

Participatory Action Research Experiences for Undergraduates

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Abstract: We present a new conceptual model situating research experiences for undergraduates within a context of participatory action research. The purpose of the theoretically grounded Participatory Action Research Experiences for Undergraduates (PAREU) model is to act as a second year addition to traditional, lab-based research experiences where undergraduate science students, social science experts, and community members collaborate to develop research with the goal of enacting change. In addition to providing practical benefits for communities with needs solvable by scientific research, the model builds on and expands student skills gained from traditional research experiences. Deep and sustained engagement among scientists, social scientists, and community leaders is expected to empower community members, create better informed citizens, and improve their ability to solve problems.

Keywords: Postsecondary Education, Out-of-School Learning, Community Development

Introduction

Because “social life is a dialectical struggle” between structure and agency, the two are inseparably linked (Musolf, 2003). Structure refers to the social practices and arrangements that constrain and exert power over individuals, while agency comprises the social actions by individuals and groups that challenge or oppose these ‘norms’ (Ritchie, Mackay & Rigano, 2006). Sociologists have long explored the balance of power between institutionalization and social construction of societal norms in an effort to better understand how some people are empowered and others are disenfranchised (e.g., Berger & Luckmann, 1966; Giddens, 1984). The relationship between structure and agency is, therefore, relevant to the discipline of science education because it impacts who makes decisions around socioscientific issues, what those decisions are, and how they are enacted. Formal science knowledge is produced and possessed by individuals with an advanced degree in science. In the current structure, formal science knowledge is regarded highly in society at the expense of those who have traditional knowledge but little or no formal post-secondary education in the sciences (Mueller & Tippins, 2010). The traditional knowledge that may be drawn upon by different individuals or communities to make socioscientific decisions is often not valued by other groups as important to the decision making process. Subsequently, there is a hierarchical power dynamic wherein formal science knowledge is valued more than other knowledge, further marginalizing non-scientists.

The discourse norm of each social group is distinct because language is culturally bound and individuals, as a result, communicate with others in different ways (Gee, 2014). For example, although scientists engage in dialectic argumentation with one another within their respective community of practice (CoP), their communication style with those outside of their CoP falls more often into demonstration argumentation (Mooney & Kirshenbaum, 2010; Walton, 2005). Dialectical argumentation involves the equal negotiation of proposed claims as both parties seek to find truth. In contrast, demonstration argumentation involves only one authoritarian voice, which seeks to explain truth by supporting a claim with evidence (Walton, 2005). It is not surprising that individuals communicate differently with others who they do not

perceive as legitimate participants of their CoP (Lave & Wenger, 1991). If one group has access to knowledge that is empowering and excludes the other group from engaging in dialectical discussion, it creates a hierarchical system wherein one or more CoPs believes that they are superior to others. To move past the prearranged typifications of “scientist” and “non-scientist,” we argue for the need of a mechanism to shift the traditional hierarchical structure to one of interconnected CoPs where all voices are valued (Berger & Luckmann, 1966).

As part of a larger study around research experiences for undergraduates (REU), a second-year component based on participatory action research (PAR; Habermas, 1998) was implemented within a historically marginalized community in southern Louisiana. The community is suffering economic and social impacts associated with extreme land loss where contributors such as climate change have caused adverse effects such as fishery decline, loss of native plants used as medicines, and increased hurricane damage due to factors such as sea level rise and saltwater intrusion. Members of the community planned to use findings from this PAR program to help secure governmental financial aid. Social and natural science researchers who developed the program expected that community members would benefit from an increased understanding of the science (and how these findings were generated) as a result of the PAR-based REU. This new knowledge would enable them to make scientifically informed decisions that would benefit their community and the lives of individuals within it. The program developers anticipated using the evaluation of this program to justify future grant support. Student REU participants were expected to develop stronger understandings of the real-world relevance of their scientific research, improve their public communication skills, and be more likely to remain in STEM studies/careers. Because climate change has become a highly politicized socioscientific issue, it is important for scientists to not only learn effective communication skills and reframe their message but to also develop empathic listening skills so they know what concerns non-scientists have and how to value their local knowledge (Moser, 2010; Nisbet & Mooney, 2007).

The prolonged experience of the student participants in this program enabled us to begin to identify themes related to how individuals from different CoPs interact with one another. From these themes, we propose a conceptual model of Participatory Action Research Experiences (PARE) for programs that describes how change agents can help increase collective agency across CoPs. It is our intent that this model serve as a means to empower all participants to be agents of change. This includes students, social and natural scientists, and the community. However, we posit that this model can be used as part of education programs whose aim is to allow different CoPs to converge as they work towards addressing a common socioscientific issue.

Theoretical Framework

Communities of Practice (CoP)

A Community of Practice is a group of individuals with three key components. First, they share an area of interest (a domain), and membership implies a commitment to this specific area of interest. Second, members must be actively engaged in shared activities and exchanging information. Third, membership in a CoP includes a practice wherein members develop a shared repertoire of resources (Wenger, 1998). The third element is what distinguishes a CoP from a community of interest. A CoP is often formed as a group of individuals learns together over time, forming a dynamic, informal social structure within an already existing structure (Wenger,

2009). A CoP involves more than the technical knowledge or skill used in a task; it involves practice, or ways of approaching problems that are shared among members. Learning is viewed as the movement from legitimate peripheral participation to being a core participant after a transitional period (Lave & Wenger, 1991). This movement occurs through participation in authentic activities of the community. The CoP model is applicable to apprenticeships, including science research experiences during which a student learns about scientific processes with an expert (e.g., Barab & Hay, 2001; Feldman, Divoll & Rogan-Klyve, 2009). Participating in a science CoP allows members to engage in scientific inquiry through which they build conceptual understanding, and develop an identity as a scientist. By actively participating in a CoP, members move from the periphery to the core as they transition from novice to expert. This transformation is facilitated by the acceptance of other experts within that CoP of newcomers. “Apprentices learn to think, argue, act, and interact in increasingly knowledgeable ways, with people, who do something well, by doing it with them as legitimate, peripheral participants” (Lave, 1997, p. 19).

Many interrelated CoPs exist in a complex social system, which are often hierarchical. Wenger (2009) argues that learning within each CoP naturally creates boundaries through a shared history of learning. Vertical (hierarchical) accountability often exists within social systems made up of multiple CoPs, even while horizontal accountability through negotiation and engagement in joint activities exists within CoPs. Although these two forms of accountability both have strength, and should interplay with each other, their value is not always visible. In order to better integrate the vertical and horizontal structures, transversal agents (i.e., *change agents*) who can move between these structures can break through boundaries between CoPs. Because in our current social structure, scientist and non-scientist CoPs exist in hierarchy while valuing horizontal accountability within their own CoP, this “CoP within complex systems” model is appropriate as we examine the impact that research experiences for change agents can have on members’ agency within and outside their own CoP.

Research experiences for undergraduates (REU)

In response to a shrinking pipeline of undergraduates choosing to pursue and persist in science fields, significant funds are set aside for internships that provide students opportunities for authentic, student-centered learning within the context of research (e.g., National Research Council, 2000, 2003; National Science Foundation, 2003). The National Science Foundation funds perhaps the largest number of research internships by offering funds to support REU programs at numerous universities and organizations that are designed specifically for science, mathematics, and engineering fields. Many effective models for undergraduate research programs exist, and these typically share three main characteristics: (a) advising; (b) supplemental instruction; and (c) research (Villarejo, Barlow, Kogan, Veazey, & Sweeney, 2008). Advising is received from mentors and graduate students while supplemental instruction most often comes from peer mentorship, , conferences, and the independent research. The research that occurs in REU’s varies vastly by model, institution, and discipline (Lopatto, 2009). The research roles for undergraduate students in REU programs are defined by: contact time with a mentor; the nature of the mentor-mentee relationship, who conceptualizes research projects; the relationship of the undergraduate researcher with the rest of the research group; and the level of responsibility given to the undergraduate researcher. Common outcomes across most REU programs include students’ personal/professional development, ability to synthesize knowledge, improvement in research skills, professional advancement, intellectual growth, and retention in

STEM fields (Seymour, Hunter, Laursen, & DeAntoni, 2004; Lopatto, 2000; Maton, Hrabowski, & Schmitt, 2000).

Participatory action research (PAR)

PAR is based on the well documented premise that people working together are more likely to be democratic and the results are more likely to be implemented, supported, and successful than if they act singularly (Scott, 1998). The goal is to solve concrete problems through collaborative research grounded in group reflection and decision making. The entire research process is collaborative; from determining research questions to decisions about research methods, outcomes examined, data collection and analysis, and translating the research into a plan for action. Reflection is a central part of PAR because it allows participants to find inconsistencies in systems, structures of power, and dominance that can be changed. Through analytical discourse, knowledge is created, supporting change to occur (Fanon, 1961).

PAR differs from both science and social science research (Kemmis & McTaggart, 1988) and sets itself apart even from other forms of action research because of the central role that community experts play. There are six important aspects of PAR (Kemmis, 2005): PAR is 1) a social process, 2) participatory, 3) practical and collaborative, 4) emancipatory, 5) critical, and 6) reflexive within a historical context. Essentially, PAR is a philosophical and methodological process for bringing unheard voices into the public sphere (Habermas, 1998) and giving an equal voice to everyone with the goal of mutual collaboration and problem solving. The mechanisms to bring about such a change and the main drivers of the change must be argued and negotiated as part of PAR. PAR strives for action or change, going beyond seeking to understand a problem. Developing an REU program within the context of PAR has the potential to support students who may otherwise exit the field altogether (James, Starks, Segrest, & Burke, 2012).

Methods

Context

The four partners who developed the PAR-based research experience include a university climate science research center, two geoscience REU programs, and a research institute known for collaborating with communities and organizations to conduct research that builds on community knowledge and scientific knowledge in the southern Louisiana community where this study took place. The university research center has supported over 50 undergraduate interns at seven universities, all of whom have matriculated into either graduate study or professional positions focused on climate change. Most of these interns studied climate science in a lab or field-based experience, and others conducted interdisciplinary studies related to climate science that overlap areas such as Psychology, Sociology, Ecology, Political Science, and Education. The two REU programs involved in this partnership act as undergraduate-to-graduate bridge programs. These are extremely successful programs with an average undergraduate-to-graduate success rate of at least 80%. The aim of the final partner, the research institute, is to support applied research focused on sustainability and resilience efforts related to the natural, technological, and environmental risks in the region. To accomplish this, the institute facilitates the exchange of knowledge about research-based science and traditional ecological knowledge. Over 85% of the graduate students trained through their interdisciplinary research assistantship in community adaptation have received their degrees and gone on to relevant professional positions and doctoral programs in other institutions. Through this

assistantship program, the institute has supported majors of sociology, public administration, political science, geography, anthropology, economics and civil engineering.

South Terrebonne parish is home to a community of people that have lived off the land and water for centuries, sharing a unique connection to their environment. Their history began with involvement in the sugar industry during the 1880s, then transitioned to oil and gas extraction as well as commercial fishing by the mid-1900s (Gould, 1984; Woodman, 1979). Today the parishes of coastal Louisiana are responsible for providing about one fourth of the nation's supply of crude oil and natural gas. Coastal Louisiana has also become the number one producer of shrimp, oyster, and crawfish in the United States (Benoit, DeMay, Pitre, & Carmondy, 2010). Unfortunately, the area has faced dramatic geomorphologic changes that result from centuries of industry and urbanization related activities (Austin, 2006). From the years 1932 to 2000, Louisiana has lost approximately 25 percent of land area (approximately equivalent to the size of Delaware). With the persistence of the current land loss rate and additional projected impacts of sea level rise, Louisiana will experience a land loss rate equivalent to losing an average of one football field per hour (Couvillion et al., 2011).

After having previously participated in lab-based REU program, three undergraduate research interns participated in PAR-based projects that supported community viability in the face of current and historical ecosystem change by integrating physical science, geospatial technology and traditional ecological knowledge. For nine weeks, the interns lived and worked in Louisiana coastal communities and learned how projects can be defined by, guided by and assessed against community priorities. Unlike the structured REU experiences these interns experienced in prior summers, the entire process and design of the PAR-based experience was organic. The undergraduate interns went to Louisiana with some ideas about their project, but once they integrated into the community, all of their original "plans" changed. Interns were introduced to participatory action research methods by social and natural science faculty mentors helped them apply PAR methods within the community to address the scientific concerns of the community. They received support and guidance about PAR throughout the summer. In addition, the interns were introduced to scientists with local research specialties at universities and federal applied research centers in the area. The interns relied upon these supports as they worked with community members to develop and implement community-based research projects around land-loss, ecology of culturally important plants, and water quality.

Undergraduate Student Participants

Two of the three interns who participated in the PAR-based research experience agreed to participate in this study. The two participants chose pseudonyms that are used here. Prior to attending university, Felicia grew up in a low-income family on the east coast and spent much of her childhood in New Jersey, North Carolina, and Virginia. At the time this study was conducted, Felicia was about to be her final undergraduate year at a historically black college for women. Felicia was recruited into the PAR-based program through another lab-based REU program she had previously participated in because of her interests in studying environmental change and its impacts on traditionally marginalized populations. At her university, she was working toward a double major in anthropology and environmental science. She is now in graduate school at a large public research university, studying environmental sociology. The project she participated in during the PAR-based experience focused on identifying plant species vulnerable to salt water intrusion and land loss, and understanding

which of these plants were valued by the region's Native American tribes for cultural and medicinal reasons.

Sarah was born in Nairobi, Kenya, and grew up in an upper-middle class family in Maryland. During her formative years, she regularly spent time with her family in Kenya. Sarah was about to begin her final undergraduate year at a private STEM-focused university studying Meteorology when she participated in the PAR-based experience. She had spent the previous three summers participating in a lab-based REU program, and was recruited into the PAR-based experience because of her interest in studying hurricane impacts on communities. Sarah has since earned her graduate degree in Meteorology at a public research university, where she extended the PAR-based research in the Southern Louisiana community for her graduate work. Her research was carried out with local mentors and in conjunction with the Southern Louisiana community to develop a mobile phone app prototype to raise awareness of the cultural impacts of extreme land loss as well as the importance and benefits of community collaboration. Sarah is currently a high school mathematics teacher and has plans to found an institution for environmental awareness regarding climate change impacts for the region in which she lives and teaches.

Positionality of the Researchers

This study that describes the experiences of undergraduate students as they completed a PAR-based research experience was conducted by four individuals at a research university. Because this study was conducted with undergraduate students, both of whom were from underrepresented communities, it is important for the researchers to be aware of their positionality (Banister, Bunn, Burman, Daniels, 2011). The researchers were cognizant of aspects of themselves that may put them in the same positions of power they are interested in overturning. Three of the researchers are women from of European descent, two of whom hold academic positions and the other of whom is a graduate student at a large research university. One of the researchers is a women of South Asian decent with an academic position at this same university. Three of the researchers have graduate degrees in a natural science field and are interested in the social impacts of science research, and their research is broadly focused on promoting good science communication and outreach efforts. We discussed our positionality with Felicia and Sarah and contacted them after data analysis and interpretation was completed in order gauge the extent to which our findings align with the their experiences and feedback.

Data Collection & Analysis

Data were collected in three one-hour interviews with each of the two participants (either in person or online through Skype). The interview questions were developed using the constructs described in the Undergraduate Research Student Self-Assessment (Hunter, Weston, Laursen, & Thiry, 2009). The first interview occurred before the PAR-based experience and focused on prior REU experiences, motivations for participating in the PAR-based experience, academic goals, expectations about the research experience, and skills needed to accomplish personal and program goals. The second interview took place immediately after the PAR-based experience and focused on the participants' personal and professional growth, the reactions of others to their research, recommendations for future students who may participate in a similar programs, and perceived impact of the experience on the community. The final interview occurred six months after the experience and focused on the use of skills gained during the PAR-based experience, how others (i.e., community, peers, faculty, other scientists) reacted to the students' PAR experience, the influence PAR project on the student researchers' perspective on science and

society, impact of the experience on student researchers' learning and participation in science, and influence of the program on graduate and/or career choices.

Data were analyzed following a thematic analysis approach (Braun & Clark, 2006), and constant comparative coding methods were used (Glaser & Strauss, 1967; Birks & Mills, 2011). First, open codes were developed to capture the initial patterns observed and used to create axial inductive codes. All codes were collapsed in several rounds and organized into categories based on themes (Saldana, 2009; Birks & Mills, 2011). Domain and matrix analyses were used to examine the relationships between codes and ensure that they were representative of the data, as well as to compare and contrast between interviews and themes (Spradley, 1980; Gibbs, 2007). Three members of our team completed this process independently and compared our findings. In this process, we were able to further refine our salient themes. For example, the initial codes of: voice elevation, community reaction to collaboration, empowerment, NOS knowledge, articulation of relevance of social research to society, and improved communication between stakeholders were collapsed into our final themes: communication and content knowledge. These themes informed our propositions presented below. Hence, trustworthiness was increased through prolonged engagement (multiple interviews with the same subjects), negative case analysis (matrix analysis), checking findings against raw data (constant comparative approach), peer debriefing, and cogenerative dialogue (Lincoln & Guba, 1985; Eldon & Levin, 1991).

Findings

Students and community leaders developed research projects through the PAR process based on the needs of the community and expertise and interest of the two groups even though participants had not received formal training in this method. As a result of this community-based experience, the interns report that they and the community member partners experienced increased agency through two developed knowledge sets: 1) communication and 2) understanding of the nature of science and social science. Through the improved skills of being able to articulate concerns and suggestions with those within their respective CoPs as well as those in other CoPs, participants and community members further developed 1) the ability to bring a broader group of people together to listen to one another and 2) share solutions to perceived problems related to climate change.

Improved Communication with Other CoPs

In contrast to the authoritarian voice often used by the science community when speaking with individuals outside their CoPs, both student participants saw the value of being able to communicate with non-scientists. Although they recognized this prior to the experience, they grew in their perceptions of how communication should occur between different CoPs. Before her internship, Sarah spoke of communicating with community members as if she were a scientist conveying information, *"I still have valuable information in terms of taking scientist's research and being able to communicate it to a community. That's something some scientists may not have done, or do, even though they should"* (Interview 1). After the experience, they moved away from demonstration argumentation toward the dialectical. Felicia corrected her own language about communication during the second interview.

Felicia: So, basically, I went out in the community, I did ethnography, I was interviewing people, tape recording...

Interviewer: What were you interviewing them about?

Felicia: Um, Well, I guess the word “interview” is not good because it was more like “conversation” because the methodology for PAR is conversational.

Later, she expanded on this (Interview 2):

Felicia: I think [the experience is] very effective because now, in a sense, we are kind of like local experts on the area just by talking to people. Not necessarily going through and mapping stuff and reading the papers, just by talking to people we know so much—we know more than enough information about the area. We can’t even describe everything that we learned. So, I think that talking, and conversations, is very important.

Sarah flipped the traditional hierarchy around when she talked about the conversations she had with community members.

Sarah: Instead of me going in as this higher research area that knows everything, I went in there ... needing to learn something from the communities and they are the ones that had the valuable knowledge. I was not necessarily the knowledgeable one and so in seeing the community and seeing the environment and seeing how vulnerable they actually are, that internship just made me learn that you need to look more into such communities to be able to help them...

Both participants acknowledged the need to look past the prearranged categories each person has placed members of other CoPs into. In this case, they were talking about the assumptions they had made prior to traveling to Louisiana. Sarah describes reflecting on one’s a priori assumptions as a skill one needs to have in order to be an effective communicator.

Sarah: You need to be able to know to not go in there with all these biases and assumptions about the people. Like I went in there with all these biases and assumptions, but then that’s part of PAR, decolonization, getting rid of all of that to be able to do your work efficiently. But if you can’t do that, then you’re not going to be able to do your work. So, I talked to a lot of people about the issues over there, in the bayou, and it gets people angry, how nothing is being done, but you can’t get angry about it or else you’re going in there in a certain mindset, saying, “okay, I’m going to help these people.” But, it’s not you helping because you’re like working with them to get their story out.

The student participants were not the only partners who benefitted from the experience. In the second interview, Sarah described one of the community leader’s transformation to that of a border crosser. Whereas he started the summer shying away from conversation with scientists outside his CoP, by the end he had become comfortable engaging and interacting with scientists. Sarah conveyed that in the beginning he felt he did not know the technical “jargon” and did not feel like his language was sophisticated enough to use when speaking with scientists.

Sarah: ... in the beginning of the summer he wanted me to do everything and I was like, “no.” I mean, I said yes, it was fine, but then I started bringing him along to all these meetings that I had so then he started to see how communication happened between me and scientists. So, then by the end of the summer he was able to talk to scientists. He was okay with it.

By the end, Sarah recognized that this community member felt more comfortable with his own language as he realized the same message could be conveyed both with his language and the scientific technical language. In fact, Sarah kept in contact with this particular community leader, and by the third interview she mentioned that he had attended several science-focused conferences to present the work he and other community members had done with Sarah over the summer and had continued to do after she left.

Better Nature of (Social) Science Understanding

Felicia and Sarah came to the summer research experience with different levels of science and social science experience. Felicia was in an academic program that blended environmental health and anthropology, so she had experience with ethnography and other social science research methods. However, she noted that her physical and atmospheric science background was quite small compared with other interns in the lab-based REU in which she had participated the prior summer. Her discussion about that experience was focused on her being a novice.

Felicia: Okay, my first summer I worked under [an esteemed research scientist] and I studied ozone formation in the upper troposphere using WRF-Chem data analysis. So, basically, they said I was privileged to work under such an esteemed scientist that she brought me on in her research. Before participating in this project I had no programming experience. I didn't really know anything about atmospheric chemistry. I was a novice and after doing this project I learned so much and I'm excited about everything else I've done on this.

Contrasted to this, Sarah, who had participated in lab-based research experiences the two previous summers, talked about those experiences in a collective voice (i.e., she used the word "we"). When discussing this, Sarah related that she used the collective voice because she thought so highly of her mentors that she did not feel it was her right to claim the research as her own. She said that without her mentors, the research was not possible. By using the collective voice, it was her intent to make certain she gave them the credit they deserved.

Sarah: The first summer my research mentor was [an esteemed research scientists]. And I actually worked with him last summer as well because I enjoyed working with him greatly. My interest is in hurricane impacts, and so the first summer I ended up doing, or making, a hurricane damage index that would estimate the potential damage of a storm before it makes landfall in dollar amounts. We were comparing it to the Saffir-Simpson scale that is used now ... if they heard like a dollar amount of how much damage something would cause they would react to it differently, as opposed to saying "oh, this storm may knock down some trees."

Although both women had a desire to undertake interdisciplinary research, Felicia had more past experience with social science methods from her undergraduate coursework. Even with the prior social science knowledge, Felicia still did not feel like an expert in social science research, PAR in particular. In her second interview, she reflected on the disconnect between the classroom and the field: "...I thought I knew what [PAR] was, but I think I really didn't because it's very different from what I thought it was. It's so different reading something theoretically in a book versus being down there doing it." Later in the interview, she expanded on this experience:

Felicia: It was just at first we were still in that mindset of [the laboratory], how research is done. It took a while for us to get over that.

Interviewer: So, your whole—I'm not going to say whole...your whole vision of what research is really changed.

Felicia: Yes, it did. It definitely did. And I feel like I had a leg up on Sarah and [a student from another program] because my coursework has included things on decolonization and sociology, but they—I think it was harder for them because they didn't have that background.

Interviewer: If nothing else, at least you had the vocabulary.

Felicia: I had the vocab, but I didn't understand it. So, that was hard for me. But I was like "oh, yeah, decolonization."

The embedded community experience brought to the forefront the differences between lab-work and fieldwork, particularly when the fieldwork involves collaborating with members of another CoP. Although both women grew in their knowledge of social science, Felicia seemed to have moved farther along the novice-to-expert path, particularly in methods relating to PAR. When asked about her research in the second and third interviews, her language was much more inclusive of other CoPs. She recognized this explicitly during her third interview.

Felicia: So you know like I don't understand how you can be doing environmental research without being in the environment. You have to talk to people and see what they are talking about and hear their voices and hear their stories to really get it. Otherwise, I don't understand how you can learn it all without being there to apply it.

Sarah, as well, talked about the importance of being in the field and listening to collaborators from other CoPs. However, her discussion of the scientist/non-scientist relationship centered on context. When asked if the PAR-based research program had impacted her current work (hurricane modeling), her focus was on her own work, and not the work of a collaborating group. The PAR process was used to provide context to the research, not to develop a research study around mutually beneficial goals. When she entered the community, Sandra saw the PAR and the hurricane modeling as two different entities. The PAR project was completely different from the hurricane modeling she had done the previous two summers. She went into the summer with the understanding that she was dropping the hurricane modeling to pursue this PAR project. While PAR did not affect her previous research, it affected her in other ways and ultimately her interests.

Sarah: But the PARS [sic] isn't necessarily going to affect the modeling directly, but at the same time it is going to put it into context and help me as a researcher to understand and motivate me even more to do this modeling and see why it's important. So, it's not necessarily going to affect the research, but it's going to affect the researcher.

Interviewer: How so? I want to make sure that I get this because your point is interesting.

Sarah: Yeah, so I am just saying that to do the PAR methodology is more of a gain to the researcher to help them understand why they're doing the research.

Interviewer: Oh, okay. Good. That's awesome. [The project leader] wants to know how you grew professionally. Do you have anything to add that would help us answer his question?

Sarah: Professionally? I know now, even more than I did before, how important it is if you are doing research to understand the people that you're doing the research on. For the past couple years I have been doing the hurricane modeling. You're actually just looking at a model, looking at a hurricane going by on the computer screen, but I'm not thinking about the people that are living there. But now it is something that I'm going to think about that's going to be in my head.

Although it was clear from all three interviews that Sarah respected the community members and wanted to learn from them, her language about research in the community centered on the scientist as the researcher and community members as the research subjects as opposed to research partners. This is interesting, as Sarah actually continued her partnership with the community after the summer experience. She went so far as to develop a data collecting manual for the community members so they could continue the work. Furthermore, she moved away from the modeling because of the calling she felt to do community-based work.

Throughout the PAR-based research program, the community members changed their perceptions of science and math. This allowed them to begin thinking like a scientist and doing research to help positively impact their community. In her second interview, Sarah discussed the changes she saw in the community members with whom she worked.

Sarah: ...compared with how they were thinking and talking with me in the beginning of the summer, I think it changed. Just the way they think and inquire about things now has matured in that short period of time because someone was there to like poke at their brains.

Interviewer: Really?

Sarah: Yeah, so I feel like now they know that they have the potential to think a different way and create knowledge for themselves out of that new thinking.

This idea arose in her third interview as well, where Sarah noted that community members saw that "*science is not necessarily all math and numbers*", which freed them from their fear of science, and allowed them to participate fully in the research as researchers and not simply community members.

Empowerment Within and Outside CoP

In our study, the Southern Louisiana community was clearly the marginalized group. Felicia noticed that at the beginning of the program, community members were interested in and open to a partnership with the student participants, because they knew it could help them. But that sense of empowerment was through elevated voice, and a greater awareness of those outside their CoP to the issues within that community.

Felicia: So, I think the community members, they were—they might not understand what we were doing but they were willing to help out because they feel like any type of awareness could have increased funding and allowed them to maybe get federal recognition or just increase funding so they can actually be included—like right now they're not really included in the 2012 Louisiana Master-Plan. So, it's, like, political. They appreciate us for political and economic reasons.

Through their collaboration on research, their growth in communication skills and changing perceptions of the nature of science led to a sense of empowerment to be more proactive as researchers toward the goal of enacting change. Felicia talked about encouraging one of the community leaders who wanted to take online botany classes in order to bring that knowledge back to the community. Sarah discussed the changing identities she saw in her community partner, which led to their empowerment.

Sarah: Doing the research with the community empowered them in a way that they know that what they have in their head, their knowledge, can be used for research... Because they're stuck with this stereotype that they are not smart. And that gets to them. I mean, they know that they're smart but because it's always pushed on them that they're not, they just keep quiet and their voices aren't heard and they don't think that they're going to be heard because it won't be heard most of the time but at least now they know that they can think a certain way and get their voices heard.

Sarah further explained that through the experience, the community members have moved from the periphery of research, where they simply provide input to the researcher, toward being central to carrying out the research.

Sarah: This project has become something that the community is able to partake in and create for themselves and have their own project, which for me is the more important part.

In speaking about the community leader with which she worked most closely, she recounted, "he said he 'wanted to do something to help my people out, but I don't know how to do it.'" Through the PAR-based collaboration, Sarah noted that he was essential to developing the mobile application central to their research study, even though he still insists he is not a "science person."

The student participants, too, were more confident in themselves and empowered to continue combining social science and natural science research. Felicia described growing as a researcher through the relative independence of the program.

Felicia: Umm, before starting this, I didn't know what I was getting into, so I feel like it forced me to mature as a researcher, my confidence really grew because I was out there and I had to really you know I had the assistance from my mentors, but at the same time I had to really draw from my inner strength...I'm glad I had the opportunity because I've grown so much, I think, in confidence in talking about my research and just learning different methods. You know, usually in undergrad you're just doing what your teacher tells you to...

Sarah mentioned that the skills and confidence she gained in the research experience transferred to teaching. Her background was in Meteorology, and when she was asked to teach environmental science, she had to first teach herself the material she was going to use in class. Her ability to acquire knowledge on her own gave her the confidence to stand up in front of undergrads to teach things she did not necessarily have a background in.

Sarah: So that whole confidence thing, in me being able to build up something myself, definitely helped out in me being able to teach and particularly [in teaching]

environmental science because ... I originally was not in environmental science. [Before I could teach environmental science] I had to teach myself everything before I had to teach the students and so all the skills I learned over the summer were definitely helpful in the Fall.

In contrast to the Felicia during the first interview where she felt like a natural science novice, by the third interview, Felicia's growing confidence had empowered her to feel able to educate science experts on the expanding view of science. It also allowed her to break free from the fear of being labeled a pariah in the science community for integrating social science into her research.

Felicia: So, I think when I present in front of more physical scientists, I'm going to be actually educating them on how science is expanding and you can't just limit yourself to one definition. But, I haven't gotten there yet.

Interviewer: Now, did you have that set before you went there or was it...

Felicia: A little bit because I'm studying sociology and environmental science at my school, but it wasn't fully developed. Like, after doing this research with CHART it's like—I can speak on it.

Interviewer: You've got depth.

Felicia: Yeah, I've got depth. I had, like, initial ideas, but it was more like—I guess I felt like there was a stigma attached to doing social impact or that type of work. And then, once I did this project, I felt like—I feel like no stigma. I know what I do is relevant and I can talk to anyone about it and tell them how important it was. It helped me a lot.

When asked how science experts viewed the collaborative work she had done over the summer, Sarah described a changing viewpoint. She ruminated that perhaps that the hierarchy is slowly shifting due to a younger generation of scientists like herself.

Sarah: My advisor from undergrad was completely gung-ho about me going into atmospheric science for grad school. As soon as I told him that I was going to do environmental science and I had that calling to do more of a social science experience. He was disappointed in me in a way, which was disheartening. He was so close to me in all of my undergrad. I emailed him letting him know what I was doing this past summer. He seemed excited, but not wholeheartedly excited... Fortunately, he was at the meeting in January and sat in my talk and apologized to me... and was ecstatic about the type of work I was doing. I don't know if that is what it takes for the physical science to realize that it's important to talk about problems. More scientists can do that and cross that bridge. An interdisciplinary movement is slowly happening, it's more up to the younger generation of scientists to start it and make it happen.

Discussion and Implications

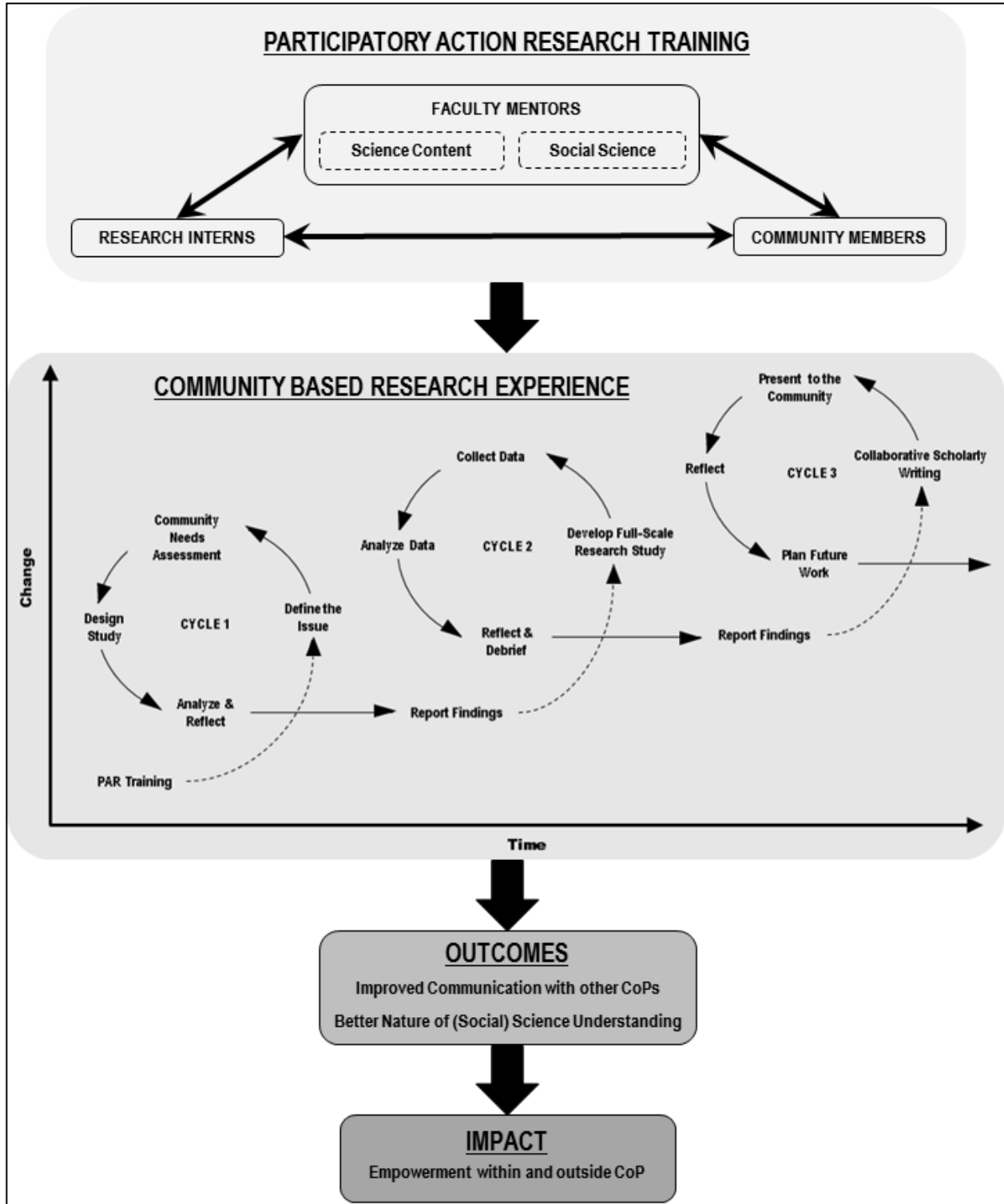
The themes present in the participant interviews reveal the potential for a community PAR-based research experience as a follow-up to more traditional lab or field-based research experiences. Specifically, such a program has the potential to positively impact 1) student communication skills, particularly to non-science audiences, 2) student and community understanding of the nature of science and social science, and 3) student and community within and outside their communities of practice. The themes we found in participants' interviews were

surprising to us, as the initial focus of the study (and inherently the interview questions we asked) was aligned with outcomes of traditional lab and field-based experiences. The prevalence of the themes throughout all three interviews of both Sarah and Felicia led us to dig deeper and more intentionally understand the students' experiences and perceptions as they related to communication, empowerment, and knowledge building for both themselves and the community.

A Model for Community-Based (Under)graduate Research Programs

Based on the themes that emerged through the participants' interviews and follow-up member checking conversations with the participants, we have developed a program model that supports productive collaborations between multiple stakeholders as they address socioscientific issues (Figure 1). The Participatory Action Research Experience (PARE) model is an extension of the PAR framework because through intentional programming, it facilitates the convergence of experts from different CoPs to collaborate with one another in a research process adapted from Coghlan and Brannick's (2010) Action Research Cycle .

Figure 1. The PARE model describes how change agents help increase collective agency across CoPs. The goal of PARE is to empower agents of change to draw on multiple funds of knowledge to facilitate communication about socioscientific issues between distinct CoPs.



The PARE model was developed not only with the participant experiences in mind, but also their recommendations for critical components in a PAR-based research program. Within the model, students, faculty mentors, and community members collaborate to plan, enact, and implement community-based research with the aim of positively impacting the community. First,

the students go through training around PAR methods and develop a communication plan for when students are in the communities, as faculty mentors may be communicating from a distance. Intentional, pre-planned and sustained PAR methods training was added to our model, as most students who would participate in this type of program would have little to no social science methods training, let alone PAR experience. The participants expressed that, although they did receive a reading list and had access to a social science expert, there was a need for more training around PAR prior to work in the community. We also found communication between the student participants and the faculty mentors to be a critical component, as the two participants experienced some frustration with more organic communication methods that arose. Providing a structure for this communication is vital. Therefore, our model also shows direct communication between the community members and the faculty mentors as well, so that communication does not necessarily need to be filtered through the traditional hierarchy of the community member to the student participant to the faculty mentor.

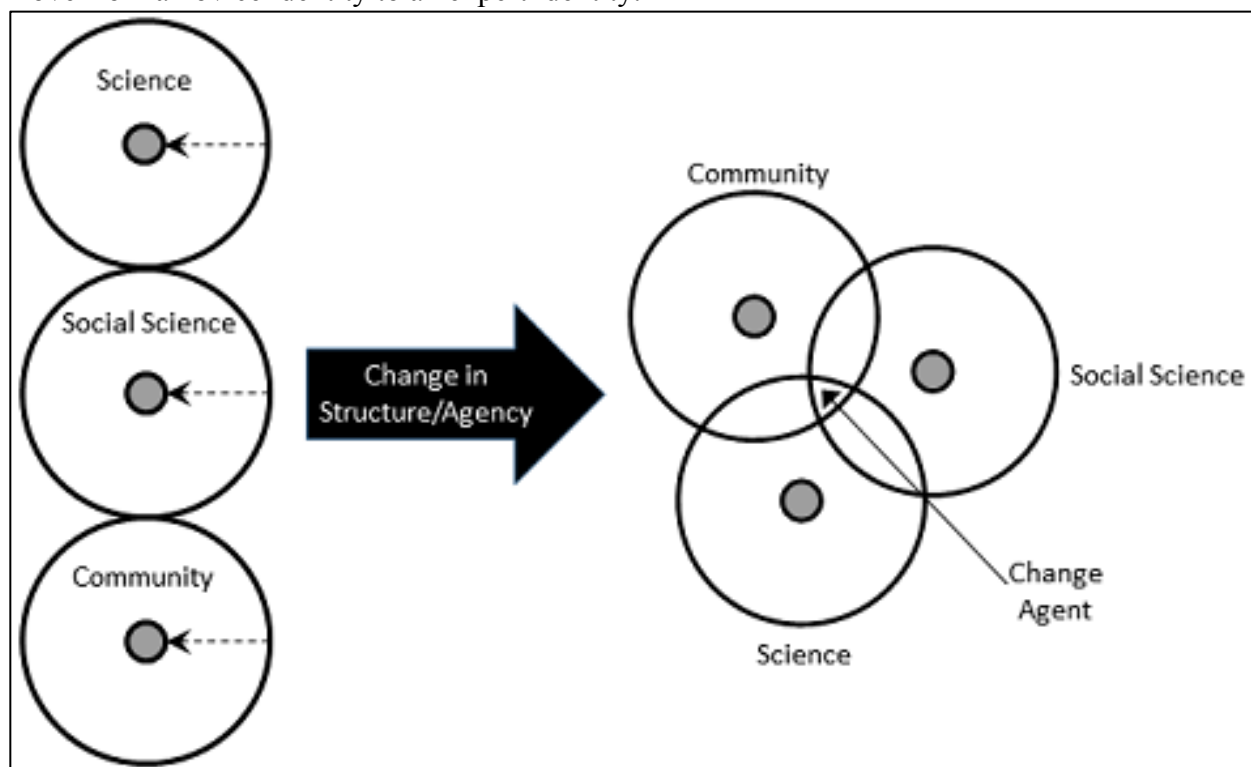
After the PAR methods training, students go into the partnering community. Ideally, the student interns would live in the community as they engage in collaborative research with community members. The collaborative research process follows 3 cycles of systematic actions taken by students and community members toward the outcome of enacting community change. In Cycle 1, the group defines one or more issues relevant to the community that may be informed by a scientific research study. This is followed by a community needs assessment related to these issues. An initial study is designed and implemented, and then the collaborative group reflects on the findings and reports back to the larger community. These data inform Cycle 2 where the group adapts or scales their study, or they decide to focus on a different issues, and the process is repeated with reflection and reporting occurring at the end. Ideally, the experience will allow time at the end for Cycle 3 to occur where collaborative writing and presentation back to the community or other audiences occurs. This cycle again ends with group reflection and planning for future work that could be undertaken by the community members themselves or in collaboration with other scientists.

It is important to note that throughout this process, the collaborative research team made up of the student interns and community members may rely heavily on support from both science content and social science faculty mentors. Although student interns will have had prior lab or field experience, since this model does not replace the existing REU programs, students' level of content and research expertise will vary. The student participants in this study received varying degrees of support from their mentors, and most of their science content mentors were located far from the communities where they were situated, which made communication difficult. It is important that a communication plan be developed and implemented during the training period to ensure interns and the community members have access to their mentors. The close proximity of the social science faculty member seemed to be instrumental. Sarah commented that if the social science mentor were not there "*the amount of time we would have spent on phone calls our Skype would have been inconvenient. There needed to be constant communication with the social science mentors, especially with all the reflection that is necessary.*" In this study the social science faculty mentor was also a part of the community where students were situated. This was probably a fairly unique situation, and other projects wanting to transfer this model would need to also lay the groundwork for community access well in advance of the students being sent into a community.

Potential Benefits of the PARE Model

In essence, the purpose of the PARE model is to begin to develop student interns as change agents who can move within and across multiple CoP, thus challenging the current hierarchical structure and moving toward a shared power structure (Figure 2). The model was designed to be mutually beneficial for all participants involved.

Figure 2. The PARE model describes how change agents help increase collective agency across CoPs as opposed to individual agency within a CoP thus moving from a hierarchical to a shared power structure. CoPs are represented by concentric circles where the arrow demonstrates the move from a novice identity to an expert identity.



In our study, Sarah and Felicia were empowered to move across boundaries, during which they received mentoring from an expert change agent (i.e., the local minister/social scientist). They interacted with other social and natural science research members, the student interns, and the local citizens. Through the experience of boundary crossing and collaborative research, the two participants reported improved communication skills that allowed them to talk with community members about their needs and about science. They also noted that their understanding of the nature of science and social science, and specifically how they may overlap, was much improved. The PARE program helped the two participants decide to pursue graduate studies in STEM fields (both in aspects of Environmental Science) with clear goals of working with community members on authentic (not theoretical) issues. Hence, these two women of color chose to remain in the STEM pipeline and still identified with their original CoP. The PARE program was transformative because it empowered them to move across boundaries and feel

confident and skilled in communicating with others to enact meaningful change while still feeling respected and valued in the STEM CoP.

Similarly, the participants noted changes in community members as well. Both participants observed an increased confidence in community members around their abilities to understand and undertake science research. For example, community members no longer felt like the subjects of research; they felt like researchers. In fact, the interns noted that some of the community members seemed more comfortable speaking with scientists and one of them had attended several conferences. Through this experience, many of the community appeared to be carrying on the work that was left off by the collaborative research at the end of the study and were using technologies developed through the experience to better their community.

Limitations of this Study

We recognize that there were several limitations to this study. First, we were only able to interview two of the three student participants. Interviews with community members, faculty mentors, and program administrators were beyond the scope of the original evaluation within which this study took place, and, therefore, we did not have access to these participants. Any observations about growth of and benefits to the community were filtered through the student interns, and, therefore, may not be aligned with the lived experiences of the community members. This study only enables us to adequately speak to the potential student benefits of the PARE model. However, because we feel the voices of all participants are vital to understanding the full extent of the benefits and drawbacks of the PARE model, we have expanded this study and are currently collecting a broader set of data from other participants.

This was also a small study with only two participants, and a larger study may provide more detailed information on the lived experiences of all participants. Scaling the PARE model or transferring it to another context (e.g., a graduate degree program) would also enable us to understand how transferrable the model is beyond an undergraduate research experience.

Conclusions

When individuals are able to bring their own funds of knowledge (personal, social, professional, etc.) and have it valued, they are empowered (Moll, Veléz-Ibañez, & Greenberg, 1989). Soliciting multiple funds of knowledge warrants a balancing of structure-agency relationships. If members of different CoPs are unable to cross boundaries into other CoPs because they “speak different languages,” then some groups may feel disenfranchised. Within hierarchical social systems, accountability within separate CoPs differs. For example, within research, members are accountable to each other through peer review, but they are also accountable to granting agencies on which they are dependent. Consequently, individuals exist within vertical and horizontal accountability structures (Wenger, 2009). Within vertical hierarchical social systems, the incentive to “hear the voices” of those far removed from those in power (e.g., funding agencies, government), is decreased.

Our findings are extremely relevant for science education researchers who design programs that bring different stakeholder groups together (e.g., graduate education, research experiences for teachers, graduate student K-12 partnerships, and parent volunteer programs). We do not advocate that people must change their identities to align with other CoPs. Rather, we argue that people should become polylingual to communicate with members of other CoPs and find “hybrid spaces,” (Calabrese Barton, Tan, & Rivet, 2008). We believe the PARE program model shows promise and warrants further testing. Moreover, we encourage our social science

colleagues to facilitate the empowerment of future change agents, because as Sarah exclaimed, we need a “younger generation of scientists” who can engage in interdisciplinary research.

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