RESEARCH ARTICLE

Youth participatory action research: Integrating science learning and civic engagement

Youth participatory action research provides a meaningful approach to science learning and raising critical consciousness.

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Abstract

Strengthening young people's scientific literacy and civic engagement are important educational goals for Cooperative Extension. We implemented youth participatory action research (YPAR) projects over three years at five schools. The YPAR approach integrates science learning and civic engagement by empowering youth, with the help of adult facilitators, to decide upon a community issue to research, design and implement their research, and then plan a service project based on research findings to address the issue. We explored young people's and educators' perspectives on which project elements influenced youth participation, examined opportunities for youth science and civic-related learning, and asked educators to reflect on their own learning and development. Using data generated from youth focus groups and educator interviews, we found that YPAR grounds science learning in young people's lived experience. It also provides a meaningful approach to science learning through raising young people's critical consciousness of community issues. YPAR may be used in other extension programs to increase motivation for deeper and sustained participation in learning experiences.

Young people are faced with complex social, economic, and environmental issues, requiring them to become scientifically and civically engaged; their willingness to participate in public discourse is essential to the healthy functioning of democracy (National Academy of Sciences 2007; Rudolph and Horibe 2015). The University of California 4-H Youth Development Program has a role to play in providing youth with meaningful science learning that helps them make consequential contributions to personally and socially relevant issues.

Deepening scientific literacy

School-based science has an important role in improving young people's scientific literacy. However, despite new national standards (NGSS Lead States 2013), standardized testing has revealed low scientific literacy among youth in the United States, which has been stagnant for decades (NCES 2016). Scores on standardized tests have shown that youth at all grade levels

A 3-year UC study found that youth participatory action research (YPAR) is a promising model to engage youth with science learning while helping to prepare them to become both scientifically and civically engaged. *Photo*: National 4-H Council/Ben McKeown.

— elementary, middle, and high school — need to improve (NCES 2016). Additionally, the amount of time dedicated to science instruction in U.S. elementary schools is minimal (Blank 2013; NRC 2021). Further, there is too much use of didactic teaching methods, which have been shown to be largely ineffective for deepening scientific literacy (Rivera Maulucci 2010; Upadhyay 2021). In addition, educators are not well prepared to use effective experiential teaching methods (Banilower 2019). These challenges have limited young people's opportunities to prepare for the workforce and to engage in science-related public issues (Roth and Barton 2004). Furthermore, students — especially students of color — often find that science education minimizes involvement in authentic community issues, deemphasizes knowledge of and sensitivity to cultural diversity, and seldom brings awareness to structural inequity of science-related issues (Aikenhead 2006, 2022; Bottie et al. 2021; Jones and Burrell 2022).

Youth spend a great deal of time learning outside of a classroom (Banks et al. 2007; Falk and Dierking 2010). There is a growing recognition about the value of informal science learning (NRC 2009). Approaching science from a community perspective may give voice to youth and expand their access to science-related civic engagement (e.g., activism, public engagement, informed decision-making). Smith et al. (2015) argue that a critical component for advancing scientific literacy is offering youth authentic, community-based opportunities to apply science to real-world issues.

Critical consciousness

Our society needs civically engaged individuals who are able and willing to participate in public discourse. Young people have historically been limited in their forms of civic engagement, particularly when confronting social injustices (Kirshner 2015). There is a tendency to minimize young people's reflecting on "the structural awareness of social inequality and the ways in which historical processes perpetuate modern day disparities" (Diemer et al. 2021).

Supporting youth in deepening their civic engagement to confront and act against injustices can be accomplished, in part, by strengthening their critical consciousness (Gonzalez et al. 2020). Critical consciousness is developed through a cycle of reflection and action that strengthens three core components: critical reflection (awareness of social inequities), political efficacy or critical motivation (perceived ability to enact social change), and critical action (making change by participating in social activism) (Christens et al. 2016; Watts et al. 2011). Critical action involves addressing collective problems through joint action, mobilizing political pressure, and participating in both formal activism (attending public meetings, protesting, voting) and new forms of expression, such as forming online affinity groups (Bennett 2008).

Youth brainstorming action ideas for their project. The YPAR curriculum included developing a research plan, practicing data collection skills, conducting research, and analyzing data. *Photo*: Steven Worker.

Youth participatory action research

Youth participatory action research (YPAR) is a program model that combines science and civic engagement, where youth conduct research and then act to improve their lives and communities (Cammarota and Fine 2008; Mirra et al. 2016). In YPAR, youth explore and determine a research topic relevant to their lives; design and implement the research (including choosing methods, collecting and analyzing data, interpreting and sharing results); and then plan an action project based on their research findings (e.g., sharing results with decision-making bodies). Relationships between youth and adults constitute a core element of YPAR. This is referred to as the pedagogy of relationships (Mirra et al. 2016) and is conceptualized in positive youth development as developmental relationships (Scales 2018). The important aspect is the presence of supportive, caring adults who are willing to share power and establish productive youth-adult partnerships (Zeldin et al. 2013).

YPAR has shown benefits in strengthening scientific literacy and critical consciousness. Scorza et al. (2017) implemented YPAR in iterative cycles, in which young people administered surveys and presented findings, and argued that the youth were better able to "name their world in order to change it" through this process. Scott et al. (2015) found that YPAR helped students become change agents by supporting them in developing authoritative voices, renegotiating identities as a social process of belonging, and beginning to envision their role in creating a more just world. Reich et al. (2015) found that, through partnering with youth as researchers, a team generated new ideas in solving issues with public schooling that likely would not have been conceived by adults alone.

Given the growing base of literature on the value of YPAR, we found it surprising that it has not been widely adopted in 4-H and is only now emerging in other Cooperative Extension programs (such as UC CalFresh Healthy Living). Additionally, there are gaps in the literature about key pedagogical elements that

influence youth participation, and thus their opportunities for learning. Almost absent from the literature are YPAR educators' reflections on their own learning and growth, which is a key strategy to advancing effective teaching (Sellars 2012).

Investigating YPAR outcomes

The purpose behind our research was to advance knowledge about the core pedagogical elements that help YPAR become a successful program model to engage youth in science learning and civic engagement. Our research objectives were to explore young people's and educators' perspectives on (1) key YPAR project elements, influencing youth participation, (2) opportunities for youth science and civic-related learning, and (3) educators' own learning and development.

Curriculum and participants

We implemented YPAR projects over three years at five schools with youth of color (see table 1). Educators were Cooperative Extension employees. Most educators were Latino or Latina; one was Asian. Educators were trained in the Community Futures, Community Lore curriculum (UC Davis 2021). The curriculum included support for the educator and youth getting to know each other, then choosing a focus, developing a research plan, practicing data collection skills, conducting research, analyzing data, creating a shareable product, and taking action to address their chosen topic.

Programs were implemented weekly during the school year for 60 to 90 minutes each session. Youth identified their own research topics; the only criterion was that it be a social or environmental issue. In practice, YPAR sessions were facilitated by the adult educator, with each session involving activities from the curriculum. Groups were facilitated in English, with the exception of Site 1, which was facilitated in Spanish. Activities were experiential, with youth actively involved in large and small group discussions, simulation activities, and independent work. Youth cohorts spent time identifying their own research topics with no constraints; youth were encouraged to select any environmental, economic, or social topic. Educators emphasized verbally that youth would be engaging in science research on their topics to plan for an action/service project. Youth identified topics that included creating an after-school club for learning and practicing English; reducing school cafeteria "fake food"; adding an ethnic studies class to school course options; addressing community racism and bias; and raising awareness on Native American history and accomplishments (table 1).

Developing patterns of meaning

Our research was exploratory, operating within a social constructivism epistemology, with a goal to "rely as much as possible on the participants' view of the situation" (Creswell and Poth 2018). We sought to "inductively develop a . . . pattern of meaning" rather than starting from a theory (Creswell and Poth 2018). Thus, we employed a multi-site, semi-structured interview design to solicit adolescent and educator meanings and experiences (Krueger and Casey 2015;

TABLE 1. Site descriptions, data sources, youth demographics, and YPAR research topics

Site	Grades	During or after school	Number and length of sessions	Youth	Data generated	Youth-identified research topic
1	High school	Y1: During	Y1: 23 (75min)	Y1: 16 (16 Latinx; 6 female/10 male)	Y1: 4 youth focus groups & 1 educator interview	Increasing afterschool options for learning the English language
		Y2: After	Y2: 8 (75min)	Y2: 10 (10 Latinx; 4 female/6 male)	Y2: 4 youth interviews & 2 educator interviews (same educators as Site 4 Y2)	
2	Middle school	Y1: After	Y1: 11 (90min)	Y1: 4 students (4 Latinx; 4 male)	Y1: 1 youth focus group	Reducing school cafeteria "fake food" and increasing healthy options
		Y2: After	Y2: 12 (60min)	Y2: 7 students (5 Latinx, 2 African American; 5 female/2 male)	Y2: 1 educator interview (same educator as Site 3 Y2)	
3	High school	Y2: During	Y2: 13 (60min)	Y2: 11 students (5 Latinx, 2 African American, 4 non-identified; 6 female/5 male)	Y2: 1 youth focus group & 1 educator interview (same educator as Site 2 Y2)	Adding an ethnic studies class to school course options
4	High school	Y2: After	Y2: 12 (60min)	Y2: 8 (5 Latinx, 1 African American, 2 White; 5 female/3 male)	Y2: 2 youth interviews & 2 educator interviews (same educators as Site 1 Y2)	Y2: Addressing community racism and implicit bias
		Y3: During	Y3: 21 (60min)	Y3: 14 (8 Latinx, 1 African American, 3 White, 2 Asian; 10 female/4 male)	Y3: 2 youth focus groups & 2 educator interviews	Y3: Strengthening how local businesses work with and serve teenagers
5	High school	Y3: After	Y3: 24 (60min)	Y3: 12 (10 Asian, 2 Asian & White, all female)	Y3: 1 youth focus group	Raising awareness on Native American history and accomplishments

Y1 = Year 1 2018–2019; Y2 = Year 2 2019–2020; Y3 = Year 3 2020–2021.

Weiss 1994). During spring 2019, 2020, and 2021, the authors conducted educator interviews individually and youth focus groups in small groups. We developed semi-structured interview protocols, with 16 educator prompts (see Appendix A online) and 10 youth prompts (Appendix B). Interviews were recorded and transcribed. In total, we conducted six educator interviews (Year 1: one interview, Year 2: three interviews, and Year 3: two interviews) and 15 youth focus groups (Year 1: five focus groups, Year 2: seven focus groups, Year 3: three focus groups). Note that, due to the COVID-19 pandemic, Years 2 and 3 interviews were conducted remotely using a virtual meeting platform; thus, chat logs (when used) were also included as a data source.

We applied thematic analysis to anchor our inquiry in the data (Braun and Clarke 2006; Braun and Clarke 2022). Thematic analysis is a flexible analytical method for constructing themes in qualitative data (Terry and Hayfield 2021); it has been applied in a wide range of disciplines, including social sciences (Braun et al. 2019). The authors were experienced with applying thematic analysis to qualitative interview data.

The first four authors analyzed transcripts collaboratively using a consensus-based and systematic process designed to emphasize diverse perspectives. The first analytical steps were coding the 2019 educator transcripts and developing independent codes. These codes were used as a sensitizing lens for developing codes for the 2019 youth transcripts. The four researchers then discussed their reasoning and the evidence relied on for code development and application. To analyze the 2020 and 2021 educator and youth transcripts, one author served as the primary coder, with the other three authors as secondary reviewers. We then met to reach consensus on code application, a form of accountability to reach inter-coder agreement. Additionally, when an analytical decision was made — for example, the conditions under which a code was applied to text — the primary coder was responsible for returning to earlier transcripts to ensure appropriate code application. We originally had one code for "science learning," which we then further analyzed using Smith et al.'s (2015) definition of scientific literacy, looking for evidence of youth reflecting on their experiences in relation to content knowledge, reasoning skills, attitudes and interest related to science, and authentic contributions. See table 2 for a final list of themes and codes.

The second analytical step was to segment the data for deeper analysis across sites. Text excerpts for each code were combined from each transcript (denoted with youth/adult, site name, and year). One researcher was assigned to each code to identify patterns across sites, supported by evidence. Each researcher completed an analytical memo for his or her assigned codes (Merriam and Tisdell 2016). These memos were presented to the team for discussion and reinterpretation; the memos went through several versions before the team reached consensus.

Learning and engagement

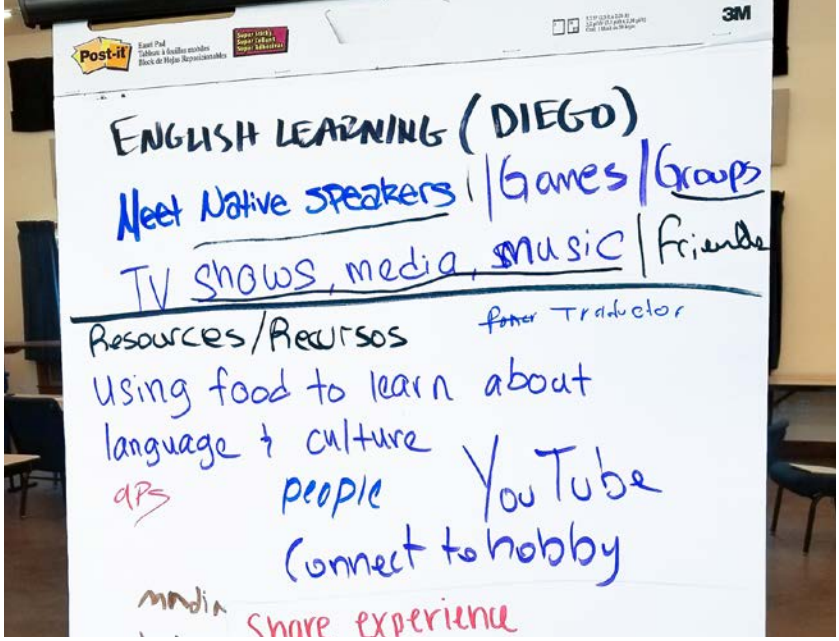
We discuss findings in three parts aligned with our research objectives: (1) young people's and educators' perspectives on key YPAR project elements influencing youth participation, (2) opportunities for youth science and civic-related learning, and (3) educators' reflections on their own learning and development. We replaced real names with pseudonyms.

An emergent finding was the importance of topic selection. Young people reported that they were more motivated to participate when the topic reflected something relevant in their lives. All cohorts selected topics influenced by their personal experiences, which

TABLE 2. Emergent codes and themes*

Theme	Codes
YPAR process and elements	• Youth (psychological) ownership of YPAR • Topic reflecting youths' lived experience (voiced connections between YPAR and youth lives) • Pandemic impacts • Affordances, constraints, or influence of setting (personal or cohort)* • Implementation of the YPAR curriculum (motivation to join, stay/leave, or curricular lessons)*
Educator roles and learning	• Educator-as-resource (roles) • Educator preparation* • Educator learning and growth
Science learning	• Science-related content • Reasoning skills, science practices • Science-related interest, attitudes, and motivation • Science contributions, applications, real-world connection
Critical consciousness (civic engagement)	• Critical reflection (self-awareness, social awareness, global awareness) • Critical motivation (political efficacy, perceived ability and capacity to enact change) • Critical action (actively seeking to make change)
Youth development*	• Youth development (confidence, youth voice, sense of agency, empowerment) • Social connection (peer-to-peer or educator-to-peer)

* The table includes all codes and themes identified during data analyses; however, we only report on those related to our three research objectives.



Student inquiry questions. Young people reported that they were more motivated to participate when the topic reflected something relevant in their lives. *Photo*: Steven Worker.

were directly related to the power dynamics within their school and community. For example, recent immigrant youth (Site 1) experienced a classroom environment that did not sufficiently meet their need to learn English, a skill they recognized as necessary for learning and social acceptance. Youth at another location (Site 3) identified racism through their own direct experiences and an awareness of similar experiences by other youth of color. These youth took risks to address issues that are meaningful and relevant to their lives, have larger social and cultural implications beyond their own communities, and represent forms of structural inequities and injustices. The significance of topic selection was evident; young people voiced displeasure when the selected topic was something they were not interested in.

> *Make sure everyone is engaged and find the topic interesting to them because they're not gonna care about the project and making something happen if they're not interested. — Naomi (Site 4, 2021)*
>
> *^Exactly. — Joey (Site 4, 2021)*

Educators' influence

Youth and educators both described various roles the adult educators played that either promoted or constrained youth participation, as well as shaping the YPAR process and outcomes. Youth reported that educators acted as mentors. The young people also reported that they felt they were able to relate to the educators in different ways, such as their similar or shared ethnic background, cultural experiences, and age. Youth viewed educators as listeners who provided guidance in their YPAR experiences.

> *I think I was placed in a very unique position just because of my age . . . So I really never saw myself as a teacher, more of a mentor just because I've been in their position more closely than [co-educator name] has. — Malcolm (educator, Sites 1 and 4, 2020)*

As mentors, the educators facilitated YPAR while allowing youth to make decisions and take ownership of their projects. Educators mentioned that bilingual ability helped them serve as translators for open communication and as a resource to provide support for the youth. Besides shared language, educators also described shared personal cultural experiences that enabled them to relate to youth, and vice versa, which also afforded them opportunities to facilitate open conversations. An educator reflected,

> *And a lot — most of the students I had were of a Hispanic background . . . so, especially since I can relate because I'm from this background as well. — Alina (educator, Sites 2 and 3, 2020)*

The ability of educators to serve as a cultural translators helped them explain and relay information in a way that was understandable and relatable to youth (e.g., technical scientific terms and concepts). Furthermore, throughout the YPAR process, educators provided the time, space, and flexibility for youth to discuss matters that were both related and unrelated to the project. Establishing a safe space allowed for trust to develop between educators and youth, resulting in successful YPAR experiences.

> *It was these students who come from very, like, diverse backgrounds and sometimes don't have that person . . . in their school to say, "Hey, I got you" or "Hey, I'm listening" — like actively listening . . . and actually validates your thoughts and feelings . . . instead of just passively. — Alina (educator, Sites 2 and 3, 2020)*

Pandemic impacts

Encouraging and maintaining youth engagement and motivation was a key focus for educators, especially when the COVID-19 pandemic forced the shift from in-person to virtual programming in the middle of the 2020 school year. During this shift, educators described being flexible and learning ways to adapt the curriculum to time, space, and technology limitations. For example, educators described adding interesting activities from other curricular resources to supplement the primary curriculum and shortened certain activities to allocate more time for youth to work on their projects, in order to keep them motivated. Additionally, educators felt uncertain about youths' ability to understand the material through online interactions; as a result, educators adopted different practices. For example, one educator shared that, when sessions were virtual, he did a lot more speaking than the youth did. Furthermore, educators described using a lot of flexibility and patience in adapting to virtual programming.

> *Be patient with the students. Everybody was dealing, or still kind of dealing with virtual remote learning. And yeah, really reach out to those quiet kids early on . . . really reach out more and listen,*

do something that elicits their responses . . . don't worry so much about how fast you're going but worry about making sure everybody's coming up along. — Derek (educator, Site 4, 2021)

Educators also described celebrating small victories with youth and providing them with recognition for work being done, to keep youth engaged and motivated in their YPAR projects. This was important for both in-person and online programmatic platforms.

Learning by doing

Young people shared that their participation in YPAR helped them strengthen their scientific literacy as it relates to social science issues, including all four aspects of scientific literacy (Smith et al. 2015): content knowledge, scientific reasoning skills, attitudes and interest, and applied participation.

At all sites, young people reported that their prior experience, identity, and culture informed the selection of a group research topic. Both educators and youth reflected that their topics had saliency in the young peoples' lives and reflected their passion for creating change; e.g., more relevant methods to learn English (Site 1), improving food options (Site 2), and addressing racism and bias (Sites 3 and 4). The youth-identified topics were social science issues, cross-disciplinary, and personally meaningful.

See that fake cafeteria food, they just heat it up; but when you actually want to cook the real food, you have to actually, like, use time and actually know when it's like done. They [school administration] should spend less money on the equipment [physical education] and all that because it's still in pretty good shape and more on food, like actual food. — Mike (Site 2, 2019)

Youth reported engagement in science practices, most notably exploring existing literature (conducting background research to see what others had done before, looking up previous empirical research, data collection tools, and findings), designing and collecting data through surveys and interviews (methodology), and learning that research methods would vary based on the research question.

It would just be a different procedure [for another topic] compared to like the food [topic]. — Eurico (Site 2, 2019)

Educators observed and recognized youth participation in various science practices, including selecting appropriate methods for data collection and analyses. For example, one educator shared about the young people's survey methods.

We talked about all the research methods, and surveys seemed to be the most effective one for them to . . . answer their research project question. — Derek (educator, Sites 1 and 4, 2020)

When asked how they saw youth develop scientific practices, another educator responded about quantitative data analysis.

Doing data analysis, getting the surveys and putting them into a graph or a nice chart for it to be, like, aesthetically pleasing, but also being able to grasp the idea that's at hand. — Alina (educator, Sites 2 and 3, 2020)

Another educator observed that youth learned the value of using science to address a research topic.

When we looked at the data, when we analyzed the data . . . I think that's where the students learned the value and the impact that this program — these survey questions — can be valuable to our research question. — Malcolm (educator, Site 4, 2021)

Passionate about change

While youth recognized that they were engaged in science practices, they said that the science itself was not the primary aspect that excited or motivated them to join or stay in the program. Youth were passionate about creating change in their community around their identified topic. Science was one tool to help achieve that change. When youth were asked "what was interesting?" almost all spoke about science in relation to their research topic.

The project we did was interesting because we collected information from people to be able to understand . . . the best methods to learn English. — Barrett (Site 1, 2019)

I really enjoyed seeing all our efforts coming to fruition [raising awareness of Native Americans] . . . and how much we've learned through different methods. — Takara (Site 5, 2021)

Using science to solve problems

Youth reported that science methods may be used to help solve problems or provide answers. They recognized that they could apply science to issues that directly impacted and were relevant to them. The YPAR model, coupled with the participants' lived experiences (e.g., recent immigrants learning English at Site 1; a shared racist experience at Site 3), led to the selection of a topic and helped youth see how they might make change using science. An educator commented that youth saw a connection between their topic and science:

So, deducing the problem was really scientific because they've got to understand their community and everything surrounding it and see and as they chose bias and racial — racial bias . . . What questions can we formulate to do some research for ourselves and definitely try to help the community

understand the problem at hand? — Malcolm (educator, Sites 1 and 4, 2020).

Youth also demonstrated a growing ability to reflect critically upon social structures experienced by marginalized groups. When asked what kinds of problems can be addressed through science, a youth responded:

The program helped us analyze the problems of society, and if we would teach it to someone else, I think they would be equally equitable with all people. — Damiān (Site 1, 2019)

Youth reported that science methods may be used to help solve problems or provide answers. They recognized that they could apply science to issues that directly impacted and were relevant to them.

Having youth and adults reflect on this fourth dimension of scientific literacy was surprising to the researchers. It was noteworthy that young people began to see science not as a discrete subject but rather as a tool for social transformation. Young people were appropriating scientific tools to better understand and change their world and using science practices as a means for critical reflection and action.

Reflecting on social issues

Youth reported growing in their ability to analyze and reflect on social issues and injustices; in other words, they developed critical consciousness to varying degrees. Critical consciousness manifested differently across the sites. Youth articulated experiences of attending school and living in their communities, and an increased awareness of how their participation in YPAR might be used to address and create change.

A lot of discrimination on the part of people who tell you that you are less for not knowing how to speak the language [English], because this is a country where only that language is spoken, or it is the main language of the country. And you could have regular classes as a normal student, so to speak, for the ones who do speak the language. — Julia (Site 1, 2019)

For example, Site 1 youth had an immediate need to learn English to help them navigate and be accepted in a new country. Their immigration status and language acquisition may have impacted their ability to critically analyze school structures. That is, Site 1 youth sought out-of-school activities to learn English as opposed to addressing the inadequacy of the school's language acquisition program. In contrast, youth at the other school sites were grounded in their place of residence and therefore were more able to critically analyze social forces that revealed inequitable structures and practices that helped guide their topic.

Improving teaching practices

Educators shared that they improved their awareness and abilities in facilitating youth development and science education using the YPAR approach, especially in youth leadership and youth-adult partnership. The YPAR process was a shift from a traditional expert-driven teaching approach. Youth engaging in YPAR took ownership of their learning and projects, while the facilitators guided them. Through this process, educators learned to listen instead of telling youth what to do; they learned to "take a step back" and let youth lead. The active engagement of youth helped educators teach research topics that might not be easy or interesting for youth to learn.

Like, you need to take that step back, guide them, facilitate them. You're here for if they had any questions. Like, I'm here to help you and if you need, if you guys are stuck, that's where I come in. I'm here because this is your project, this is your baby. — Alina (educator, Sites 2 and 3, 2020)

So, yeah, for me, coming into my first year doing this is really a learning curve for me. I've really learned about what the program stands for, what the goal is, how to help the students, not just necessarily teaching but be a mentor. — Malcolm (educator, Sites 1 and 4, 2020)

Educators also discussed learning about youth development, including developmental domains of adolescent youth, and how that impacts their group management and facilitating strategies. Working with older youth, educators described learning the dynamics of the group and providing them with flexibility and expectations as successful strategies.

Integrating science and action

Young people and educators from our YPAR project reported that youth strengthened aspects of their scientific literacy by engaging in analysis of a research question around a personally meaningful topic. Youth reported enhanced motivation to participate when the topic was relevant; conversely, youth reported a lack of motivation to participate when they were not interested in the topic. In our three years of experience, we found YPAR to be a promising model to engage youth with science learning while promoting engagement with authentic, real-world issues, to help prepare youth to become both scientifically and civically engaged. While it is likely that not all youth experienced the same level of growth in their scientific literacy, cross-site data analyses revealed there were opportunities for engagement in science practices and civic engagement. Levels of participation varied, due in part to the COVID-19 pandemic, and in large part to the educators, and their ability to act as cultural translators, mentors, and academic supports. Attending to the key pedagogical elements presented here (topic selection and educator roles) will likely help future YPAR projects improve opportunities for youth to strengthen their scientific literacy and critical consciousness.

A novel aspect of our research project was conceptualizing the relationship between development of scientific literacy and critical consciousness using

a YPAR program model. We posit that there is likely a dynamic, multidirectional relationship between students' lived experiences, their selection of a YPAR topic, opportunities for engaging in science practices (and thereby science learning), and the development of critical consciousness. As we shared, young people selected a YPAR topic that reflected their lived experience, something that was relevant to their lives, and something they might be able to change. Educators provided YPAR as a process tool for studying their issue, using science tools and adult partnership. These all served to validate young people's lived experience and also led youth to critical questioning, development of a sense of efficacy, and then motivation for action. The potential value of YPAR to promote science literacy and critical consciousness is well known in the YPAR scholarly community (in social justice and activism; e.g., Ayala et al. 2018); however, it has been relatively absent as an approach in the positive youth development and Cooperative Extension circles. We hope our work moves YPAR forward as a useful program model integrating science learning and civic engagement.

Regarding raising critical consciousness specifically, the youths' awareness of some of the oppressive forces within their community environment (racism), sense of power to work against inequities (healthy school food), and engagement in collective action against oppression (ethnic studies) reflects their development of critical consciousness. Youth were members of, and lived in, communities in which power was primarily held by the dominant white culture. The weight and sense of that power impacted many of the youth involved in the YPAR project. Some expressed their own sense of inaction or lack of agency to address their concerns or ideas due to their understanding of the hierarchy of school systems and their perceptions of non-support from some school administrators of the dominant culture. Research has demonstrated that youth are interested in addressing complex issues that impact their lives and creating a more equitable future, and that they thrive when they feel connected to their schools and communities and feel supported to use their voice for social change; (see Lerner et al. 2005). For youth of color and marginalized youth, critical consciousness is associated with healing (Diemer et al. 2021) and what Phan (2010) calls "psychological armor" to mediate the negative effects of oppressive social forces. We argue that focusing on raising the critical consciousness of young people will likely also promote positive youth development in culturally relevant ways.

The COVID-19 pandemic greatly impacted our work. Our educators displayed a timely and flexible transition to virtual programming. The YPAR philosophical underpinnings — rooted in justice and critical consciousness — can be sensitive and require trust between youth and educators, which is more challenging in virtual environments. While our team of educators was mostly successful at maintaining youth interest, there were setbacks, and we generated many lessons learned in successful (and unsuccessful) methods in building trust and continuing to engage and motivate youth in virtual environments.

Scaling up youth programs

Future research is needed to explore how to scale up and disseminate YPAR more broadly in a variety of 4-H and other youth programs. There needs to be attention to sustainability; the educator plays a pivotal role, and enough time must be dedicated to fully implement YPAR. This will require either resources to hire staff or very dedicated and committed volunteers. Additionally, the issue of topic selection is an aspect ripe for future exploration. We placed few boundaries on topic selection, but we know it is a key element influencing youth's motivation and investment in the project. Would future YPAR efforts with boundaries on topic selection realize as much youth motivation or personal relevance? Furthermore, future work remains to examine how the context of program implementation influences youth participation. Our research did not analyze this specifically; however, we observed differences in participation and topic selection between cohorts taking place in school or after school. In-school programs seemed to generate more students but were constrained by school-based norms. After-school programs generally had fewer students, but they appeared more committed to the program.

Engaging youth in relevant educational experiences situated in community issues may improve motivation for deeper and sustained participation in learning experiences, while also preparing them for the real world. Efforts to improve scientific literacy and civic engagement are imperative, as demonstrated through the 2017 March for Science and more recently by vaccine hesitancy during the COVID-19 pandemic. YPAR is a promising approach to increase civic engagement and create effective public leaders. Both of these are priorities for change efforts in UC ANR research and extension. CA

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