



# “No, This Is Not My Boyfriend’s Computer”: Elevating the Voices of Youth in STEM Education Research Leveraging Photo-Elicitation

Daniel Edelen<sup>1</sup> · Kristin Cook<sup>2</sup> · L. Octavia Tripp<sup>3</sup> · Christa Jackson<sup>4</sup> · Sarah B. Bush<sup>5</sup> · Margaret J. Mohr-Schroeder<sup>6</sup> · D. Craig Schroeder<sup>7</sup> · Thomas Roberts<sup>8</sup> · Cathrine Maiorca<sup>9</sup> · Jessica Ivy<sup>10</sup> · Megan Burton<sup>3</sup> · Andrea Perrin<sup>6</sup>

Accepted: 4 March 2024  
© The Author(s) 2024

## Abstract

We aim to elevate the stories and voices of youth in integrated STEM education, particularly those who have been historically marginalized and excluded from STEM spaces. Our research uses photo-elicitation to decenter the power of researchers and educators and elevate the experiences and expertise of youth in STEM. Findings are presented from three instrumental case studies, examining the perspectives of youth on what it means to do STEM, who belongs in STEM, and why STEM is important. The findings reveal that youth often perceive STEM as a siloed approach but also emphasize the need for greater integration of mathematics in STEM. Furthermore, the study highlights the importance of STEM identity development, showing that belonging in STEM is not just about future careers but also about fostering a sense of belonging in the present. Additionally, the study uncovers that youth invoke empathy and social consciousness when explaining the importance of integrated STEM, emphasizing the need to address racial, gender, and professional biases in STEM educational spaces. This prompts a reconsideration of the motivations behind integrated STEM education, emphasizing the value of developing STEM literacy for the well-being of all youth, not just as future workforce preparation.

**Keywords** Integrated STEM · Equity · Participatory research · Photo-elicitation · Identity · Sense of belonging · Innovative research · Youth and STEM

During the last several years, integrated science, technology, engineering, and mathematics (STEM) instruction gained some traction in both formal and informal education settings, though not always consistently or systematically (Denson

---

✉ Daniel Edelen  
dedelen@gsu.edu

Extended author information available on the last page of the article

et al., 2015; Kelley & Knowles, 2016). Current STEM education research has noted that historically marginalized and excluded youth are less likely to see themselves as STEM professionals and feel a sense of belonging in the broader STEM fields (Coxon et al., 2018; Vincent-Ruz & Schunn, 2018). While the field has noted positive impacts upon youths' identity development, for example, learning environments that affirm and encourage students' identities promote positive STEM identities, particularly for historically marginalized populations (Jong et al., 2020). There continue to be opportunity gaps and representational gaps for historically marginalized youth in STEM (Aish et al., 2018). As K-12 schools continue to implement integrated STEM, there remains a dearth of educational research that centers the perspective of youth that are involved in these learning opportunities. In fact, most STEM education research has predominantly focused on teachers' implementation of STEM tasks or professional development (Edelen et al., 2023). If we are to provide equitable opportunities for all youth in STEM, research practices should be focused towards capturing the perspectives, lived experiences, and stories of those experiencing marginalization and exclusion in STEM, the youth.

To elevate the stories of youth, we take up an approach to research and writing described as photo-elicitation (Mitchell, 2011) to decenter our power as researchers and educators by positioning the experiences and expertise of youth, in STEM education, at the forefront. Throughout our research, we use a collective approach to writing; thus, we intentionally use "we" to signal our co-constructed ontology and epistemology that guided this research and our perspectives of STEM education. As a team, we are a collection of teachers, researchers, and students that have been working together on various STEM education research and formal and informal STEM teaching from a span of more than three years to well over a decade. We use three instrumental cases (Stake, 2006) to demonstrate how photo-elicitation methods can be used to (re)position the experiences of youth at the center of STEM education research.

## Photo-Based Research

Photo-based research is characterized by a qualitative approach to gaining insight into the lived experiences of youth through the use of reflection on photo images (Mitchell, 2011). Often, these reflections forefront conversations around identity, cultural background, personal associations, and background experiences with a particular issue. Photo-based research appears in several forms in the education literature base and can be categorized on three basic fronts: (1) who actually captures the photos, (2) what is captured in the photos, and (3) what the photos are used to do. In all types of photo-based research, photographs are used as an anchor on which to reflect and make meaning.

With regard to who actually captures the photos, sometimes photos are selected by the researcher to evoke a response from participants (i.e., "traditional photo-elicitation"). Collier (1957) described traditional photo-elicitation as open-ended interviewing where the researcher presents a photo and asks probing questions to the participant. The use of the photos in the interview creates an opportunity for a

reflection that brings forth one's cultural perspective, background, and experiences. In other cases, photos are captured by the participants themselves (i.e., "reflexive photo-elicitation"). In this latter form, participants are the creators of the reflective tool to capture their own photos with increased voice and authority over the issues that impact their lives (Lapenta, 2011).

Regarding what is captured in the photos, researchers sometimes select what should be featured in the photos. In this way, researchers may choose photos that will help them understand participants' views on an issue. In the case of reflexive photo-elicitation, researchers may choose a prompt such as "environmental issues in your community" and participants may select what photos best depict the issues on which they wish to focus (Cook & Quigley, 2013).

Regarding what the photos are used to do, traditional and reflexive photo-elicitation aim to uncover youth thinking and connection to an issue. Whether photos are taken by the researcher or by the participants, the goal is a deeper understanding of the participants' perspectives than could be accomplished by interviewing alone. Because participants have more ownership over what they wish to talk about or reference in the photos, these methods disrupt the power imbalance that can inhibit dialogue between a researcher and a participant.

A third form of photo-based research termed "photovoice" extends this photo elicited reflection to engage participants in action research (Wang, 1999; Wang & Burris, 1997). Photovoice not only allows participants to capture their own photos and have autonomy over what they wish to reflect on, but it includes a community event whereby participants dialogue with informed community members who may be in a position to mobilize change with regard to the issue. In this way, photovoice serves as both a decolonizing research method and a pedagogical tool for understanding complex issues from multiple viewpoints (Cook, 2015).

## **Photo-Based Research in STEM**

Photo-based research has gained traction in the fields of science, mathematics, and engineering education at various levels to uncover student thinking, reposition youth as knowers, and in some cases generate dialogue between youth and STEM professionals. Often, this research seeks to understand a youth's sense of belonging or connection to the content—a worthy approach in content areas such as science and mathematics where there can be a divide between specialists and the general public.

In engineering education, Pitterson et al. (2016) used traditional photo-elicitation methods to investigate the ways in which engineering researchers felt a sense of belonging in a community of practice designed to develop skills to conduct scholarly research on the teaching and learning of engineering. Pitterson and colleagues noted the importance of photo-elicitation in enabling conversation about sensitive issues such as isolation and the need for support amongst the participants. They recommended this research tool for broaching potentially uncomfortable issues in interviews.

In mathematics education, Lembrér (2019) used reflexive photo-elicitation to gain an understanding of parents' knowledge, experiences, and views of early

mathematics learning in the home. Conducting interviews with parents, Lembrér noted that the photo-elicitation strategy helped balance the power dynamic between the parents and the mathematics researcher by bringing forth the social and cultural capital of the parents and their home activities. Lembrér found that parents were seeking validation from the researcher about the photos of mathematics learning in their home—a concern that arises in all interviewing settings. This research cautions users to remember the aims for participant voice and choice in the use of and reflection on photos.

Photo-elicitation and photovoice have also been used to study mathematics teachers' identities in professional development settings. Kor and Lim (2020) studied the perspectives of 11-year-old students on what they considered effective mathematics teaching. The researchers suggested that the use of photo-elicitation and photovoice enhanced students' critical reflection and was a viable research tool for understanding the needs and perspectives of learners.

In science education, a burgeoning body of research explored the use of photovoice in environmental issues and sustainability. Recognizing the power imbalance that exists between scientists and non-scientists, these studies have aimed to create dialogic spaces between learners of science and scientists. The collection of studies has found that photovoice:

- Bridges classroom science with community science (Cook, 2014; Cook & Buck, 2010)
- Deepens perspectives and content knowledge (Quigley et al., 2011; Waters & Cook, 2020)
- Engages students in relevant and authentic inquiry (Cook & Quigley, 2013)
- Encourages students to take ownership of their personal connection with science (Cook, 2015)
- Sharing experiences with climate change led students to construct hope and build agency around climate issues (Herrick et al., 2022; Trott, 2019)
- Broadens all participants' understanding of environmental issues of personal relevance and impact (Cook et al., 2016)

While these studies offer examples of photo-based research in the fields of science, mathematics, and engineering education, expanding the use of photo-based research into integrated STEM education can offer different important insights to educators. STEM education is part of our global and national rhetoric and exists across formal and nonformal educational spaces; however, teacher preparation does not typically include crossing disciplinary boundaries in STEM methods and the way STEM is offered in K-12 school settings can vary greatly across contexts. Understanding the lived experiences of youth related to integrated STEM education can help educators potentially improve these learning environments for all. Using photo-based research in STEM education can ultimately have the “potential to authentically leverage student voice in research on policy and school improvement in ways that promote equity and critical social justice” (Walls & Holquist, 2019, p. 159).

## Methodology

Because our aim is to make visible the ways youth can be (re)positioned at the forefront of education research in integrated STEM education, we use Stake's (2006) instrumental case study as our methodological approach. Our goal is twofold. One, we aim to illuminate the stories that youth tell about themselves within and about STEM. Two, our goal is to elucidate how photo-based approaches to research in educational spaces (Mitchell, 2011) can be used to (re)position youth at the center of STEM education research. The purpose of instrumental case studies is to provide insights into a particular phenomenon; thus, the case under investigation is used to facilitate understanding of participant-centered research for STEM education (Mills et al., 2010). For the purpose of this report, we present three unique cases to gain insights into centering youth, through photo elicitation, to facilitate an understanding of STEM. While we will present our analysis (described later), our overarching goal in this report is to demonstrate how STEM education research can center the perspectives and stories of participants. In addition to using an instrumental case study, we utilize an ethnographic perspective (Green et al., 2012) to guide our logic of inquiry. Our cases (described in detail later) were collected as part of a much larger and ongoing informal STEM education experience (i.e., STEM summer camp).

## Context and Data Construction

During summer of 2020, we developed a way to engage youth in a photo-elicitation task. Our goal was to position them as experts of their experiences of integrated STEM education. To do so, we created a digital task that centered on using photo-elicitation to respond to three interrelated questions. Each youth in the summer camp had the opportunity to respond to the questions. We asked three questions: (1) What does it mean to do STEM? (2) Who belongs in STEM? and (3) Why is STEM important? For the task, we asked youth to respond to the prompt with a photo. Additionally, we provided space for youth to detail their thinking or rationale behind photo selection. Figure 1 details an example prompt that was given to youth.

## Analytical Framework

To analyze the prompts that youth submitted, we (re)conceptualized the Equity-Oriented STEM Literacy Framework (Jackson et al., 2021). The framework was originally designed as a conceptual framework for STEM literacy that posited equity as its central core element (Jackson et al., 2021). The framework privileges the perspectives of youth, particularly those who have been historically excluded in STEM opportunities and lacking access to high-quality integrated STEM learning experiences. To (re)conceptualize the framework as an analytical framework, we used the six components of the framework for disrupting systems of inequity in STEM: 1) dispositions, 2) STEM identity development, 3) empowerment, 4) critical thinking

Prompt: Who belongs in STEM? 🗣️



What does your picture show or represent? 🗣️  
It shows that astronomers are a big part of STEM in the field of science.

Why did you select your picture? 🗣️  
I selected this picture because I want to become an astronomer when I grow up and work for NASA.

What is important about your picture? 🗣️  
My picture is important because it tells a lot about me. I am really interested in Mars. It also shows some things astronomers do in NASA.

Fig. 1 Photo-elicitation sample student response

and problem solving, 5) utility and applicability, and 6) empathy as kinds of discourse that youth can communicate in and around STEM (see Jackson et al., 2021). As a kind of discourse, we take up a notion that youth communicate insights into their conceptions and constructions of STEM through their photos and words. Each kind of discourse communicates a different component of equity-oriented STEM. Dispositions are the youth's general attitude towards, their interest in, and their motivation in and towards STEM. The STEM identity component focuses on positive development of youth's identities, sense of belonging, and becoming STEM literate persons. Empowerment focuses on the ways in which youth feel empowered through and in STEM spaces. Critical thinking and problem solving focuses on the skills required and developed in STEM that youth use to solve complex problems. The utility and applicability component are the ways the youth communicate how STEM can be used in their interpretation of the real world. Empathy is the articulation of humanization and care in STEM spaces or a sense of solving for others as part of the STEM solution-seeking process. We specifically used each of these kinds of discourse to discursively analyze the photo-elicitation prompts as a key component of our logic of inquiry.

### Logic of Analysis

To analyze, we met as a subteam of authors to discursively analyze each of the cases. Our collective analysis followed a three-phase approach. For phase 1, we met as a subset team of authors to conduct a moment-by-moment discourse analysis (Bloome et al., 2005) where we considered what the youth was signaling through their photos and associated words within each of the prompts. Importantly, because we analyzed collectively at the same time, we openly discussed each discursive move the youth signaled until we noted 100 percent consensus agreement amongst all researchers.

As part of our collectively analyzing phase 1, we sought to position the youth as an expert of their own experiences. Once each case was discursively analyzed at individual level, we then transitioned to phase two. In phase 2, we again met as a collaborative research team and discursively analyzed each of the three cases to understand a holistic view of the collective understanding of STEM education amongst the three youths included in this study.

Because our goal was to illuminate how photo-elicitation research elevates the voices of youth in STEM education research, we present our findings as a moment-by-moment discourse analysis (Bloome et al., 2005). Each prompt and photo represents a singular moment and is conceptualized as part of the dialogue between the youth and us as STEM education researchers.

## Findings

Our goal of this report is not to present an in-depth analysis of each of the cases but to instead make visible the ways photo-elicitation can serve to potentially (re)position the voices of youth at the center of STEM educational research.

### Case One: Nadia

The first case we highlight is from Nadia's photo-elicitation task. In her task, she chose photos that highlight the applicability and utility of STEM as well as the importance of everyone belonging in STEM spaces as STEM identity development and empathy. Her first photo in response to "What does it mean to do STEM?" see Fig. 2, displays the four disciplines that make up STEM. This photo is a recreation of her original photo due to copyright concerns. While her usage of a siloed photo asserts a non-integrated approach to doing STEM, it does illuminate an understanding of the applicability of each of the associated disciplines. By using pictorial representations of each of the disciplines, Nadia communicates the utility of each of the disciplines in STEM-related fields. For example, the technology quadrant of the photo displays what appears to be a microchip. Here, Nadia is detailing more than just the letter "t" or word "technology" but instead shows a specific application of the technology discipline, indicating a deeper understanding of doing STEM.

Additionally, Nadia's choice of photos illuminates a deep sense of belonging and empathy in STEM spaces. She elected to use two photos, for prompts two ("Who belongs in STEM?") and three ("What does it mean to do STEM?"), that detail inclusive discourse and pictorial metaphors. For prompt two, Nadia elected to use a photo detailing President Biden (at the time, he was the Vice President of the United States) interacting with another youth around a computer (see Fig. 3). In centering the voices of youth, we should not assume why she selected this photo, but we do notice elements of the photo that display a youth with an older male collaboratively working, two people of two different races, and a national leader engaged in STEM. Additionally, she selected a photo indicative of the importance of collaboration in

Fig. 2 Nadia's prompt 1 photo

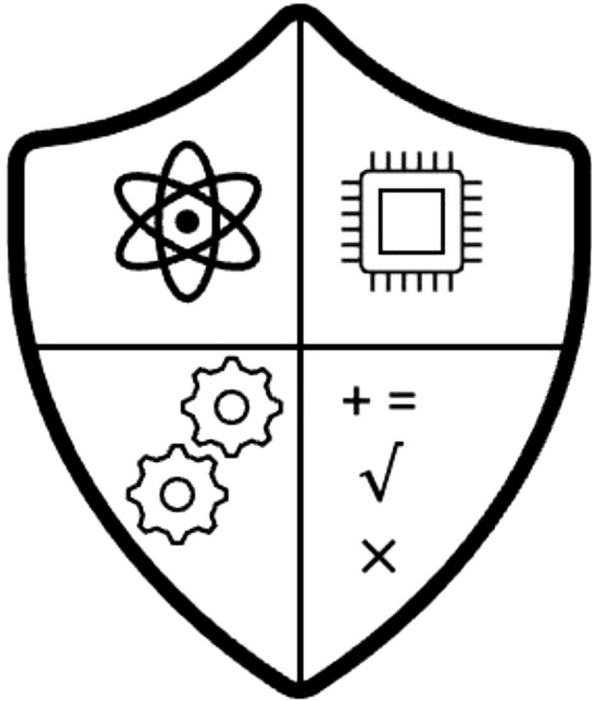


Fig. 3 Nadia's second photo.

Note: From *Whitehouse features student robots* [Photograph], by White House 2014, Wikimedia Commons ([https://commons.wikimedia.org/wiki/File:Joe\\_Biden\\_with\\_a\\_student\\_during\\_Computer\\_Science\\_Education\\_Week\\_2014.jpg](https://commons.wikimedia.org/wiki/File:Joe_Biden_with_a_student_during_Computer_Science_Education_Week_2014.jpg)), Public Domain

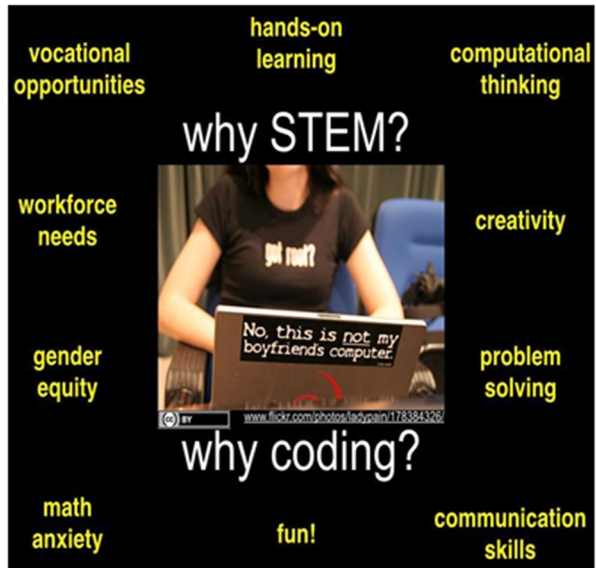


STEM spaces as she selected a photo that displays two people gathered around one computer, as opposed to independently using the two computers in the photo.

In her third photo, empathy and empowerment are highlighted through her photo selection (see Fig. 4). When asked on the importance of STEM, she pushes for empowerment while attending to push for STEM to be a space for more inclusion.



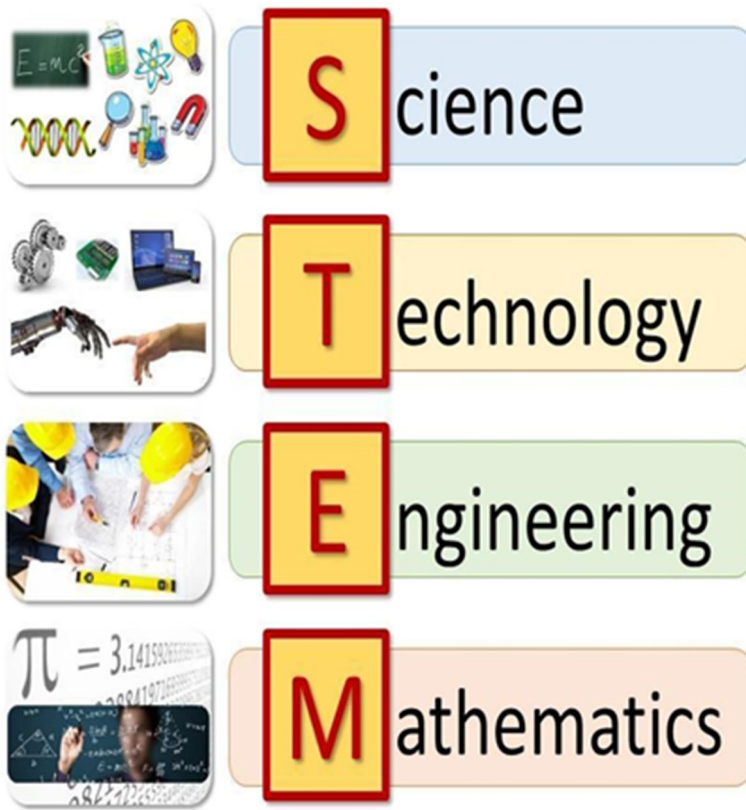
**Fig. 4** Nadia's Third Photo.  
 Note: from Why STEM? Why coding? [Photograph], by W. Freyer, 2013, Flickr (<https://www.flickr.com/photos/wfryer/11347987415>). CC BY 2.0



By using photo-elicitation and discursive analysis, we can use more than just the photos. In this photo in particular, Nadia uses a photo with words around an inside photo that also displays words on a laptop. Discursively, Nadia is communicating the importance of STEM through many of the words in yellow (e.g., creativity, problem solving, or hands-on learning). She also calls attention to critical issues in STEM education like “gender equity” in the words displayed on the outside. Additionally, in the photo in the side of her selected photo, a sense of feminism and inclusion of women and girls is communicated through the sticker on the laptop. Here, the photo displays the words “No, this is not my boyfriend’s computer.” This directly points to the importance of breaking down the barriers of male centric STEM practices to be inclusive of all persons in STEM spaces, including but not limited to women and girls.

### Case Two: Myra

Case two details the photos that Myra chose to use in responding to the prompts. Her photos, in many ways, are similar to Nadia’s, which we build on in the following section. In Myra’s first photo, she displays the four disciplines of STEM (see Fig. 5). She also shows the applicability of each of the STEM disciplines, although in a disconnected manner. Discursively, we were able to additionally include the words she uses to justify her selection of the photo. She stated, “I chose this because it showed exactly what people do in all the different components of STEM. It also shows clearly what each letter of STEM stands for.” When prompted on the importance of her photo, she stated, “It is important because it tells that STEM is multiple things and not just science and it tells what those things are.” In centering the words Myra uses, we can understand more about what it means to do STEM from her



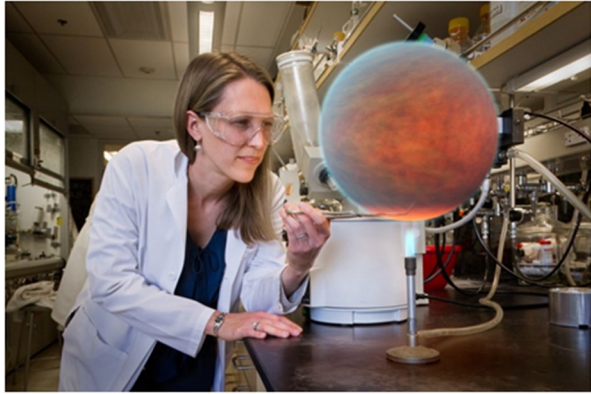
**Fig. 5** Myra's first photo. Note: from Representación visual de las diferentes áreas de conocimiento involucradas en Educación STEM [Photograph], by G. Rebollo, 2015, Wikimedia Commons ([https://upload.wikimedia.org/wikipedia/commons/0/0e/Educaci%C3%B3n\\_STEM.jpg](https://upload.wikimedia.org/wikipedia/commons/0/0e/Educaci%C3%B3n_STEM.jpg)). CC BY-SA 4.0

perspective. She states “not just about science,” which points to her own understanding that STEM is sometimes viewed as a “science first” integration lacking meaningful integrations with the other disciplines but wishes to point out that STEM is also about the other disciplines.

In her second photo, she highlights her own identity development in STEM. Using a photo of an astronomer (see Fig. 6), she communicates her own desire to work for NASA. She states, “I selected this photo because I want to become an astronomer when I grow up and work for NASA.” Her use of “become” was central to understanding her perception of identity development in STEM. By using the future tense, she describes a process of growth in and through STEM spaces to one day become a STEM specialist. Through a discursive lens, we note that she feels that she has not yet reached this point and uses an adult astronomer to describe an aspiration.

In her third photo, Myra describes her photo selection as “a worker constructing a building” (see Fig. 7). When prompted on the importance of her photo, she

**Fig. 6** Myra's second photo.  
Note: Picture Courtesy NASA/  
JPL-Caltech



**Fig. 7** Myra's third photo.  
Note: from construction worker,  
ladder, metal, tall, worker, work-  
man, city, architecture, building,  
industry [Photo], Bicanski, n.d.,  
Pixio (<https://pixnio.com/media/construction-worker-ladder-metal-tall-worker>), CC0



continued “It is important because it shows exactly how buildings are built. It shows how to use STEM to build things. It also shows how hard workers have to work even with STEM, so we should appreciate them.” Her discourse is important to understanding her intent in using the photo. She centers others, *empathy* in our framework, to describe the importance of STEM. Additionally, she centers a non-traditional STEM career when describing importance. By centering others, she is communicating the critical role of empathy for STEM and being inclusive of careers beyond the traditional roles that typically depicted.

### Case Three: Grace

The photos that Grace chose to use to respond to the prompts represent a different way that photo-elicitation can be employed. In two of the three photos, Grace chose to create her own photos (see Figs 8 and 9). For her first photo, Grace drew four quadrants and then drew detailed depictions of each of the STEM disciplines.

Fig. 8 Grace's first photo

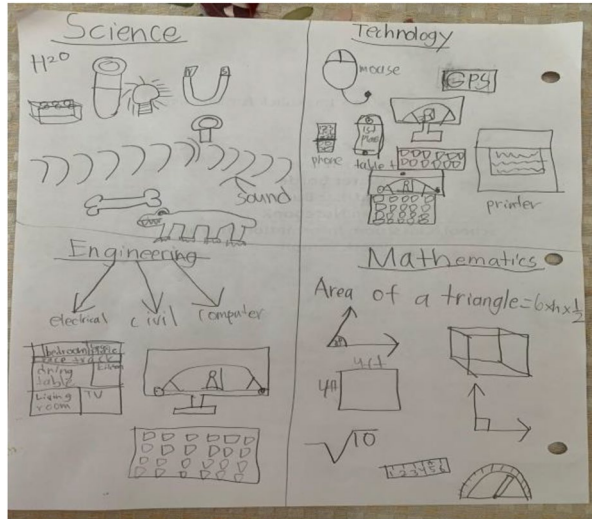
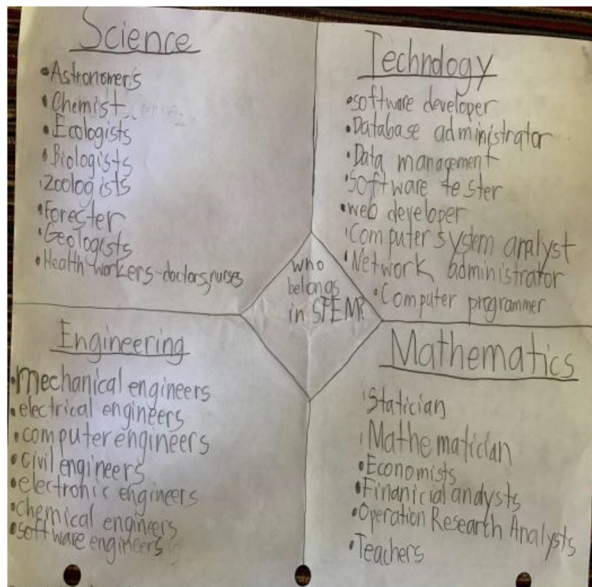


Fig. 9 Grace's second photo



Interestingly, she details utility and application for three of the STEM disciplines, science, technology, and engineering, while mathematics is depicted through more symbols of common mathematics problems. The mathematics symbols imply a more instrumental understanding and use of mathematics, rather than an applied or connected use of mathematics as with the other subjects. We found a lack of applicability of mathematics across all three of the cases, which we explore more in the following section.

In her second photo, when asked “Who belongs in STEM?” she detailed the same four quadrants and then identified a list of STEM careers (see Fig. 9). Her words highlight an important connection to multiple framework components. She states, “I selected this photo because it shows who belongs in STEM. It is important because it shows all the people who work hard to help the world to exist. STEM is in every corner of the world.” By drawing connections to careers in STEM, she is noting the applicability of STEM and identity development. She also invokes a strong sense of empathy for those in STEM careers by pointing to how they “help the world exist.”

In her final photo, Grace detailed the importance of STEM. Unfortunately, we are unable to include her selected picture due to copyright concerns. An example of her picture can be seen on the blog “Kids in STEM: Science, Technology, Engineering, and Math” (Flannigan, 2017; link in references). Her selected picture depicts four boxes under the header “Why is STEM important.” The four boxes detail the importance of learning across environments, early exposure to STEM, career choices, and fun of STEM activities. She states “It shows that children can learn across different environments, early exposure to STEM, STEM subjects are important and rewarding career choices, and STEM activities are fun.” Although the prompts asks Grace to detail the importance of STEM, she uses the space to denote that everyone has access to early STEM exposures. Her photo also highlights a sense of identity development for future careers.

## Discussion

In the following section, we illuminate commonalities across all three of the youth’s photo-elicitation tasks. We organize this section by the prompts that the youth were asked to respond.

### Prompt One: What Does It Mean to Do STEM?

Across the three cases, each youth signaled their perception of what it meant, to them, to do STEM. All three cases used a photo that depicts a siloed approach to doing STEM. Although the prompt asked youths “What does it mean to do STEM?” each youth chose a photo showing a siloed interpretation of STEM. Myra also uses her written words to communicate their understanding of STEM being siloed as they state, “It represents what STEM stands for.” In respecting their insights, we acknowledge that they bring in a wealth of lived experiences into the photo-elicitation task. Because we take up a participatory centered perspective, we assert that youth are making visible much more than their perspective of what it means to do STEM but also their experiences with STEM up to the point in time that they responded to the prompt. Thus, to these youths, doing STEM is a process of siloed approaches to each of the subjects.

Although a siloed approach of doing STEM was signaled, each of the youth do present the utility and applicability of the STEM subjects, with the exception of mathematics. This fits in with other literature (e.g., Shaughnessy, 2013) detailing the

lack of clear and grade level appropriate mathematics within STEM tasks. Thus, to these youth, they are communicating a need for greater involvement with mathematics in STEM education tasks. Myra goes as far as to state, “It is important because it tells that STEM is multiple things and not just science...” Here, she is building from her own experiences to denote that STEM is more than just one subject, but is instead the culmination of multiple subjects.

### **Prompt 2: Who Belongs in STEM?**

For the second prompt, two of the photos implicate a unique sense of becoming in STEM education. Myra and Grace both depict STEM careers, and interestingly detail many uncommon STEM careers. Through their depiction of STEM careers, they describe a sense of aspiration and acknowledgement of multiple possible careers. In fact, Myra describes her desire to one day be an astrologist. In this prompt, the youth describe that to belong in STEM is to have a career in STEM; thus, their sense of belonging is a delayed membership, one that takes a career to obtain belonging. Here, these two youth do not depict a sense of current belonging in STEM but instead show the importance of a STEM career. Nadia does depict a youth that could be around the same age, which is counter to the other two photos in this prompt. Nadia demonstrates that age or sense of career is not a part of belonging in STEM. Thus, more work is needed in this area to better understand youths’ conception of belonging in STEM spaces.

In this specific prompt, youth signaled an importance of STEM identity development in K-12 spaces. In the field of integrated STEM education, there is limited research that has been conducted specifically on identity development (Jackson et al., 2021). Not understanding how youth develop integrated STEM identities has placed us well behind related fields (e.g., mathematics education, science education) in critically taking up research, curriculum, and professional development for developing positive STEM identities in K-12 STEM spaces. We cannot conceptualize the STEM identities of youth and how they develop without researching in such a way that they can tell their perspectives and sense of belonging and becoming. Future research must begin to address this gap in research and practice.

### **Prompt 3: Why Is STEM Important?**

All three youths made visible the key component of *empathy* in their responses regarding the importance of STEM. Through their photo selection, the youths signaled how STEM can and should be about others. Through our discursive analysis, we found that the youth invoked more empathic responses to this prompt as compared to prompt 2, which directly asks them to reflect on persons in STEM. We found this to be particularly interesting given that when they were prompted to reflect on the importance of STEM they invoked empathy and caring for others. In our previous work (see Bush et al., 2024), we reviewed several studies that directly call attention to the importance of empathy in integrated STEM. When students were positioned to share their expertise on the importance of STEM, they invoked

feelings of empathy. While this finding is novel in its own right, it is more profound when the youth additionally signal critical issues in STEM and bring attention to ameliorating harmful racial, gender, and professional biases in STEM educational spaces.

This particular prompt and youth responses calls into question neoliberal pushes for STEM as a priority because of workforce development or being globally competitive (e.g., National Academies of Science, 2014; Sutter & Camilli, 2018). Moving forward with integrated STEM education and STEM education initiatives, we need to further understand the youth's impetus for learning STEM and becoming STEM literate persons. While we acknowledge the importance of well positioning youth as future STEM workers, this is an approach that undervalues the humanistic, personal, equitable, and ethical considerations for why every youth deserves the opportunity to develop STEM literacy and become STEM doers and thinkers. Further, the purpose of integrated STEM learning experiences is not just about preparing youth as future adults, it's about respecting youth and their contributions of their current STEM expertise. Teachers and researchers must look for and leverage ways to foster youth, as they currently are, as well as cultivate who they are becoming (Lounsbury, 2015).

## Implications for Centering the Voices of Youths

Although significant research exists around exploring student perceptions of STEM (e.g., Roberts et al., 2018, Coxon et al., 2018; Denson et al., 2015), few studies intentionally center youth voices in STEM education research. In this study, we discursively constructed meaning through photos and words as youth offered valuable insights into their previous lived experiences with STEM, the applicability of STEM in their life, and their view of their future in STEM. Using the Equity-Oriented Conceptual Framework for K-12 STEM literacy (Jackson et al., 2021) allowed us to consider ways photos selected by the youth provided avenues for disrupting the systems of oppression and privilege. For example, Myra's photo raised critical issues in STEM related to gender equity. Several photos showed an inclusive perspective of who belongs in STEM and who does STEM. This is a distinct shift from traditional views of STEM and should be explored further to better understand youth's evolving perspectives of STEM as they have more lived experiences in STEM. Their voices were heard through their photo selections and responses. The framework focused us on how youth incorporated components of STEM literacy (e.g., empathy, stem identity development, and utility and applicability of STEM) in their conceptualization of STEM, while empowering and uplifting their choices and voices.

In STEM education research, we must continue to seek ways to affirm the voices of young adults as we provide opportunity and access to high-quality integrated STEM learning experiences for youth as they currently are. Currently, much of the impetus for STEM education research involving youth is undergirded by potential future STEM careers. This perspective contributes to an adult-only perspective in social science research (Guerrero et al., 2023) but only positions youth as developing positive STEM identities to meet global economic needs. Photos from prompt 3

directly call such neoliberal pushes into question. Future research should build from a perspective that youth's perspectives are worthwhile to the STEM field as they currently are, not just as future STEM workers.

### **Pedagogical Implications for Teacher Education in Integrated STEM**

This report highlights the importance of centering K-12 youth, elevating their voices and perspectives, and preparing educators based on what we learn from youth. By centering the voices of youth in teacher education, teacher educators highlight the importance of learner-centered classrooms and knowing youth holistically in order to meet their needs. Knowing these perspectives can better inform teacher candidates and inform future directions for teacher education. Furthermore, it can help inform how we are providing positive opportunities for learners to build their STEM identity—regardless if they choose to pursue STEM as a career.

Using techniques such as photo-elicitation in the classroom can be a transformative experience for both the learner and the teacher. As educators, we can help students transition from being learners only to being contributing members of society. We can help to position our students as capable, motivated members of the community who have valuable ideas informed by their own unique experiences and backgrounds. Valuing the contribution of students' funds of knowledge honors their cultural and social experiences, which inform their ways of viewing the world as well as their identity in STEM (González et al., 2005). Best practices in culturally sustaining pedagogy include bringing voice to students' lived experiences and providing space for thinking about content in relation to which is relevant and situated in their experience (Paris, 2012). Through this kind of education, responsible learners become responsible community members who take ownership of their STEM identity, regardless of their choice in career path.

### **Concluding Thoughts**

In this report, we used a photo-elicitation approach to elevate the voices of youth with the goal of initiating a conversation and interest in centering the voices of youth in integrated STEM education research. As we continue to push for integrated STEM in K-12 education and beyond, it will be crucial to include the voices of all those involved with learning and teaching, but to specifically elevate and center youth. In our report, we outlined one specific way to center the perspective of youth at the forefront of research. Through a photo-elicitation approach, we made visible how youth envisioned their place in STEM, their sense of belonging and becoming STEM literate people, and how they conceptualized STEM education. We contend that through centering the voices of youth, the field of STEM education has much to learn about what it means to do STEM, who belongs in STEM, the importance of STEM education, and how we can do it so well that we systematically dismantle negative stereotypes around STEM and create an enthusiastic and positive culture and story around STEM.



## Declarations

**Conflict of Interests** The authors declare no competing interests.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

## References


- Aish, N., Asare, P., & Miskioğlu, E. E. (2018). People like me: Providing relatable and realistic role models for underrepresented minorities in STEM to increase their motivation and likelihood of success. In *In 2018 IEEE Integrated STEM Education Conference (ISEC)* (pp. 83–89). IEEE.
- Bicanski. (n.d.). Construction worker, ladder, metal, tall, worker, workman, city, architecture, building, industry [Photograph]. Pixio. <https://pixnio.com/media/construction-worker-ladder-metal-tall-worker>
- Bush, S. B., Edelen, D., Roberts, T., Maiorca, C., Ivy, J. T., Cook, K. L., Tripp, L. O., Burton, M., Alameh, S., Jackson, C., Mohr-Schroeder, M. J., Schroeder, D. C., McCurdy, R. P., & Cox, R., Jr. (2024). Humanistic STE(A)M instruction through empathy: Leveraging design thinking to improve society. *Pedagogies: An International Journal*, 19(1), 60–79. <https://doi.org/10.1080/1554480X.2022.2147937>
- Cook, K., & Buck, G. (2010). Photovoice: A community-based socioscientific pedagogical tool. *Science Scope*, 33(7), 35–39.
- Cook, K., & Quigley, C. (2013). Connecting to our community: Utilizing photovoice as a pedagogical tool to connect college students to science. *International Journal of Environmental and Science Education*, 8(2), 339–357.
- Cook, K. (2014). Beginning a classroom inquiry: Using photovoice to connect college students to community science. *Journal of College Science Teaching*, 43(6), 22–27.
- Cook, K. (2015). Grappling with wicked problems: Exploring photovoice as a decolonizing methodology in science education. *Cultural Studies of Science Education*, 10(3), 581–592.
- Cook, K., Brown, A., & Ballard, G. (2016). Using photovoice to explore environmental sustainability across languages and cultures. *Discourse and Communication for Sustainable Education*, 7(1), 49–67.
- Bloome, D., Carter, S. P., Christian, B. M., Otto, S., & Shuart-Faris, N. (2005). *Discourse analysis and the study of classroom language and literacy events: A microethnographic perspective*. Erlbaum.
- Collier, J. (1957). Photography in anthropology: A report on two experiments. *American Anthropologist*, 59(5), 843–859. <https://doi.org/10.1525/aa.1957.59.5.02a00100>
- Coxon, S. V., Dohrman, R. L., & Nadler, D. R. (2018). Children using robotics for engineering, science, technology, and math (CREST-M): The development and evaluation of an engaging math curriculum. *Roeper Review*, 40(2), 86–96.
- Denson, C. D., Hailey, C., Stallworth, C. A., & Householder, D. L. (2015). Benefits of informal learning environments: A focused examination of STEM-based program environments. *Journal of STEM Education: Innovations and Research*, 16(1), 11–15.
- Edelen, D., Cox, R., Bush, S. B., & Cook, K. L. (2023). Centering students in transdisciplinary steam using positioning theory. *Electronic Journal for Research in Science & Mathematics Education*, 26(4), 111–129.
- Flannigan, C. (2017). *Kids in STEM: Science, technology, engineering, and math*. FIX. <https://www.fix.com/blog/getting-kids-involved-in-stem/>

- González, N., Moll, L. C., & Amanti, C. (Eds.). (2005). *Funds of knowledge: Theorizing practices in households, communities, and classrooms*. Routledge.
- Green, J., Skukauskaitė, A. & Baker, W. D. (2012). Ethnography as epistemology: An introduction to educational ethnography. In J. Arthur, M. J. Waring, R. Coe, & L. Hedges (Eds.), *Research methodologies and methods in education* (pp. 309–321). Sage
- Guerrero, A. L., Peña, I. N., & Dantas-Whitney, M. (2023). Ethnographic spaces of possibilities: Interactional ethnography in focus. In A. Skukauskaitė & J. Green (Eds.), *Interactional ethnography: Designing and conducting discourse-based ethnographic research* (pp. 163–182). Routledge.
- Herrick, I., Lawson, M., & Matewos, A. (2022). Through the eyes of a child: Exploring and engaging elementary students' climate conceptions through photovoice. *Educational and Developmental Psychologist*, 39(1), 100–115.
- Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3(1), 11.
- Kor, L., & Lim, C. (2020). A view through a different lens: Eliciting pupils' conception of a good mathematics lesson using photovoice. *The Mathematics Enthusiast*, 17(1), 63–84.
- Jackson, C., Mohr-Schroeder, M. J., Bush, S. B., Maiorca, C., Roberts, T., Yost, C., & Fowler, A. (2021). Equity-oriented conceptual framework for k-12 stem literacy. *International Journal of STEM Education*, 8, 1–16. <https://doi.org/10.1186/s40594-021-00294-z>
- Jong, C., Priddie, C., Roberts, T., & Museus, S. (2020). Race-related factors in STEM: A review of research on educational experiences and outcomes for racial and ethnic minorities. In C. C. Johnson, M. J. Mohr-Schroeder, T. J. Moore, & L. D. English (Eds.), *Handbook of research on STEM education* (pp. 278–288). Routledge.
- Lapenta, F. (2011). Some theoretical and methodological views of photo-elicitation. In E. Margolis & L. Pauwells (Eds.), *Sage handbook of visual research methods* (pp. 201–213). Sage.
- Lembrér, D. (2019). Using photo-elicitation in early years mathematics research. *Proceedings of the Eleventh Congress of the European Society for Research in Mathematics Education*, 1912–1919.
- Lounsbury, J. H. (2015). Lest we forget - The open window. *Middle School Journal*, 46(5), 14–16.
- Mills, A. J., Durepos, G., & Wiebe, E. (2010). *Encyclopedia of case study research*. SAGE.
- Mitchell, C. (2011). *Doing visual research*. Sage.
- National Academy of Sciences. (2014). *STEM integration in K- 12 education: Status, prospects and an agenda for research*. National Academies Press.
- Paris, D. (2012). Culturally sustaining pedagogy: A needed change in stance, terminology, and practice. *Educational Researcher*, 41(3), 93–97.
- Pitterson, N. P., Ortega, J. D., Streveler, R. A., & Adams, R. (2016). *Voicing the indescribable - Using photo elicitation as a method to uncover belonging and community [Paper presentation]*. In *American Society for Engineering Education (ASEE) Annual Conference & Exposition 2016*. New Orleans United States. <https://doi.org/10.18260/p.27186>
- Quigley, C., Rodriguez, A., Cook, K., & Buck, G. (2011). Photos of real life: Kindergartners use photography to explore science in their surroundings. *Science and Children*, 48, 47–51.
- Rebollo, G. (2015). Educación STEM [Image]. Wikimedia Commons. [https://commons.wikimedia.org/wiki/File:Educaci%C3%B3n\\_STEM.jpg](https://commons.wikimedia.org/wiki/File:Educaci%C3%B3n_STEM.jpg)
- Roberts, T., Jackson, C., Mohr-Schroeder, M. J., Bush, S. B., Maiorca, C., Cavalcanti, M., & Cremeans, C. (2018). Students' perceptions of STEM learning after participating in a summer informal learning environment. *International Journal of STEM Education*, 5, 1–14. <https://doi.org/10.1186/s40594-018-0133-4>
- Shaughnessy, J. M. (2013). By way of introduction: Mathematics in a STEM context. *Mathematics Teaching in the Middle School*, 18(3), 324–327.
- Stake, R. E. (2006). *Multiple Case Study Analysis*. Gillford Press.
- Sutter, L. E., & Camilli, G. (2018). International student achievement comparisons and US STEM workforce development. *Journal of Science Education and Technology*, 28, 52–61. <https://doi.org/10.1007/s10956-018-9746-0>
- Trott, C. (2019). Photovoice for children's climate change engagement: Using digital photography to bridge knowledge and action. *The Earth Scientist*, 35(2), 20–25.
- Vincent-Ruz, P., & Schunn, C. D. (2018). The nature of science identity and its role as the driver of student choices. *International Journal of STEM Education*, 5(48). <https://doi.org/10.1186/s40594-018-0140-5>

- Walls, J., & Holquist, S. (2019). Through their eyes, in their words: Using photo-elicitation to amplify student voice in policy and school improvement research. In K. K. Strunk & L. A. Locke (Eds.), *Research methods for social justice and equity in education*. Palgrave Macmillan.
- Wang, C. (1999). Photovoice: A participatory action research strategy applied to women's health. *Journal of Women's Health, 8*(2), 185–192. <https://doi.org/10.1089/jwh.1999.8.185>
- Wang, C., & Burris, M. A. (1997). Photovoice: Concept, methodology, and use for participatory needs assessment. *Health Education & Behavior, 24*(3), 369–387. <https://doi.org/10.1177/109019819702400309>
- Waters, C., & Cook, K. L. (2020). Designing environmental science curriculum with photovoice to engage nonscience majors. *Journal of College Science Teaching, 49*(5), 28–25.
- Wesley, F. (2013). Why STEM? Why coding? [Photograph]. Flickr. <https://www.flickr.com/photos/wfryer/11347987415>
- White House. (2014). Joe Biden with a student during computer science education Week 2014. Wikimedia Commons. [https://commons.wikimedia.org/wiki/File:Joe\\_Biden\\_with\\_a\\_student\\_during\\_Computer\\_Science\\_Education\\_Week\\_2014.jpg](https://commons.wikimedia.org/wiki/File:Joe_Biden_with_a_student_during_Computer_Science_Education_Week_2014.jpg)

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

## Authors and Affiliations

**Daniel Edelen<sup>1</sup>**  · **Kristin Cook<sup>2</sup>** · **L. Octavia Tripp<sup>3</sup>** · **Christa Jackson<sup>4</sup>** · **Sarah B. Bush<sup>5</sup>** · **Margaret J. Mohr-Schroeder<sup>6</sup>** · **D. Craig Schroeder<sup>7</sup>** · **Thomas Roberts<sup>8</sup>** · **Cathrine Maiorca<sup>9</sup>** · **Jessica Ivy<sup>10</sup>** · **Megan Burton<sup>3</sup>** · **Andrea Perrin<sup>6</sup>**

<sup>1</sup> Department of Early Childhood and Elementary Education, Georgia State University, Atlanta, GA, USA

<sup>2</sup> School of Education, Bellarmine University, Louisville, KY, USA

<sup>3</sup> Department of Curriculum and Teaching, Auburn University, Auburn, AL, USA

<sup>4</sup> School of Education, Saint Louis University, St. Louis, MO, USA

<sup>5</sup> School of Teacher Education, University of Central Florida, Orlando, FL, USA

<sup>6</sup> Department of STEM Education, University of Kentucky, Lexington, KY, USA

<sup>7</sup> Fayette County Public Schools, Lexington, KY, USA

<sup>8</sup> School of Inclusive Teacher Education, Bowling Green State University, Bowling Green, OH, USA

<sup>9</sup> School of Teaching, Learning, and Educational Sciences, Oklahoma State University, Stillwater, OK, USA

<sup>10</sup> Purdue University Northwest, Hammond, IN, USA