing at least five photos that you feel best capture your experiences and some of the challenges you may face participating in an REU for the first time.

You can find some guiding questions below to help you:
- What are your experiences and some of the challenges you may face participating in an REU?
- How has your participation in this program changed your view on computer science/computing?
- How has your participation in this program affected your life?

Each photo should have a unique title and caption. The caption should be no more than a few sentences. Keep in mind some of the technical and ethical considerations we discussed in the introduction.

Step 2: Turn in pictures.

Initial photo submissions are due by [due date] before we sit down to discuss our photos. You may drop them into the folder with your name here.

Step 3: Discuss photographs.

On day 5 of the REU we will regroup to share some of our photos and identify emerging themes in our images. This will also be an opportunity to discuss shortcomings and recommendations we may have through guidance from the photos.

The time allotted for discussion will also include the chance for us to receive feedback on our photos, titles, and captions.

Step 4: Select one final photo you would like to include in the archive.

After the first discussion, each individual will pick one image that they would like to include in the final gallery exhibition. Final photos can be submitted to the following link here.

Step 5: Community Exhibition

Traditionally, the photovoice activity culminates with a gallery exhibition in which the research group can present their work to stakeholders, policymakers, agents of change. In this case, you will collectively have the opportunity to present our creativity to the organizers of the REU, who may use the outcomes to improve the experience for the next group of students.

Potential Timeline:

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6 (weekend)	Day 7 (weekend)	Day 8	Day 9	Day 10	Day 11	Day 12
Introduction to photovoice	X											
Take photos.	X	X	X	X								
Turn in photos.					X							
Discuss.					X							
Opportunity to take more photos.						X	X					
Turn in final photo									X			
Discuss.									X			
Community Exhibition											X	