"The prettiest photos are the ones that have happy people in them": the use of photovoice in an upper-division physics capstone project course

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Photovoice is a type of participatory action research that aims to enable people to act as recorders and agents of change in their communities. When using the photovoice methodology, participants take photos in response to open-ended prompts and write short captions to accompany their photos. At the end of the photovoice process, participants engage in a focus group where they collectively determine some themes that their photos show, allowing them to co-create the research being done. We implemented the photovoice methodology in a project-based upper-division physics course in which the students partnered with a company in the quantum industry to work on a real-world collaborative project. We present here an example of how photovoice can be used as part of a physics course with a focus on some preliminary results from the students' focus group. These results demonstrate that the focus group allowed us as researchers to gain new types of information from our students that we may not otherwise have learned, and that the students appreciated the photovoice process, particularly after engaging in the focus group activity.

I. INTRODUCTION AND BACKGROUND

Photovoice, a type of participatory action research methodology [1], is a process that allows participants to represent and enhance their community through the taking of, and reflecting on, photos, thereby empowering them to act as agents of change [2]. This methodology has been used in a variety of contexts including education [3–6], where the student voice is not always heard, even when designing new educational experiences [7].

During the Fall 2022 semester, a new type of course was implemented at the University of Colorado Boulder. This was a quantum industry capstone course called Quantum Forge, in which students worked on a team throughout the entire semester to accomplish a real-world goal for their industry partner. In order to learn about students' in-the-moment reflections and allow opportunities for student ownership over their experiences in the course [8–10], we chose to implement photovoice as one way to assess student experiences in this course. Furthermore, photovoice allows students a way to provide feedback on the course, giving them influence over the future of Quantum Forge.

A. Photovoice

The photovoice methodology consists of equipping participants with cameras and asking them to document some aspects of their lives or their communities through photos. Participants first take photos in response to an open-ended prompt and write short captions explaining the importance of their photos. Then, in a focus group or interview, participants discuss the photos that they have taken with members of the research team, and participants describe the significance of the photos that they have taken. Finally, photovoice projects frequently end with an exhibition, where the findings of the research can be communicated to individuals, often policy-makers, who can affect change within the community [3]. Because photos allow participants to capture in-the-moment thoughts and activities, photovoice allows participants to effectively share their personal expertise, knowledge, and experience with researchers and policy-makers [2].

Photovoice was developed based on theoretical literature on education for critical consciousness, feminist theory, and documentary photography [2]. It has been used in many contexts, beginning with a group of rural women in China [2]. It has also been used in educational settings, such as investigating student identity in a classroom focusing on diversity [4]; the academic and financial experiences of community college students [3]; the health needs of students at Rutgers University [5]; and 7th grade students' conceptualizations of success [6]. Nevertheless, we are unaware of its use in a physics course up to this point.

B. Course Context

We implemented the photovoice methodology in Quantum Forge, a small, upper-division, project-based capstone course. In this course, during the 2022-2023 school year, students partnered with a company in the quantum industry to accomplish an authentic project involving optimizing heat exchangers for a dilution refrigerator. This course meets the university's research requirement for graduation, so students can elect to take Quantum Forge in lieu of the traditional advanced lab course or a formal research experience.

The course ran for the first time in the Fall 2022 semester, with eight students participating. All eight students worked on a team together to accomplish this project; this teamwork context is vastly different than what most students have encountered in the past. The intended duration of the project was a total of two 15-week semesters; however, during this iteration several students graduated after the first semester and therefore did not take the course for the second semester. Data from only the first semester are presented here.

The students met with the instructor twice each week and then had designated time to work on their project after one of these weekly meetings. Each week, students were asked to respond to open-ended metacognitive reflection questions, as well as the photovoice prompts. The course included additional activities not directly related to the project such as modules teaching industry skills and visits with representatives from local quantum companies. These activities decreased in frequency as the semester went on so the students could focus on their project. Additionally, while students were not required to participate, they were given the opportunity to participate in interviews with the researchers.

C. Motivation for the use of photovoice in this course

We implemented photovoice in this course as a way for us to gain reflections from the students on how the course was going, their thoughts about the collaborative nature of the course, and their thoughts on the quantum industry. Because this is a new type of course, it was important to get feedback from students and understand the student experience each week rather than simply once or twice during the semester. By allowing the students to create visual images in response to open-ended prompts, they could draw our attention to aspects of their experiences that we might not have otherwise asked about. Students can take photos of moments otherwise inaccessible to anyone other than those that are present, meaning that photovoice allows students, instructors, and researchers access to some thoughts, activities, and reflections that would not be accessible using different methodologies [2].

Also, because this course engaged students in important and authentic work, we wanted the students to participate in a reflective practice that would encourage them to own their experience and have a voice that could shape the course community. Photovoice has the potential to do this by changing what is seen by students, instructors, and researchers as "valuable knowledge" [4].

Finally, photovoice has been suggested as a potential methodology to use within the context of physics courses or

programs [6]. Because we are not aware of photovoice being implemented in the context of a physics course before, we wanted to examine this methodology within this new context to see what we might be able to learn from physics students using this tool.

We, therefore, have two main goals for presenting this work here:

1. To introduce how photovoice can be used in a project-based physics capstone course through an example
2. To present some preliminary results from the student focus group.

II. PHOTOVOICE IN QUANTUM FORGE

Students in the course were asked to respond to a photovoice prompt every week. The prompts were varied and focused on students' experiences with teamwork, interest in the quantum industry, and engagement with the course overall. Each week, the students submitted a photo and a caption for their photo explaining how it related to the prompt via a Qualtrics survey. Example prompts include:

1. Take a photo of something that motivated you to take this course.
2. Take a photo that represents how your team has decided to divide up tasks so far.
3. Take a photo representing what you find most interesting at the moment about pursuing a career in quantum industry.

At the end of the semester, students were invited to participate in a focus group to discuss and interpret the photos that they had taken throughout the semester. They were encouraged to talk as openly about their experiences as they felt comfortable. Seven of the eight students in the course participated in the focus group activity.

During the focus group, the students viewed the entire collection of photos that they had taken throughout the semester. Students were given the option to not share any of their photos in the focus group, but all students elected to have all of their photos shown. The photos were grouped by which theme (teamwork, quantum industry, or course experience) the photo's prompt best aligned with. The students were then asked several questions about the photos and about their general experience using photovoice, including:

1. What themes do you notice in these photos?
2. Do the comments other people made about your photos resonate with you? Were there any comments that surprised you?
3. To what extent did participating in the focus group activity change your perception of the photovoice activity as a whole?

The research team then compiled a list of takeaways to share with the course instructor. The students were shown this list and offered the opportunity to make any changes they felt were necessary. This allowed us to complete the photovoice cycle of allowing participants to influence the future design of the course.

III. METHODS OF ANALYSIS

The focus group was recorded using an Owl Labs Meeting Owl 3 [11], so that the researchers could review both video and audio of the entire group. Authors KAO and VB watched the focus group recording and collectively created a content log [12]. The focus group content log was used in two ways. First, themes that students identified in their photos were used to categorize the photos. Details from this analysis will be presented in future work. Second, the content log from the focus group was used to identify 1) important parts of the discussion where students pointed out interesting things that we may not have noticed without the focus group, and 2) some student takeaways from their experience with the photovoice process as a whole. These passages of the focus group were then transcribed in detail and some of them are presented in Sec IV.

IV. RESULTS FROM THE FOCUS GROUP

We present here two takeaways from the focus group as an example of the potential benefits of using photovoice in a project-based physics course. The first is a set of student discussions that brought to our attention things that we may not have noticed without the focus group. The second takeaway is about students' thoughts about the photovoice process and their experience with it in this course.

A. Topics of interest in photos identified by the students

The students identified several themes that were important to them in the focus group. These themes included the excitement and novelty in quantum industry and the course, money and jobs, the students' prioritization of each others' happiness, and a new interpretation of an important location.

First, the students brought up the parallels between the excitement and novelty they saw in their photos about the course and the novelty of the quantum industry as a whole. One student, Owen, stated,

> "I was saying some of [the photos] are kind of like the excitement or novelty of a new thing, which, I would agree, I think most of us can say this is the first time we've been working on this sort of project before. And just, being brand new to it, it's all kind of fun and interesting."

Another student, Jasper, replied,

> "And I think the industry kind of reflects that feeling a little bit, too. Like, quantum as an industry prospect is a very new idea, I think, in terms of how long it's existed. So all these companies... all these other people, a big part of what I think motivates their work is the excitement of the novelty of it, and so, I guess that's part of what makes quantum industry exciting but also maybe dangerous as a career."

Together, these two students identified that excitement and novelty were a part of their experience with the course and their expectations about the quantum industry. This seems to indicate that the students are seeing the course as a parallel to the quantum industry; they are identifying that their work in the course is novel and exciting in a similar way to that of the industry as a whole. While we have noticed students' excitement about the course in other places, the focus group gave students an opportunity to share with us the way this feeling paralleled their feelings about quantum industry.

Next, we present an instance where one student was surprised that more of the photos did not center around money and jobs. We highlight here the discussion that followed about how students were viewing the role of money and jobs in relation to this course. One student, Charlie, said,

> "I'm surprised more people didn't take pictures about getting a job. I took the pictures with the money in them and a big reason I took this class is to be able to get a job after college... I'm just surprised that, I guess, other people didn't take it for the same reason."

A second student, Reese, clarified that money was an important motivating factor for them, but that their happiness was more important than money,

> "I would say that it's a motivating factor but if I don't like it then it doesn't really matter. I could be making like two hundred thousand dollars a year but if I'm miserable then that means, like, almost little to me because I won't be happy."

Charlie then replied, saying,

> "Yeah, yeah, I agree with you, I don't wanna make it seem, like, all about the money. I was thinking, it was just– getting a job is, like, necessary for me to be able to do the things I like, you know?"

Finally, Jasper added that they don't think there's anything wrong with "saying that you want to have a life of, like, stability... I don't think there's anything, like, immoral about wanting that."

These three students are looking at the role of money and jobs in several different ways, and none of these unique perspectives would have been captured given the photos and captions alone. The focus group was able to highlight the perspectives of students who did not address this theme in their photos and captions, and provided additional nuance to those perspectives that did appear in the photos and captions. The first student volunteered their motivation for taking the course in response to the photos presented, which opened up space for the other two students to add their perspectives on money and jobs in relation to this course.

Another student perspective that we gained from the focus group was about a common type of photo that appeared in their photovoice responses. During the focus group, many students brought up the fact that the whiteboard in their lab space was photographed frequently. We had noticed this as well, but the students added some nuance to the way we thought about these photos. Initially, the students claimed that the whiteboard photos were a consequence of "laziness," with Owen stating, "I think there's a very obvious 'I was lazy this week' sort of picture, which happens to be the whiteboard this time around."

Later on, however, another student, Stella, mentioned that there might be something deeper being represented in the whiteboard photos. Stella states,

> "I do like that, um, the whiteboard ones are all completely different prompts. It– it's kinda funny. Like, they're- they all have sort of like that vibe of teamwork, but every single prompt of the whiteboard photos is different. Which I think just goes to show that, um, I'm not sure if we took pictures of it because it's... immediately what we go to when we think of this class is 'oh, the whiteboard. Cause that's where I'm with everyone.' Um, I don't know, I just think it's kinda nice."

Reese then agrees that the whiteboard photos all fit very well with the prompts, reiterating that their experience with teamwork largely happens around the whiteboard. Owen then mentions that of all of the equipment available to them, they use the whiteboard most and that it has been "doing the heavy lifting."

This discussion led us to determine that the many photos students took of the whiteboard had more significance to them than we, or they, initially thought. The focus group, therefore, allowed us to identify a location that was important to the students and their teamwork experience that we may not have otherwise understood in this way.

Finally, the students at the focus group brought up the fact that the happiness of the group was a priority to them. Owen said,

> "I do think it's interesting how my photos all have pictures of people. It kind of speaks to the way that I've approached the project. I absolutely care most about the people. The progress doesn't matter so much to me. If you guys are unhappy then I don't care how far along we are, you know?... I think the prettiest photos are the ones that have happy people in them."

This student identified the fact that they had taken photos mostly of people and tied it to the fact that they were invested in the group's happiness and cared most about the people, which is a connection that is not immediately visible from the photos or the associated captions. This sentiment was echoed by other students who agreed that the happiness of the group was their priority. Without the focus group, we would not have had the opportunity to learn how this student cared about the well being of their group as a whole.

B. Student reflections about the photovoice process

At the end of the focus group, we gave students the opportunity to provide feedback on their experience with the photovoice process. Overall, the students expressed that the experience of engaging with photovoice was valuable and helped them realize things about their teammates and the course.

For instance, the students pointed out that the photovoice process allowed them to realize that they all had a similar experience with the course. During the focus group Owen said, "We were definitely thinking about a lot of similar things and this really brought that to life. I wouldn't have otherwise known." Stella agreed, "I do think it's really nice to see how everyone is, like, we're all on the same boat. And it's just nice to see what everyone took photos of, honestly."

Both of these quotes show that students felt that the photovoice process allowed them to understand that their feelings about the project were shared by others, indicating that photovoice can bring students together over shared experiences.

The students also emphasized that the focus group experience itself was incredibly important to their experience of the photovoice process. For instance, when asked how the focus group impacted their perception of the photovoice experience, Jasper replied, "It really brought it together, I feel like. It's the 'voice'."

As students continued to talk about the impact of the focus group, Stella said,

> "I agree with everyone, it brings it all together. Because some weeks I was like, ugh, I have to do the photovoice?... and I have to do my reflection, and I have to submit, like, my lab scan, and all of this other stuff on the same Friday, but then, like, seeing it now, I definitely think it was more valuable than I realized at the time."

These students indicated to us that the focus group tied together their experience with photovoice as a whole, allowing them to see the value in the activity and to bring their voice to the table.

Finally, the focus group allowed us to hear from students that reflection in the form of photovoice was more memorable than other forms of reflection. For instance, Reese said,

> "Yeah, I would also say it's also a lot easier to remember when these were taking place and what not, so if I were just, like for the [reflection questions], I probably could not tell you what day of the week, what day of the month, or semester I wrote those. But this I could give you a rough estimate of, 'oh that was like the first two weeks,' so it's like, yeah, you can better track your progress that way."

This demonstrates that reflection in the form of photovoice helped students engage in self-reflection in a different way than traditional forms of self-reflection, allowing them to reflect back on their photos at the end of the semester and remember specific moments about their journey throughout the course.

V. CONCLUSIONS

The implementation of the photovoice process in Quantum Forge yielded valuable information for both researchers and the broader physics education community. These preliminary results from the focus group allow us to share some of the ways in which photovoice can benefit both of these groups.

One way that the photovoice methodology benefited us as researchers is that we came away from the focus group activity with a list of themes that will guide our future analysis of photovoice photos and captions, interview data, and reflection questions. Through their participation in the focus group, the students were able to contribute to the research process by telling us which themes they saw in their own work that were important to them. As mentioned in Sec IV, many of these themes would not have been noticed or interpreted in the same way without student input.

Furthermore, the focus group allowed us as researchers to better understand how to improve the photovoice experience for students in the following semester of the course. The students indicated that they would appreciate having two focus groups in the next semester of the course.

In addition to researchers, instructors can also benefit from the data produced by photovoice. These data are potentially different than other forms of data typically collected by instructors and education researchers. Furthermore, these data are guided by what students find most important, allowing us to have insight into what is valuable to our students that we might not otherwise know to ask about.

Finally, from the student perspective, photovoice has the potential to provide a positive experience, allowing them to share their ideas and experiences with researchers and with one another, and giving them an opportunity to engage in self-reflection that is memorable and meaningful.

While photovoice has given us the opportunity to learn a great deal from the students in Quantum Forge, there are some significant limitations to implementing photovoice in a class setting. For instance, engaging students in a focus group activity may be challenging in a larger class, as well as getting students to buy into the process.

Although photovoice may not be a viable option in all physics courses, we have demonstrated that it may be a fruitful research methodology in some situations. Especially in classes where student feedback is particularly important, photovoice may allow researchers and practitioners access to unique perspectives and allow students to affect change in their educational experiences.

VI. ACKNOWLEDGEMENTS

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