Integrating a Virtual Science Outreach Into the Science Classroom Through Participatory Action Research

Shelby Anne Montague

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INTEGRATING A VIRTUAL SCIENCE OUTREACH INTO THE SCIENCE CLASSROOM THROUGH PARTICIPATORY ACTION RESEARCH

By

Shelby Montague

A Dissertation
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Abstract

Calls for increased involvement in science outreach have come from scientists (Alberts, 2018; Friedman, 2008), from professional organizations (Jayaratne et al., 2003; Lee, 2018; Toolin, 2004) and from funding agencies (Broadening Participation, 2008; Catsambis, 1995) to increase students’ interest in science, technology, engineering, and mathematics (STEM) and STEM careers. One model of science outreach is the scientist in the classroom model, where a STEM professional visits a school classroom either in-person (Peker et al., 2012; Pratt and Yezierski, 2018) or virtually (Barry et al., 2022; McCombs et al., 2007).

The St. Jude Virtual Journal Club is a scientist in the classroom program where participating classes receive three virtual visits from three different scientists. Scientist participants are trained in effective science communication prior to their virtual visits. To better support teachers in the program, the current project asked teachers to design their own research into the St. Jude Virtual Journal Club program through participatory action research (PAR). PAR was chosen to ensure that teachers had an active voice throughout the research process.

The four participating teacher co-researchers chose to evaluate two research questions: 1) Does participation in the St. Jude Virtual Journal Club increase students’ interest in STEM or STEM careers?, and 2) Are students able to understand the content and to think through applications of the St. Jude Virtual Journal Club talks? Through student surveys and reflections, we found that, while our population of students held less stereotypical views of scientists prior to the outreach program, student reflections focused more on the actions and motivations of scientists after the program. We also found that our students were able to understand most of the content of the talks and were able to make some connections between the talks and the subject content but not to the same extent for all the speakers and classes.
This study offers a novel approach to integrate teachers into science outreach research using PAR methodology. Use of PAR methodology is a powerful way to give teachers voice and to ensure relevancy of science outreach to their classrooms.
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Chapter 1

I am not the Lorax, I Cannot Speak for the [Teachers]

For the third time that spring, the moment I signed off Zoom my students immediately turned and started talking to me and to each other about the speaker we had just heard. The students had plenty of opportunity to ask questions at the end of the talk, and they completed a survey about the talk and the speaker that had open-ended questions, but there were still comments and questions they felt that they couldn’t or that they didn’t want to share outside of our classroom. I apologized to them yet again for having posted the research summary only one day before the talk, which was not enough time for all of them to read it in advance. I learned a lot from these impromptu conversations about their perceptions of each scientist, of their presentations, and of their understanding of what was presented.

I had already been thinking about what else I could do in my classroom to integrate the content into the AP Biology curriculum. I hadn’t spent much time preparing my students for the talks, even though we teachers received a summary of each research study in advance. Part of that was my fault, having class periods that were already too packed with content to add one more thing. But part of it was a lack of time to prepare, not always receiving the summaries far enough in advance to read them and to consider how to prepare the students for that content. I thought, “If I had the summaries and the papers a little more in advance, I could change my instruction in the class before the presentation to start discussing the content. Then the students will be more prepared to interact with the scientist during the presentation and to ask deeper questions. Then I can write some AP-style questions based on the presentation to add to a quiz or a test in the class periods after.”
The St. Jude MemSTEMM Ambassadors outreach program is designed to train the scientists for the St. Jude Virtual Journal Club presentations. I serve as a liaison to this training; my role is to help the scientists and the facilitators to understand the content of the AP Biology curriculum and of high school science curriculum more generally and to present the research at a level appropriate for the student audience. Survey results from other teachers indicated that they too would like additional curricular supports before and after the journal club presentations, so I shared my own thoughts about what supports we should add with the outreach facilitators. But instead of framing it as “this is what I would like to have for curriculum support”, I presented it as “this is what AP Biology teachers would like to have for curriculum support,” without having asked another AP Biology teacher what he or she might actually want.

My original plan for this project was to use a mixed methods research design. I would create curricular supports for the talks. I envisioned that these supports would include general suggestions for how to integrate primary research into the classroom, specific suggestions on how each talk could address AP Biology Science Practices and Topics and possibly NGSS standards as well, and assessment questions based on each talk. I imagined that certain in-class laboratory experiments could be conducted along with some of the talks to help students better understand some of the scientific processes discussed by the scientists. Once I learned the specific subjects of each of the scientist’s talks for this year, I could better decide which types of lessons, experiments, and questions would best fit within the AP Biology curriculum.

Once I had created these curricular supports, I would then ask teachers participating in the St. Jude Virtual Journal Club to implement them in their classes. I expected to ask teachers for their feedback through interviews and surveys, including how well they integrated into their classrooms and how well they tied in with their curriculum. I also planned to ask for student
artifacts, such as lab reports and test samples. I would implement these supports in my own classroom as well and ask for feedback from my own students. I could then take these data, evaluate what worked and what didn’t, and finish with a nice list of suggestions for changes and additions to the curricular supports I had designed. This felt like a nice linear, logical project where I could set specific goals and deadlines and finish with a nice linear, logical set of findings for St. Jude and my final dissertation.

I didn’t immediately realize my mistake. Because I am an AP Biology teacher, it makes sense that my experience can help inform this question of what would best support teachers and students in integrating the outreach into the classroom. It is as I began this process of outlining specific curricular supports and designing my thesis proposal that I realized my error: instead of working with other teachers to choose curricular supports and then design those supports, I assumed that my own personal experiences and wants could speak for those teachers.

I had learned about action research, and participatory action research (PAR) in particular, in an introductory methods course. I had also read papers about teachers using action research within their own classrooms to evaluate or to modify their curriculum or their teaching practices. As I began preparing my mixed methods approach, this idea of group participation and going directly to the teachers to ask what they want kept coming to the front of my thoughts. I have sat through “bad” scientist talks that were too complex for my students, and I have spent time modifying or completely rewriting outreach curriculum to make it fit my students’ level and my own teaching needs. I kept thinking of this one quote from a science outreach program, where the teachers said they felt like the outreach was “being done to them” and not something being done with them or for them (Falloon, 2013). Why was I now deciding to do the same to my fellow teachers in the St. Jude Virtual Journal Club program?
In recognition of this error of judgment on my part, I changed course on this project. To understand the impact of the St. Jude Virtual Journal Club outreach program on teachers, including what curricular supports teachers may or may not want, I collaborated with other teachers in a participatory action research (PAR) project. A change in the St. Jude Virtual Journal Club made this collaboration even more important and timely; the outreach organizers decided to expand the program into other high school science classes beyond AP Biology. This change meant that we needed to consider other curricula when training the scientists for how to present to the students. It also meant I needed other teacher perspectives outside of AP Biology. Through the PAR process, we teachers collaboratively decided upon our research questions, our methods, and our data collection. Instead of assuming my experience can speak for other teachers and imposing my own interests on them, I brought them into the process and valued their individual experiences equally to my own.

Significance – Why Science Outreach

A national call for more workers in science, technology, engineering, and mathematics (STEM) has existed for many years (Alberts, 2018). To achieve this goal, scientists have been encouraged to become involved in P-12 education through outreach. Calls for involvement in outreach from the life science community have come from scientists (Alberts, 2018; Friedman, 2008), from professional organizations (Jayaratne et al., 2003; Lee, 2018; Toolin, 2004) and from funding agencies (Broadening Participation, 2008; Catsambis, 1995). There is an especially great need to increase the number of workers from underrepresented groups in STEM, including women and people of color. In 2019-2020, only 34.0% of all STEM degrees were awarded to women. The statistics for people of color are even more grim, with only 7.2% of STEM degrees being awarded to students who identify as Black or African American and 12.3% being awarded...
to students who identify as Hispanic (De Brey et al., 2021). Potential reasons for the lower numbers of underrepresented groups in STEM include: traditional science curriculum is not taught in a way that is relevant to their everyday experiences (Emdin, 2010), family and community differences and school context impact achievement (Elmeskey & Seiler, 2007), and students have a lack of awareness of STEM career options and of exposure to STEM role models (National Academies, 2011).

Recent shifts in science education aim to improve equity across the K-12 sector as indicated in *The Framework for K-12 Science Education* (National Research Council, 2012), which states that all students should have both high academic goals and the opportunities to learn science. Unfortunately, opportunities to learn vary greatly by school and location (Tate, 2001). Many schools in urban areas, with large percentages of students of color and/or students in poverty, provide shallow opportunities such as note-taking and PowerPoint presentations (Haberman, 1991; National Research Council, 2012). Much research has been reported that identifies the challenges of teaching in urban settings (Coffey & Farinde-Wu, 2016). Some of these challenges for science in particular include lack of resources, such as textbooks, science supplies, or field trips (Oakes, 1990), and less qualified teachers (Ingersoll, 1999). Furthermore, under-resourced schools are more likely to use “scripted” curriculum (Ede, 2006) or curriculum that is simplified to the point of having teachers read a specific script to students for each lesson. Although teachers can learn to use this curriculum for meaningful learning with the appropriate support, it often narrows the focus of teaching only to areas that are likely to be tested (Milner, 2013).

In contrast, teaching primary literature in the classroom can increase students’ inquiry and critical thinking skills and promote a deeper understanding of scientific concepts and the
nature of science (Brill et al., 2004; Hoskins et al., 2007; Stelnicki et al., 2011). When research is presented by scientists, students report feeling that the research being studied is more authentic and relevant (Falloon, 2012). Exposure to scientists from diverse backgrounds can also work to dispel misconceptions about who scientists are and who can be a scientist (Gladstone & Cimpian, 2021). This is especially important for female and Black, Indigenous, People of Color (BIPOC) students (Gladstone & Cimpian, 2021). Yet, many BIPOC youth in Memphis, TN lack access and opportunity to engage with scientists and high-quality STEM education due to systemic practices of racial segregation and inequitable distribution of resources (Frankenberg et al., 2017; Kiel, 2008).

Primary literature is not often taught in high school for several reasons: 1) primary literature is generally written for a specialized audience and is difficult for those outside of the field to understand (Snow, 2010), 2) postsecondary programs in education typically do not teach preservice teachers how to read primary literature, and 3) prescribed curriculum meant to prepare students for high-stakes testing does not include primary literature. Many teachers may have never had the opportunity to learn how to read primary literature. Teachers are more confident teaching topics and using pedagogical techniques with which they are familiar (Kelley et al., 2020; Kind, 2009), which is why teachers need resources to improve their pedagogical content knowledge with respect to teaching primary literature.

Research shows that science outreach designed around interactions with scientists has the potential to address needs and concerns for all three involved parties: scientists, teachers, and students. Scientists have the potential to improve their science communication skills, their knowledge of curriculum and pedagogy, and their creativity (Eng & Febria, 2011; Kaser et al., 2013; Munson et al., 2013; Tomanek et al., 2005). Professionals and organizations that
participate in outreach are more involved in their communities (Ferrara et al., 2018). Teachers have the potential to increase their content-area knowledge, improve or expand their pedagogical knowledge, and increase their comfort with hands-on activities (Bruce et al., 1997; Houseal et al., 2014; Kaser et al., 2013; Laursen et al., 2007; Lott, 2003; Yerrick & Beatty-Adler, 2011). Students have the potential to learn cutting-edge science, learn more about STEM careers, and improve their attitudes towards STEM (Bruce et al., 1997; Clark et al., 2016; Laursen et al., 2007; Melber, 2003; Pluth et al., 2015; Wyss et al., 2012). Even short interactions with scientists, lasting less than one hour, have the potential to increase student interest in science and in STEM careers (Clark et al., 2016; McCombs et al., 2007; Ramsey & Boyette, 2019).

Virtual outreach has been shown to improve student content knowledge (Kubasko et al., 2008), to increase students’ perceptions of the relevancy of their studies (Falloon, 2012), and to improve students’ perceptions of STEM (Barry et al., 2022; McCombs et al., 2007), STEM professionals (Barry et al., 2022; Woods-Townsend et al., 2016), and STEM careers (Wyss et al., 2012). Teachers who have used videos of scientists in their curriculum have reported benefits from having an “alternative authority” in the classroom, offering up more opportunities for democratic discussions (Chen & Cowie, 2013). However, teachers have also reported that virtual outreach would benefit from additional support and/or materials in advance of the visit (McCombs et al., 2007).

**Purpose Statement**

One of the primary goals of science outreach is to increase interest in STEM and participation in STEM careers. By encouraging interactions between the participating groups, especially between the scientists and the students, students’ knowledge of STEM and STEM careers can be constructed (Vennix et al., 2018). This study focuses on the third group of
participants: the teachers. As facilitators of knowledge within their classrooms, teachers serve as an important bridge between the scientists and the students, and the interests and abilities of the teacher may strongly influence the success of the outreach program (Aslam et al., 2018; Baeten et al., 2020). Through a participatory action research (PAR) project, I relied upon teachers’ unique knowledge and experiences to discuss, to decide upon, and to implement research questions related to integration of a virtual science outreach program into our classrooms.

The purpose of this project was to include teachers in the exploration of the impact of an in-school virtual science outreach program, the St. Jude Virtual Journal Club, on our students and ourselves. As co-researchers, we identified our goals, wants, and needs for integrating the outreach into our classrooms and our curricula. We then decided on specific research questions and methods and implemented those methods during the St. Jude Virtual Journal Club program in Spring 2023.

My overarching research question was, “What is the impact of the St. Jude Virtual Journal Club on teacher participants?” In collaboration, we decided on two research questions for our students/classrooms:

1. Does participation in the St. Jude Virtual Journal Club increase students' interest in STEM or STEM careers?
2. Are students able to understand the content and to think through applications of the St. Jude Virtual Journal Club talks?

These two questions were different from what I had initially envisioned for this study when I wrote my original overarching research question, which was that we teachers would reflect on ourselves and our personal goals for the outreach program as well as on our students
and our goals for them. This was true to the PAR process; the group was interested in examining our students more than ourselves, and our research questions reflect that interest.

**Overview of the Current Study**

This study contains two main pieces that occurred simultaneously: 1) the implementation of the PAR process, and 2) the investigation of the research questions chosen by us teachers.

Teachers who had volunteered to participate in the St. Jude Virtual Journal Club were asked to volunteer to participate in this PAR project. Of the six teachers (not including myself) participating in the outreach program, four indicated interest in the PAR project. One of these four teachers joined initial conversations but was unable to continue with the PAR project due to personal time constraints. In total, four teachers (three others and myself) participated in the PAR project, which I refer to as the St. Jude Virtual Journal Club (SJVJC) Teachers’ Project. We began by discussing our motivations and goals for participating in the St. Jude Virtual Journal Club and in the PAR project. As a group, we then discussed and decided upon our two research questions. We also discussed our personal stances and ethical concerns as we formed our research questions and decided upon our methods. Because of the nature of the questions, we decided to utilize a combination of pre/post surveys of students’ attitudes and reflection prompts for our methods. The Virtual Journal Club talks occurred between February and April, with each teacher hosting three scientist talks during those months. We asked students to complete a pre-program reflection before the first scientist talk, a post-talk reflection after each of the three talks, and a final post-program survey and reflection after the completion of all three talks. At the end of the journal club, we began discussion of how to analyze the data, but due to the timing of the end of our data collection (middle of May) and the beginning of summer break (end of May), I completed the majority of data analysis independently. As I organized the data
and came to conclusions, I solicited comments and feedback from my teacher co-researchers on each of the pieces, ending with a final report of our project that was shared with the St. Jude outreach facilitators in August 2023.

Throughout the teachers’ project outlined above, I continually practiced self-reflection of the PAR process itself and of the decisions and actions being taken by our group. Each step in the research process brought new questions and concerns. Not all of the teachers remained equally engaged throughout the process. I often felt personal conflict as I balanced my multiple roles as the lead researcher for this project, as a participant in the SJVJC Teachers’ Project, as a full-time teacher, and as a student myself. I tried to temper my personal interests and voice and instead consider the interests and tone of the entire group as I performed additional work and tasks outside of our meetings in my role as the researcher. I had to balance these roles as I taught my own students in the classroom, discussed the outreach program and our chosen project with the other teachers, drove the overall process as a researcher, and continued to learn how to do this type of research as a student.

The overall PAR process and the SJVJC Teachers’ Project are each detailed in its own chapter. Following the description of my theoretical framework in Chapter 2, Chapters 3 and 4 dive further into the PAR process that occurred during the SJVJC Teachers’ Project, including the challenges, decision points, and participation. Chapter 5 will focus on the SJVJC Teachers’ Project and the results of our group investigation. In the final chapter, I conclude with reflections on the overall PAR process.
Chapter 2

Theoretical Framework

The theoretical framework for this study is pragmatism (Biesta, 2010; Dewey, 1902/2015; Dewey, 1916/2015). In pragmatism, the mind is not considered a blank slate but instead is shaped by an individual’s experiences. It is through our experiences that we build knowledge (Biesta, 2010; Dewey, 1902/2015). This concept is important in multiple areas of this project, including in considering how to train the scientists for outreach and how to present research to the students.

One of the primary goals of science outreach is to increase interest in STEM and participation in STEM careers. By encouraging interactions between the participating groups, especially between the scientists and the students, students’ knowledge of STEM and STEM careers can be constructed (Vennix et al., 2018). This study focuses on the third group of participants: the teachers. As facilitators of knowledge within their classrooms, teachers serve as an important bridge between the scientists and the students, and the interests and abilities of the teacher may strongly influence the success of the outreach program (Aslam & Adefila, 2018; Baeten et al., 2020). Consistent with key tenets in pragmatism, in this study I rely upon teachers’ unique knowledge and experiences to discuss, to decide upon, and to implement research related to the integration of the outreach program in their classrooms. I begin with a discussion of these key tenets and follow with how these ideas served as a guide for my research.

Pragmatism

Pragmatism focuses on the importance of action in the creation of knowledge. Knowledge that is pursued for its own sake is theoretical. Truth itself isn’t an external reality that we can only attempt to understand; we discover truth and knowledge as we interact with our
environments and integrate this information into our existing knowledge (Biesta, 2010; Dewey, 1916/2015). We must always be open to the possibility that a “truth” may change as we gain new experience and new knowledge (Neubert, 2009). The key tenets of pragmatism that guided my study include: 1) thinking leads to action, 2) problems can be solved through logical thinking followed by action and reflection, 3) reflection on the consequences of action creates knowledge, and 4) experiences and interactions with our environment are what build knowledge.

1. Thinking Leads to Action

Pragmatism is a theoretical approach that focuses on the importance of action. Pragmatists are focused on the problems faced every day and what actions a person can take to influence those problems (Biesta & Burbules, 2003; Cherryholmes, 1999). “Pragmatism” comes from a similar Greek root as the word “praxis”; “pragma” means “action” and “prattein” means “to do” or “to act” (Harper, n.d.). Both terms are used to describe a focus on the importance of doing over the importance of thinking or theorizing. In pragmatism, we seek to find the processes and to do the actions that will work best for what we want to accomplish (Ozmon & Craver, 2008). As described above, if an action is not taken because of the thinking that occurred then the knowledge is only theoretical.

2. Problems Can Be Solved Through Logical Thinking Followed by Action and Reflection

While pragmatism places heavy emphasis on the importance of taking actions, thinking is still an important aspect of the pragmatic approach. When we as people face a problem in our lives, regardless of whether the problem is social, psychological, scientific, or something else, we begin by thinking about what actions we can take to address the problem. We then choose which action we think would be best and try that action. We gain new knowledge based on the consequences of that action, and we learn because of our reflection on the meaning of those
consequences. If we have not achieved the desired result or solved the problem, we then evaluate new courses of action based on what we learned from our previous actions.

This logical, ordered approach to thinking about problems in everyday life was a key aspect of pragmatism as proposed by John Dewey (Childs, 1956; Ozmon & Craver, 2008). Dewey believed that pragmatism is similar to the scientific method in its logical approach to problem solving but that this method should be applied widely to beliefs, truths, controversies, and ideas (Dewey, 1908). Genuine thought begins with a problem that can be explored experimentally by generating ideas to approach the problem then choosing one to try (Ozmon & Craver, 2008). This leads to what Dewey called “intelligent action” as distinct from trial and error because we can consider the different actions in our minds then choose which one we think is best (Biesta, 2010, p. 106).

3. Reflection on the Consequences of Action Creates Knowledge

Within pragmatism, the generation of ideas is the first step to building knowledge. However, the consequences of the action taken are what is most essential for the creation of knowledge. Ideas don’t simply exist for their own sake, but they are instead tools to be used to solve problems, leading to chosen actions and their resulting consequences. Without the application of the idea to the problem, and evaluation of the resulting consequence of action, the idea cannot truly represent new knowledge (Dewey, 1916/2015; Biesta, 2010). It is only through experiences and action that we generate new knowledge.

4. Experiences and Interactions are the Source of Knowledge

As a person develops, he gradually builds knowledge based on his experiences. For example, a baby quickly learns to associate the taste of milk with a positive experience. The
baby does not learn this knowledge in any theoretical capacity prior to her actual experience of tasting milk. She can then start to build additional knowledge related to the taste of milk, such as associating positive feelings with the caretaker who gives her the milk. Knowledge is built up from interactions with the environment, including the physical and social environments. It is only through interactions, or transactions, that we can learn about our world (Biesta, 2010; Dewey, 1902/2015; Dewey, 1916/2015). We can only build our knowledge as it relates to our prior experiences, and we cannot build knowledge without experiences (Dewey, 1902/2015).

Different sets of experiences will lead to different types of knowledge. Each person will develop a knowledge based upon his experiences and interactions with his environment. As such, each person’s experiences are equally real and valid regardless of their personal history or profession (Biesta, 2010). One type of knowledge is not fundamentally “better” or “more important” than another but instead they are different ways of knowing about the world. This transactional nature of our relationship with our environments guides our thoughts and our actions; we cannot separate our knowledge from our environment (Cherryholmes, 1999).

**Pragmatism in Education**

Pragmatism in education incorporates these key tenets into the classroom and the curriculum. Emphasis is placed on the construction of knowledge rather than the transmission of information from teacher to students. Students are encouraged to learn through experiences and to participate in active learning (Dewey, 1902/2015). Learning should integrate information from the external environment into the child’s internal environment, making connections between the child’s current knowledge and experiences to build upon that knowledge (Dewey, 1902/2015). Children should also be taught to think experimentally, using logical thinking to approach a problem and choose the best course of action, followed by reflection on the
consequences of the action (Childs, 1956). We as people are a part of our environment and cannot be separated from it. True knowledge is perceiving and understanding the connections between ourselves and the world around us based on our prior knowledge and experiences (Dewey, 1916/2015).

Pragmatists emphasize the importance of the environment, including the social environment, on the education of the child. Each child’s knowledge and experiences need to be considered to best teach that child (Dewey, 1902/2015). Additionally, because no learning occurs in isolation, the other lessons a child is learning must also be taken into consideration, such as whether school is enjoyable or what actions are socially acceptable to his peers (Childs, 1956). In this sense, teachers act as organizers of information instead of as experts. Teachers should choose what information to present and in what context so that it is best able to reach their specific group of students.

Teachers are uniquely positioned to understand their children’s needs because of the time spent with them in the classroom and because of their training. This position gives them insights into what is relevant to their students and what their current environments are. In education it is important that connections are made between the curriculum and students’ experiences so that they may acquire that content as knowledge. Without these connections, the information itself is meaningless (Dewey, 1916/2015). It is in this sense that pragmatism is “practical” - it is the application of an idea into an action, then the observation of what occurs because of that action, that leads to the creation of knowledge (Dewey, 1908).

**Pragmatism in Qualitative Research**

Because of the focus on the importance of different types of knowledge in pragmatism, Dewey took an important step in breaking down the mind-world, or objective-subjective,
dualism present in other philosophies. The world is not something that exists separately from the mind, and there is not a reality that exists outside of our own experiences that we should strive to understand. Instead, because of the construction of knowledge based on our interactions with the environment, different types of knowledge exist because of different interactions and experiences (Biesta, 2010). In other words, “meanings emerge from, but are not reducible to, certain causal, existential conditions” (Rosenthal & Bourgeois, 1982, p. 21). It is important not to isolate objects from the experiences through which they were reached (Rosenthal & Bourgeois, 1982).

Pragmatism provides an entry point for positivist researchers into qualitative research. Because of the focus on the interactions between organisms and their environment, scientific theories such as evolution (which states that changes in a species occur as a result of interaction with their environment) fit within a pragmatist framework (Dewey, 1916/2015). Qualitative research requires a change in thinking from how STEM researchers, and often STEM teachers, are traditionally trained. STEM professionals think of the truth as an external absolute reality that is independent of the self, and their role as a researcher is to elucidate this truth. As such, STEM professionals can feel uncomfortable with the need for narrative and personalization in qualitative research (Oliver et al., 2013). Pragmatism can allow an easier transition into qualitative research since it focuses on what is true for the research study being conducted at the time, rather than what is the absolute truth (Oliver et al., 2013).

Pragmatism also offers a justification for mixed methods qualitative research. Research is often divided into “qualitative”, meaning not using numbers, and “quantitative”, meaning using numbers. This is a false dichotomy, since numbers can be used qualitatively and words can be quantified, and this limits the researcher’s ability to communicate their results most effectively (Biesta, 2010). Dewey’s pragmatism breaks down the dualism between the objective
and the subjective. Instead, interactions and experiences with the world around us build our knowledge; there is not a separate reality beyond the one we are currently experiencing. Different types of approaches, such as qualitative versus quantitative methods, generate different types of knowledge and different connections because different actions are taken in these approaches. One approach isn’t inherently better than the other, but instead they all build different types of knowledge (Biesta, 2010). Use of different and varied approaches can build a fuller understanding of a phenomenon because of the types of knowledge gained through them.

**Pragmatism in This Study**

Pragmatism provides the lens through which I view this study. I use pragmatism as a way of creating knowledge about the integration of science outreach into high school curriculum. Outreach in general focuses on promoting interactions, and it is through these interactions that we create new knowledge. Through interactions with each other and with the St. Jude educators, the scientists learn about communication and education. Through interactions with each other and the scientists, the teachers learn more detailed science and improve their pedagogical content knowledge. Through interactions with each other and the scientists, students learn more about different paths into STEM careers and about different types of STEM research. Finally, through interactions between the trainers, the scientists, the teachers, and the students, all participants learn more about the others’ perspectives and knowledge when approaching science and science education.

Teachers are the focus of the current study as participants in the project, using participatory action research (PAR) as a methodology. Through our interactions with each other, we teachers build new knowledge of our content and our pedagogy. Additionally, we work together to build knowledge of the outreach program and of best practices for integrating the
outreach program into our curriculum. We work together to identify goals and actions to achieve those goals, then reflect on the consequences of those actions to form conclusions. In this study, a mixture of qualitative and quantitative methods was chosen to answer our research questions. Different methods provided different ways of learning about these questions with respect to the outreach program. Pragmatism as the construction of knowledge through action provides a justification for the implementation of different actions to generate different types of knowledge about the outreach program with the teachers themselves. Pragmatism may also provide an entry point for science teachers who are more likely to have experience with positivist methods and approaches, including the scientific method, into qualitative research methods.

Literature Review - Science Outreach

Models of Science Outreach

Calls for increasing numbers of STEM professionals have escalated over the past two decades (e.g. National Academies, 2007). Not only will there be more STEM jobs than there are available trained workers, minority groups in STEM, including African Americans, Hispanics, Native Americans, and women, continue to be underrepresented in STEM careers (National Academies, 2011). The scientific community has called for participation in outreach to K-12 schools, to post-secondary institutions, and to the community in general (Alberts, 2018; Friedman, 2008; Lee, 2018).

There are several different models for K-12 science outreach programs. One model is called the “scientist in the classroom” model. In this type of outreach, a scientist visits a classroom, either in-person or virtually, and typically gives a talk about their research or assists with delivering a lesson or activity to the students. In a second model, students are invited to visit the scientist’s workplace, either as a field trip or an out-of-school event. These visits give
students an opportunity to see a “real” science lab and to attend talks or complete activities related to science. After-school programs and activities offer a third model for science outreach. These could be STEM clubs led by local postsecondary STEM students or professionals, mentorship for science fairs or other science-related competitions, or supplemental curriculum to what is learned during the school day. These three models target students as the subjects of the outreach program.

Other outreach models target teachers or STEM professionals as the subjects of the program. In a fourth model, professional development programs, trainings, or talks targeted to teachers can be designed to increase teachers’ content knowledge. Curriculum resources can also be created and made available to teachers as a form of outreach, either with or without training related to the resources. In a fifth model, science outreach is targeted specifically to STEM professionals. These programs may design outreach to require minimal time commitment from STEM professionals, or they may be designed to offer training and preparation for outreach to STEM professionals. Some programs combine these aspects together for STEM professionals and for teachers, grouping them together to design curriculum and activities for students collaboratively.

Many outreach programs integrate multiple of these models together. A program focused on the scientist in the classroom model may also offer resources to participating teachers. A program focused on training teachers in new content knowledge may also offer field trips for the teachers’ students. Because of these overlapping aims, there is also overlap in the design and implementation of the different outreach programs. Each of these five models is described in more detail below.
1. **Scientist in the Classroom Science Outreach**

Scientist in the classroom models of outreach center around a scientist visiting students during the school day. Some outreach programs center around a single scientist visit, either virtually (Barry et al., 2022; McCombs et al., 2007) or in-person (Peker et al., 2012; Pratt and Yezierski, 2018). Programs try to include multiple scientist visits, training for teachers, and/or training for scientists prior to the classroom visits (Bruce et al., 1997; Pegg et al., 2009; Yonai and Blonder, 2020).

Most scientist in the classroom programs identify goals to increase student interest in STEM and STEM careers. A program where teachers could schedule up to four scientist visits reported increased student engagement and interest in STEM (Laursen et al., 2007). After a single virtual scientist visit, students reported that they thought the topic was interesting and that they enjoyed learning science that way (McCombs et al., 2007). In another program, after a 30-minute virtual talk students reported more positive perceptions of science and of scientists (Barry et al., 2022). Scientist in the classroom programs are sometimes a preferred outreach model because they take place during the school day, increasing the number of students who participate in the outreach.

2. **Student Visits to Scientists and Institutions as Science Outreach**

Postsecondary institutions, businesses, and informal science education centers (such as museums) sometimes host teachers and/or students for visits. These visits can occur as field trips during the academic day, meaning more students can participate than if they occur out of school (Clark et al., 2012; Woods-Townsend et al., 2016). Some programs are multi-day experiences or trips requiring travel. One field-based program included a 4-5 day trip to Yellowstone where students experienced field research (Houseal et al., 2014). Virtual field trips allow students to
visit places they otherwise could not visit due to time, money, or both. One such program allows students to visit the Great Barrier Reef virtually and hear a talk from a scientist working at a nearby aquarium (Francis et al., 2020).

These outreach programs often have similar goals to the scientist in the classroom programs, to increase student interest in STEM and STEM careers. Similarly, these programs have reported increased interest in science and scientists and increased student engagement (Clark et al., 2016; Houseal et al., 2014; Woods-Townsend et al., 2016).

3. After-School Programs and Activities as Science Outreach

Outreach practitioners can sometimes have difficulty scheduling outreach during the school day, whether as a scientist in the classroom visit or as a field trip. The school day schedule does not always accommodate professionals’ schedules, visitors to schools may be restricted, or outreach may not fit within the school curriculum. Offering outreach outside of the school day can allow professionals who cannot visit during the school day to participate in outreach. It also allows other community members, including parents and families, to participate. Science festivals open to the community are one example of this type of outreach, allowing community members to visit multiple scientists and complete activities (Boyette & Ramsey, 2019). Museums also offer science outreach that can target specific student populations (Melber et al., 2003). Similar to the other outreach programs reported above, goals of these programs focus on student engagement with science and scientists and on interest in science careers (Boyette & Ramsey, 2019; Melber et al., 2003).

4. Science Outreach Targeted to K-12 Teachers

Outreach programs may target K-12 teachers as the subjects of outreach instead of directly targeting students. There can be several reasons for this choice, including difficulty
accessing K-12 schools and wanting longer-term impact by “teaching the teachers”. Professional development programs increase teachers’ content knowledge and pedagogy for strategies such as inquiry-based learning (Baeten et al., 2020; Brown et al., 2014; Korb et al., 2005). These programs often occur during the summer, with some continued activities during the school year. Many of them focus on the development of curriculum or activities that teachers can implement in their classrooms.

Scientist-teacher partnership outreach programs focus on developing collaborations between scientists and teachers for teachers to develop new curricular materials with the scientists. These scientist-teacher partnerships often begin in the summer, with additional meetings occurring during the school year and often including at least one scientist visit to the classroom (Brown et al., 2014; Knowlton et al., 2015; Miranda et al., 2018; Pegg et al., 2009; Shanahan & Bechtel, 2019). Curriculum materials are one of the primary outputs of these programs, and teachers and scientists generally report positive impacts on their teaching and their communication skills.

5. Science Outreach Targeted to STEM Professionals

Science outreach programs are sometimes designed for STEM professionals to be “plugged in” to the outreach, meaning they are expected to make minimal time commitment to the outreach. This may be done to respect the scientists’ time, or it may be done because of concerns about commitment to an outreach program with additional requirements. Outreach programs that offer some sort of training typically focus on teaching scientists how to communicate with diverse audiences (Kaser et al., 2013; Thiry et al., 2008; Yonai & Blonder, 2020). These programs recognize the value of scientist participation in outreach while also acknowledging the importance of preparing scientists. Scientists who have participated in these
trainings have reported improvement in their communication skills (Yonai & Blonder, 2020) and changes in their own pedagogy (Kaser et al., 2013; Thiry et al., 2008).

**Benefits of Science Outreach**

Well-designed science outreach can positively impact all three primary stakeholders: scientists, teachers, and students.

Scientists have the potential to improve their science communication skills, their knowledge of curriculum and pedagogy, and their creativity (Eng and Febria, 2011; Kaser et al., 2013; Munson et al., 2013; Tomanek, 2005). Genetics faculty who participated in a scientist-teacher partnership reported that they used inquiry-based teaching in their own courses and that they adjusted their instruction to accommodate diverse student audiences (Kaser et al., 2013). In another scientist-teacher partnership, faculty reported that they wanted the outreach program to continue for longer and that they created new curricular materials for their own courses because of their participation (Knowlton et al., 2015). Faculty also reported an increased awareness of the issues facing K-12 education after participating in the outreach program (Knowlton et al., 2015). Another group of scientists said they felt energized because of their participation in a scientist-teacher outreach program and that it gave them new perspectives on their research (Munson et al., 2013). Undergraduate and graduate students who participated in a community outreach program felt that their creativity in science had increased (Eng & Febria, 2011). Professionals and organizations that participate in outreach are more involved in their communities (Ferrara et al., 2018). Through their participation in outreach, scientists learn and develop expertise about how to interact with non-scientists and become more active community members.
Teachers have the potential to increase their content-area knowledge, improve or expand their pedagogical knowledge, and increase their comfort with hands-on activities (Houseal et al., 2014; Kaser et al., 2013; Laursen et al., 2007; Lott, 2003; Pegg et al., 2010; Yerrick & Beatty-Adler, 2011). Collaborations with scientists can improve teachers’ content knowledge of new areas of science and lead to a better appreciation for strategies such as hands-on activities and inquiry-based learning (Laursen et al., 2007; Pegg et al., 2010). Teachers also report changes in attitudes towards science after participating in outreach (Houseal et al., 2014). Participation in outreach also provides teachers with real-world problems and experiences that they can then integrate into their teaching (Bruce et al., 1997; Yerrick & Beatty-Adler, 2011).

Students have the potential to learn cutting-edge science, to learn more about STEM careers, and to improve their attitudes towards STEM (Bruce et al., 1997; Clark et al., 2016; Laursen et al., 2007; Melber, 2003; Pluth et al., 2015; Wyss et al., 2012). Increases in student engagement and interest in STEM occurred in several different types of outreach programs, including scientist-teacher partnerships (Laursen et al., 2007; Pluth et al., 2015), student field trips to science institutions (Clark et al., 2016; Woods-Townsend et al., 2016), and multi-day field trips (Houseal et al., 2014). Even short interactions with scientists, lasting less than one hour, have the potential to increase student interest in science and in STEM careers (Boyette & Ramsey, 2019; Clark et al., 2016; McCombs et al., 2007). Well-designed outreach programs also have the potential to improve content knowledge and to teach standards (Kaser et al., 2013; Kesidou & Koppal, 2004; Melber, 2003).

Other community members can benefit from science outreach as well. Outreach events can be designed to target both students and their families, such as family science nights, science festivals, or other after-school events (Boyette & Ramsey, 2019; Eng & Febria, 2011).
Community members and students can learn more about STEM companies, their goals, and careers in these companies through outreach activities (Vennix et al., 2018). Engaging directly with scientists may also improve public perceptions of science and scientists (Stylinski et al., 2018).

**Characteristics of Successful K-12 Science Outreach Programs**

As described above, K-12 science outreach programs can take many different forms. Regardless of the exact type of outreach, effective programs have the following in common: 1) they prepare the outreach practitioner, especially in how to communicate to the expected audience, 2) the outreach is at an appropriate level for the intended audience, and 3) the outreach offers something not otherwise regularly available in the classroom.

Ensuring the outreach practitioner is prepared for the K-12 science outreach program is vital to the program’s success. A lack of preparation can lead to negative outcomes for the intended audience and for the presenter (Pratt & Yezierski, 2019; Thiry et al., 2008). Conversely, preparing with the audience in mind is an important part of science outreach models (Thiry et al., 2008; Varner, 2014). Training scientists in communication leads to a decrease in the use of jargon and a better ability to connect their research to the curriculum (Yonai & Blonder, 2020). Scientists also note improvements in their communication abilities, in their pedagogy, and in their mentoring (Stylinski et al., 2018).

Successful K-12 outreach also needs to be appropriately targeted to the audience. One way to ensure this is to address academic standards with the outreach, so that the design of the outreach is at the appropriate grade level (Kaser et al., 2013). Collaborations between teachers and scientists can also help create outreach targeted to students. Teachers’ expertise is in the classroom and in pedagogy, and they can help ensure the outreach is suitable for their students.
Effective outreach programs also ensure that teachers are appropriately targeted. Teachers should benefit from the outreach program, bringing new perspectives and cutting-edge science into their curriculum (Kaser et al., 2013; Knowlton et al., 2015). Outreach programs are more successfully disseminated when teachers are engaged in the project and when the outreach can be adapted to the educators’ local needs (Krasny, 2005).

Finally, successful K-12 outreach should offer something beyond what is typically available in the classroom. This may be in the form of new hands-on activities, learning new scientific content, or interacting with a scientist to learn about a new career. This is beneficial for both teachers and for students. Students’ interest in science and science careers may increase as a result of outreach, as described above. Students also can use equipment and complete activities that they would not otherwise have access to, leading to authentic learning experiences (Laursen et al., 2007). Teachers value feeling like they are a part of the scientific process in programs based on research experiences (Baeten et al., 2020). Teachers who participate in outreach also appreciate becoming a part of a community of practice that includes the outreach program/practitioner (Aslam et al., 2018).

**Challenges to Successful K-12 Science Outreach**

One of the primary challenges to successful K-12 outreach is time. All participants – including the outreach practitioners – often cite a lack of time as a barrier to outreach. Institutions might not support outreach activities, making it more difficult for potential outreach practitioners to take time out of the workday (McCann et al., 2015). Conversely, some outreach programs limit the amount of training and time required for the outreach practitioners in advance to try to overcome this barrier, but this can lead to disorganized outreach efforts or topics not being explained at an appropriate level (Pratt & Yezierski, 2019).
Teachers face challenges with time as well. It can be difficult for teachers to commit their time to an extended outreach program, especially ones that occur over the summer and/or for multiple years (Aslam et al., 2018; Baeten et al., 2020; Brown et al., 2014). Teachers also have difficulty committing classroom time to outreach programs. The need to finish a prescribed curriculum and to prepare students for high-stakes testing are two reasons teachers may not feel they are able to “sacrifice” instructional time to an outreach program (Aslman et al., 2018; Tomanek, 2005). Even when teachers choose to participate in an in-school outreach program, not enough time or resources may be devoted to preparing the students for the outreach, potentially limiting the benefits for students (Laursen et al., 2007; McCombs et al., 2007). Additionally, teachers may choose to implement only part of an outreach program due to time constraints or lack of resources, limiting the effectiveness of outreach designed to be completed in its entirety (Krasny, 2005).

Independent of time as an issue, how best to prepare scientists and teachers for outreach is another challenge to successful K-12 science outreach. Most outreach programs focusing on scientist-teacher partnerships begin the collaboration in a summer professional development program (Brown et al., 2014; Falloon, 2013; Kaser et al., 2013; Knowlton et al., 2015; Pegg et al., 2009; Shanahan & Bechtel, 2019). Outreach programs that sustained the interaction during the academic year generally reported more success (Falloon, 2013; Kaser et al., 2013; Knowlton et al., 2015; Pegg et al., 2009) than those that were limited only to summer collaborations (Brown et al., 2014; Shanahan & Bechtel, 2019). Teachers and scientists also need to be prepared to approach the partnership with their own areas of expertise (i.e. content knowledge for scientists and pedagogy for teachers) but also to be willing to cross boundaries to create a shared vocabulary (Tanner et al., 2003).
Scientists need preparation in education, pedagogy, and communication to be most successful in K-12 outreach (Laursen et al., 2007; Munson et al., 2013; Peker et al., 2012; Varner, 2014). Training in communication is especially important; most scientists approach outreach from the deficit model of communication, assuming that the audience simply needs to know more about the topic (Stylinski et al., 2019; Tomanek, 2005). The deficit model focuses on one-way communication from the scientist to the audience, and outreach that is perceived as one-way communication is less likely to be effective (Falloon, 2012; Varner, 2014). Effective outreach should emphasize a two-way dialogue between the scientist and their audience (Kaser et al., 2013; Varner, 2014).

Three Primary Areas of Needed Research in K-12 Science Outreach

Three areas of needed research in K-12 science outreach are:

1. Formalized training in communication and K-12 education for outreach practitioners
2. Increased measurement of student outcomes
3. Better understanding of teachers’ needs and motivations for outreach

1. **Formalized Training in Communication and K-12 Education for Outreach Practitioners**

Training outreach practitioners prior to their participation in the outreach program is vital to ensure the goals of the program are being met (Besley & Tanner, 2011). As described above, many scientists approach outreach through the deficit model of communication. Outreach practitioners have reported that training in communication and in K-12 education prior to their participation in outreach improved their ability to communicate with diverse audiences (Thiry et al., 2008; Stylinski et al., 2019) and their pedagogical skills (Eng & Febria, 2011), and, in one program, a one-hour training led to a decrease in the use of jargon and an increase in the ability to connect research topics to middle school curriculum (Yonai & Blonder, 2020).
While some outreach programs have reported successes, best practices for training scientists in communication have not been established. The trade-off between the need for training and the time required for training needs to be explored; is there a minimal time/content required for successful communication training? Which topic(s) are most important for scientists to learn? How and when should scientists practice communication skills?

2. Increased Measurement of Student Outcomes

Many outreach programs rely on reporting of outcomes from the outreach practitioners, teachers, or both. Student outcomes are not always examined; one study stated that they did not collect data from students because of the challenges associated with getting student feedback (Laursen et al., 2007). Accessing student data can be difficult because of restrictions on research put in place by school districts and because of the need for approval from a parent or guardian to collect student data. For outreach programs that emphasize the importance of reaching K-12 students, often to increase their interest in STEM and STEM careers, it is difficult to know whether this goal is achieved without receiving some feedback from the students. Some studies have gone around this by asking the teachers and scientists what their perceptions of the students’ interest and engagement were (Laursen et al., 2007). Others have instead chosen to focus specifically on scientists, teachers, or both, excluding student outcomes in their reporting (Eng & Febria, 2011; Miranda et al., 2018; Pegg et al., 2009; Peker et al., 2012).

To better address student outcomes, feedback from students should be solicited in any K-12 outreach program targeted to students. Questions are most often asked about students’ interest in STEM and STEM careers, but changes in students’ content knowledge could also be examined. While the collected feedback should change based on the intended goal(s) of the
outreach, student outcomes should be included as one goal of any K-12 science outreach program.

3. **Better Understanding of Teachers’ Needs and Motivations for Outreach Programs**

Most K-12 outreach programs are designed from the “top-down”, meaning an institution, group, or planner(s) design and lead the outreach. This can lead to disconnects between the goals of the outreach program and the goals of the schools and the teachers that the outreach is targeting. One program that offered an outreach curriculum to teachers suffered because teachers felt the outreach was being “done to them” (Falloon, 2013). Another program lacked buy-in from teachers because it was initially structured as a one-way flow of information from the outreach practitioners to the teachers and students (Tomanek, 2005). It was only after restructuring the program to include the teachers as partners and to ask for their guidance in what they need that the program succeeded.

Scientist-teacher partnerships seek to avoid this trap by including the teachers as partners in the creation of the outreach and curriculum. However, these programs can also suffer if the partnerships are not established on an equal footing, recognizing the expertise of both the scientist and the teacher. This one-sided “partnership” can have negative consequences, including a mismatch between the needs of teachers and what the outreach is providing (Tomanek, 2005), lessons not being integrated into the curriculum (Tomanek, 2005; Falloon, 2013), and scientists not perceiving personal benefits from their participation (Falloon, 2013).

More research into teachers’ desired outcomes for science outreach needs to be done to better understand their needs and motivations. Teachers are often considered the gatekeepers of outreach, and sometimes their role is over once they allow outreach into the classroom. There has been research into the motivations of scientists to perform outreach, likely because they are
considered the more “difficult” party to recruit (Andrews et al., 2005; Laursen et al., 2007; Laursen et al., 2012). However, teachers are a vital piece of the puzzle, and their motivations need to be explored as well. Additionally, how to address the motivations and needs of teachers who do not actively participate in outreach should be investigated.
Chapter 3

Participatory Action Research Methodology

The methodology chosen for this study is participatory action research (PAR). PAR places importance on generating goals and ideas with the participants and on obtaining results that can be put into practice immediately. As described by Bradbury, action research more broadly walks a middle path between reflective observation and engaged activism (Reason & Bradbury, 2015, p. 4). Translating theory into action can be difficult in education, especially with the demands placed on teachers’ time, the implementation of prescribed curriculum, and the administration of high-stakes testing. PAR was chosen here to ensure that theories and ideas are put into practice throughout the research study and are continually evaluated.

Participatory action research (PAR) was also chosen because of the importance of including teachers in a research process that is meant to benefit their own classrooms. PAR is a type of action research that centers on the importance of the participants themselves acting as researchers, including deciding on the research question(s), collecting and analyzing data, and taking action based on the results (Fals-Borda & Rahman, 1991; Park et al., 1996). PAR has been described as a spiral of steps, where planning, action, observation, and evaluation of the action happen quickly and continuously throughout the research project (McTaggart, 1994). Because of the continually changing nature of PAR, and because the academic researcher does not maintain sole control and ownership of the research project, the process of PAR has also been described as “designing the plane while flying it” (Smith et al., 2010).

While PAR has often focused on groups that are marginalized or oppressed in some way, this study will focus on using teachers as producers of knowledge. This study does not contend that teachers are a marginalized population in a broad sense. However, teachers are often
excluded or overlooked in discussions of curriculum and instruction. PAR has been used successfully to improve teachers’ pedagogical content knowledge and as a way of providing ongoing professional development for teachers (Eilks & Markic, 2011). One model for the integration of PAR in science education centers around a cycle of development of teaching strategies and materials that are tested in practice, evaluated, and then revised after reflection, leading to a new cycle with the revised teaching strategies and materials (Eilks & Ralle, 2002). Through the inclusion of teachers in this process, teaching strategies and materials are developed that can improve practice for many different learning groups (Eilks & Ralle, 2002; Eilks & Markic, 2011).

Similarly, science outreach programs are often designed without consideration for teachers’ wants or needs, instead focusing on the wants and needs of the outreach practitioners and/or the sponsoring institutions. A well-designed outreach program can fail if teachers feel the outreach is something that is “being done to them” (Falloon, 2013). To avoid the trap of assuming I know what teachers want in terms of outreach and curriculum, I instead bring the study to them, asking them what research questions related to outreach are most important to them, how they want to collect data for those questions, and what their goals are for the outreach and for their classrooms.

**History of Participatory Action Research**

Different accounts of the origin of participatory action research are described in the literature, but most action researchers attribute the first account of PAR to Kurt Lewin in about 1934. Lewin worked as a consultant to the Harwood factory to increase the skill and productivity of its workforce. A group of workers that decided on their own division of labor and were invited to comment on the training they received were much more productive than
workers who were trained didactically, leading Lewin to formulate action research as focused on the discussion of problems followed by group decisions (Adelman, 1993).

Participatory action research continued to evolve through the work of Paulo Freire, Orlando Fals-Borda, and Mohammad Anisur Rahman. Paolo Freire worked as an educator in Brazil and in Chile in the 1960s-70s. His work centered on enabling previously illiterate people to understand the world, to transform their environments, and to be heard and respected (Charles & Ward, 2007). Building on Freire’s approach, Fals-Borda and Rahman (1991) worked with oppressed people and their community organizations as a part of social activism in South America and in Africa. As PAR continued to spread to other areas of research, such as medicine and public health, economics, and social work, Fals-Borda and Rahman continued to emphasize the importance of this method as a democratic approach that seeks to empower its participants.

In education, use of PAR began in the 1940s and 1950s at the Teachers College in Columbia University. Stephen Corey called for teachers to be active participants and equal partners in the research process in order to influence American education in beneficial ways (Jacobs, 2016). At the time, participatory action research as a research process was criticized. Strong criticisms against the use of teachers in action research were put forth by Harold L. Hodgkinson in 1957. Some of his criticisms included the lack of training in research in teacher education programs and a lack of time for research, and that teachers may become stagnant in their teaching practice by defending their pedagogy with the results of their action research (Hodgkinson, 1957). It was Paolo Freire’s work in the 1970s that led to a resurgence of action research and PAR in education.

PAR continues to grow as a research method. PAR has been used as an approach in multiple areas of study, including youth participatory action research, teacher action research,
and community-based action research (Center for Community and Civic Engagement, 2022). The general goals of these programs are the same, to invite participants in a community to conduct research and to generate knowledge about themselves.

**PAR in Teacher Professional Development**

In education, PAR has been used as a form of teacher professional development (TPD). PAR as an approach to TPD relies on the importance of engaging teachers in self-reflection and of developing professional learning communities for teachers (Paz Morales, 2019; Vaughan, 2019). Teachers felt their professionalism increased after involvement in a multi-year PAR project (Eilks & Markic, 2011). Teachers also increased their self-confidence, knowledge of professional practice, and understanding of their students after participating in action research (Vaughan, 2019). Knowledge is accepted as a form of power in our society, and PAR encourages teachers to accept this position of power and take responsibility for their decisions inside and outside of the classroom (Jacobs, 2016).

Engaging teachers in PAR puts them in a position of viewing themselves and their classrooms as the objects of research, encouraging changes in power dynamics between teachers, students, and administrators (Paz Morales, 2019). This can lead to changes in how power is shared between these groups and can lead to teachers becoming more open to student involvement and participation in the classroom and to new perspectives on a question or project (Brydon-Miller & Maguire, 2009). However, this can also lead to tensions between these different groups. The traditional educational model positions the teacher as delivering information with the students being the recipients of information, not decision-makers. The confines of high-stakes testing and prescribed curriculum can make it difficult for teachers and students to change this traditional power dynamic (Galleta & Torres, 2019).
Interaction Between Pragmatism and Participatory Action Research

Participatory action research shares several foundational tenets with pragmatism. In fact, John Dewey is sometimes cited as an originator of action research since much of his work in education focused on putting ideas into practice at the Laboratory School in Chicago. PAR is focused on doing – while formulating theories may be one step of action research, it is not the focus. Knowledge is generated through action and the evaluation of that action. Additionally, PAR emphasizes the importance of collaboration in the generation of knowledge because everyone is capable of producing knowledge. These and other tenets of PAR closely align with tenets of pragmatism, as described below.

1. Thinking Leads to Action

One of the key tenets of pragmatism is that thinking for its own sake does not constitute the construction of knowledge, but it is the action taken as a result of thinking followed by the evaluation of that action that generates knowledge. Taking action is necessary in pragmatism; ideas are tools that we use to cope with our environments. This is a key tenet of PAR as well, which is why “action” is in the name. Generating ideas and theories without attempting to put them into practice does not constitute knowledge production. The goals of PAR cannot be separated from the process of PAR because the process of learning about and researching the identified problem is intended to lead directly to action to solve the identified problem (Park et al., 1996). The ideas generated as part of PAR are meant to be tools to be used to solve a problem.

2. Problems Can Be Solved Through Logical Thinking Followed by Action and Reflection

According to pragmatism, taking action is required to generate knowledge. However, action should not be taken without carefully thinking through the possible actions and their potential outcomes first. It is through the careful consideration of possible actions, the selection
of the action we think is best, then the evaluation of the outcome of that action that we can
generate new knowledge. If the first idea does not generate the outcome we desired, we can
begin the process again by considering a new set of actions.

PAR utilizes this same process. The spiral nature of PAR relies on the implementation of
action while the research project is ongoing. The process begins with the generation of research
questions and theories followed by the planning of action and the implementation of that action
(McTaggart, 1994). As actions are evaluated, this process continues to take new actions or to
build upon the results of the initial action. This is one implementation of the process of
knowledge generation as described by pragmatism.

3. Reflection on the Consequences of Action Creates Knowledge

Taking action leads to the generation of knowledge, but it is not the action itself that
leads to knowledge. We must reflect on the consequences of the action and use that information
to modify our existing knowledge structures and to guide future actions. Similar steps are taken
in the process of PAR. To know which actions are benefitting the goal(s) of the project, and
which ones are not, participants must evaluate the results of their actions. Evaluation should also
guide future decisions made by the researchers and the participants as they continue their project.
The evaluation step also ensures that the research is accessible to and usable by the participants
themselves (Park et al., 1996).

4. Experiences and Interactions are the Source of Knowledge

A key tenet of participatory action research is that the participants can generate
knowledge for themselves. Each participant has unique knowledge based on their own
experiences in the world, and this knowledge is real and valuable (Fals-Borda and Rahman,
1991). PAR is meant to empower people to gain more information about their own situations to
enact change (Fals-Borda and Rahman, 1991). It can be difficult for university researchers to
approach PAR because they are part of a certain knowledge structure that is outside of the community conducting the research. They must participate in the community in order to construct knowledge with the participants (Park et al., 1996).

John Dewey emphasized the importance of interactions, or transactions, in the generation of knowledge. It is through the building of experience with the world that we develop and learn knowledge as children (Dewey, 1902/2015). We cannot be separated from our environments, just as PAR cannot be conducted outside of the community. Our different experiences with the environment lead to the development of different types of knowledge, and all these different types of knowledge are important (Biesta, 2010). In PAR, all participants can make valuable contributions to the research project because no one person’s knowledge is more important than another’s.

**Relationship of PAR to This Study**

The idea behind this project began to implement and to evaluate the use of curricular resources as part of a science outreach program. This is thought to be one way to improve the success of an outreach program and to encourage the adoption of outreach into the classroom by teachers. However, as I began writing the research question and the goals for this project, it became clear to me that I was making assumptions about the wants and needs of teachers based on my own experiences, without including input from other teachers. Because one of the primary goals of this project is to integrate science outreach into the classroom in a meaningful way, I realized I cannot do that without: 1) understanding what teachers need to prepare themselves and their students, 2) understanding other constraints teachers have on their time and their students’ time, and 3) working with teachers to generate and to test ideas.
The specific research questions addressed in this study were decided upon by the participating teachers. The participants were four teachers (including myself) who had agreed to participate in the outreach program and this PAR project. My overarching research question was, “How does participation in the St. Jude Virtual Journal Club impact teachers?” Based on conversations and group discussion with my PAR co-researchers, there was more interest in understanding the impact of the outreach program on our students. We decided upon the following two research questions:

1. Does participation in the St. Jude Virtual Journal Club increase students' interest in STEM or STEM careers?
2. Are students able to understand the content and to think through applications of the St. Jude Virtual Journal Club talks?

Participatory action research best supported the implementation of this research plan. We worked together to identify problems and to brainstorm solutions. In PAR, the goal is to produce knowledge that can be put into action; by working directly with teachers, we were able to discuss what we can reasonably implement in our teaching practice and what we cannot. We were not generating ideas that cannot be tested in the classroom or that may work in theory but have not been tested. Instead, we implemented our research in our own classrooms throughout the course of the project, allowing us to take actions and to evaluate their results.

Even within a single school, different classes composed of different students can have very different needs. One approach that works well with one class of students may not work as well with another class of students. By using PAR, we drew upon each other’s knowledge and experiences to generate ideas for integrating outreach that can reach all students. Everyone’s knowledge is important and valid, and no one person in the group is the “expert”. Teachers
know best what will work for their students, and this is knowledge that other stakeholders, such as outreach practitioners, do not have. By working together to generate research on integration of science outreach, we were then able to report back to the outreach program about what practices work best for us and for our students and what suggestions we have for improving the program in future.

**Methods (How I Learned to Stop Worrying and Love the Process)**

Because of the nature of participatory action research, I didn’t know my methods until I started to work with my participants. While I anticipated using a combination of interviews, journals, and artifacts, my participants ultimately chose the exact methods. As this project progressed, I found I was often splitting myself between what felt like two different projects with different methods occurring simultaneously. The first project was the overall PAR project framed by our interactions and my own reflections and personal thoughts, and the second project, the St. Jude Virtual Journal Club (SJVJC) Teachers’ Project, was that chosen by the PAR group consisting of surveys and reflections to answer our research questions. In recognition of these sometimes competing, sometimes complementary goals as well as the different approaches taken in each, these two projects are described in different chapters. The current chapter focuses on the methods related to the PAR process that occurred in parallel with the SJVJC Teachers’ Project, with my own personal thoughts from written reflections included in italics. Analysis of the PAR process as it occurred is described in Chapter 4. The SJVJC Teachers’ Project itself is detailed in Chapter 5, including our questions, methods, analysis, and results.

**Positionality**

I have served as a teacher liaison for the St. Jude MemSTEMM Ambassadors program for the past three years. As a liaison, I have attended several of the trainings with scientists,
helped edit summaries of the research papers the scientists prepare for the students, and given
feedback on practice presentations. Many of the questions I have answered are about what the
scientists can expect the students to know and what they should explain. For the past two years,
I also participated in the program as a teacher. My AP Biology classes received three virtual
visits from three different scientists in February and April 2022 and again in February, March,
and April 2023.

I serve as the teacher liaison because of my background in biological research. I
completed a PhD in Cellular and Molecular Physiology, studying fruit fly olfaction, then
completed three years of postdoctoral research in neuroscience, studying fruit fly learning and
memory. While my studies were not in the field of cancer research, I am able to read and to
understand primary literature. It is now my ninth year teaching high school science, having
taught Biology and AP Biology for four years. I can read the research papers chosen by the
scientists and help decide which techniques, figures, and conclusions should be presented and
how these should be described to high school students.

Part of the motivation for this study is my experience participating in the outreach
program as a teacher in Spring 2022. I had insider knowledge because I had helped with the
training program, but I found I still didn’t have much time to integrate the journal clubs into my
curriculum. I didn’t know which scientist was presenting to my students until a few days before,
which is when I received the summary. It was not enough time for me to assign and to discuss
the summary with my students prior to the scientist’s visit. Additionally, my students wanted to
discuss their thoughts about the scientists and about their papers with me after the end of each
journal club presentation. They all filled in surveys at the end of the presentation as feedback for
the scientist, but I expect they likely told me more than they wrote in those surveys. Lastly, I
was able to write AP-style free response questions for one or two of the research papers that my students were then able to answer, but I would have liked to prepare questions for all three.

I began this research project thinking I would develop more curriculum support, such as writing practice questions, then ask teachers to implement them in their classrooms and share the results. I then started to think about what other supports they might want or need, such as earlier access to the research summaries or scheduled seminars to discuss how to read primary literature. As I continued to think in this way, I realized I was assuming that I could predict what other teachers would want based upon my own interests. Which then made me realize I was making the same mistake I had read about in other research papers: I was adding more things that were “being done to” the teachers rather than making them part of the process (Falloon, 2013).

**Participatory Action Research Skills**

Because PAR cannot be fully planned in advance, I did not know what techniques or data analysis I would use in advance. Such an exercise would have been contrary to the purpose of PAR. However, some planning was essential for the PAR project to be successful. As Chevalier, Buckles, and Bourassa state, “Failing to plan an action research process equals planning to fail in the process” (2013; p. 613).

While I could not plan a specific set of research methods and techniques, I did plan for a set of skills that will be necessary for the successful completion of the PAR project. Two of these skills are self-reflection as a continuous process before, during, and after the project and listening.
1. Self-Reflection

In PAR, the researcher becomes an active member of the community and serves as an organizer or a facilitator of the participants who actively perform the research. Because I held several positions and interests within this study, as a participating teacher, as a member of the outreach team, and as a doctoral student completing a dissertation, I needed to reflect on my own knowledge and experiences throughout the process. These different roles led me to influence the project or to behave in certain ways at different points during the project, and it was important that I reflect on why that may be the case.

Self-reflection is sometimes also described as self-inquiry. Instead of looking outwards, in self-inquiry we direct our questions inwards (Herdman-Barker and Erfan, 2013). I journaled my thoughts and experiences throughout the PAR process and sought to evaluate how my thinking and actions were influenced by my internal self. Self-reflection has been identified as a key skill for any participatory action research project, and all participants are encouraged to reflect and evaluate their participation, their goals, and their research agenda throughout the process (Fals-Borda and Rahman, 1991).

I first began engaging in the self-reflection process as I designed and planned the project. The choice of PAR as a methodology was a result of self-reflection; I realized that I could not assume that my experience as a teacher could speak for all teachers. As I continued through the research process, I continued to write personal reflections on the progress of the project and on my role within the project. As I analyzed the data, I set aside additional time for self-reflection on decisions made within that process. Finally, as I prepared our report for St. Jude and as I prepared this dissertation, I have again taken time to reflect on the overall PAR process as well as on specific steps within the project. It is an interesting exercise to reflect on a reflection.
2. Listening

The skill of listening seems simple on the surface. A person speaks, and you listen to what they say. Listening with intention can be difficult. A person may be communicating more than the words they are saying, through their body language, their tone, their intonation, and so on. In PAR, which is meant to be collaborative throughout, this meant that I and the other participants needed to practice active listening with each other. It is through listening that we better understand each other and grow to trust each other, and through listening we are better able to generate knowledge with one another (Pryce, 2013).

The skill of listening is one of the foundations of a successful collaborative project. In PAR, both the researcher (myself) and the participants (fellow teachers) have a common goal, and everyone can contribute towards accomplishing that goal. “[The participants] interact, collaborate, discuss, reflect, and report in collectives on an equal footing, each one offering in the relationship what he knows best” (Fals-Borda and Rahman, 1991, p. 152). I needed to focus on developing my listening skills and to encourage the other participants to develop their listening skills as well. We accomplish our best work when we build relationships, not just relationships with me as the researcher but also relationships between the other teacher participants (Maguire, 1993).

Related to listening, I also needed to avoid the use of jargon in relation to science outreach, to education research, or to primary scientific literature. I have expertise in all these areas, but not all these areas of expertise were shared by my participants. Conversely, some of the other participants held expertise in certain areas, such as prior participation in outreach programs or teaching other science curricula, and we had to be careful not to fall into a discussion that would exclude others without that knowledge. By focusing on listening,
especially in the early stages of the project, I came to a better understanding of the other teacher participants’ areas of expertise. I also paid close attention to the language and the vocabulary that we were all using so that I communicated at an appropriate level.

Listening was especially important in the beginning of the project, while I was coordinating participants and then while we were deciding on research questions and methods. In recruiting fellow teachers, I had to be careful to listen to their needs and their concerns without imposing my own needs and concerns or my own expectations on the conversation. Asking them to participate is asking for their time, which is a valuable commodity for teachers. I needed to address their concerns and to work to adapt the project and its parameters to meet those concerns. Not many teachers actively expressed time as a concern; however, because I practiced active listening, I could tell time was an issue because, in several conversations, teachers expressed how busy they were, or they described other time commitments. I also was careful to practice and to model listening as we decided on research questions and methods, repeating back what I heard from the participants and sometimes rephrasing what they said to ensure I understood the key ideas.

**Overview of the PAR Process**

In this study, our PAR process had to fit within the external timeline imposed by the St. Jude Virtual Journal Clubs. As a result, we did not complete multiple cycles of action research but instead focused on completing a single cycle. A summary of our PAR research cycle is shown below (Figure 1).
We began with observations of our interests and goals for ourselves, our interests and goals for our students, and our motivations for participating in the outreach program and in this project. We then focused on our common goals to discuss and decide upon our research questions and research methods. Next, we implemented our chosen methods within our classrooms with our own students during the St. Jude Virtual Journal Club talks. Finally, we planned to evaluate the data and then to communicate the results to the St. Jude educators.

Because of external factors affecting our timeline, namely the timing of the St. Jude Virtual Journal Club and the timing of our schools’ academic calendars, we did not complete all these steps in the time frame I would have liked, and we did not complete all of these steps as a group. The timeline below gives an overview of when each step was completed, and the external factors influencing the project and who participated in which parts of the project are explained in the next chapter.
Overview of the Anticipated Timeline Compared to the Actual Timeline

Because of the nature of the academic year and the scheduling of the St. Jude Virtual Journal Club, I prepared an anticipated timeline for the PAR project (Table 1). I was unable to follow this timeline as closely as I would have liked. One of the biggest delays I experienced was in recruiting the other teacher participants, as described below. Once I had recruited participants, I began scheduling Zoom meetings at the beginning of December, but I was unable to find a date and time with everyone could meet. Our first group meeting didn’t occur until the middle of January. Once we decided on research questions and methods, I then submitted a new IRB application. Unfortunately, we were unable to administer the pre-program survey as we had planned because we had not yet received IRB approval when the St. Jude Virtual Journal Club talks began in mid-February, but we were able to ask students to complete pre-program reflections as part of our typical teaching activities. Data analysis did not begin in earnest until the end of May; that month was especially busy for our group, and I was again unable to schedule a meeting with everyone. In July and August, I then completed the data analysis on my own and prepared a report, which I shared with the educators involved in the outreach program.

The table below compares the anticipated timeline with the actual timeline of the project:

<table>
<thead>
<tr>
<th>Step(s)</th>
<th>Anticipated Timing</th>
<th>Actual Timing</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinate Participants</td>
<td>November</td>
<td>November - December</td>
<td>• Contact potential teacher participants</td>
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<td></td>
<td></td>
<td></td>
<td>• Follow up conversations with interested teachers</td>
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<td></td>
<td></td>
<td></td>
<td>• Schedule initial meetings</td>
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<tr>
<td>Identify Research Questions</td>
<td>November - December</td>
<td>January</td>
<td>• Discuss participants’ backgrounds and interests</td>
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<td></td>
<td></td>
<td></td>
<td>• Discuss ethical positioning</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Decide on research questions</td>
</tr>
<tr>
<td>Step(s)</td>
<td>Anticipated Timing</td>
<td>Actual Timing</td>
<td>Actions</td>
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<td>-------------------------------------------------------------------------</td>
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<tr>
<td>Identify Research Methods</td>
<td>December</td>
<td>February</td>
<td>• Present options for research methods to participants</td>
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<td></td>
<td></td>
<td>• Discuss pros/cons of various methods</td>
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<td></td>
<td>• Choose methods to answer research questions</td>
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<tr>
<td>Collect Data</td>
<td>January - April</td>
<td>February - April</td>
<td>• Regular meetings with participants to discuss progress and concerns (2x per month)</td>
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<td></td>
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<td></td>
<td>• Sharing of ongoing data collection</td>
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<td>• Evaluating methods and data collection, revisiting choices as needed</td>
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<tr>
<td>Analyze Data</td>
<td>April - May</td>
<td>May - July</td>
<td>• Finish data collection</td>
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<td>• Consolidate data</td>
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<td>• Review data, discuss results and their interpretation</td>
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<td>• Decide on conclusions</td>
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<tr>
<td>Communicate Results</td>
<td>June - July</td>
<td>July - August</td>
<td>• Discuss format for presentation of data and conclusions</td>
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<td></td>
<td>• Prepare report</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Communicate results to St. Jude outreach team</td>
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</tbody>
</table>

Recruitment

The first recruitment email for my project was sent to the teachers on November 10, 2022, sent by one of the St. Jude program coordinators on my behalf (Appendix A). The content of the email was brief, stating that one of the participating teachers (me) was sharing information about a research project she would like to conduct with their help. I had prepared a one-page description of the project that was attached to the email. I sent a follow-up email response on November 16, 2022, stating that I would love to help teachers integrate the outreach into their classrooms and that, even if they are unsure of committing to the project, I would love to have a conversation about their expectations and hopes for the outreach. I received no responses to
either email, and, as the next week was Thanksgiving, I decided to wait to try one more email after the holiday.

On Friday, December 2\textsuperscript{nd}, one week after Thanksgiving, I sent out one final round of recruitment emails (see Appendix B for an example). I chose to personalize these emails, sending them to each individual teacher (including their name in the salutation) instead of sending them to a group. I included a one-paragraph description of the project in the body of the email instead of putting that information in an attachment. I also requested that, even if the individual could not participate in the project, we could schedule a phone or video call so that I could learn their motivations for participating in the project and what they hope their students get out of it. After having received no responses to the first two emails, I received responses from five out of six of the teachers within the week, with one of these five responding that she is unable to commit to the PAR project. One of the remaining four teachers joined in initial conversations but then was unable to continue in the project. Ultimately, three teachers in addition to myself, making the group four teachers total, participated in the PAR project.

From this recruiting experience, I learned that I should begin with personalized requests for participation when possible. The literature supports that some degree of personalization increases online engagement in multiple contexts, including job recruitment advertisements (Piffleman & Pfeuffer, 2022) and email marketing (Harley Nobil & Cantoni, 2023). The initial recruitment email was sent by a St. Jude educator because she is the one who had been in contact with the individual teachers to ask them to join the St. Jude Virtual Journal Club. We felt it would be more appropriate for her to send that initial email for several reasons, including possible privacy concerns (sharing email addresses with me) and questions about legitimacy (potential participants knowing the request is not spam or a scam). Perhaps the combination of
these two approaches, beginning with an email from a trusted source then following up with personalized requests, is what led to successful recruitment in this case.

(From Jan. 15th, 2023) Thinking back on these first few months, I might have asked [the St. Jude educators] for more information about what teachers they intended to include and how they planned to reach out to teachers. I knew they had issues with recruiting teachers in the past, with getting the information out to local teachers and with identifying contacts within the schools, but I didn’t realize the time it would take for the teachers to be recruited. In future years, [the St. Jude educators] may have better contacts and the recruiting may happen quicker.

Communication

Communication in this project occurred over email and through Zoom meetings. Initial contact occurred over email, followed by Zoom interviews with each participant after receiving an affirmative response to my email. Group meetings were scheduled every 2-4 weeks from January through May based on responses to Doodle polls asking for participants’ availability in a 1-2 week time frame. In most meetings, three out of four of us were in attendance.

During each Zoom meeting, I wrote notes on what was discussed and who made which comments. I made the choice not to record the meetings and then type up a verbatim transcript. I was concerned that the other participants may not speak as freely if they knew they were being recorded, and I wanted to avoid making it seem like I was an interviewer/researcher and they were the subjects. I was also concerned that I may not speak as freely as a teacher if I knew the conversation was being recorded. Within one week of each meeting, I typed up my handwritten notes in a Google doc and shared them with the other participants. I always sent an email notifying them that the meeting notes were ready and requested that they notify me of any
changes I should make. I never had a participant request that I make any changes, removals, or additions to the meeting notes.

In the Zoom meetings, I sometimes found that our conversation could become stilted or one-sided. Depending on who was attending the meeting, often one or two participants would do most of the talking. I tried to ensure that everyone in the meeting had an opportunity to add their thoughts and opinions into our discussions, but I know I may not have always succeeded in this. Additionally, there were times when I had differing thoughts or opinions that I did not voice. One reason for this was my concern about my positionality as a researcher and as a possible “expert”. I did not want to influence the group to follow what I wanted either intentionally or unintentionally. Another reason for why I did not always express my own differing opinions was simply not wanting to be an antagonist to the rest of the group. I find myself doing this in other situations as well, such as in meetings with other teachers at work. There are times when I keep my opinions to myself if I feel they will not change the overall course of the conversation or affect the final decisions made. This played out at times during our PAR group meetings, in particular when we selected the first research question.

Towards the end of the project, in June, July, and August, most communication occurred over email. After unsuccessfully trying to schedule meetings with the group twice in May, I asked (over email) if I could proceed with the data analysis on my own and send out my results and conclusions for feedback as I worked over the summer. The other participants agreed that it would be best. This wasn’t entirely surprising; completing analysis and writing the results are necessary for academic projects but may not be as valuable for other participants (Herr and Anderson, 2005).
I did meet two participants in person at other events in June. I met Alexis at a one-day STEM teaching symposium (Alexis was a speaker), and I met Beth at an Advanced Placement professional development event. We discussed this project briefly in each of those encounters, but I didn’t push for too much discussion since we were doing other things at each event. I did enjoy physically meeting people with whom I had spoken for hours over Zoom and making new connections with like-minded teachers.

**Participants**

I attempted to schedule a group meeting at the end of December, but only one person was able to attend. Because I had already had one individual meeting with a participant prior to this, and this December meeting became an individual meeting, I decided I would continue with individual meetings with each of the participants.

The St. Jude program had specifically targeted AP Biology classes for the past two years, so in prior years all the participating teachers had been AP Biology teachers. However, this year teachers of other subjects were recruited into the outreach program as well, including Anatomy and Physiology and Research Methods classes. All the teachers volunteered to participate in the outreach program. Because of these parameters, I wouldn’t consider us to be “typical” high school science teachers; we are teaching upper-level classes, and we are already interested in participating in outreach. However, for these reasons I believe as a group we were more interested in participating in a research project.

We began with five total participants in the PAR project, including myself. One participant began the project with us but was unable to continue after we selected the first research question due to personal reasons. Because he contributed to this project, I include him in the description of the participants below. Of the four teachers who remained throughout the
PAR project, two of us were in the same Southern metropolitan area teaching AP Biology, with the other two teaching other subjects in another Southern state and in a Midwestern state. We all taught junior and senior high school students, all our courses were electives (not required for graduation), we all had research experience outside of teaching, and our years of teaching experience ranged from 8-28 years.

I had individual conversations with each of the other four participants in December and the beginning of January. I treated these conversations similar to a semi-structured interview. I prepared the following questions to ask each participant, but I allowed the conversation to flow naturally between questions.

1. Introduce yourself – your background, your current school, your teaching experience
2. Why did you volunteer to participate in the St. Jude Virtual Journal Club?
3. Why did you agree to participate in this project? What are your goals? What are your goals for your students? For yourself?

As mentioned above, the main reason why I proceeded with these individual meetings was because of difficulty scheduling a group meeting with all of the teachers in December. At the time I attributed thought this may be due to Winter Break in our schools’ calendars, but scheduling group meetings never did become any easier, as I described in a personal reflection. Because of this difficulty, I speculated on whether I should change course on the project. We were able to make our first decisions about our research question and our methods rather quickly, so I decided to stay with my original PAR research plan. Had I changed course at this stage I would have been able to take more control of the project and to steer the aims back towards my original research question asking about the impact of the St. Jude Virtual Journal Club on the teachers. While this would have produced valuable information for the outreach project, I feel I
would have lost much of my original intention when choosing the PAR approach to include teachers.

(From Jan. 15th, 2023) Scheduling these teacher meetings has been a disaster. I decided to do individual initial meetings with each teacher, just because I had tried to schedule a group meeting based on a Doodle poll but only had one person log in.

Maybe it would have been better to approach this as a series of case studies, especially since we are teaching different subjects and have different needs? But all of us identified having scientists speak to our students, showing different paths to science to our students, and having them hear about research from the experts as goals for our students, despite our different content areas.

Below I describe myself and my answers to the above questions, and I summarize the transcripts I have from the individual meetings with each of the teachers. I also include additional information I learned about the teachers over the course of the project.

Myself, Shelby

I have been teaching high school math and science for the past 8 years, including teaching AP Biology for the past 4 years. At the time of the project, I was an Upper School Science Teacher at a private school in the South. I was also in my third year of completing a Doctorate of Education in Instruction and Curriculum Leadership at the University of Memphis, which is what led to this project. For the past three years, including the current year, I had served as a teacher liaison for the St. Jude MemSTEMM Ambassadors Classroom, the program that trained scientists in communication and helped them prepare their presentations for high school classes. Prior to becoming a teacher, I completed a PhD in Cellular and Molecular Physiology followed by three years of postdoctoral research on fruit fly learning and memory.
My AP Biology students consisted of seven senior girls, all of whom identified as White. They were all interested in continuing in a medical-related field in college, which is why they chose AP Biology. All but one of the students had taken Biology the prior year. As part of our course curriculum, I taught students how to read primary research papers using the CREATE method (Hoskins et al., 2007). We would typically read 3-4 research papers throughout the course of the year, and I would assess students on their ability to analyze and interpret data by writing AP-style questions using figures from the papers.

I wanted my students to participate in the St. Jude Virtual Journal Club so that they would hear about current research from active scientists. I wanted them to see the different types of people who can be scientists and to learn about their career paths. Learning new content was a secondary goal in my view. Especially because all my students had expressed interest in medical careers, I wanted them to see the research path. For me personally, I am interested in integrating science outreach into regular classrooms as often as possible. However, I know that to be effective it has to be done well. This is why I have volunteered to help train scientists and why I designed this project to integrate the journal club into the classroom.

Beth

Dr. Beth was the first respondent to the recruiting email I sent at the end of November. Beth has taught for 28 years, with 27 years teaching AP Biology and 15 years teaching Research Methods. The year before the project, Beth accepted a position at a large state university in the South as the Science Fair coordinator, but she remained an adjunct instructor of the Research Methods course at a nearby science and mathematics magnet school. Students at the school have the option of completing a science fair project as part of the research methods class. Because the school is a boarding magnet school for students across the state, students submit their science fair
projects for competition in their home districts, adding to the administrative work Beth completes in the spring. Beth’s Research Methods class consisted of approximately equal numbers of male and female students with five students identifying as White, two identifying as Black or African American, and five identifying as Asian American.

Students at the school travel to the state university once per week for two hours for their Research Methods class. Students prepare talks and posters of their research, and the school has a student research journal where they can publish papers. Guest speakers regularly come to the class to present their research and to assist students with their ideas. Beth had been trying to get more diverse speakers; because the class is housed in the Engineering department, most speakers have been in engineering. She had students who had shown an interest in cancer research, but there is not much cancer-related research happening at the state university. This is why Beth said she was interested in the St. Jude Virtual Journal Club, so that her students could hear from cancer researchers.

Beth has worked with a Centers for Disease Control (CDC) program in the past that developed curriculum for teachers. She strongly recommended that any lesson plans developed as part of the St. Jude program be made available to teachers and that teachers are educated to know what resources are available.

**Cory**

Ms. Cory has been teaching for the past 21 years at a private parochial high school in the Midwest. Prior to teaching, she was a medical technologist at the Cleveland Clinic. As a teacher, she has taught across multiple science subjects, and she is currently the science department chair.
During this project, Cory taught an Anatomy and Physiology class composed of eight senior female students who all identified as White and who were all interested in medical careers. This is the class she chose to participate in the St. Jude Virtual Journal Club. She had several reasons for choosing this group to participate. She wanted these students to have experience seeing primary research and learning how to read academic papers, which is a skill she felt her students would need in college. Cory also wanted students to have exposure to career opportunities outside of “their bubble”. Cory hoped that the students who had already expressed an interest in research would learn more about that career path and that other students who were somewhat timid would become more confident asking questions.

Cory learned about the St. Jude Virtual Journal Club in an email. She volunteered for her students, but she also hoped it would present new opportunities for her. Cory stated that she does not want to become stagnant in her teaching. Learning the content of the talks, in particular cancer research, was not her priority for her students. Instead, her priority was exposing her students to new people and new ways of thinking and showing her students that they can do research.

Cory volunteered to participate in the PAR project to work with others and to contribute to the group. She stated that she enjoyed her thesis research in school, and she saw this as an opportunity to do something she found enjoyable. After discussion, we called it interest in the “academic quest” for new knowledge as a driving factor for participation in this PAR project.

Alexis

Ms. Alexis has been teaching for the past 13 years in a project-based learning environment. She is currently a teacher and the science department chair at a charter school in the South. Approximately 60% of students at the school identify as a person of color. Alexis has
participated in science research since she was 12 years old. She was a lab manager at St. Jude Children’s Research Hospital with an interest in pursuing a PhD. She chose instead to move into teaching. Alexis is involved with several other projects in the metropolitan area, including building a biotechnology lending library and working with an organization focused on increasing participation of underrepresented students in STEM careers.

Prior to COVID, Alexis and her students participated in a Cancer Learning in my Backyard program, until that program ended. This would be the second year her AP Biology students participated in the St. Jude Virtual Journal Club program. For her students, she wants them to understand different research tracks and to see possible career paths. She likes that the researchers are trained as part of the St. Jude Virtual Journal Club and that their presentations are engaging. Alexis stated that reading primary research is tough, and the St. Jude program is a way to have someone explain the research at a deeper level for her students. Her students were also participating in a research project with someone at a large Northeastern university, and she was hoping that the St. Jude program would help enrich that project. She is interested in starting a student research journal at her school so that her students have an opportunity to publish their work with the university project.

Alexis hopes that her students are college-ready and that they have opportunities to publish their research. For the St. Jude program, she requested access to the original research articles in addition to receiving the scientists’ summaries. She stated that she had difficulty accessing some of the papers and that she would like to engage students with reading the original papers in advance of the presentations.
**Josh**

Mr. Josh participated with us in the month of January, but he was unable to continue past then due to other commitments. Because he did join in discussion of our research questions, I chose to include him here, although I do not include him as one of the four members of the project.

Josh has been teaching for the past four years; the first of those four years he completed as part of a one-year residency as part of a teaching program. All four of those years he’s been at a Southern charter school focused on science, math, and technology. Approximately 99% of students at the school identify as a person of color. He teaches Chemistry and STEM classes. He is originally from the area where he now teaches but moved away for about ten years before returning in 2017. While in college, Josh did summer research projects with a professor at his school, so he has some experience with “real” research.

Josh learned about the St. Jude Virtual Journal Club program through an email that was forwarded to him from his science coordinator. He lacks resources to do certain labs and activities at his school, so he hopes his students can gain some experience with the scientific method in the “real world” through the program. One of his personal goals for his classes this year was to focus on the scientific method. He planned for his Honors Chemistry students to participate in the program so that they would have more exposure to scientists, to careers, and to scientific methods. Josh already had plans for curriculum for his classes; in particular, he was thinking he would have his students choose their favorite scientist/presentation then research secondary sources to learn more.

Josh’s goals for himself weren’t much different from his goals for his students. He wanted to learn more about scientists and careers. He also wants his students to learn science
from somebody other than him. Because his school is small, there is a good chance that students will have him as a science teacher for two years in a row.

At the end of January, as I was scheduling a meeting to finalize research questions and discuss methods, Josh informed me in an email that he wouldn’t be able to continue participating in this project due to time constraints. His class was also unable to participate in the St. Jude Virtual Journal Club.

Ethics

Ethical considerations when using PAR can be difficult. Many traditional ethics reviews require approval in advance, meaning the project plan and how it will address ethical concerns have to be presented prior to beginning the project. This is how most institutional review boards (IRBs) operate. However, in PAR there isn’t a defined plan prior to beginning the project because the project must start in order to make a plan. This can present a dilemma in deciding when and how to seek formal ethical approval, and it often leads PAR researchers to think of IRB approval as an annoyance (Lake and Wendland, 2018).

With my fellow participants, we discussed our ethical stance(s) early in the project, along with deciding on the research questions. We discussed what we each consider to be important ethical considerations and how we want to approach these within the context of our study. This democratic process of ethical discussion amongst the researcher and participants is called covenantal ethics (Brydon-Miller et al., 2013). In particular, we discussed the need to gain support for our participation in the research project from our administrators. We also discussed the importance of transparency with our students, ensuring we have their assent as well as their parents’ or guardians’ permission. We emphasized to our students that participation in the project was entirely optional and would have no effect on their grades.
I received approval of a provisional PAR framework in August 2023. Once we decided on our research methods, I submitted a second IRB application for our specific research questions and methods. I did receive approval of that IRB as well, but not until after our research talks had begun. Additional description of the timing of the IRB approval and the beginning of our data collection is included in Chapter 4.
Chapter 4

The PAR Process

In this chapter, I describe the PAR process as it played out in this project, beginning with our first group meeting. I include contributions of different participants, content of our discussions and emails, and my personal thoughts and reflections throughout the process. I continue to include relevant sections from my personal reflections in italics. The research questions, methods, data analysis, and findings of our project, which I refer to as the St. Jude Virtual Journal Club (SJVJC) Teachers’ Project, are described in Chapter 5.

Selection of First Research Question

After completing individual meetings with each of the participants, I scheduled our first group meeting for January 15th, 2023. Three of us, Alexis, Josh, and myself, were present for this first meeting. We began with introductions, then I gave some information I learned through my individual meetings about our goals for our students and for ourselves as part of the St. Jude Virtual Journal Club. I opened up the meeting for their thoughts about what research questions we might fit with our goals and what we hope to gain from participation in the journal club.

At first, Alexis and I proposed a question related to how well students understand the role that science plays in their day-to-day lives. However, Josh stated that he was more interested in how students’ interest in STEM or STEM careers might be influenced. Alexis followed this up by saying she was also interested in this question and if the program increased her students’ “buy-in” for STEM interest or STEM careers. We then discussed how we might know if the program was successful and what “success” for the program might mean. The discussion then started to coalesce around the idea of STEM identity and how students develop a STEM identity. I asked if making connections to daily life or if development of STEM identify was more
important to us. Josh felt these could both be explored with a single question, and Alexis felt STEM identity was more important. We ended with the tentative question, “Does participation in the St. Jude Virtual Journal Club increase students’ interest in STEM and/or in STEM careers?”

I could feel myself trying to steer the conversation away from the question of “success” and STEM identity as we were discussing it while trying not to shut down either Josh or Alexis. I had started the meeting by mentioning that one of our common goals was for students to make connections between the science presented to them and their daily lives. This is where the initial question of more broadly understanding the role of science in their daily lives arose. Both Josh and Alexis mentioned that they want their students to learn more about the scientific method and about how to design research project. But then Josh raised the question of STEM careers, and Alexis enthusiastically agreed that this is something she would be interested in as well. After some discussion, I brought the question of how science connects to daily life up again, asking if they felt this question or the question of STEM identity was more important. Both Alexis and Josh agreed that the question of STEM identity was more important. This was one of several moments throughout the project when I felt conflict between my roles as a researcher and as a PAR participant.

(From Jan. 29, 2023) I’ll admit I’m disappointed. This is a question often asked in outreach programs. The question of how we will know if the St. Jude Virtual Journal Club is “successful” came up in our meeting, and this is one way that many programs measure success. However, it will make things easier from here on out. There is various literature out there with surveys, interviews, draw-a-scientist tests, and so on that examine this question for students of
various ages in various outreach programs. But, I worry that our work won’t be as novel as a result.

One benefit of this research is that we’re starting with the teachers, so it should be easier to collect student responses (at least in theory). We are already all interested parties, and we have lots of contact time with our students. We do still need to ask for permission to collect student responses from our various schools. I’m thinking surveys will be preferred to limit the amount of time they take and for consistency across our schools and classes.

Scheduling with the teachers continues to be difficult. Only two out of four responded to the poll I sent out last week, so I chose a date/time that works for them... I’m thinking I’ll make it through this entire project having never had a single meeting with all five of us together at once! It feels like it makes more work for me, because I then have to make more effort to follow up with the teachers not in attendance, but maybe it doesn’t actually because our meetings may be quicker/more streamlined with fewer people?

Selection of Research Methods and Second Research Question

Before our next meeting, on January 30th, 2023, I sent a survey to the group asking about which methods they feel we should use to address the proposed research question. I kept the survey anonymous with the hopes that, if someone was concerned about expressing disagreement in the meetings, then they may be willing to write that in the survey. Ironically, I didn’t express my own disagreement with our first research question either in the meeting or in the survey. I sent out a link to the notes from the Jan. 15th meeting as well so that Cory and Beth, who hadn’t been able to attend the meeting, would be able to read the summary of our discussion. In response, Beth emailed a question about the research question (there was some confusion about the research question being different from the questions we would ask our
students in our methods); early on in this process I could tell she was interested and invested in this research project.

In the research methods survey, I included the research question in the survey description, followed by a modified Likert scale asking about three research methods that had been mentioned in our Jan. 15th discussion: pre/post student surveys, Draw a Scientist Test, and pre/post student reflections. The Likert scale was described as follows:

1. Definitely shouldn’t do this
2. This shouldn’t be a priority
3. No strong feeling for or against doing this
4. We should do this if we can
5. We should definitely do this

After the Likert question, I included three open-ended questions:

1. Do you have strong feelings about why one of the above methods should or should not be included?
2. Are there any methods not written above that you feel should be included?
3. Do you have any other thoughts or comments about the methods you would like to share with us?

Overall the group felt that we could or should use all three of the methods proposed as shown in the figure below (Figure 2). There weren’t any responses to the open-ended questions.
In our Jan. 30th meeting, Cory and Beth were able to attend but Alexis and Josh were not. Just before the meeting Josh emailed me to let me know he would not be able to continue with the PAR project. Cory and Beth had not met yet, so we began with introductions. We then discussed the notes from the first meeting, including the first research question. Cory and Beth both agreed that they wanted to know if the outreach program affected their students’ interest in STEM careers. Cory in particular shared that her students were all interested in health-related careers, and she hoped that the outreach program would introduce them to research careers. I then transitioned us directly into the Methods discussion, sharing the results of the survey with the group. I started talking about the Draw-a-Scientist Test (DAST), sharing results from Chambers (1983) about which characteristics students described and how it changed from kindergarten through fifth grade. I also shared results from Mead and Metraux (1957) where high school students wrote reflections about scientists after being given one of three prompts. I then asked for their thoughts about the DAST or written student reflections for our methods.

Figure 2. Teacher Responses to Methods Survey

![Bar chart showing teacher responses to methods survey.](chart.png)
Both Cory and Beth commented that they try to have their students regularly reflect in their classes and liked the idea of written reflections. I commented that, since our students are high schoolers, we shouldn’t need to worry about vocabulary or writing ability like we might for younger students, but drawings may still be beneficial. However, we all agreed that we were concerned that our students may be hesitant to draw and may not add as much detail as we may like. Cory and Beth commented that the students in their classes participating in the journal club were very verbal and willing to share their thoughts and opinions in class. We decided that a well-worded prompt for a written reflection may elicit better responses from our students compared to drawing.

I had proposed the Mead and Metraux (1957) prompt of “When I think of a scientist, I think of…” because it was straightforward. This paper was also the start of literature examining students’ perceptions of science and of scientists and first characterized some of the stereotypes of a scientist that persist today (such as a scientist being a white male in a lab coat wearing goggles). Approximately 35,000 high school students were surveyed in that study. The stereotypes described formed the basis of other instruments such as the Draw a Scientist Test (Chambers, 1983). Although the original research is dated, its application and adaptation in more recent research support its use for the purpose of this study. Similar prompts and questions have been used to examine college students’ perceptions of computer scientists (Cheryan et al., 2013) and changes in students’ perceptions after short interactions with scientists (Woods-Townsend et al., 2016). Cory and Beth agreed that the Mead and Metraux prompt would work well for our purposes, especially since it was short but also likely to elicit good student responses.
I then asked about the third method included in the survey, pre/post surveys of student opinions. I shared a document with them where I had compiled some of the Likert-style questions I had found in Falloon (2012) and McCombs et al. (2007). Both studies focused on programs that utilized videoconferencing with scientists as outreach. I asked about including survey questions with a reflection prompt, separating them, or only doing one or the other; I expressed concern about the amount of time it may take in class to implement both. Cory stated that she felt whatever class time it took was worth it, because what we learned would help us out. Beth commented that she would likely post a survey and a reflection on different days so they don’t write the same things on both, but she also felt that it was important to learn what the students are getting out of the scientist visits.

We then started to discuss more specifics about what questions we may want to include on the survey, thinking about what would best help us answer the research question. Beth wanted to know more about what the students understood from the talk, what stood out, what made them curious to know more? She also was interested in how students were following the scientific process within the talk, how they were connecting to content learned in class, and what they would want to investigate next. Cory added that she wanted to know if her students were able to think like scientists, to connect to the content learned in class and to think about what next step might be taken. Beth added that she wanted to know if her students were seeing the applications of the research, if they were having an aha! moment and what that moment is. I interjected and said that this felt like a separate research question from the one we had proposed. These sounded like questions that would be based on the individual talks and not necessarily the overall program. I proposed we write 3-4 questions for students to answer after each of the scientist’s talks to address these questions, then write a separate survey with a reflection prompt.
for before and after the overall program. We agreed we would approach it this way, and, since we were over the time we had scheduled for the meeting, I said I would follow up with a draft of a proposed research question along with the pre-program and post-program survey and reflection and the post-talk reflection questions.

Proposed second research question: Are students able to understand the content and to think through applications of the St. Jude Virtual Journal Club talks?

While I had hoped that Beth or Cory might want to change the first research question, which would have made it easier for me to express my own reservations, their support did mean there was a consensus on continuing with this research question. However, I was happy that we agreed to include the second research question as well. This felt much more like a “teacher question” to me. Outreach programs often evaluate their success based on changes in students’ interest in STEM or STEM careers, but most evaluations do not ask about how well students are connecting content to their classes. This felt more novel to me and, personally, I was more interested in the results of this question as I felt it could directly inform my teaching practice.

**Time Crunch: IRB Approval and the Start of the St. Jude Virtual Journal Club Talks**

Shortly after the January 30th meeting I began preparing an IRB proposal for our proposed methods, pre-program and post-program surveys and reflections and three post-talk reflections (one after each virtual scientist talk). As I started preparing the IRB, I decided that I wanted to include the other teachers as co-investigators on the project. After contacting the IRB to ask if this would be possible, I received a reply on February 6, 2023 that they could be co-investigators as long as I ensured they had the appropriate human subjects research training for the project. Because this would be an additional time commitment for the teachers, I then emailed them to ask if they would be willing to complete the CITI training for human subjects
research. All of them agreed that they were interested in being co-investigators and were willing to complete the online training in order to do so.

I was very pleased that everyone agreed to be co-investigators. I was concerned about asking for additional time from the other participants to complete the CITI training. No one expressed any reservations about it. I felt that this further solidified our status as equals within the group. It also meant that we would each be able to collect data directly from our students rather than needing an external researcher (me) to be in charge of the data collection. It was my hope that our students would be more willing to participate and more willing to give honest reflections because it is their own teacher who is making the request.

I prepared a draft of our proposed methods in Google Docs so that the other teachers could offer comments and suggestions there, and I prepared the surveys and reflections in Qualtrics for their review. The other teachers had requested using Google Forms for ease of access, but privacy concerns with Google Forms were raised by my committee and the IRB. I also prepared a Student Assent Form (Appendix E) and a Parental Permission Form (Appendix F). I completed my initial submission of the IRB on February 14th, 2023, was told to go through Human Subjects Approval on February 15th and resubmitted that same day. I then received a request for changes to the assent form and parental request form along with a request to prepare a student assent script (Appendix G) on February 20th, which I prepared and resubmitted that same day. I received the official determination that the research project is human subjects exempt on February 21st (Appendix D).

The reason for the rapid turn-around with each of these submissions is because I knew we were about to start the St. Jude Virtual Journal Club talks. They typically start in the middle or end of February. I was trying my hardest to receive the final IRB determination prior to the first
talks so that we could administer the pre-program survey and reflection. Unfortunately, I was not quick enough. I received an email from the St. Jude program coordinator on February 10th that my first scheduled talk would be on February 16th. One of the other teachers, Cory, had her first talk scheduled for February 15th. After consulting with my advisor, we agreed that we could ask students to complete the pre-program reflection, since this is something we would do as part of our normal teaching, but we could not administer the survey without IRB approval. Which means that, because of the one-week lag between the start of the talks and receiving IRB approval, we were not able to administer pre-program surveys and so were also unable to make pre-program and post-program survey comparisons at the end of the project.

Once IRB approval was secured, students were asked for their assent and their parents were asked for permission to use the students’ pre-program reflections and to complete post-talk reflections and the post-program surveys and reflections.

(From May 6th, 2023) I tried to prepare the IRB submission as quickly as I could once we had discussed and decided upon methods. Unfortunately we didn’t get the approval until after the journal clubs had started. This means we won’t have pre/post survey data for our students, but we will hopefully have pre/post reflections on what it means to be a scientist from most of them.

As part of the IRB I asked if the other teachers could be my co-investigators, since they are each leading the study for their own students. It took a few days to determine what training they should do, and I was able to ask them to complete training through U of M’s CITI training program without any additional cost. I followed up with each of them about completion of the training several time, but I do not have 100% confirmation that all three completed it. That is
something I should have been more on top of and/or stricter about sending me a confirmation of its completion.

Note: Beth and Cory confirmed their completion of the CITI training. I never received confirmation from Alexis, but she also never collected data from her students.

**Finalizing Research Methods**

On February 15th, 2023, I met with Cory and Alexis to discuss the survey and reflection questions and to finalize how we wanted to administer them. Cory logged in to the meeting first, and she had just had her first St. Jude Virtual Journal Talk that day. We spent the first few minutes of the call discussing how she felt about the talk while we waited for Alexis to log in. Her impressions of this first talk are included below.

To start the meeting, I told Cory and Alexis about the timing issues with the IRB approval. I let them know that we could still do the pre-program reflections, but we could not do the survey. Cory already had her first talk, and my first talk was the next day, but Alexis’s was not until the following week. I let her know that she should not plan to give the surveys for now. My main goal for this meeting was to review and edit the survey and reflection questions and to remind them of the CITI training and consent procedures.

We began with the pre-program and post-program survey questions and reflection prompt (Appendix H). The survey questions came straight from a research paper (Kind et al., 2007), and no one had any additional feedback on those. Same for the reflection prompt that came from Mead and Metreaux (1957) (“When I think of a scientist, I think of…”).

We spent more time discussing the post-talk reflection prompts (Appendix I). We spent time editing the wording of the second question to make it more explicit about asking students if they connected the talk to what they learned in class, deciding on, “Did you make any
connections between the content of the talk and things you’ve learned in science classes? If so, describe one connection. If not, why not?” Alexis raised the concern about the original question not being specific enough, because it did not ask students to describe a connection. I agreed that I could envision my students simply writing a “yes” or “no” answer with no elaboration. We agreed that we would ask our students to complete each post-talk reflection the next day if possible but within one week of the talk. Our different school schedules meant that not all our classes met every day, and we wanted to allow flexibility for times when class may be busy or other things may come up that prevent us from sending the survey the next day.

I sent everyone links to the Qualtrics surveys and reflections that I had created with the questions we discussed. We wrapped up the meeting, and I said I would follow up about IRB feedback once I heard from them. On February 21st, once I received the exempt determination, I emailed the group to let them know and included the Student Assent Form, Parental Permission Form, and Student Assent script as attachments. Over the next few weeks, I received emails from Cory and from Beth confirming the collection of their student assent and parental permission forms. I never received confirmation from Alexis, which was concerning, but I learned why at the end of the project. Her students had completed the surveys at the end of each talk that were administered by St. Jude and were included in the scientists’ presentations; they hadn’t completed the pre-program or post-program surveys and reflections or the post-talk reflections that were a part of our project. In our meeting on March 22nd, Beth asked about when to administer the post-talk reflections. She hadn’t done that yet but said she would soon for her talk that had just happened. It was science fair season for her students so they were more focused on those at that time. From these questions and comments, I realized that I may not have
communicated our expectations clearly or that I may have had different perceptions of the decisions made during our meetings.

(From May 5th, 2023) As I sent out the initial Qualtrics links to the survey and the reflections, it also wasn’t clear to all of the teachers which surveys they should send out to their students and when. I didn’t realize this until a few weeks later, after Cory sent an email to clarify and then I had a meeting with Beth where she said she hadn’t done the post-talk reflections. I feel there should be a better way to organize the information and have it more readily posted and available for the teachers, but that might not have helped with the clarity issue anyways.

It’s going to make it difficult to do any pre/post program comparisons or to do any comparisons over time for the speakers since we’re all going to have different sets of students who were able to see the talks and who them completed reflections about the talks.

(From May 11th, 2023) If I do a project like this again, I need to be much more on top of who is collecting what data and when. One of my teacher participants, Alexis, doesn’t seem to have sent out the surveys and reflections at all; I can’t tell if any of her students have completed them.

(From May 23rd, 2023) I get the sense that [Alexis] didn’t understand that we had our own reflections we had written for the research project, because she referenced the St. Jude survey that had been sent out by [one of the St. Jude program coordinators] as one her students had completed in class.

**Our Impressions as Teachers of the St. Jude Virtual Journal Club Talks**

While we were focused on our students in our two research questions, we also wanted to have an account of our thoughts and impressions as we went through the Virtual Journal Club
talks. The final goal of this project is to give feedback and suggestions to the St. Jude educators; we wanted to give them information about what worked for our students as well as what worked for us. Our impressions were recorded more informally than those of our students; in our meetings, we discussed what was working, what wasn’t working, and what suggestions for changes we may have.

In our meeting on February 15th, Cory had shared her impressions of their first talk. She said that she felt her thoughts about the scientist and the talk were likely different from her students’ impressions. At the end of each talk, St. Jude includes a survey where students give feedback to the speaker about how well they understood the talk and what could be improved. Cory expressed concern that her students may not be giving honest responses since the speaker is still on the video call when they complete the survey. She felt that the written summary was very good, but the talk itself was too much lecture without enough interaction with the students. Cory’s students had read the summary and prepared questions before the talk, but they did not have time to ask any questions and felt discouraged as a result. Even with the questions built into Mentimeter, the interactive presentation software used by the St. Jude Virtual Journal Club, the speaker would pause for student responses but then continue with the talk without waiting to see if there were any questions. She felt concerned about how the next two talks would go after this first one.

My first talk was originally scheduled for a day and time when my class did not meet. I fortunately caught the mistake, and we were able to change to another time. The St. Jude educator was unable to introduce the speaker as a result, but, since I was experienced with the Journal Club, I did the introduction myself. My students seemed confused by some of the content of the talk, but I also prompted my students that this is professional development for the
scientists and that they want honest feedback about how things went. I believe they did provide their honest thoughts in the St. Jude survey at the end of the talk.

In a meeting on March 22nd, 2023, Beth and Alexis shared how their first talks had gone. Both commented that several or all of their students had missed at least one talk. Beth’s students had an early dismissal due to sports one day, and Alexis’s students were pulled from class for a senior event shortly before her second talk. This meant that none of Alexis’s AP Biology students attended their second talk, and instead she recruited some of her Biology students from the previous year to come to the talk so that she didn’t have to cancel it. Several students had missed Alexis’s first talk because of a school event as well. In my personal reflections, I noted that I don’t think that any of my seven students saw all three of our speakers due to sports dismissals, illness, and other absences. We all agreed that Spring seems to be a very busy time, and Beth suggested that Fall may be better in general since there are fewer student dismissals and disruptions.

Wrapping up the St. Jude Talks and Transitioning to Data Analysis

Knowing that the Spring is busy, I tried to limit the number of times I was contacting my co-researchers while the St. Jude Virtual Journal Club talks were ongoing. I tried to schedule an April meeting when I sent out the notes from the March 22nd meeting, especially because Easter and Passover were both in April so I knew scheduling in the first part of that month might prove especially difficult.

In our next meeting on April 10th, Beth and I were the only two in attendance. We discussed some of our upcoming obligations, including Beth’s science fair schedule in May and the AP Biology professional development in June. I then asked her opinions about how we should start data analysis. One question I had was whether we should plan to read our own
students’ responses first, or if it would be better to read responses from other students before reading our own. I could see benefits to both: we know our own students better and have a better sense of what they should know and what connections they should make, but it may be better for our overall analysis if we read other students first so that we aren’t relying on our personal knowledge of the students. Beth said she would want to start with her own students but also read other responses to compare. She also thought that reading the students’ responses for a talk then reading the scientist’s summary for that same talk could be a good way to see if the students “got it”. I also asked about coding of our students’ responses and how coding might work. Because we were both familiar with AP Biology curriculum, which uses scoring guidelines to grade students’ free response answers, Beth suggested making a scoring guideline for each reflection question. We could write a set of things we would like to see for each question, then create a rubric to score the responses.

I sent a follow up email on April 16th, after my class had completed their last scientist talk. In the email, I included reminders about finishing the post-talk reflection for the final talk and completing the post-program surveys. I also stated that we would be transitioning into data analysis soon. I mentioned Beth’s rubric idea. At the beginning of May, I sent out drafts of the rubrics for each of the reflections (one document for the pre-program and post-program reflection and a second document for the post-talk reflection questions).

(From May 5, 2023) I’m now trying to switch us over into sorting and analyzing our students’ responses. Beth suggested making rubrics… I liked that suggestion; it’s something very familiar to us teachers, and it can get us started with coding or categorizing the responses. We’ll likely need to keep adding or editing these as we go, but I’m hoping it’s a good start.
A few of the teachers have expressed that they will continue participating as we get into summer, as they are able. I’m really hoping we have at least a preliminary analysis finished before the end of May, so that I can work on polishing it and writing a report for St. Jude in June and July. I know the people at St. Jude will be receptive to our information and to our suggestions.

At our next scheduled meeting, on May 11th, once again only Beth and I were able to attend. We discussed the rubrics for a few minutes, but Beth hadn’t been able to read and comment on them yet due to her schedule. She did read and comment on them after the meeting. We then spent some time discussing the schedule of the St. Jude Virtual Journal Club talks, that trying to do them in January and February may work better. I also mentioned that we may not have enough data to do pre-program and post-program comparisons for individual students but that I would plan instead to focus on cohort comparisons. This meeting did not last as long as some of our others. Beth had already put in more time and had been more responsive than our other co-researchers in the previous few weeks, and I didn’t want to take up more of her time. I really appreciated her input and her suggestions, but I was also disappointed that neither of the other teachers had attended and offered their input.

(From May 23, 2023) I may have reached the end of the participation I can expect from the other teachers. For the past several weeks, Beth is the only one I have heard from.... I have to decide if I continue on with Beth, assuming it may just be the two of us, or if I continue on my own. I worry that if I continue on my own I’ll miss out on another perspective that may change what I find. But I don’t want to put it on Beth to do more work than she may have expected when she joins (sic). I also worry that with just the two of us I would become the “boss” with Beth simply following my lead or completing what I want and how I want it. I’m not sure if that
would add value beyond me working on my own, and I wouldn’t want to take Beth’s time if I’m ultimately not using her input.

I tried two more times to schedule meetings about data analysis, once in the last week of May and once in the first week of June. It quickly became clear that, now that summer had begun for all of us, responses were slower, making scheduling more difficult. On June 4th, I sent an email to the group asking if I could get started on data analysis on my own and request feedback as I worked through that. All three agreed that would be the best way to proceed for now and that they would continue to help and to offer feedback as able through the summer. Alexis asked for a copy of the students’ responses so that she could read through them. I shared these with her, but I never received any thoughts or feedback in response. Later in June, I sent another email letting the other co-researchers know I had done an initial reading of the responses and, if it was alright with them, I would plan to continue with data analysis on my own. This is a form of “member checking” and is one way to keep participants involved in the analysis and dissemination processes (Herr and Anderson, 2005). Beth and Cory both appreciated this and offered feedback along the way; I never received a response from Alexis. I then transitioned into completing the data analysis and conclusions on my own.

(From June 21, 2023) The end of May was busy for everyone, and the beginning of June didn’t seem to get much better, and I was out of touch during the week of the AP reading. I sent an email yesterday to let everyone know I’m going ahead with data analysis on my own for now but that I hope everyone will review my analysis and conclusions when I have it ready. I also added that I don’t want anyone to feel excluded and to let me know if they want to work on analysis with me.
I have to admit I’m a little relieved to be going into the analysis on my own. As much as the point of this project is to incorporate other teachers’ voices, it will be easier to go through the students’ responses on my own. I do hope that I don’t end up injecting too much of my personal voice into the analysis and conclusions because of that though.

The Data Analysis Process

Through June and July, I focused on analysis of the pre-program and post-program reflections, the post-program surveys, and the post-talk reflections. Detail about the analysis of each of these data sources is described in the next chapter. As I proceeded through the data analysis, I took detailed notes about the steps I followed and the decisions I made in the analysis process. I felt this was especially important because I was proceeding with the data analysis without regular input from my co-researchers so I wanted to be sure that I could explain to them why I made the choices I did.

One of the first observations I made as I gathered the data at the end of April was the variability in how many students completed each of the reflections. Not all students chose to participate in the research program, and not all those students who chose to participate were able to complete all reflections. One of our classes did not complete any of the reflections due to scheduling difficulties and miscommunication. Most students in the remaining three out of four classes completed the pre-program reflection, but students in only two out of four classes completed the post-program reflection. Part of the reason for this was the timing of the program completion at the end of April; many of our students were seniors, and seniors at our schools finished classes at the end of April or beginning of May. I also did not follow up with my co-researchers as regularly as I should have while the talks were ongoing. This was due in part to my reluctance to “nag” the other teachers and also because I felt very busy as a teacher during
this time. If I had checked the reflections being entered into Qualtrics more regularly I might have been able to catch some of the miscommunications earlier.

The post-talk reflections were also not completed consistently. Not all students were present for all the talks, so they were asked not to complete post-talk reflections for the ones they missed. Depending on when the talk was presented and the school schedule, some students had a week or more between hearing a talk and when their class next met. Beth’s class met only once a week, and my class met approximately every other day but sometimes went several days between meetings. Post-talk reflections were emailed to these students, but it was harder to encourage completion when class time was not available. This meant that there were few responses for some of the talks and that I would not be able to track changes in the reflections for individual students since most students lacked at least one reflection.

I began analysis with the pre-program and post-program reflections. I identified key words and ideas in each of the students’ responses, then classified them into categories and subcategories. This was my first foray into content analysis, and I tried to follow published methods and recommended techniques as much as possible. I performed this analysis twice to check for internal consistency; I would have preferred having my co-researchers perform the analysis with me to check for interrater reliability. Once I was confident in my assignment of key words and phrases to categories and subcategories, I moved on to analysis of the post-talk reflections.

(From June 28, 2023) I don’t feel I gained any new insights into the data by doing [the analysis a second time]. While I spent last night feeling like I wasted a day, this morning I realize that I needed to do that, or something like it, to know I was ready to move on to the next step with the pre/post reflections.
I spent some time considering how I wanted to analyze the post-talk reflections, mostly considering if I would code them like what I had done for the pre-program and post-program reflections. But, because this felt like the “teacher question” to me, I wanted to analyze it like a teacher. Beth had already recommended rubrics, and we had made a draft of the types of responses we might expect for each of the post-talk reflection questions. I decided to turn this draft into a more formalized rubric using formatting that I use for grading rubrics in my own classroom. This is how I evaluate my students’ work on various types of assignments, and it made sense to me that it should be how I evaluate the students’ “work” on the post-talk reflection questions. As I proceeded with this analysis, I felt personal validation in choosing rubrics.

(From July 5, 2023) I’ve been letting the post-talk reflection analysis bounce around in my head the last few days. I’m not sure coding is going to be the best approach; yes, it may help me see if students are getting the key ideas out of each talk… but I’m not sure that coding will answer the other questions we teachers had. I’ve decided to spend a little time going back to some of my old textbooks and science teaching books instead to think about ways of analyzing formative assessment data…

I think it makes sense to go back to rubrics again. I can bring up the summaries of each scientist’s talk; while my students didn’t see all of the speakers represented in the post-talk reflections, I have seen all of the talks and/or read all of the summaries because of my role in the training of the scientists. I should be able to pull out a few key ideas from each and understand enough about the topics to know if students are getting these key ideas.

(From July 7, 2023) I’m feeling better about deciding to go back to formative assessment principles and rubrics for the post-talk reflections. We wrote those questions as teachers more so than researchers, in my opinion, so we should look back at the student responses like teachers.
There are things that can inform the St. Jude program, but we wanted those questions/responses to inform us and our teaching as well.

As I wrapped up each stage of analysis (pre-program and post-program reflections then post-talk reflections), I sent a draft of the data with key findings to my co-researchers. I didn’t receive specific feedback on these drafts, but both Cory and Beth responded with quick acknowledgements such as “Looks good”. I didn’t receive a response from Alexis. I put together a draft of a report for the St. Jude educators at the end of July. Again Cory responded that it looked good, and Beth added some comments and specific feedback into the document. I then sent the report to the St. Jude educators during the first week of August, effectively wrapping up our PAR process.

A timeline summary of the PAR process is shown in Figure 3 below.
Figure 3. PAR Project Timeline for the St. Jude Virtual Journal Club Teachers’ Project
Chapter 5

The St. Jude Virtual Journal Club Teachers’ Project

In this chapter, I begin with a description of the MemSTEMM Ambassadors training program and the St. Jude Virtual Journal Club outreach. I then transition into a description of the SJVJC Teachers’ Project, including our research questions and the methods, analysis, and findings for each of the questions.

Overview of the MemSTEMM Ambassadors and St. Jude Virtual Journal Club

There are two components to this outreach program: the MemSTEMM Ambassadors training program for scientists and the St. Jude Virtual Journal Club program for high school classes. In the MemSTEMM Ambassadors program each fall, scientists are trained in science communication best practices and work to prepare a written summary and a presentation of a chosen research paper. In the St. Jude Virtual Journal Club program each spring, the scientists present their research papers to three different high school classes, and each high school class hears talks from three different scientists.

MemSTEMM Ambassadors Training Program

The MemSTEMM Ambassadors training program is designed to prepare scientists to communicate complex topics to high school students. The participating scientists are volunteers with an interest in improving their science communication skills. The scientists commit to four scheduled training sessions in the fall and three presentations to high school students in the spring. Over the course of the fall, each scientist prepares a 1-2 page written summary and an interactive presentation of the research article of their choice.

Each of the four training sessions is focused on a particular topic related to communicating with high school students: 1) Science Communication Objectives, 2) Reducing
Scientific Jargon, 3) Storytelling through Images, and 4) Hosting a Virtual Science Journal Club for High School Students (Table 2). In the first meeting, the overall purpose and timeline of the program are shared with participants along with a discussion of what they can expect. Participants also start to consider how to communicate their research to a general audience beginning with creation of a “headline”, or a statement describing the key idea of their talk using simple terminology. In the second meeting, participants learn what is meant by “jargon” and practice identifying jargon in their papers. They start to rewrite key ideas of their article using simpler language. The third meeting is focused on best practices for integrating images and figures into their presentations. This meeting also focuses on the need to simplify figures from the original research paper and the need to include additional figures and images to visualize complex ideas. The final meeting focuses on the presentation to the high school classes. The scientists use an interactive presentation software called Mentimeter. This software allows the integration of questions into the presentation, giving the students a chance to interact with the scientist. This training session focuses on learning how to use Mentimeter and the types of questions that can be integrated into their presentations to ensure students are engaged and understanding the talk.

Table 2. MemSTEMM Ambassadors Training Sessions

<table>
<thead>
<tr>
<th>Approximate Date</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-September</td>
<td>Science Communication Objectives</td>
<td>• Introduce scientists to the training program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Overview of the St. Jude Virtual Journal Club</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Discussion of overall process</td>
</tr>
<tr>
<td>Mid-October</td>
<td>Reducing Scientific Jargon</td>
<td>• Define “jargon”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Practice identifying and rewriting scientific jargon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Work on identifying and removing jargon in their own written summaries</td>
</tr>
</tbody>
</table>
Table 2 (Continued)

<table>
<thead>
<tr>
<th>Approximate Date</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
</table>
| Early November   | Storytelling through Images | • Examine images and identify effective and ineffective characteristics  
• Consider how images help relay key information  
• Identify key figures or images necessary for their own presentations |
| Early December   | Hosting a Virtual Science Journal Club for High School Students | • Introduction to Mentimeter software  
• Examples of different levels of interactive questions  
• Draft questions for their own presentations |

Prior to the St. Jude Virtual Journal Club, scientists are invited to participate in practice talk sessions with the training facilitators and other scientists. During these sessions, they can practice using the presentation technology and receive feedback on the content of their presentations. Throughout the MemSTEMM Ambassadors program, the scientists have opportunities to provide feedback to each other, and they receive feedback from the training facilitators.

**St. Jude Virtual Journal Club**

In the Spring, scientists, teachers, and students interact through the St. Jude Virtual Journal Club. St. Jude educators schedule three scientist talks between February and April for each participating class based on the class schedule and the scientists’ availabilities. When possible, one talk is scheduled in each of the three months.

Prior to each scheduled talk, the teacher is emailed the scientist’s written summary to share with their students. Teachers are encouraged to have students read the summaries prior to the talk. Because the talks are virtual, teachers are also encouraged to test their technology setup prior to the start of the talk. On the day of the talk, the scientist, the teacher, and one of the
St. Jude educators join the videoconference on the platform chosen by the teacher (typically Zoom or Microsoft Teams). The St. Jude educator introduces the training program and the scientist at the start of the talk, and at the end of the talk the educator administers a survey to the students asking their perceptions of the scientist and the presentation. Students are asked to join the Mentimeter presentation using a personal device (laptop or cell phone).

At the end of the program (completion of all three scientist talks), students and teachers are asked to complete a survey evaluating the program for St. Jude.

**SJVJC Teachers’ Project Timeline**

The SJVJC Teachers’ Project began in the winter of 2022 and completed in the summer of 2023. We progressed through the project based on the timing of the St. Jude Virtual Journal Club’s scheduled scientist talks as described in the table below (Table 3).

*Table 3. Timeline of the SJVJC Teachers’ Project*

<table>
<thead>
<tr>
<th>Step(s)</th>
<th>Timing</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinate Participants</td>
<td>December - January</td>
<td>• Conversations with individual teachers</td>
</tr>
</tbody>
</table>
| Identify Research Questions | January - February | • Discuss ethical positioning  
                          |                                                            | • Decide on research questions                                 |
| Identify Research Methods | February | • Present options for research methods to participants  
                          |                                                            | • Discuss pros/cons of various methods  
                          |                                                            | • Choose methods to answer research questions                   |
| Collect Data            | February - April | • St. Jude Virtual Journal Club talks  
                          |                                                            | • Group meetings to discuss progress and concerns  
                          |                                                            | • Sharing of ongoing data collection                             |
| Analyze Data            | May - July      | • Review data, discuss results and their interpretation  
                          |                                                            | • Decide on conclusions                                         |
| Communicate Results     | July - August   | • Prepare report  
                          |                                                            | • Communicate results to St. Jude outreach team                 |
Recruitment

The participants in this study were recruited from an existing pool of volunteer teachers. These teachers had already agreed to participate in the St. Jude Virtual Journal Club program in Spring 2023. Educators at St. Jude recruited these teachers from existing contacts and from reaching out to schools across multiple states to cultivate contacts with upper-level science teachers. Because we are volunteers in the outreach program and are teachers in our classrooms, we may be referred to as “boundary crossers”, or participants who are able to understand the language and the culture of two different domains (in this case, the science outreach program and our classrooms) (Kilpatrick et al., 2009).

Summary of Participants

Teacher Participants

Detailed descriptions of each of the teacher participants are included in Chapter 3. Table 4 below summaries the teaching experience, other work experience, and courses participating in the outreach program for each of the participants.

Table 4. Summary of SJVJC Teachers’ Project Participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Years of Teaching Experience</th>
<th>Prior or Relevant Experience</th>
<th>Class Participating in the SJVJC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Me</td>
<td>8</td>
<td>Research Scientist</td>
<td>AP Biology</td>
</tr>
<tr>
<td>Beth</td>
<td>28</td>
<td>Science Fair Coordinator</td>
<td>Research Methods</td>
</tr>
<tr>
<td>Cory</td>
<td>21</td>
<td>Medical Technologist</td>
<td>Anatomy and Physiology</td>
</tr>
<tr>
<td>Alexis</td>
<td>13</td>
<td>Lab Manager</td>
<td>AP Biology</td>
</tr>
<tr>
<td>Josh*</td>
<td>4</td>
<td>Undergraduate Summer Research</td>
<td>Honors Chemistry</td>
</tr>
</tbody>
</table>

*Josh left the project prior to selecting research methods and collecting data.

Student Participants

Each of the teacher participants had one class that was participating in the St. Jude Virtual Journal Club. The students in each of those classes were asked to participate in this
research project. It was made clear to the students that they were not required to participate and that participation would have no effect on their grades.

Of the three classes that had students participate in the research project, two consisted of entirely female students. The third class was split approximately evenly between male and female students. In total, 23 female students and 6 male students were included, but not all students responded to all the reflections. Most of the participating students identified as White (19 students). Five students identified as Asian and two students identified as Black or African American.

**Ethics**

We received IRB approval for our selected research methods and questions (Appendix D). The teachers acted as co-investigators, and each teacher solicited assent from her own students using an assent script (Appendix G). Students who participated in the research project signed an assent form (Appendix E), and their parent or guardian signed a permission form (Appendix F). It was made clear to the students that participation in the research project was voluntary, that it would not affect their ability to participate in the outreach program or in regular classroom activities, and that it would not affect their grades in any way. Any identifying information has been removed to ensure students’ anonymity, and data is reported in aggregate.

**Research Questions**

As a group, we decided to investigate the following two research questions:

1. Does participation in the St. Jude Virtual Journal Club increase students' interest in STEM or STEM careers?

2. Are students able to understand the content and to think through applications of the St. Jude Virtual Journal Club talks?
Research Question 1. Does Participation in the St. Jude Virtual Journal Club Increase Students’ Interest in STEM or STEM Careers?

Research Methods

To answer the first research question, we created a written reflection and a survey for students. The reflection, which we administered both before the program (pre-program) and after the completion of all three talks (post-program), asked students to write a paragraph completing the prompt: “When I think of a scientist, I think of…” This prompt was taken from Mead and Metraux (1957), which investigated scientist stereotypes. We chose this prompt because of its length (being fairly short) while still allowing students to give detailed descriptions. Because our students are upper-level high school students, we felt that they would be more likely to give us detailed written descriptions over detailed drawings, which is why we decided not to use the Draw-A-Scientist Test (Chambers, 1983). We also asked students a set of Likert-style survey questions asking about their perceptions of science, of themselves as scientists, and of science careers. These survey questions were taken from Kind et al. (2007), which developed measures to evaluate students’ attitudes towards science (Appendix H). These reflections and surveys were created in and administered through Qualtrics.

Data Analysis

Analysis of Pre-Program and Post-Program Reflections

To answer our first research question, “Does participation in the St. Jude Virtual Journal Club increase students' interest in STEM or STEM careers?”, we created a survey and a reflection. The reflection, which we administered both before the program (pre-program) and after the completion of all three talks (post-program), asked students to write a paragraph completing the prompt: “When I think of a scientist, I think of…”
Because this research question asked about changes that occurred as a result of the St. Jude Virtual Journal Club outreach program, we wanted to compare students’ pre-program reflections with their post-program reflections. The analysis method that best allowed us to categorize students’ responses and visualize them for comparisons was quantitative content analysis. In one approach to quantitative content analysis, text is read and analyzed as content units into different categories. The number of content units in each category is then quantified to gain a sense of the frequency of certain content units and categories (Franzosi, 2008).

I began analysis of the pre-program and post-program reflections by creating categories, followed by reading of student responses and sorting of their key words and phrases into these categories. I then further broke the categories down into subcategories. Finally, I quantified the numbers of key words and phrases, or content units, in each category and subcategory and used these numbers to gain a sense of how students were describing scientists and of what changes occurred between pre-program and post-program reflections. Examples of students’ words and phrases are included as well, because “snippets of words will provide concrete examples of what’s behind the numbers, so contextualize them, give them life” (Franzosi, 2008, p. xli).

After Beth’s suggestion about creating rubrics to guide our analysis, I created an outline of the types of responses I thought we might read in the pre-program and post-program reflections based on conversations with my own students as well as published research (such as Chambers, 1983 and Mead & Metraux, 1957). I started with the following categories: Physical Characteristics, Personality, Subjects, People, Actions, and Importance/Value. I then wrote out some differences we might see between the pre-program and post-program reflections, such as more stereotypes of white males wearing glasses and lab coats in the pre-program reflections and more descriptions of cancer research in the post-program reflections (Appendix J).
Once I finished the set of expected categories, I read through each student’s pre-program reflections and highlighted key words and phrases that I felt were unique or contained a main idea of that student’s response, for example “analyze” or “white coat”. I then read through each student’s post-program reflection and went through the same process of highlighting key words and phrases. I then sorted these words and phrases into the six categories described below to begin organization of student responses (Lupia, 2018). These descriptive categories were similar to those first outlined in the Scientist Reflection Analysis Rubric in Appendix J:

1. Actions - things that scientists or researchers might do, like running experiments, solving problems, teaching
2. Places - where science might occur or where scientists may be found, like a laboratory
3. Motivations - reasons why scientists do science, like curing cancer, finding new discoveries
4. People - examples of scientists, specific individuals like Einstein or more general categories like doctors
5. Characteristics - mostly physical but some personality characteristics, like white man in a lab coat, curious, intelligent
6. Other – codes I felt were important but couldn’t clearly place in another category (for now), things like subjects of study, stereotypes

After completing this initial analysis, I wrote all the key words and phrases on individual note cards, adding tally marks to indicate when a particular word or phrase occurred more than once. One category at a time, I laid out the note cards from that category then sorted them into subcategories based on similarity of words and phrases or similarity of ideas (see Figure 4 for an
example of coding the “Actions” category). During this process, I also moved the words and phrases I had initially identified as “Other” into one of the five other categories or into a different sixth category I created during this review, “Topics/Types of Science”. Table 5 below describes the subcategories and lists examples for each.

![Subcategories and examples](image)

*Figure 4. Creating Subcategories in the Action Category by Manually Sorting Content Units*
### Table 5. Categories, Subcategories, and Examples Used for “When I think of a scientist, I think of…” Pre- and Post-Reflections

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategories</th>
<th>Example Content Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Actions</strong></td>
<td><strong>Scientific method</strong> - things scientists do that</td>
<td><strong>Scientific method</strong> - “scientific method”, “analyze”,</td>
</tr>
<tr>
<td></td>
<td>could be classified as one or more steps of the</td>
<td>“conclusions”</td>
</tr>
<tr>
<td></td>
<td>scientific method</td>
<td><strong>Working</strong> - “learn”, “study”</td>
</tr>
<tr>
<td></td>
<td><strong>Working</strong> - activities not specific to scientific</td>
<td><strong>Education</strong> - “teaching science”, “teach”</td>
</tr>
<tr>
<td></td>
<td>method but still regular parts of scientific work</td>
<td><strong>Research</strong> - “conduct research”, “performing experiments”</td>
</tr>
<tr>
<td></td>
<td><strong>Education</strong> - additional actions related to</td>
<td><strong>Targets</strong> - “discovering something”, “developing theoretical concepts”</td>
</tr>
<tr>
<td></td>
<td>teaching and others’ learning</td>
<td><strong>Creation</strong> - “try new things”, “exploring innovative ideas”</td>
</tr>
<tr>
<td></td>
<td><strong>Research</strong> - more specific statements related to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>performing experiments or research</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Targets</strong> - goals of research or projects in</td>
<td></td>
</tr>
<tr>
<td></td>
<td>science</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Creation</strong> - actions requiring creativity or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>thinking outside the box</td>
<td></td>
</tr>
<tr>
<td><strong>Places</strong></td>
<td><strong>Work spaces</strong> - physical locations where science</td>
<td><strong>Work spaces</strong> - “lab”, “laboratory”</td>
</tr>
<tr>
<td></td>
<td>happens</td>
<td><strong>Tools</strong> - “microscope”, “technology”</td>
</tr>
<tr>
<td></td>
<td><strong>Tools</strong> - specific tools used for research</td>
<td></td>
</tr>
<tr>
<td><strong>Motivations</strong></td>
<td><strong>Personal</strong> - motivations intrinsic to the scientist</td>
<td><strong>Personal</strong> - “life missions and goals”</td>
</tr>
<tr>
<td>- reasons why scientists do</td>
<td><strong>Questions</strong> - questions accepted beliefs, ethical</td>
<td><strong>Questions</strong> - “ethical concerns”</td>
</tr>
<tr>
<td>science</td>
<td>concerns</td>
<td><strong>Results</strong> - “find new discoveries”, “solve problems”, “save lives with their discoveries”</td>
</tr>
<tr>
<td></td>
<td><strong>Results</strong> - external physical outcomes that may</td>
<td><strong>Purpose</strong> - “research has a purpose”, “benefit the future of science”</td>
</tr>
<tr>
<td></td>
<td>motivate a scientist</td>
<td><strong>Understanding</strong> - “make sense of how the world works”, “characterize everything”, “strive for a larger understanding”</td>
</tr>
<tr>
<td></td>
<td><strong>Purpose</strong> - more general statements about</td>
<td></td>
</tr>
<tr>
<td></td>
<td>science having a purpose</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Understanding</strong> - motivations for scientists to</td>
<td></td>
</tr>
<tr>
<td></td>
<td>learn more or to understand more about science</td>
<td></td>
</tr>
</tbody>
</table>
### Table 5 (Continued)

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategories</th>
<th>Example Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motivations</strong> (continued)</td>
<td>• <strong>Social aims</strong> - reasons to pursue science and research that will benefit others or society more broadly</td>
<td>• <strong>Social aims</strong> - “benefits someone or something”, “make a difference in the world”, “make the world better”</td>
</tr>
</tbody>
</table>
| **People** - examples of scientists or science careers | • **Professions** - specific types of scientists or researchers  
• **General descriptors** - broader categorization of people who are/become scientists  
• **Specific people** - named scientists | • **Professions** - “doctor”, “researcher”, “microbiologist”  
• **General descriptors** - “expert”, “family friend”, “explorer”  
• **Specific people** - “Einstein”, “Bill Nye” |
| **Characteristics** - physical and personality descriptions of scientists | • **Positive drives** - reasons for scientists’ work  
• **Miscellaneous** - other interesting descriptors that didn’t fit well elsewhere  
• **Qualifications** - what it takes to be a scientist  
• **Outside the box thinking** - descriptors of scientists as creative thinkers who are innovative  
• **Physical traits** - mostly stereotypical physical descriptors  
• **Smarts** - scientists as intelligent, smart, or driven to learn  
• **Methodical** - descriptors of ways in which scientists are deliberate and intentional | • **Positive drives** - “good intentions”, “respectable”  
• **Miscellaneous** - “healthy”, “ordinary”, “serious”  
• **Qualifications** - “not limited to those… with a job”, “do not think someone needs a degree”  
• **Outside the box thinking** - “inquisitive”, “curious”, “passionate”, “problem solvers”  
• **Physical traits** - “man”, “lab coat”, “come from all over”  
• **Smarts** - “eager to learn”, “smart”, “certain mindset”  
• **Methodical** - “dedicated”, “analytical”, “determination”, “strong-willed” |
| **Topics/Types of Science** - examples of things studied or science subjects | • **Methods** - reference to specific processes  
• **Examples** - specific examples of types of research or subjects of research  
• **Categories** - more general examples of types of research or subjects  
• **Value** - one student wrote about concern that STEM is valued more than social sciences | • **Methods** - “observational methods”, “scientific experiments”  
• **Examples** - “bacteria”, “plant life”, “natural world”  
• **Categories** - “social sciences”, “hard science”, “biology”  
• **Value** - “some people value STEM research more than social science research” |
After recording these categories and subcategories along with their assigned words and phrases into a spreadsheet, I decided to analyze the students’ responses again from the beginning to check myself for consistency and to ensure I hadn’t overlooked any important words or phrases in the student responses. I printed out the student responses (my first reading of responses had been completed on the computer), then highlighted key words or phrases. Using the table of categories and subcategories I had created, I then wrote the category and subcategory for each of the highlighted words and phrases in the margins of the printout. I then typed these, sorted by subcategory for each student, back into a spreadsheet. I didn’t have any changes in my identified key words and phrases or in my assignments to categories and subcategories during this second round of analysis, at which point I moved on to analysis of the reflections.

To create quantitative visualizations of the content of the students’ reflections, I typed in the number of content units used in each subcategory for each student into an Excel spreadsheet. For example, if a student wrote “white lab coat” and “goggles” in their reflection, both of which are in the Characteristics category and Physical Traits subcategory, I typed a “2” into that subcategory’s cell. If a reflection did not include any words or phrases in a particular category or subcategory, that cell was left empty. I added up the number of words and phrases in each category and subcategory to gain an overall sense of the amount of content in each, and I counted the number of students whose reflections included at least one word or phrase in each category or subcategory to visualize the proportion of reflections mentioning each.

**Analysis of Post-Program Survey Data**

The post program survey responses were collected and evaluated. Responses ranged from 5 - “Strongly Agree” to 1 - “Strongly Disagree”. The medians of students’ responses to each question were graphed to gain an overall sense of how students felt about each of the
written statements. Median and mode are more appropriate measures of central tendency, rather than mean, for ordinal data (Urdan, 2017). Due to a lack of pre-program surveys and a relatively small number of student responses, no additional analyses were performed. The small number of responses (n=16) from our specialized student population (junior and senior high school students who have self-selected to take an additional high school science elective) along with the clustering of the values (most responses clustered close to 5 – “Strongly Agree” or 1 – “Strongly Disagree” depending on the valence of the statement being evaluated) means statistical analysis would not yield meaningful information. Nonparametric tests are preferred for this type of data and for small sample sizes, but because the student responses are clustered then assigning ranks will not yield a distribution of responses (Mangiafico, 2016).

**Results for Research Question 1**

We had hoped to compare survey responses from before the program to after the program to examine any changes in student interest, but we were unable to collect pre-program survey responses due to time constraints (described in Chapter 4). Fortunately, we can see if students’ perceptions of scientists changed from pre-program to post-program by examining the students’ reflection responses. The numbers and types of words and phrases in the categories and subcategories were analyzed for similarities and differences in pre-program and post-program reflections.

**Pre-Program Student Reflections**

From looking at the numbers of words and phrases organized by category, Actions and Characteristics were the most often mentioned by the students (n=24) in their pre-program reflections (Figures 5 & 6). Seventeen out of 24 students (70.83%) had at least one word or phrase that was classified as Actions. Nineteen out of 24 students (79.17%) had at least one
word or phrase classified as Characteristics. A similar number of students also mentioned at least one Motivations word or phrase (16 out of 24, 66.67%). Six students (25%) included a physical space in their description, and five of those students specifically said “lab” or “laboratory” in their descriptions. Only 2 students (8.33%) mentioned some sort of tool or technology in their pre-reflection. Nine students mentioned People (37.5%), and ten mentioned a Topic/Type of Science (41.67%).

Figure 5. Numbers of Pre-Program Reflection Content Units Organized by Category
Figure 6. Percent of Students Using At Least One Content Unit by Category for Pre-Program Reflections

Within the Actions subcategory (Figure 7), most students mentioned something having to do with the Scientific Method (8 students), Working (8 students), or with Research (13 students). There is likely some overlap within these subcategories; Research includes responses that specifically mention research, conducting research, or experiments. The Scientific Method category includes actions that could be a step of the scientific method, and Working includes more general actions like “studying”. The Research category was likely the most consistent/identical in codes across all the reflections since “research” and “experiments” were mentioned often and this is how the subcategory was defined. Overall, I take this to mean most students focus on the process of the scientific method and the act of conducting research and doing experiments to be defining features of scientists.
Most of the Motivations key words and phrases were classified as Results, Understanding, or Social Aims subcategories (Figure 7). The largest number of responses fell in Understanding, with 15 content units from 10 students in this subcategory. Most of the students focused on scientists being motivated to find answers to questions or to understand more about a topic or about the world as a whole. To me, this points towards students seeing scientists as motivated by a desire for knowledge more than for a specific purpose or result.

Characteristics was the most mentioned across all the reflections (n=19, 79.17% of students). I anticipated more physical stereotypes would be mentioned in characteristics, like “male”, “lab coat”, and “glasses”. In the Physical Traits subcategory, seven students mentioned a “lab coat”, “white coat”, or “white lab coat”, three mentioned “goggles” (none mentioned “glasses”), and only three mentioned a “man” or “male” (Figure 7). Two of these students specifically stated that they thought of the stereotype when including one or more of those
physical descriptors. Students were much more focused on other characteristics of scientists, especially Outside of the Box Thinking (n=5 students), Smarts (n=4 students), and Methodical (n=8 students). These subcategories included descriptions of scientists as problem solvers, intelligent, and dedicated. Overall students focused more on personality when thinking about characteristics of scientists over physical attributes.

**Post-Program Student Reflections**

The most common categories in the post-program reflections were Actions, Motivations, and Characteristics, same as in the pre-program reflections (Figures 8 & 9). There were even fewer People and Places key words and phrases than in the pre-program reflections. However, there were approximately the same number of Topics words and phrases, even though there were fewer total student responses (n=16). The number of Examples words and phrases in the Topics category increased (13 content units in 6 post-program reflections compared to 6 content units in 5 pre-program reflections). Of the sixteen total post-reflections, fourteen of them had at least one Actions word or phrase (87.5%), thirteen had at least one Motivations word or phrase (81.25%), and ten had at least word or phrase Characteristics code (62.5%). By contrast, only three reflections mentioned Places (18.75%), two of which mentioned “lab” or “laboratory”, and only two mentioned People (12.5%), neither of which were specific people (“researcher” and “explorer”).
Figure 8. Numbers of Post-Program Reflection Content Units Organized by Category

Figure 9. Percent of Students Using At Least One Content Unit by Category for Post-Program Reflections
The Scientific Method and Research subcategories came up most frequently in the Actions category in the post-reflections (Figure 10). Three students described studying in some way, which was included in the Working subcategory. Three students mentioned Creation, such as “innovating” and “coming up with something new”. Overall students focused mostly on the act of research and the implementation of the scientific method when they thought of scientists.

**Figure 10.** Numbers of Post-Program Reflection Content Units Organized by Subcategory

Motivations key words and phrases were mostly placed in the Understanding and the Social Aims subcategories (Figure 10). Seven students mentioned Motivations in the Understanding subcategory such as “understand our world” and “seek out a solution”. Overall students who mentioned a motivation considered understanding more about the world and expanding knowledge as the most common motivation for scientists. Working to benefit others or the world and aiming to discover or solve something were the next two most mentioned motivations for scientists.
Only four reflections mentioned Physical characteristics (Figure 10). Two of these mentioned “white coat” or “lab coat-wearing”; one of these also mentioned “man” and “stereotype”, and this was the only student to mention either of those two words or phrases in the post-program reflections. The other two students that mentioned Physical characteristics included that scientists can come “from all over” the world. Interestingly, there were two students that mentioned Qualifications, and both stated that there isn’t a specific degree or qualification needed to be a scientist. Overall students were not focused on physical characteristics or stereotypes in the post-program reflections. Instead, they considered scientists to be creative, dedicated, intelligent people without mentioning specific clothing/equipment, sex, or ethnicity.

Lastly, there were more Topics/Types of Science key words and phrases than I had anticipated. Maybe having seen more examples of research through the St. Jude Virtual Journal Club made students think more about topics and fields than before the program. Seven students mentioned at least one Topics content unit (Figure 10).

Comparison of Pre-Program and Post-Program Reflections

Similarities. In both the pre-reflections and the post-reflections, students were more focused on the Actions, Motivations, and Characteristics of scientists than on Places, People, or Topics (although there was a larger proportion of reflections mentioning Topics (Examples) in the post-program reflections, Figure 11).
Figure 11. Percent of Students Using At Least One Content Unit in Pre-Program and Post-Program Reflections

The Actions key words and phrases that were used most often focused on implementing parts of the scientific method (either specifically mentioning the scientific method or steps such as “asking questions” or “analyze”) or performing research (specifically mentioning “research” or “experiments”). “Studying” or “learning”, which I categorized as Working, were also mentioned in both pre-program and post-program reflections.

Motivations key words and phrases about understanding more about the world or a topic or about seeking to expand knowledge were the most frequent subcategories in both the pre-program and post-program reflections. While additional motivations were often mentioned in addition to an Understanding motivation, most students seem to consider scientists as wanting to pursue science for the sake of learning. A desire to see results, such as new discoveries in general or for a specific purpose (like saving lives or cures for cancer), was a less frequently mentioned motivation. Finally, several students in both pre-program and post-program
reflections said that scientists were motivated by some social aim, meaning they were working to benefit someone or to change the world.

I expected more physical characteristics to come up in both pre-program and post-program reflections. By contrast, most of the Characteristics key words and phrases in both reflections focused on personality and work ethic of scientists. Only 7 pre-program reflections mentioned a white coat, which dropped to 2 in the post-program reflections. Three pre-program reflections mentioned “man” or “male”, and this dropped to 1 in the post-program reflections; this one reflection also acknowledged that this was a stereotype. Both pre-program and post-program reflections described scientists as curious, smart, and methodical. Slightly more pre-program reflections focused on Methodical words and phrases with similar numbers for Outside the Box Thinking and Smarts words and phrases.

**Differences.** Three main differences jumped out, although each occurred in a small number of reflections. The first is the change in how many reflections mentioned “lab” or “laboratory”. Six pre-program reflections used this word while only 2 post-program reflections did. All the scientists’ talks in the St. Jude program were presented by bench scientists, meaning they have all mostly worked in a laboratory setting. I would have thought this would have led to more students thinking of science as being performed in a lab.

The second difference is in the "Characteristics" category. There were even fewer Physical characteristics mentioned in the post-program reflections. Two of those were about scientists coming from all over the world or leading to opportunities around the world. This was not mentioned in any of the pre-program reflections. There were also two post-program reflections that mentioned that it doesn’t take a specific job or a specific degree to be a scientist. Again, no pre-program reflections mentioned words or phrases similar to this idea.
The third difference was in just one post-program reflection. The student identified herself as a social scientist. She stated in her reflection that she didn’t appreciate that STEM fields are more valued than social and behavioral sciences. All the St. Jude talks were more focused on traditional biological research and mostly on cancer research. I wonder if this focus was off-putting for this particular student.

**Post-Program Survey Responses**

The results from the survey questions were not surprising. The students who completed the post-program survey were in Research Methods or AP Biology courses; these are students who have chosen to take difficult elective science courses. The first set of statements were written to measure students’ thoughts about learning science in school, the second set to measure students’ self-concept in science, and the third to measure students’ future participation in science (Kind et al., 2007). These students had strongly positive thoughts towards learning science in school, with most students strongly agreeing with the statement “We learn interesting things in science lessons” and strongly disagreeing with the statement “Science is boring” (Figure 12). Students’ self-concept in science was more moderate. Students gave lower responses to the statements “I find science difficult” and “In my science class, I understand everything.” They much more strongly agreed with “I get good grades in science” and “Science is one of my best subjects.” Lastly, most students indicated some interest in participating in science in the future with most students agreeing with the statements “I would like to study more science in the future”, “I would like to study science at university”, and “I would like to have a job working with science.” A similar number agreed that they would like to become a scientist, but most students disagreed with the statement “I would like to become a science teacher” (Figure 12).
Findings for Research Question 1

We are unable to answer this research question. We had hoped that comparing survey results from before and after program participation would answer this question, but we were unable to collect pre-program surveys. We were able to examine if and how students’ perceptions of scientists changed based on their responses to the reflection, “When I think of a scientist, I think of…”

Based on the pre- and post-program reflections and surveys, we did not see many changes in our students’ perceptions of scientists. As mentioned previously, I did not find this too surprising given our student populations. Stereotypical descriptions of scientists have overall decreased since Mead and Metraux’s pioneering study (1957). Research has suggested a link between students’ self-efficacy and stereotypical elements: the more positive a student’s self-efficacy, the more positive her attitude and the fewer stereotypical elements included (Finson, 2002). The students in this study are junior and senior high school students who have chosen to
take an advanced elective science course. As a group, I would expect these students to have more interest in science, to have more experience with scientists, and to have a higher self-efficacy in science compared to other high school students. As revealed by the post-program surveys, these students do have a positive perception of their abilities in science. Therefore, I may not expect three virtual scientist talks to have a big impact on these students’ perceptions of scientists.

In the pre-program reflections, the prevalence of codes under Actions, Motivations, and Characteristics indicates that the students completing these reflections think more about what scientists do and why they do it when they think of a scientist. They also think of the traits that lead them to be successful at those actions and motivations. The Characteristics were more focused on creative thinking, intelligence, and dedication over skin color, sex, or what they wear. I feel this is encouraging, that our students were already thinking beyond a traditional media stereotype when thinking about scientists before beginning the St. Jude Virtual Journal Club outreach program.

Students did seem to be less focused on Physical Traits in their post-program reflections as compared to their pre-program reflections. Several students mentioned “lab coats”, “goggles”, and “man” or “male” in the pre-program reflections, but only two mentioned any of these traits in their post-program reflections. Only one of the four scientists who gave talks to our students was male, and three out of four of the scientists were non-white. Other outreach programs reported a decrease in the perception of scientists as wearing a lab coat and goggles after a virtual scientist presentation (Barry et al., 2022), and inclusion of female role models has improved students’ perceptions of and attitudes towards women in science (Finson, 2002).
Students in their post-program reflections focused on the actions of scientists, specifically executing the scientific method, performing research, and studying, and on personality characteristics of scientists, including curiosity and intelligence, when thinking of scientists. Motivations were also very common, with most of the motivations described focusing on the desire of scientists to understand more about the world. Specific examples of topics were mentioned more often, especially compared to more general categories of science like “biology”. People and Places were hardly mentioned at all. Short interactions with scientists have been shown to change students’ perceptions of physical characteristics of science and make them more aware of types of science and careers in science (Woods-Townsend et al., 2016).

Taken together, students’ post-program reflections indicate that they are more focused on the actions scientists take and the characteristics and motivations behind these actions when they think of scientists rather than on specific people, places, or physical characteristics. It is possible that students became more aware of the determination and the creative thinking required in science as a result of the scientists detailing their backgrounds and their research processes. I find this change to be positive and encouraging, and I hope it’s something we find consistently as we continue the St. Jude Virtual Journal Club.

Because we were unable to collect pre-program surveys, we are unable to do any comparisons to how students’ perceptions of science, their abilities in science, and their future participation in science changed. However, based on the post-program surveys we can see that our students overall enjoy science, feel capable of doing science, and are interested in pursuing science classes and/or a science career. This was true for both female and male students and for students of different ethnicities. Outreach programs have reported increases in student interest and engagement in science (Laursen et al., 2007) and improved attitudes towards science and
perceptions of science careers (Crawford et al., 2021), and an outreach program specifically targeting female students, GEMS, found increases in girls’ interest in and excitement about science after participation (Dubetz and Wilson, 2013).

Again, because these are students who have already self-selected into elective science courses, I would not be surprised if these students held these beliefs prior to participation in the St. Jude Virtual Journal Club. It is encouraging to know that, if that was the case, then hearing the scientists’ talks did not discourage students in their interest in science and future participation in science.

In future years in my own teaching, I may choose to focus more on the scientific process, emphasizing that determination and creative thinking are just as important, if not more important, than intelligence. By the time students choose to enroll in my advanced science course, they have already chosen to take an extra science class. In terms of students’ perceptions of science and scientists, I may use the St. Jude Virtual Journal Club for students to see application of course content as well as to emphasize science research careers.

**Research Question 2. Are Students Able to Understand the Content and to Think Through Applications of the St. Jude Virtual Journal Club Talks?**

**Research Methods**

To evaluate the second research question, we created a set of post-talk reflection questions. This reflection, which we administered after each of the three talks, asked students several questions about that particular talk. We wrote these reflections questions as a group based on our personal interests, what we wanted to learn about our students and what they were gaining from the talks (Appendix I). These reflections were created in and administered through Qualtrics.
Analysis of Post-Talk Reflections

The pre-program and post-program reflection was focused on students’ perceptions of scientists. The questions included in the post-talk reflection were more focused on students’ understanding, or lack of understanding, of the talk’s content and their ability to connect the talk to what they have learned in class (Appendix I).

Post-talk reflections were analyzed differently than the pre- and post-program reflections. Since these more closely reflected questions we as teachers would ask our students in class or in formative assessments, we decided to analyze these like a teacher. Rubrics are often used to guide students in understanding what is necessary to complete an assignment successfully. Rubrics also help teachers focus on the intended learning outcomes for their students and how students will meet these outcomes in addition to standardizing grading (Allen and Tanner, 2017; Luft, 1999). Teachers can pinpoint student weaknesses in content knowledge or skills through use of rubrics (Bharuthram, 2015). Rubrics can also be used to evaluate student understanding of new through processes (Sabel et al., 2022) and students’ ability to connect concepts learned in class to questions outside of class, such as making voting decisions (Sabel et al., 2017).

To begin our analysis, we brainstormed what we would expect to see in student responses, including what a “good” response might include and what a “bad” response might include. I then created a rubric to “grade” the students’ responses to each question (Appendix K). The rubric served as a way for me to standardize how I categorized each student’s response as well as an exercise for me to consider what students may write based on their level of understanding of the talk. To create the different levels within the rubric, I reviewed the scientists’ written summaries for the key ideas, experiments, and results mentioned in each. That way I had a better sense of the “correct” content of each talk. A student response of “3” is the
highest score, indicating clear understanding of the key ideas, a clear connection to course content, etc. A student response of “1” is the lowest score, indicating a misunderstanding of the key ideas, a lack of connection to course content, etc. Student responses were read and “graded”, given a score of 1, 2, or 3 along with a brief statement about why that was the assigned score.

In more traditional educational research, the rubrics we created would go through further development and testing before using them for analysis. Because of the nature of the PAR process, we were unable to perform these steps. These methods were decided upon by the participants during our discussion of data analysis in April and May. We didn’t know that this would be our approach to analysis before this time, and because of the external timelines of this project (in this case, namely the end of the academic year), we didn’t have time to test the rubrics before using them for analysis.

**Results for Research Question 2**

To answer this research question, we reviewed student responses to a set of post-talk reflection questions. We decided to treat the post-talk reflections similar to a formative assessment in our classrooms. These questions were graded using a rubric to get a sense of how well students were understanding and connecting to each talk.

*Post-Talk Reflections Analyzed by Scientist*

The lowest rubric scores (indicating less student understanding) were in the Content Connections and the Next Investigation questions (Figure 13). These two categories had the largest proportion of “1” and “2” rubric scores. Students were not always able to describe a connection between the talk and things they have learned in science classes, or they were not able to describe a connection specific to that talk’s content. For example, one student stated, “I did not because I did not gain the knowledge in science classes in order to make any connection
to the paper” in response to this question, which scored a “1” on the rubric. When describing what next steps the student would take if they were the scientist, most student responses said they would repeat the current experiment in some way. This included repeating the experiment to get more data, repeating the experiment on another model or another patient population, or performing the same procedures with a different drug or a different cancer. For example, one student answered, “I am not sure”, which scored a “1”. Another student answered, “I think I would investigate any issues with the solution, since there isn't enough research on the cons of blocking the channels” after scientist Z’s talk. Because this statement focused on a repetition of the experiment already presented in the talk, it scored a “2”.

The figure below shows the rubric scores for each scientist and each question. For each of the post-talk reflection questions, each scientist is listed using letters W through Z. Rubric scores of “1” are shown in blue, “2” in red, and “3” in yellow. The total numbers of student responses varied for each scientist.

![Post-Talk Reflection Rubric Scores by Scientist](image)

*Figure 13. Rubric Scores by Question for Students’ Post-Talk Reflections*
Rubric scores were similar across all four scientists. The largest differences occurred in the Key Ideas question (for X, overall lower rubric scores) and in the Content Connections question (for Z, overall higher rubric scores). When asked to write one or two key ideas from the talk, students overall had a slightly more difficult time correctly describing the content of Dr. X’s talk (about DNMT3A Overgrowth Syndrome and the creation of a mouse model of DOS). A few students did not have the correct context of the talk (“One of the ideas that they presented was how they used rats to model cancer research,” a mouse model was used) or oversimplified the ideas of the talk (“The transmission of disease through germ cells and somatic cells results in varying intensity levels of the sickness,” which shows confusion about the content of the talk). In describing a connection between the content of the talk and something learned in a science class, the majority of students were able to describe at least one connection with Dr. Z’s talk. Most of the responses mentioned ion channels (“I learned about ion channels in the first semester, and I realized that this was something that I had discussed in my biology class.”) or plasma membranes (“One connection is through AP Biology in which we learned about the plasma membrane and cell signaling.”) as a connection. A chart with overall comments on each of the questions for each scientist is below (Table 6).

I did not assign rubric scores to the final post-talk reflection question which asked students, “What is one thing that could have been better in the talk?” Most student responses centered around an improvement in content. Some of the talks were confusing overall (“I was a little confused just by all of the complex ideas and abbreviations it was a little heard to follow.”) and “If Dr. Z could have explained the steps and findings in simpler terms, I think I would have taken away more from the talk.” as two examples), and across several talks students requested
more interactivity and more time for questions (“I feel like it could have been more interactive.” and “There could have been more interactive questions.” as two examples).
Table 6. Overall Comments on Post-Talk Reflection Student Responses - Sorted by Scientist

<table>
<thead>
<tr>
<th>Scientist</th>
<th>Key Ideas</th>
<th>Content Connections</th>
<th>Learn More</th>
<th>Next Investigation</th>
<th>What could be better</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>5 out of 9 students described that low-dose antibiotics, leukemia, and gut health were related in some way in the talk; 4 out of 9 students who had &quot;2&quot; responses mentioned one of these three things or didn't provide context/provided incorrect context for the study</td>
<td>4 out of 9 responses said there was no connection to course content; most of the other responses stated a clear connection, such as bone marrow's location and its role in leukemia and the use of gene expression as a tool</td>
<td>Most students (6 out of 9) had something that could be specific to the talk to learn more about, such as how stages of cancer or individuals are affected by the treatment and gut bacteria</td>
<td>Almost half of students (4 out of 9) would repeat the current experiment in some way, the remaining students would perform similar experiments on other diseases or using other drugs</td>
<td>4 out of 9 students wanted more time to ask questions and more opportunities to be interactive. 6 out of 9 students requested more focus on the procedures, the results, and/or other information.</td>
</tr>
<tr>
<td>X</td>
<td>3 out of 8 students correctly identify DNMT3A mutation (change in epigenetic regulation) and/or DNMT3A Overgrowth Syndrome mouse model as key ideas. 3 out of 8 students who had &quot;2&quot; responses identified</td>
<td>Students who made connections (4 out of 9 “3” responses, 2 out of 9 “2” responses) mostly described mutations and their consequences, with two students mentioning connections to DNA</td>
<td>4 out of 8 students wanted to learn something more about animal models or the mouse model. The remaining students had interest in the mutation and its effects on methylation or protein products.</td>
<td>Most students did not have specific ideas for what to test next beyond continuing the experiments presented. Most wanted to check the mouse models further or to turn the findings into a treatment. (7 out of 8</td>
<td>3 out of 8 students didn't have a specific suggestion for improvement. The remaining responses requested more explanation of one or more areas of the talk, including the graphs, the experiments themselves,</td>
</tr>
</tbody>
</table>
**Table 6 (Continued)**

<table>
<thead>
<tr>
<th>Scientist</th>
<th>Key Ideas</th>
<th>Content Connections</th>
<th>Learn More</th>
<th>Next Investigation</th>
<th>What could be better</th>
</tr>
</thead>
<tbody>
<tr>
<td>X (continued)</td>
<td>methylation, mouse model, or mutation without context or with incorrect context. 2 out of 8 students did not correctly identify a key idea; one was oversimplified, one stated incorrect information.</td>
<td>transcription and methylation. One student didn't add information that wasn't included in the talk. The remaining 3 out of 8 students did not make connections.</td>
<td>“2” responses</td>
<td>and practicality of the research.</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>Most students (7 out of 9) mentioned venetoclax, multiple myeloma, and/or effectiveness of ven when used with another drug. The two responses that weren't a &quot;3&quot; were too general or oversimplified in their descriptions.</td>
<td>4 out of 9 responses stated there was no connection, with 3 of these stating that the talk was very hard to understand. The remaining students all made connections, mostly to mitochondria and Krebs cycle.</td>
<td>3 out of 9 students said they wanted the talk explained more simply (“2” responses). The remaining &quot;2&quot; responses said they wanted more general information about medicines or cancer. &quot;3&quot; responses wanted to know more about the cell viability assay and about the enzyme reactions.</td>
<td>&quot;3&quot; responses wanted to test another drug, other types of cancer, or other factors affecting ven (4 out of 9 students). 2 students did not describe a next investigation. The &quot;2&quot; responses had more general statements about testing ven or individual responses (3 out of 9 students).</td>
<td>Almost all the responses said the talk needed to be simpler. Several students mentioned that the acronyms or abbreviations were confusing (3 out of 8). Most said that the talk did not seem like a high school level talk (4 out of 8).</td>
</tr>
</tbody>
</table>
All except one response (out of 15) received a "3" for describing calcium ion channels, TRPC3, Alzheimer’s or neurodegenerative disease, and/or Pyr3 and JW-65 drugs to block TRPC3 or calcium ion channels.  

Most students’ responses (13 out of 15 “3” responses) wanted to know more about Alzheimer’s, others showed more specific interest in ion channels' role in disease. Two responses were not as specific to this study but more generally interested in what causes disease or relationship of channels to other diseases.  

Several students wanted to continue the current experiment, by testing in other animals or humans or continuing with testing this drug (6 out of 15 "2" responses). Others wanted to explore the role of other ion channels in Alzheimer’s or how JW-65 affects other channels (9 out of 15 “3” responses).  

Most students stated some parts were difficult to understand or not connected well to other parts of the talk (11 out of 15). Some (2 out of 15) expressed difficulty with the audio or with the link to the interactive questions.
Post-Talk Reflections Analyzed by Talk Number and by Course/Teacher

To check that differences in the rubric scores based on scientist couldn’t be easily explained by talk sequence (meaning was it the first, second, or third talk heard by the students; Figure 14) or by course/teacher (Beth - Research Methods, me - AP Biology, Cory - Anatomy and Physiology; Figure 19), I created graphs of the rubric scores when they were sorted by these parameters instead of being sorted by scientist.

The biggest difference in both graphs occurs for the Content Connections question. When analyzing by talk, students were more able to make connections to their course content for the third talk compared to the first two, with no scores of “1” and only one score of “2” for this talk (Figure 14). However, most responses for the third talk were also for Dr. Z’s talk; it is possible that students were better able to connect to Dr. Z’s content regardless of when it was presented, or it is possible that students were better able to connect to Dr. Z’s content because they had already seen two other scientists’ talks and they are more familiar with the talk format. Both the first and second talks had approximately equal numbers of “1” scores and “3” scores, indicating students either were unable to connect the talk to their course content or that they saw clear connections between the talk and their course content.

The figure below shows the rubric scores for each talk in sequence and each question. For each of the post-talk reflection questions, each talk is listed based on the order in which it was presented to students. Rubric scores of “1” are shown in blue, “2” in red, and “3” in yellow. The total numbers of student responses varied for each talk.
When analyzing by course/teacher, students in Anatomy and Physiology made fewer connections to their science class content (greater number of “1” rubric scores), but scores across the other categories were similar for all three courses (Figure 15). The talks may not have been as relevant to the content presented in Anatomy and Physiology, or other differences in pedagogy between this class and the other two (such as teaching primary literature) could explain the difference in content connections.

The figure below shows the rubric scores for each course and each question. For each of the post-talk reflection questions, each course is listed using abbreviations: “RM” is Research Methods, “APB” is AP Biology, and “A&P” is Anatomy and Physiology. Rubric scores of “1” are shown in blue, “2” in red, and “3” in yellow. The total numbers of student responses varied for each course.
Findings for Research Question 2

It seems that students were able to understand the key ideas of the talks and to identify something related to the talks that they would like to know more about. The majority of students scored a “2” or a “3” on their responses to these reflection questions indicating that they had a clear or reasonable understanding of the talk and that they understood the talk well enough to identify something that made them curious to know more. This wasn’t a surprise; as mentioned above, our students are all upper-level students who are motivated to learn science.

Connecting to the course content may be more difficult for certain talks or subjects. This can be seen in the lower Content Connections rubric scores for Anatomy and Physiology compared to the other subjects. The lower scores could be because the talks did not connect as well to their class as they did to Research Methods and to AP Biology. The Virtual Journal Club program was originally aimed towards AP Biology classes, so the content of the talks may still be better suited for that subject. It could also be because the specific talks (W and Y) seen by
those students were more difficult to understand and to connect to content. Finally, it could be because of differences in how these courses are taught. The students in the Research Methods and AP Biology classes were taught how to read primary literature. Teaching primary literature in the classroom has been shown to promote a deeper understanding of scientific concepts and the nature of science (Brill et al., 2004; Stelnicki et al., 2011; Hoskins et al., 2007). This may have helped those students better understand the research talks because of increased familiarity with research methods and data presentation.

To better connect to course content, more information about the presentation would need to be shared and earlier in the school year. As a teacher, it may be difficult to integrate the talk content if it’s not related to what is being taught at the time, but it is difficult to change the order of content without adequate planning. It is also possible that additional communication and collaboration between the scientists and teachers could help with integrating the talk into course content. The specific focus of the talk, the time spent on background information and the information to be included, as well as the interactive questions asked during the presentation could all be adjusted depending on the class. However, this would require more time and practice on the part of the scientist, so it may not be as practical as making adjustments on the side of the teachers. A preview of the talk or a meeting between the teachers and the scientists prior to the start of the program may help teachers better understand what each scientist will be presenting and how that talk might be integrated into their course. Teachers have requested this type of additional pre-talk support and classroom resources in another virtual outreach program (McCombs et al., 2007).

As a teacher, I’m overall happy with what I saw in the post-talk reflections. In future, I would spend more time trying to make explicit connections between the talks and the course
content. I would also go more into the nature of science and scientific thinking to try to improve students’ ability to ask more specific questions about the research and to identify next steps. I believe more explicit instruction and follow-up with students about decisions made in experiments and about potential next steps could improve students’ ability to think about the nature of science and propose a next experiment beyond a repeat of the current experiment. This could potentially be approached at a more general level, with steps that could be applied to understanding any primary research paper study.
Chapter 6

Conclusions

In this study, I have worked collaboratively with three other science teachers using PAR methodology to investigate the impact of the St. Jude Virtual Journal Club outreach program on our students. As a group, we discussed what we would like to learn about the outreach program and about our students and what our personal goals were for the outreach program and for this PAR project. We worked together to define research questions, choose methods, collect data, and analyze the data. We obtained valuable results that can be used to inform future iterations of the St. Jude scientist training program, the MemSTEMM Ambassadors Classroom, as well as the implementation of the classroom-facing outreach program, the St. Jude Virtual Journal Club. By utilizing PAR, I was able to integrate other teachers into each step of the process and avoid the trap of assuming their interests and ideas would be the same as mine.

My interest in this project was a direct result of my personal experiences. As a scientific researcher, I entered classrooms with very little preparation on how to speak to middle and high school students. As a high school teacher, I have hosted scientists and professionals with varying degrees of preparation themselves. With the already numerous constraints on classroom instructional time, I was interested in making the outreach program as integrated into the curriculum as possible. I already had ideas about how to do this, again based on my own classroom experience. In my initial conceptualization of this project, I would prepare a curriculum, likely a combination of hands-on activities and AP-style test questions, for teachers to implement alongside the scientist talks.

Fortunately, I realized that this was not the best approach to integrate the outreach program into other teachers’ classrooms. While all the participating teachers were teaching AP
Biology at the time, many of us approach the curriculum differently, sometimes teaching units in different orders, integrating different labs, or following a unique teaching method such as project-based learning (Blumenfeld et al., 1991) or a flipped classroom model (Bergmann & Sams, 2012). We also sometimes have unique requirements and constraints placed upon us by our schools. How I planned to integrate the outreach into my classroom may not work for someone else. A specific quote from a paper describing a science outreach program has stuck with me; the teachers described the outreach program as something “being done to them” and not with them (Falloon, 2013). I realized that I needed to take a step back and instead ask other teachers what they want. This led into the creation and implementation of the PAR project described here.

I began with an overall idea of how we would proceed through the PAR process, but the exact course of the project wasn’t determined until I began working with my co-researchers. I prepared an anticipated timeline of when we would complete which steps, such as choosing research questions, and I reviewed PAR literature to identify important skills. However, the exact questions, methods, and data collection were all determined during the course of the project itself. The preparation I had done in advance was to prepare myself for multiple possibilities, effectively to prepare myself to relinquish control of the project itself.

The group participating in the PAR project consisted of four teachers, including myself, who had committed to participating in the St. Jude Virtual Journal Club outreach program. Data produced included meeting transcripts, emails, student surveys and reflections, and my personal reflections. The group made all major decisions together up until the final data analysis stage, at which point I proceeded on my own due to time constraints. I prepared a formal, academic-style summary report that was shared with the leaders of the St. Jude Virtual Journal Club.
program. In this chapter, I will describe my personal reflections on the overall PAR process followed by the significance of, implications of, and future research related to this study.

**Reflections on the PAR Process**

I have learned several valuable lessons through the PAR process. At several points within the project, I found myself in conflict between the multiple roles I was occupying as a teacher, a project participant, as a researcher, and as a student. Giving up control of the overall project was difficult for me, but doing so has led to a project that I otherwise could not have conceived on my own. The logistics of working with a group and following external timelines were both difficult. Finally, the connections made with the other teachers and the collaboration within the project were beneficial both for the project as well as for my own teaching practice.

**Conflict Between My Multiple Roles within PAR**

Throughout this project I could feel a tension between my role as a participant in the project and as a researcher. In each email I sent, every meeting we had, each draft I prepared, I reminded myself to consider both roles and where I should be situated within each role for each step of the PAR process. At other points within the process, I felt tension between my roles as a classroom teacher and as a researcher, especially when interacting with my students. Lastly, there were times when I had a role as an expert within the group while at the same time I was still learning as a student myself. Below I describe how I situated myself within each of these roles and include points in the PAR process when that role was especially important and/or had strong conflict with my other roles.

**Researcher.** This role as a researcher often felt like my primary role within the project. This was my dissertation project, and I was the driver of the process from the beginning through to the end. As the researcher, I felt I had to act as the expert at certain steps. I had to
ensure the logistics of the project stayed on track and followed procedures. For example, I prepared and submitted the IRB applications, and I kept track of submitted permission forms, assent forms, consent forms, and CITI trainings. When preparing research methods, I asked for feedback from my co-researchers, but ultimately, I offered most of the suggestions along with support from published literature for those methods. As I entered into the data analysis stage during the summer, most of my co-researchers were not as able or as interested in continuing, but as the researcher I knew I would complete the project.

I felt conflict as a result of this role more than any other. This was a novel role for me; this was very different from the scientific benchwork I had done in my previous graduate program. I had not had to navigate how to act as a researcher in the context of education, and I was taking on this role while also taking on the role of project participant. I knew the importance of maintaining boundaries as a researcher, but as a participant in the PAR process I also needed to break down these boundaries. I also felt I could not always dedicate the amount of time I should to this role as a researcher because of my responsibilities as a full-time teacher. Lastly, I often felt unsure of what next step I should take because I am a student learning how to conduct this type of research, but as the lead researcher I felt I should know what next step to take. The PAR skills of listening to my fellow participants as well as continually reflecting on the PAR process were essential as I tried to negotiate these personal tensions.

**Project Participant.** In my individual meetings with the other teachers at the beginning of the PAR process, I made a specific effort to emphasize the importance of our collaboration. I shared some of my personal background and my reasons for pursuing this project with each of the other teachers, but I took special care to acknowledge to each of them that they have experiences and knowledge that I do not. I wanted to hear from them, about their students, their
curriculum, their schools, their successes, and their failures. In this regard, we were all equals, as we all had our own unique backgrounds and teaching experiences that informed our current teaching practices and our interest in participating in science outreach.

As I learned more about each of the other participants, it became easier to position myself as one of the group and not an outsider. Two other participants had work experience prior to becoming teachers, just like me. One of the other participants had completed a doctorate program while she was teaching, just like I was doing. All of us wanted our students to learn more about how to do science and to interact with scientists. All of us love science. If anything, I found myself feeling like the least “expert” when it came to teaching. I had the fewest years of teaching experience of the four teachers who remained in the project. The other teachers mentioned other outreach programs that I had never heard of. This sharing of experience and knowledge is exactly what I had hoped to gain by choosing a PAR approach.

The times where I felt conflict in this role were when I had difficulty distinguishing my wants as a participant from my wants as a researcher. In particular, I was not happy with our first research question. As a researcher, there is nothing wrong with this question, and it is one that has been asked to evaluate outreach programs, but I had been hoping we would choose something that isn’t asked as often or that hadn’t been asked yet. I was also disappointed with this question as a participant. I was less concerned with the “success” of the outreach program and more concerned with my students’ learning and how the outreach supported that. Because selection of this question occurred early in the process, I did not feel at that time that I could express these opinions without possibly swaying the group more as a researcher or “expert” than as a fellow participant.
**Teacher.** Time was the source of most of the conflict I felt with my role as a teacher. Throughout this project, I was employed full-time as an Upper School Science Teacher. I was teaching four different subjects in five classes, which meant I had a good amount of preparation I had to do for each class. Only one of these classes, the AP Biology course, was participating in the St. Jude outreach program, which also meant that any additional supports or assessment questions I prepared would only be used in one of my classes. I would still need to prepare lessons, activities, and assessments for three other subjects. Beyond course preparation and my other duties as a teacher, I also had to devote time to my roles as a researcher to keep this project moving forward and as a participant to attend meetings and respond to emails. It often felt like there was not enough time to devote to these latter two roles because of my teaching obligations.

Because the PAR group decided to collect data from our students, I also felt some concern about discerning my roles as a researcher and participant from my role as a teacher. I feel fortunate that my students and their guardians were very interested in the research project and most of them chose to participate. However, even though I repeatedly stated that there was no consequence if they chose not to participate and it would not affect their grades in any way, I was still concerned that some of them may have participated because they did not want to “disappoint” me or because they felt it might “help” them in some way. There is a power dynamic between teachers and students in the classroom, and I was in the position of power.

**Student.** The purpose of this project was to fulfill a graduation requirement. Yes, I have a personal interest in science outreach and integration into K-12 curriculum. Yes, I am invested in the MemSTEMM Ambassadors Classroom and the St. Jude Virtual Journal Club programs. Yes, I enjoy collaborating with other teachers and trying new things in my
classroom. All these things contributed to the design of this project. But the project itself likely would not have happened if it were not for my role as a student. Being a student drove me to become a researcher, but I was (and am) still learning how to be a researcher because I was a student.

This role as a student sometimes felt in conflict to my role as a researcher. As described above, I sometimes felt I should know what to do but didn’t always. Being a student helped me negotiate some of these other roles. As a teacher, my students liked hearing about my experiences as a student, and I feel that sharing some of my successes and failures built trust within our classroom. As a participant, I found it easier to acknowledge to my fellow participants when I was unsure of something or when I would need to ask someone else for an answer because of my role as a student. For example, when I was preparing the IRB for our teachers’ project and I wanted the other teachers to be my co-researchers, I didn’t know if this was allowed or what would be required to make this happen. I had to reach out to contacts at the university to ask questions about how to make this work and about what requirements they would need to meet. Being a student made it easier to approach this project as a learning experience in all my roles.

I Do Not Speak for the Teachers, and That is as it Should Be

As a former scientific researcher, I had been taught a very traditional approach to research: ask a research question, formulate a hypothesis, perform experiments, analyze the results. These steps were not always linear, but there was always an expectation of generating a certain amount of quantitative data before deciding on next steps or before reformulating the hypothesis.
The PAR approach is nothing like this. I made assumptions about what the other teachers may be interested in learning, what research questions we may ask, and how we may decide to go about answering those questions. These assumptions helped guide my initial project proposal and my preparation for the PAR project. Some of these assumptions proved true; for example, we all had similar interest in having our students learn directly from practicing scientists, which is why we agreed to participate in the outreach program in the first place. However, I had also assumed teachers would have a more specific interest in developing curriculum to go with the outreach, and that was not the case. Most of the teachers already had ideas of how they would integrate the outreach into their classes, including applications to specific content areas and project ideas.

I had also hoped that my co-researchers would have more interest in asking questions about themselves as teachers and/or as outreach participants. When I prompted teachers for their personal goals for participating in the outreach during our initial meetings, several of them deflected the question or directly stated that their goals were for their students to learn about science or to interact with scientists. My overarching research question had been focused on the teachers, asking, “How does participation in the St. Jude Virtual Journal Club impact teachers?” My co-researchers chose to focus on the influence of participation in the outreach on their students. As a result, I didn’t answer this research question.

Had I proceeded with my initial plan, to develop curriculum then ask teachers to test it with their students, this project would have been more linear in its process. I would have written the curriculum, recruited teachers, had their students complete my curriculum, then reviewed how the students did and asked teachers for their thoughts. I would have more directly designed methods and collected data to address the impact of the outreach program on the teachers. This
would have been satisfying to my science brain, but I would have fallen into the same trap of making the outreach something being done to the teachers (Falloon, 2013). I also would have been adding to the teachers’ already full workloads while limiting their creativity in how to integrate the outreach program for their own students.

Giving up control of this project by redesigning it to be a PAR project has helped me realize how important it is to include other voices in the room, especially when those voices are being directly affected. This idea is situated throughout the history of PAR: the people being affected by the decisions or the actions taken should be part of that process. In thinking more specifically about science outreach, teachers are sometimes forgotten in the process (Falloon, 2013) or are not considered equal in the partnership (Tomanek et al., 2005). More scientist in the classroom programs are training scientists to be better prepared for outreach, such as the MemSTEMM Ambassadors program here, but evaluation of many of these programs focuses specifically on the scientists’ perceptions (Kaser et al., 2013; Stylinski et al., 2018). The teachers in this project appreciated that they were being given a voice, and I emphasized to them that the leaders of the St. Jude program would listen to their input. Some changes, described below, are already being implemented in the outreach program as a result.

**Time Waits for No One, Especially Not a Graduate Student (or a Teacher)**

In designing this project, I appreciated the imposition of an external timeline. I knew the timing of the MemSTEMM Ambassadors classroom training sessions, and I knew when the St. Jude Virtual Journal Club talks would begin and end. We were also working within the external timeline of the K-12 academic calendar. I knew that it may be difficult to expect the other teachers to continue work on this project into the summer, and we had other dates and school events we had to work around, such as Spring Break. This meant that I had to arrange my PAR
timeline around these dates. It also meant that I couldn’t get “stuck” in any one step of the PAR process, and it meant that I knew when my PAR cycle would end.

Of course, this also meant that we had to be ready and that we had to be done by certain dates. If I had not been operating under this external timeline, we likely would have been able to administer the pre-program surveys, because we could have waited to begin the scientist talks after we received the final IRB determination. We also may have decided on different methods entirely. We only discussed three different methods that we then voted on: surveys, reflections, and draw-a-scientist tests. We also may have spent more time discussing the research questions and selecting different questions or further modifying the ones we chose. With more time, we may have been able to explore other options or possibilities.

The overall project was molded by this interaction of external timelines and internal decision points. The recruitment process occurred in conjunction with the planning of the St. Jude Virtual Journal Club in November 2022; ideally, I would have recruited teachers earlier in the academic year, closer to September or October, so that we had more time for discussions and planning prior to the start of the scientist talks. Once we began group meetings, not everyone was able to attend each meeting, which influenced the internal decisions made at different points within the PAR process. One of our initial participants, Josh, left the project in January, which could have led to a change in the research question and/or methods if the remaining participants had decided to change course. The start of the St. Jude Virtual Journal Club talks meant that we had to start our data collection sooner than we would have liked, and the end of the academic year and the end of classes for senior students led to our data collection ending sooner than we would have liked. The end of the academic year also meant that my fellow participants were not as able to or were not as interested in continuing with the project, leading me to proceed with
data analysis on my own. These external factors directly influenced our internal decisions and processes. We created and implemented this project within the context of these factors, some of which were within our control and others that were not.

If the St. Jude Virtual Journal Club program hadn’t ended so close to the end of the academic year, and after several of our senior students were finished with classes (end of April), we may have collected more data. If our students were still in class, it would have been easier to ensure they completed the final post-talk reflections and the final post-program survey and reflection. We also may have had more time before summer for us teachers to start the data analysis process together. Or we may have been able to wait until the following academic year to continue with data analysis. This could have led to very different decisions about how to analyze and to visualize the data.

Conversely, more time may have meant we would have become “stuck” at one or more steps in the PAR process. The transition from talking about action to taking action can be difficult to navigate in PAR (Smith et al., 2010). The discussion of additional questions or methods may have taken several more weeks, and we may have still chosen the exact methods we used. Drawing out the discussion and determination of research questions could have led to too many questions being generated. Spending more time discussing the data analysis may have led to over-analyzing the data or indecision about how to interpret the data. Operating without any deadlines or time constraints may have led to the project stalling entirely as we put it second to all our other regular responsibilities (Maguire, 1993). All of us participants knew that there were external timelines to the project due to the St. Jude Virtual Journal Club schedule and our academic calendars, and I think this helped us all keep moving forward.
If we were to continue in this PAR project, for an additional academic year or possibly even longer, we could dive even deeper into what we want to learn about the science outreach program in our classes. We were unable to answer our first research question; if we were to continue in the project and prepare for another year of the St. Jude Virtual Journal Club, we could discuss our methods in more detail and prepare them well in advance of the start of the scientist talks. We could also discuss and decide whether adding or changing the methods would better address our question. I also could have waited to complete data analysis until we were able to do it as a group. This may have led to the selection of a different approach to analysis, or other teachers may have identified ideas and trends within the reflections that I did not see. Answering this question may have led us to a better understanding of how the St. Jude Virtual Journal Club is, or isn’t, affecting our students’ STEM identities, and I envision that we would then seek to learn more about why.

For the second research question, continuing the PAR process could have led to more ideas about how we can change our teaching practices to address the gaps we were seeing in our students. Making connections to content learned in other science classes led to the overall weakest responses on the student reflections. I imagine that we would want to explore this further and try methods or techniques to improve our students’ ability to make those connections. We all expressed interest in wanting our students to be able to think like scientists. The post-talk reflections revealed that many students were able to identify something they wanted to learn more about, but with more time we could go into more depth about what those things were and consider designing lessons that would explore our students’ interests.

PAR has been used as a professional development tool for teachers (Eilks & Markic, 2011; Jacobs, 2016; Vaughan, 2019). In our PAR process, we have learned new information
about the outreach program and our students’ perceptions that we can use to modifying our teaching practice. With more time or additional PAR cycles, we could dive even deeper into the influence of the outreach program on our students, into instructional materials that could help our students understand the program, or possibly into questions about the influences of the outreach program on ourselves as teachers, addressing my overarching question from the beginning of this PAR process.

The Power of Community and Collaboration

Collaboration is a skill everyone will have to use at some point in their careers. It may be as simple as working with other students in class, such as completing a lab experiment together. I’ve always emphasized the importance of being able to work with other people to my students, often using it as justification for changing students’ assigned seating in class. However, as a teacher, I find I often want to work on my own, even going so far as avoiding collaboration with another teacher if I feel it’s going to take too much time. I know I’m not alone in enjoying that I have a certain amount of autonomy and independence in my own classroom. I enjoy communicating and collaborating when it’s on my own terms, which is not the best approach to either.

Using PAR as my methodology has led me to a middle ground: the collaboration is starting on my own terms, since I made the choice to design the project this way, but I went into it knowing I would have to practice active listening and to give up a certain amount of control. The initial difficulty in scheduling a group meeting forced me instead to schedule individual meetings which effectively became semi-structured interviews. In retrospect, this helped me establish a rapport with each individual teacher and allowed me to learn more about each of them as individuals before diving into any sort of group discussion.
As teachers of upper-level science courses, most of us are the only teacher at our respective schools teaching that particular course. For example, while there was another Biology teacher at my school, she never taught AP Biology, so I didn’t have another AP Biology teacher in my school. Making connections with teachers of the same subject at other schools can provide a valuable community of practice (Kelley et al., 2020). Many schools implement professional learning communities (PLCs) amongst their teachers (Stoll et al., 2006). This project led to the creation of an informal PLC amongst the four of us, giving us opportunities to share and to discuss teaching practices with each other.

Beyond the discussion of the teachers’ project, in each of our meetings we would often end up engaged in small talk or talking about things only peripherally related to the project. We were able to share our perceptions of the St. Jude Virtual Journal Club talks with each other, and we described some of the other events that were affecting our students (such as last-minute events that pull students out of the classroom before a talk, as happened to Alexis more than once). We talked about other assignments we were giving to our students and how those seemed to help, or not help, prepare them for the talks. We also shared other projects, programs, or upcoming events we knew about with each other.

I met two of the other teachers at events unrelated to the St. Jude Virtual Journal Club program. I anticipate that we may continue to work together within the context of the St. Jude program and possibly in other contexts as well. I hope that having established these connections with my PAR co-researchers will continue to enhance my own personal network and teaching practices, and I hope the other teachers feel the same way.
Significance

The significance of this study is twofold. First, the implementation of PAR as a methodology to include teachers in science outreach research is a novel approach. Second, this study provides a better understanding of how well students understood the scientist talks and how their perceptions of scientists did, or did not, change as a result of outreach participation. This is what the teachers in this project wanted to know most about the influence of the outreach program on their students.

Use of PAR as a Methodology to Include Teachers in Outreach Research

As described above, there have been calls for an increase in science outreach as one way to encourage more STEM participation for years (Alberts, 2018; Friedman, 2008). These calls are focused on encouraging more underrepresented minorities – including people of color and women – to persist in STEM subjects and to enter STEM careers. The general idea is that, if practicing scientists interact with students, then more students will understand what it means to do science and may decide they are able to do science themselves (Barry et al., 2022; McCombs et al., 2007). Scientist in the classroom outreach programs tend to focus on preparation of the STEM professional with little or no emphasis on preparation of the teacher (Eng & Febria, 2011; Kaser et al., 2013; Munson et al., 2013; Tomanek et al., 2005).

To ensure teacher interest and participation, I chose to use PAR methodology to create a working group of teachers as co-researchers. Teachers have reported wanting more resources to support virtual scientists talks (McCombs et al., 2007). In another outreach program, teachers felt that the program was “imposed upon them by well-meaning, but educationally naïve scientists” (Falloon, 2013, p. 864). To avoid making decisions for the teachers about what they would want in terms of resources and support or in terms of outcomes for their students, I went
directly to the teachers to ask for their guidance. This has not been done in outreach programs to date; many programs have been designed as scientist-teacher partnerships, where both participants are expected to contribute to the design and implementation of the outreach program (such as Miranda et al., 2018), but no reported outreach studies have used PAR methodology with teachers.

**What Teachers Want to Know About the Influence of Science Outreach on Their Students**

The two research questions asked in the SJVJC Teachers’ Project addressed similar ideas: first, are students’ perceptions of science and scientists changing, and second, are students truly understanding the talks. The first research question is very similar to those asked in other evaluations of outreach programs. The reflection prompt and the survey questions we used were taken from previous studies that were designed to investigate students’ perceptions of scientists (Mead and Metraux, 1957) and students’ attitudes toward STEM (Kind et al., 2007). This question and our approach are well-situated within the existing literature. It is interesting that, even though it is a question that has been asked, the teachers in this project still wanted to know the answer to this question for their own students.

The second research question is more unique. This question came directly out of what we as teachers may ask our students. The reflection prompts we wrote were questions we may have asked students on a questionnaire, on a formative assessment, or in a discussion after each scientist talk. They are questions that drive at what we most want our students to learn: what does it mean to do science, and can you think like a scientist. We want our students to develop a STEM identity and to feel like they are capable of persisting in STEM majors and careers, but these feel more like long-term goals. This second question addresses more of what we would
immediately want to learn from our students so that we can make specific adjustments in the classroom to address gaps in knowledge or misconceptions.

Because these reflection prompts felt personal to us and to teaching, we decided to approach the analysis of these questions how we would approach analyzing information in teaching, by making rubrics. I evaluated student understanding of each reflection prompt similar to how I might grade a formative assessment. The use of rubrics to evaluate reflections is not a new idea, especially not in education (Luft, 1999), but it has not often been applied in evaluating student understanding in science outreach programs. More traditional quantitative and qualitative methods, such as the Likert survey analysis and in vivo coding used to address our first research question, are more common. Use of a rubric allowed me to gain a better appreciation for what students are understanding and how they are applying their knowledge, which is ultimately why we teachers participate in the outreach program.

**Future Research**

The St. Jude Virtual Journal Club currently reaches between 4 and 7 classrooms each year. This reach is largely dependent on the number of scientists trained each fall in the MemSTEMM Ambassadors program. To increase the reach of the St. Jude Virtual Journal Club, St. Jude intends to increase the number of scientists trained each year. Additionally, they intend to recruit teachers of other science courses, such as Chemistry and Biology. As this outreach program expands, we will need to continue to evaluate and to reflect on the program. Additionally, we will need to modify the scientists’ training and to increase the supports available to teachers so that the talks can be integrated into other subject areas successfully.
Future Steps for the St. Jude Virtual Journal Club

One goal of the St. Jude Virtual Journal Club is to reach students from a variety of backgrounds. The program has remained virtual so that distance is not an obstacle to participation for any school or scientist. To increase the accessibility of the program, we intend to make more resources related to the journal club freely available online. Each year of the program, we will ask one or two of the participating scientists to record their talks so that we can make those talks available for anyone to watch. This will make scientist talks available to teachers and schools who are unable to participate in the program for whatever reason and will allow teachers to choose which talks to include, hopefully increasing the dissemination of the outreach program (Krasny, 2005).

In addition to making the scientist talks freely available online, I plan to work with a group of teachers to develop curricular resources that teachers could use to integrate the talks into their classrooms. We plan to create a guide to reading and integrating primary literature in the high school classroom that teachers can use to prepare their students for the scientists’ talks. For the recorded scientist talks, we will discuss what resources should be developed to support each talk and how these might integrate into different content areas. We intend to create resources that can be used with different subjects and levels, such as Chemistry, Biology, or AP Biology, and that are aligned to the Next-Generation Science Standards or the AP Course and Exam Description, as appropriate. I will continue to use the skills I have learned through this PAR project, such as reflection and active listening, as we collaboratively produce these resources. I will also use lessons learned throughout this PAR process, especially how to navigate conflict between roles as a researcher and as a participant.
When training the scientists, we will need to consider how their written summaries and their presentations may be received by different populations of students. The overall content level may need to be brought down; previous years assumed that students were in AP Biology, which meant that there was a certain content and vocabulary with which we could expect all students to be familiar. To reach students in other science subjects, we will need to be more mindful of the best practices for communicating each scientist’s topic to a more general audience. Working with teachers of these subjects will be the best approach to ensure that the content and the vocabulary are appropriate to other high school science classes.

Finally, as we continue through each year of this program, we continue to make changes and adjustments based upon feedback from the students, the scientists, and the teachers. For the 2023-2024 academic year, we plan to make a few changes based on what we have learned from this project. First, the St. Jude educators plan to schedule the talks earlier in the year, between January and March, based on feedback from the teachers about how busy March and April are. Second, we plan to have an informational meeting with the participating teachers in December or early January, before the talks begin. The purpose of this meeting will be to ensure that the teachers know what to expect from each talk, offer suggestions for how to prepare their students for the talks, and to emphasize that this is professional development for the scientists and the students’ honest feedback is valuable.

Final Thoughts on Science Outreach

There is more work to be done here and in other science outreach programs to ensure that all the participants, students, teachers, and scientists, are heard and are valued. In this study, I sought to give a stronger voice to the teachers involved in a scientist in the classroom outreach program. As a result, we learned more about how to address both teachers’ and students’ needs
within the program. We also learned more about what students are taking away from each scientist’s talk. Because it was their teachers who were asking for this information, rather than a third-party researcher, the students may have been more descriptive in their answers. Additionally, because we teachers wrote the questions for the students’ reflections, we may have been better able to word them in a way that elicited more detailed responses from them.

As we implement this outreach program, we will continue to find ways to integrate teachers into the process, to solicit meaningful feedback from all participants, and to change and improve the program. Continued use of PAR methodology would be a powerful way to give teachers voice and to ensure relevancy of outreach for all science classrooms.
References


Coffey, H., & Farinde-Wu, A. (2016). Navigating the journey to culturally responsive teaching: Lessons from the success and struggles of one first-year, Black female teacher of Black students in an urban school. Teaching and Teacher Education. 60, 24-33. doi:0.1016/j.tate.2016.07.021


Appendix A. Teacher Recruitment Email and Attachment

Research Project related to St. Jude Virtual Science Journal Club
Research Project - S Montague.docx;

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and trust the content is safe.

Good morning, Educators,
I hope this email finds you all doing well. We are pleased that you will be a part of our Virtual Science Journal Club this Spring 2023.
One of the participating teachers, Shelby Montague, wanted to share some information regarding a separate, but related, research project to the Journal Club. She would like to collaborate with other participating teachers. Please see the attached Word document for detailed information regarding her project.
Shelby is happy to answer any questions that you may have. Please do not hesitate to reach out to her if you have any questions and/or would like to participate.
Thanks,

---
Cancer Education and Outreach | St. Jude Children’s Research Hospital
262 Danny Thomas Place | Mail Stop 762 | Memphis, TN 38105-3678
phone: 901-328-4751 | www.stjude.org
email: shelby.montague@stjude.org

Comprehensive Cancer Center

Email Disclaimer: www.stjude.org/emaildisclaimer
Consultation Disclaimer: www.stjude.org/consultationdisclaimer
My name is Shelby Montague, and I teach Honors Biology and AP Biology at St. George's Independent School in Collierville. I'm also working on my EdD in Instruction and Curriculum Leadership at the University of Memphis. For my dissertation project, I'd like to ask you to participate with me in a research project about the St. Jude Virtual Journal Club.

For this project, I want you all to help do the research with me (called participatory action research). We will decide on our research questions and methods together, and we will all be conducting the research together. My overall question is, "How does participation in the St. Jude Virtual Journal Club impact teachers?" Who better to help me answer that question than the participating teachers themselves (including me, as a participating teacher)?

We would meet 2-3 times per month for about an hour each time beginning in December. We can decide on meeting times together, and all meetings can be held virtually. Once we make decisions on research questions and methods, we would conduct the research along with our St. Jude Virtual Journal Club visits in February through April. We would then bring together our research products and discuss our results in May.

If you have any questions or if you know you are interested in participating, I would love to chat with you. Please reach out to me at smntague@memphis.edu and we can arrange a time for a phone call or a video call. Thank you for considering.

Shelby Montague, PhD
EdD Candidate, Instruction and Curriculum Leadership
smntague@memphis.edu

-Shelby
Appendix B. Personalized Teacher Recruitment Email Example

St. Jude Virtual Journal Club Project

Shelby Anne Montague (smntague) <smntague@memphis.edu>
Fri 12/2/2022 8:49 AM

To:

I wanted to reach out one more time about the research project I'm doing in collaboration with the St. Jude Virtual Journal Club. Gwen sent out information about it on my behalf last month.

In short, I'm hoping to recruit a few other teachers to work with me this spring on deciding on and creating classroom supports for the Virtual Journal Club visits. These can take whatever form we all decide upon, such as lessons before the scientist visits, practice questions based on the research presented, or discussions about basic research and primary literature with students. Or, we may decide not to make our own supports but instead research/evaluate how the current structure works for our students. It is truly open to what we as a group decide we want to learn. St. Jude would like to develop more supports for teachers and students, but they want to ensure that what they offer is what will actually help us and what we actually want in the classroom.

Even if you can't participate in the research project, I'd still appreciate if you'd be willing to have a phone or video call with me sometime in the next few weeks. I'd love to hear your motivations for participating in the Virtual Journal Club and what you hope you and your students will get out of it.

Thank you in advance for considering, and let me know if/when you are available to talk in the next two weeks.

-S Shelby, Honors Biology and AP Biology

Shelby Montague, PhD
EdD Candidate, Instruction and Curriculum Leadership
smntague@memphis.edu
Appendix C. Initial IRB Determination – Not Human Subject Research

PRO-FY2023-49 - Admin Withdrawal: Not Human Subject Research
do-not-reply@cayuse.com <do-not-reply@cayuse.com>
Mon 8/29/2022 11:53 AM
To:Celia Rousseau Anderson (croussea) <croussea@memphis.edu>; Shelby Anne Montague (smntague)
<smntague@memphis.edu>

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and trust the content is safe.

Institutional Review Board
Division of Research and Innovation
Office of Research Compliance
University of Memphis
315 Admin Bldg
Memphis, TN 38152-3370

August 29, 2022

PI Name: Shelby Montague
Co-Investigators:
Advisor and/or Co-PI: Celia Anderson
Submission Type: Admin Withdrawal
Title: Participatory Action Research (PAR) with Teacher Participants to Promote Curricular Integration of the St. Jude Virtual Journal Club
IRB ID: PRO-FY2023-49

From the information provided on your determination review request for "Participatory Action Research (PAR) with Teacher Participants to Promote Curricular Integration of the St. Jude Virtual Journal Club", the IRB has determined that your activity does not meet the Office of Human Subjects Research Protections definition of human subjects research and 45 CFR part 46 does not apply.

This study does not require IRB approval nor review. Your determination will be administratively withdrawn from Cayuse IRB and you will receive an email similar to this correspondence from irb@memphis.edu. This submission will be archived in Cayuse IRB.

Thanks,

IRB Administrator
Division of Research and Innovation
Office of Research Compliance
315 Administration Building
Memphis, TN 38152-3370
P: 901.678.2705
F: 901.678.4409
Appendix D. IRB Approval of Final PAR Methods

PRO-FY2023-274 - Initial: Approval - Exempt
do-not-reply@cayuse.com <do-not-reply@cayuse.com>
Tue 2/2/2023 2:37 PM
To:Celia Rousseau Anderson (croussea) <croussea@memphis.edu>; Shelby Anne Montague (smntague) <smntague@memphis.edu>

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and trust the content is safe.

Institutional Review Board
Division of Research and Innovation
Office of Research Compliance
University of Memphis
316 Admin Bldg
Memphis, TN 38152-3370

February 21, 2023

PI Name: Shelby Montague
Co-Investigators:
Advisor and/or Co-PI: Celia Anderson
Submission Type: Initial
Title: St. Jude Virtual Journal Club – Students Learning about Science from Scientists
IRB ID: #PRO-FY2023-274
Exempt Approval: February 21, 2023

The University of Memphis Institutional Review Board, FWA000006815, has reviewed your submission in accordance with all applicable statuses and regulations as well as ethical principles.

Approval of this project is given with the following obligations:

1. When the project is finished a completion submission is required
2. Any changes to the approved protocol requires board approval prior to implementation
3. When necessary submit an incident/adverse events for board review
4. Human subjects training is required every 2 years and is to be kept current at citiprogram.org.

For any additional questions or concerns please contact us at irb@memphis.edu or 901.678.2705

Thank you,
James P. Whelan, Ph.D.
Institutional Review Board Chair
The University of Memphis.

https://outlook.office.com/mail/inbox/id/AAQkAGUzNGU3NDU1LWYxYTk1NDdMt11Y2MyLWJHINTc0YmRjZGM1YQAQAMFALEvBUxDoPlErRo%2FONAM... 1/1
Appendix E. Student Assent Form

Institutional Review Board

315 Administration Bldg.
Memphis, TN 38152-3370
Office: 901.678.2705
Fax: 901.678.2199

ASSENT FORM

St. Jude Virtual Journal Club – Students Learning Science from Scientists

You are invited to volunteer to be in a research study being done by Shelby Montague under the direction of Celia Rousseau Anderson (advisor) from the University of Memphis. You are invited because your class is participating in the St. Jude Virtual Journal Club this spring. Participation in this research study is voluntary, meaning it is your choice.

If you agree to be in the study, you will be asked to complete a survey and a written reflection before and after the program and to answer 3-4 open-ended questions after each speaker visit (3 total).

Your family will know that you are in the study. If anyone else is given information about you, they will not know your name. A number or initials will be used instead of your name.

If something makes you feel bad while you are in the study, please tell Dr. Montague or tell your teacher. If you decide at any time you do not want to finish the study, you may stop whenever you want.

You can ask Dr. Montague or your teacher questions any time about anything in this study. You can also ask your parent any questions you might have about this study.

Signing this paper means that you have read this or had it read to you, and that you want to be in the study. If you do not want to be in the study, do not sign the paper. Being in the study is up to you, and no one will be mad if you do not sign this paper or even if you change your mind later. You agree that you have been told about this study and why it is being done and what to do.

Signature of Person Agreeing to be in the Study __________________________
Date Signed __________________________

Printed Name of Person Agreeing to be in the Study __________________________

IRB ID#: #PRO-FY2023-274
Appendix F. Parental Permission Form

Parental Permission for Your Child to Participate in a Research Study

St. Jude Virtual Journal Club – Students Learning Science from Scientists

WHY IS YOUR CHILD BEING INVITED TO TAKE PART IN THIS RESEARCH?

Your child is being invited to volunteer to take part in a research study about their learning as part of the St. Jude Virtual Journal Club. Your child is being invited to take part in this research study because their class is participating in the outreach program this spring. If your child takes part in this study, your child will be one of about 40 children across four schools to do so. Participation in this study is voluntary.

WHO IS DOING THE STUDY?

The person in charge of this study is Shelby Montague of University of Memphis Department of Instruction and Curriculum Leadership. She is being guided in this research by Celia Rousseau Anderson. There may be other people on the research team assisting at different times during the study.

WHAT IS THE PURPOSE OF THIS STUDY?

By doing this study, we hope to learn if our students increase their interest in science and science careers after hearing virtual talks from three different scientists. We also hope to learn if our students are understanding the content of the science talks, if they are connecting the science talks to what they are learning in school, and if they are able to think like scientists.

ARE THERE REASONS WHY YOUR CHILD SHOULD NOT TAKE PART IN THIS STUDY?

This study involves normal daily activities.

WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST?

The research procedures will be conducted at your child’s school. The total amount of time your child will be asked to volunteer in this study is approximately 3 hours total over the next 4 months (February through May 2023).

WHAT WILL YOUR CHILD BE ASKED TO DO?

Your child will be asked to complete one survey twice, once before the start of the program and once after the end of the program, where they rank a list of items with how strongly they agree or disagree with each. They will also be asked to write a reflection between one paragraph and one page in length twice, once before the start of the program and once after the end of the program. After the completion of each scientist’s talk (3 total talk), your child will be asked to complete a second survey consisting of 3-4 open-ended questions about that talk. These surveys and reflections will be completed as part of their regular class time or as an assignment for students to complete on their own. An approximate timeline of their participation and activities is below:

<table>
<thead>
<tr>
<th>Month</th>
<th>Activities</th>
<th>Approximate Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 2023</td>
<td>Pre-program survey, pre-program reflection</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
<td>First scientist post-talk survey</td>
<td>10 minutes</td>
</tr>
<tr>
<td>March 2023</td>
<td>Second scientist post-talk survey</td>
<td>10 minutes</td>
</tr>
<tr>
<td>April 2023</td>
<td>Third scientist post-talk survey</td>
<td>10 minutes</td>
</tr>
</tbody>
</table>
WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

To the best of our knowledge, the things your child will be doing have no more risk of harm than your child would experience in everyday life.

WILL YOUR CHILD BENEFIT FROM TAKING PART IN THIS STUDY?

Your child will not get any personal benefit from taking part in this study.

DOES YOUR CHILD HAVE TO TAKE PART IN THE STUDY?

If you decide to allow your child to take part in the study, it should be because your child really wants to volunteer. Your child will not lose any benefits or rights your child would normally have if your child chooses not to volunteer. Your child can stop at any time during the study and still keep the benefits and rights your child had before volunteering. As a student, if your child decides not to take part in this study, your child’s choice will have no effect on your child’s academic status or grade in the class.

IF YOUR CHILD DON’T WANT TO TAKE PART IN THE STUDY, ARE THERE OTHER CHOICES?

If your child does not want to be in the study, there are no other choices except not to take part in the study.

WHAT WILL IT COST YOU FOR YOUR CHILD TO PARTICIPATE?

There are no costs associated with taking part in the study.

WILL YOUR CHILD RECEIVE ANY REWARDS FOR TAKING PART IN THIS STUDY?

Your child will not receive any rewards or payment for taking part in the study.

WHO WILL SEE THE INFORMATION THAT YOUR CHILD PROVIDES?

We will make every effort to keep private all research records that identify your child to the extent allowed by law.

Your child’s information will be combined with information from other children taking part in the study. When we write about the study to share it with other researchers, we will write about the combined information we have gathered. Your child will not be personally identified in these written materials. We may publish the results of this study; however, we will keep your child’s name and other identifying information private.

We will make every effort to prevent anyone who is not on the research team from knowing that your child gave us information, or what that information is. After survey results and written reflections are collected, they will be stored on a password-protected hard drive.

Participants will be assigned pseudonyms and non-personal identifiers that will be used during all parts of the research process beyond the initial data collection. A digital key code file of participant pseudonyms will be stored in a separate location from the survey and interview data and will be password protected. At the completion of the study, all paper documentation, including consent forms, will be destroyed.

IRB ID#: #PRO-FY2023-274
We will keep private all research records that identify your child to the extent allowed by law. However, there are some circumstances in which we may have to show your child’s information to other people. For example, the law may require us to show your child’s information to a court. Also, we may be required to show information which identifies your child to people who need to be sure we have done the research correctly; these would be people from such organizations as the University of Memphis.

**CAN YOUR CHILD’S TAKING PART IN THE STUDY END EARLY?**

If your child decides to take part in the study your child still has the right to decide at any time that your child no longer wants to continue. Your child will not be treated differently if your child decides to stop taking part in the study.

The individuals conducting the study may need to withdraw your child from the study. This may occur if your child is not able to follow the directions they give your child, if they find that your child’s being in the study is more risk than benefit to your child, or if the agency funding the study decides to stop the study early for a variety of scientific reasons.

**WHAT IF YOUR CHILD HAVE QUESTIONS, SUGGESTIONS, CONCERNS, OR COMPLAINTS?**

Before you decide whether to accept this invitation for your child to take part in the study, please ask any questions that might come to mind now. Later, if you have questions, suggestions, concerns, or complaints about the study, you can contact the investigator, Shelby Montague at smntague@memphis.edu. If you have any questions about your child’s rights as a volunteer in this research, contact the Institutional Review Board staff at the University of Memphis at 901-678-3074. We will give you a signed copy of this permission form to take with you.

**WHAT IF NEW INFORMATION IS LEARNED DURING THE STUDY THAT MIGHT AFFECT YOUR CHILD’S DECISION TO PARTICIPATE?**

If the researcher learns of new information in regards to this study, and it might change your willingness for your child to stay in this study, the information will be provided to you. You may be asked to sign a new permission form if the information is provided to you after your child has joined the study.

*Signature of parent giving permission to take part in the study*  
*Date*

*Printed name of parent giving permission to take part in the study*

*Printed name of student agreeing to take part in the study*

*Name of authorized person obtaining informed consent*  
*Dr. Shelby Montague*  
*Date*
**Appendix G. Student Assent Script**

**Title of Study:** St. Jude Virtual Journal Club: Students Learning about Science from Scientists

**Principal Investigators:** Shelby Montague, EdD Candidate in Instruction and Curriculum Leadership, University of Memphis
Celia Rousseau Anderson, Advisor and Professor in Instruction and Curriculum Leadership, University of Memphis

**Co-Investigators:**
- Tina Gibson, Mississippi State University
- Chris Ronzi, Lake Catholic High School, Mentor, OH
- Nikki Wallace, Crosstown High School, Memphis, TN

**Student Volunteer Recruitment Script**

[This is the beginning of the script. Read out loud.]

Hello. My name is [insert name of PI or of Co-Investigator obtaining assent]. If you have any questions about what I am telling you, you can ask me at any time.

I am conducting a research project with other teachers to study the influence of the St. Jude Virtual Journal Club on our students. You are invited to participate in this study because you are in my class. If you agree, you are invited to complete: a survey and a reflection twice, once before the St. Jude Virtual Journal Club begins and once after all the talks are completed, and three post-talk reflections. The survey and the reflection will take approximately 10-15 minutes, and each of the post-talk reflections will take approximately 10 minutes. The surveys and the reflections will all be completed on a computer or other electronic device.

Participation in this research study is voluntary, meaning it is your choice. Your identity as a participant will remain confidential during and after the study, and we will make every effort to protect your privacy. We will not request your name on the surveys or the reflections, only your initials. Once you complete the surveys and the reflections, your initials will be removed and we will use coded identifiers instead (such as letters and numbers that are not related to your initials in any way). Whenever possible, data will be reported as a group so that individual responses cannot be identified. Any identifying information included in the reflections will be removed or altered (such as changing names) to maintain confidentiality and privacy. After we complete the study, we will store all the data on a password-protected hard drive. Any paper documents, including your assent and permission forms, will be destroyed.

I wish to repeat, participation in this research study is voluntary. Your participation in the St. Jude Virtual Journal Club or in class and your grade in this class will not be affected in any way if you choose not to participate. If you choose to participate now, you can change your mind later and end your participation. All you have to do is tell me.

Do you have any questions? [pause for questions]
Are you willing to complete the surveys and reflections as part of this research study? If so, please sign and return the assent form provided to you, and ask your parents to sign and return the permission form.

[End of verbal script.]
Appendix H. Pre-Program and Post-Program Survey and Reflection

Initials: __________
Select your teacher from the dropdown list: Dr. Beth, Dr. Montague, Ms. Cory, Ms. Alexis
Course that is participating in the St. Jude Virtual Journal Club: Anatomy and Physiology, AP Biology, Research Methods
Gender: Male, Female, Nonbinary, Prefer not to answer
Ethnicity: American Indian or Alaska Native, Asian, Black or African American, Hispanic or Latino, Native Hawaiian or Other Pacific Islander, White

Indicate how strongly you agree or disagree with the following statements using the following scale:
5 = Strongly Agree
4 = Agree
3 = Neither Agree nor Disagree
2 = Disagree
1 = Strongly Disagree

We learn interesting things in science lessons.
I look forward to my science lessons.
Science lessons are exciting.
I would like to do more science at school.
I like Science better than most other subjects at school.
Science is boring.

I find science difficult.
I am just not good at Science.
I get good marks in Science.
I learn Science quickly.
Science is one of my best subjects.
I feel helpless when doing Science.
In my Science class, I understand everything.

I would like to study more science in the future.
I would like to study science at university.
I would like to have a job working with science.
I would like to become a science teacher.
I would like to become a scientist.

Write at least one full paragraph and no more than one page completing the following prompt:

When I think about a scientist, I think of
Appendix I. Post-Talk Reflection Prompts

Initials: ________
Teacher: _____________________
Which talk was this for your class? First, second, or third
Name of Scientist who Presented Talk: _______________________

Write at least one sentence and no more than two paragraphs answering each of the following questions:

- What were one or two key ideas presented in the talk?
- Did you make any connections between the content of the talk and things you’ve learned in science classes? If so, describe one connection. If not, why not?
- What would you like to learn more about? What made you curious to know more?
- If you were the scientist, what is the next thing you would investigate after hearing this talk?
- What in the talk could have been better?
Appendix J. Anticipated Student Responses for Pre-Program and Post-Program Reflection Prompts

1. **Expected student responses for “When I think about a scientist, I think of…”**
   a) Physical characteristics
      i) Lab coat, goggles
      ii) White, male
   b) Personality
      i) Nerdy, brainy, smart, intelligent
      ii) Antisocial or socially awkward
      iii) Driven, curious
      iv) Isolated, alone
      v) Creative
   c) Subjects
      i) Chemistry, Biology, Physics
   d) People
      i) Bill Nye
      ii) Albert Einstein
      iii) Marie Curie
      iv) Watson and Crick
      v) Neil de Grasse Tyson
   e) Actions
      i) Doing experiments
      ii) Using test tubes, glassware, equipment
      iii) Educated, always learning
   f) Importance/value
      i) Discovering important information
      ii) Valued in society
      iii) Finding cures/things for other people

2. **Pre-program student responses for “When I think about a scientist, I think of…”**
   a) More stereotypes, white male in lab coat with glasses or goggles
   b) Doing experiments
      i) Test tubes, beakers, solutions
      ii) Explosions, reactions
      iii) Making new things

3. **Post-program student responses to “When I think about a scientist, I think of…”**
   a) Similarities to scientists in talks
      i) Women
      ii) Non-white - Indian, Black, Asian
   b) Cancer-related research
      i) Models or model organisms
      ii) Drug discovery
   c) Scientists’ pathways
      i) University training

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### Appendix K. Rubric for Analysis of Post-Talk Reflection Questions

<table>
<thead>
<tr>
<th>Post-Talk Reflection Question</th>
<th>3 - Clear, Thorough Response</th>
<th>2 - Some Understanding Evident</th>
<th>1 - Unclear Response or Understanding</th>
</tr>
</thead>
</table>
| What were one or two key ideas? | Student’s response aligns with key concepts presented in that scientist’s talk. Potential examples:  
- W - Treating leukemia patients with low-dose antibiotics increased some antibiotic-resistant bacterial genes in the kids’ gut microbiomes.  
- X - DNMT3A Overgrowth Syndrome results from a mutation that decreases DNA methylation; a new mouse model could help identify new genes to target.  
- Y - Ven drug therapy works better with a second drug, TTFA, on multiple myeloma  
- Z - A new drug, JW-65, worked better at blocking TRPC3 channels and was less toxic than an earlier drug. | Student’s response includes some concepts or key words presented in that scientist’s talk. Potential examples:  
- W - Antibiotics can be used to prevent infections in leukemia patients.  
- X - Changes in DNA methylation can lead to blood cancers.  
- Y - Multiple myeloma drug treatments don’t always work.  
- Z - Drugs can be changed to make them work better. | Student’s response confuses topics with another scientist’s talk or doesn’t exhibit an understanding of the content of this scientist’s talk. The key ideas described are incorrect or are an oversimplification of the content of the talk (for example, saying the talk was about cancer or about leukemia without any clarifying details). |
| Did you make any connections to class? | Student’s response includes a clear connection to at least one topic taught in a high school science class relevant to the scientist’s talk. Potential examples:  
- Cell signaling/signal transduction | Student’s response shows some thinking about the topics in the talk and topics taught in high school class but might not align well or be clear. Potential examples:  
- Lack of understanding of the talk is expressed. | Student is unable to think of a connection between the talk and content taught in class. |

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<table>
<thead>
<tr>
<th>What would you like to learn more about?</th>
<th>What is the next thing you would investigate?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student states additional relevant content knowledge he or she would like to learn. Student expresses interest in learning more about a career path. Student wants to learn more about scientific procedures or processes, including drug discovery and clinical trials.</td>
<td>Student shows clear evidence of “thinking like a scientist”. The student describes an experiment, a process, a disease, etc. that he or she would investigate next that has clear relevance to the scientist’s talk. The student’s “next thing” clearly follows from the content of the talk.</td>
</tr>
<tr>
<td>Student’s response indicates content knowledge, career pathways, or scientific processes he or she would like to learn more about without any specifics or without a clear connection to the scientist or the talk.</td>
<td>The student’s response expresses some evidence of thinking like a scientist but isn’t as clear or specific. For example, the student would want to run additional tests or trials of the same experiment to increase numbers without adding or changing anything.</td>
</tr>
<tr>
<td>Student doesn’t identify anything he or she would like to learn more about or writes a response without any connection to the scientist or the talk.</td>
<td>The student is unable to think of a next thing to investigate either by stating they cannot think of one or by leaving the response blank.</td>
</tr>
</tbody>
</table>

- Antibiotic resistance
- Lock and key enzyme function
- Epigenetics/DNA methylation
- Class connection described wasn’t mentioned in or important to the talk.
- Student states they haven’t learned anything that connects.