Participatory Action Research in Physics Education Research

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This paper reviews Participatory Action Research (PAR) as an approach to Physics Education Research (PER). It briefly describes the history of PAR as a subset of Action Research, a research methodology that involves the simultaneous investigation and solution of an issue, discusses the advantages and disadvantages that have been identified by other researchers in using PAR approaches in education research, and provides a few exemplar cases where a PAR research approach seems best suited for PER. Further, it argues that using the PAR approach may advance PER's overall goals such as broad participation in physics, enhanced student learning, and improved teaching skill/knowledge better than other existing curriculum design and dissemination models. Finally, the history of PAR in PER is explored via a literature search, and reasons are presented for the lack of PAR terminology use in PER despite the significant overlap with the principles of PAR in common PER innovations.

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I. INTRODUCTION

The goal of this paper is to provide an overview of Participatory Action Research (PAR) and reflect on its utility in Physics Education Research (PER). This article works to summarize and discuss the literature around the history, principles, and definitions of PAR and explain how PAR differs from, and is similar to, other research areas such as Action Research and Educational Action Research. This article also summarizes the advantages and strengths of PAR as well as the disadvantages and challenges of the PAR research methodology/approach. In addition, the use of PAR approach in instructional and institutional change is discussed, and it is argued that PAR may further PER's overall goals such as broad participation in physics, enhanced student learning, and improved teaching skill/knowledge better than other existing curriculum design and dissemination models. Finally, a high-level analysis is conducted of PER-Central articles that use PAR or AR to demonstrate that PAR is uncommon as a named approach in PER. This lack of engagement is intriguing since many of the educational innovations that physics education researchers have studied and found successful over the years - such as student-centered instruction, inquiry, research experiences, and much of the reflective and/or group/team focused learning activities - have significant overlap with the principles of PAR (See Fig. 1). Some potential reasons for why PER has not used PAR are presented. What makes an educational innovation PAR vs not PAR hinges on two elements and the degree to which they are embraced in the research study. These elements are: 1) Where does the study fit on the continuum of fundamental to applied research? 2) How much say do the participants - student(s) and/or teacher(s) - have in directing the research? The answer to these two questions is key to understanding the amount of alignment a PER project has with a PAR approach.

This paper will answer and explore the following research questions.

1. What is participatory action research (PAR)?
2. What makes PAR similar/unique from other methodologies?
3. What advantages/disadvantages may arise from using PAR in PER and are there research areas where this methodology might be most appropriate?
4. What are examples of PER areas of study that overlap with existing PAR use in the literature and/or that are the most conducive to PAR approach?

II. PARTICIPATORY ACTION RESEARCH

A. What is PAR?

Participatory Action Research is considered by most to be a subset of action research [1, 2]. Action research is a research method that aims to simultaneously investigate and solve an issue [1–3]. It was developed in the late 1940s by Kurt Lewin as a tactic for studying a social system while attempting to impart positive change in the system. Because, action research can be used to study any setting or field but has unique principles for carrying out the research study, it is primarily considered a research methodology and/or research approach instead of a research area or topic [3]. Importantly, action research was also developed as a methodology that would address what Lewin saw as decontextualized social science research that failed to properly account for the community/populations served. Action research is implemented by engaging people in a cyclic process of observation, reflection, exploratory action, evaluation, and modification to address the problems observed [1, 2]. Thus, action research shifts the central goal of the research away from knowledge generation to change creation.

While this central goal of change vs. knowledge is an important distinction for action research, what really sets PAR apart from other research approaches is its participatory paradigm. In traditional research, people who are outside the phenomenon under study conduct the research. This kind of traditional research is based on the assumption that the phenomena is fixed and that knowledge about it can be obtained objectively if the researcher is careful not to disturb the phenomena during research. In PAR, the people who are conducting the research are part of the phenomenon. The assumption is that the phenomena is not objective but is best known by those participating in it [1]. In addition, there is a understanding that the choice of research topic and the products and actions of the research should be chosen by those most impacted by the research, i.e. the participants themselves. Whether because of this participation paradigm or perhaps due to the reflective cycle of action research itself, which often promotes critical consciousness, PAR has a long standing history of use in research and social movements that challenge dominant, normative views such as the feminist, racial justice, and social justice movements [1]. And, PAR is often seen to have a liberatory or emancipatory component to its use [2, 3].

In the 1950s, Cory brought action research into education with collaborations with US schools, school districts, and teachers in what was called cooperative action research but is now usually called Education Action Research (EAR) [1, 3]. Educational Action Research - sometimes only called action research - covers a broad range of strategies and methods to innovate the practice of education. EAR is distinctive in that it connects research and practice by turning teachers into classroom researchers [3]. The participatory aspect of EAR is usually implemented at the teacher level and not the student level. The action aspect of EAR is often accomplished by a cyclical approach of implementing change and then researching the effects for further improvement in the next class [3]. The research aspect of EAR is usually driven by a STEM education researcher who could be the teacher but is often not.

It is worth noting that there is nothing technically wrong with the teacher researcher and the STEM education researcher being the same person. As long as both change action and research are being accomplished the designation of EAR can still be applied. However, having an "external re-

searcher" as part of research project team can be extremely valuable for many reasons. First and foremost is the simple adage, two heads are better than one. A second researcher can help provide the grounding literature and ideas for what change to implement, assist in data collection, cleaning and analysis, as well as the dissemination of findings and publication writing. However, equally important this second researcher helps provide an ethical distance that can be useful for research validity [3, 4]. This will be discussed more in the section "Disadvantages to using PAR".

In the 1990s, as disciplinary STEM education research (DBER) became growing fields, EAR was suggested as one potential solution to an increasing difficulty in STEM education research caused by low interaction between the disciplinary STEM education researchers and the STEM teaching practitioners [2, 5]. As the literature discusses, teachers are key for any sustainable implementation of innovations and reforms and taking their beliefs, prior knowledge, and attitudes seriously is a necessary precondition for success in classroom innovation [1, 2, 6]. Also, teachers have a wealth of practical knowledge about their students, school contexts, and real needs that was necessary to consider when implementing a research-based pedagogy. By employing a co-research and teacher development model that embraced the philosophy of action research a PAR model for DBER was created [2, 5, 6]. It is important to note that while the words teacher, classroom, and school are used here these terms are meant as generic designations for both formal and informal learning environments and apply to both undergraduate and graduate instruction as well as the K12 space.

So, what exactly is PAR and what makes it PAR? For the purposes of this paper we will be using PAR to denote a research methodology/approach used for STEM education research that: 1) Participatory - engages students and/or teachers/faculty as important members of the study's research team and engages them in all aspects of the research process from start (i.e. formulating the research question of study) to finish (i.e. sharing the findings); 2) Action - has a primary goal of classroom or educational systems change (i.e. some participant and/or collective change is necessary for success); 3) Research - uses a reflective, cyclical, and evaluative framework where the participants learn from the research study. Also, implied by this method are other important considerations: 4) the results are necessarily context specific to the classroom communities being studied; 5) communication and collaboration are of high importance to success; 6) if it looks like other research methods (such as qualitative interviews or case studies), you are most likely doing it wrong [1–3, 7].

B. Advantages to using PAR in a PER setting

There are many potential advantages to using PAR in PER settings. First, PAR/EAR is considered one of the most promising methods for teacher professional development and education [1–3, 8, 9]. The literature suggests this is because of the importance of reflection for improved teaching [2, 9]. Specifically, the literature notes the importance of "thoughtful consideration and retrospective analysis of their performance to gain knowledge from experience" [2]. In addition, the cyclical nature of AR as not just research that is followed by action but rather action that is researched, changed, and re-researched is of special importance in education where state of the art practice is constantly changing [1, 9].

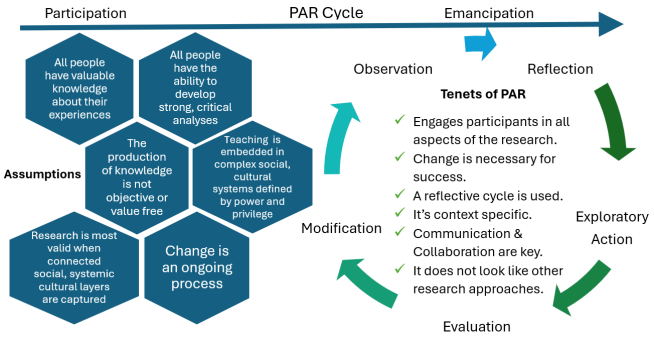

FIG. 1. Assumptions and Tenets of PAR.

Second, PAR can be useful to acquire and leverage knowledge that the research team either does not have, is low on, or is difficult to get. For example, PAR may be useful in a study exploring the experiences of students with disabilities within a Physics department. It would be difficult to achieve the specific, intersectional knowledge that is clearly necessary for this kind of study, i.e. the intersections of: student perspective, disability knowledge, department and institution perspective, and physics content. In this kind of study, a research methodology like PAR, which values - and gives voice to - the knowledge gained through lived experience of the participants and provides opportunity for that knowledge to flood into and combine with the canonical research knowledge brought by the traditional researchers, may be a good way to provide culturally responsive research or to account for the actively changing system [7, 8, 10].

In addition, other areas in PER - and disciplinary STEM education research - most clearly aligned with PAR are: new concepts or materials for teaching; knowledge about teaching and learning; documentation of teaching practice; and institutional/systemic change [1–3, 5]. These research areas highlight a third potential advantage to using PAR in a PER settings, which is the alignment of long term research goals and this research methodology.

There are many examples of PER where the creation of new curriculum and/or pedagogy is the research goal. However, the researchers' goal does not stop there. These research studies usually are also designing this material with the goal that it be adopted, adapted, or picked up by other instructors for use in their classrooms. Thus, the research goal is actually often instructional change and/or development of better teaching systems. The way the researcher is hoping to achieve this goal is with the curriculum/pedagogy that gets developed.

Thus, to accomplish the goal of the study there are two steps: 1) create the innovation; 2) get instructor/student buy in to implement it at large. When this is the case, a PAR

design may be the fastest way to achieve this larger goal. Rather than a curriculum being developed external to these future teachers and then a buy in and implementation campaign taking place to implement the innovation, teachers can be recruited into the design phase from the start. While it might feel like more work and/or that you are marketing a not yet developed/proven product, from an instructional/user perspective this has a lot of advantages [11].

Almost no curriculum can be whole scale adopted for use without editing the implementation. Some of these changes can be small like taking more time on a unit because your students move more slowly through the materials. However, some can be large and when this is done within the research study itself, the instructor has a research team to help them overcome these challenges [5, 11]. Also, from a design perspective, the final product created will be more flexible since it is informed by these implementation hurdles that have already been experienced. These issues of design and adoption are discussed broadly in Henderson et al. [11]. Here Henderson does not directly mention PAR but advocates for advanced "product testing" that has a lot of the same elements of PAR without going to so far as to integrate the testers into the research team. However, one can ask why should teachers be involved in product testing? What do they get out of it besides a not quite ready product and the research team using their time and effort to inform its product? By bringing these beta-testers into the research study, PAR allows for a more fair acknowledgement of the effort and expertise employed by the instructors who implement new curriculum/pedagogy into their teaching and acknowledges that the finished product (an implemented improved teaching experience) is not possible without these efforts.

C. Disadvantages to using PAR in a PER setting

In addition to advantages for using PAR, there are several potential disadvantages to using PAR as a research approach. These are: 1) Miss alignment of research goals and methodology; 2) inconsistent stakeholder buy in; 3) participant-researcher up-skilling needs; 4) a mixing of the observer and the observed that can "bias" your research findings.

First, it is always important in a research study to carefully consider the project's goals when choosing a methodology. Failure to properly align research goals, methodology, and collected data is one of the many reasons a research study can collapse and this methodology is no different [12].

Second, given the nature of PAR it is highly important that participant researchers be interested in being researchers and that key stakeholders of the action are interested in allowing the action. For example, a department's chair might be extremely excited about engaging in PAR curriculum reform for the Physics 100 courses; however, if the 4 faculty/instructors who teach these sections are not interested in engaging with the project as researchers, then PAR will not work for this. (It is worth noting that traditional PER has this same issue; although the bar for engaging in PER might be somewhat lower than that for engaging in PAR depending on the study design and how deeply involved in the research the participant researchers will be [13].)

Third, PAR is bringing in people who have knowledge and stake in a system, but are often not researchers, and engaging them in the difficult process of doing research. It is likely that additional time, support, and other resources may be needed for the participant researchers to be fully engaged in the research study especially if the research team envisions the participant researchers being involved for example in data analysis and/or result writing [1, 3]. Careful consideration of the interests and skills of each member of the PAR project team is key to a smooth project implementation. Also, it is advisable to create a shared vision at the beginning of a PAR project for who is doing what aspects of the project [2, 3, 7].

Fourth, PAR mixes the world of researcher and participant. This almost certainly introduces observational bias into the research study. For example, watching a teacher implement a curriculum with a hidden camera vs. watching them when they are informed of the goals of the study - and potentially even have stake in the success or failure of the implementation of the study - are very different research studies. If the study needs a blank slate research environment, than PAR is not the right methodology. As noted earlier in this paper, PAR is context specific and embraces a philosophy and understanding that the classroom environment - or other phenomena under study - is not a fixed phenomena but rather a created phenomena best understood by the participants [1, 2, 7, 10]. This philosophy is essential to both using and understanding PAR and criticisms of PAR around bias often arise from these fixed view theoretical perspectives.

When first starting a research process, a careful consideration of the advantages and disadvantages of PAR should be made.

III. HISTORY OF PAR IN PHYSICS EDUCATION RESEARCH

To explore historical use of PAR in PER, a literature search of PER-Central (https://www.per-central.org/) for papers mentioning "Action Research" was completed. Action Research was chosen for the search terms because it would catch other designations such as "Participatory Action Research" and "Educational Action Research" as well. From the thousands of articles in this archive only 31 articles were found to mention Action Research. This clearly demonstrates that, despite the alignment of PER research goals such as curriculum development and teacher education/training, PAR has only a very small history of use in PER.

A. Examples of how PAR has been used in PER

Four of the 31 articles could not be downloaded for analysis because the link was incorrect and/or led to a paywall. However, further analysis of the remaining 27 articles reveals that many articles, while using the term "action research", were not using action research as a research approach. They cited the literature of action research, proposed that their study

TABLE I. Breakdown of the Use Cases for Action Research articles found on PER-Central. Examples of each by citation.

Use Case	N	Citations	Topic Area
Department	3	[14–16]	Change, BP/DEIA, Course Reform
Teacher	5	[17–21]	Professional Development
Student	6	[22–27]	Labs, E&M, Problem Solving,..

could lead to future action research, described and discussed action research (as with this article), and/or used it in another way that was unrelated to actually doing action research. 13 of the 27 articles use of "Action Research" fell into this group.

In studying the themes from the 14 articles that were doing Action Research, some clear patterns emerged. The first thing of note is the lack of patterns in several important measures. The 14 articles span from the late 1990s up to 2023 and were distributed in time across this period. There were a mix of journal articles and proceedings. Also, while there were a couple of article clusters by the same or a subset of an author team, for the most part these articles did not clump on authorship or institution/group. Rather, a research team seemed to pick up PAR to use in a specific study but not use this approach again in other published projects on PER-Central.

Also of note, when the articles were grouped thematically by participant, three categories of participant emerged; these were Department (3 articles), Teacher (5 articles), and Student (6 articles). (See Table I for information on which articles were classified in what participant group and the research topics of focus.) The proportion of research that was student vs. teacher focused was basically equal. However, much of the literature that was teacher focused was engaged with either teacher professional development or teachers in training so this category ended up blurring the lines of student/teacher label to some extent. Finally, while these articles are deemed by the authors to be PAR, only 3 articles used the terminology PAR instead of Action Research and all three of these articles were student focused [22, 26, 27].

B. Why does PER not use PAR more?

As discussed above in advantages to using PAR, there are many topics of study in PER that clearly align with a PAR methodology/approach. For example, there is a lot of literature in PER that is around identifying difficulties students have with physics content, graphs and diagrammatic visuals used in physics instruction, mathematical representations and/or processes, etc. and then designing curriculum and/or pedagogical changes that lead to better outcomes through an iterative process of trial and assessment over semesters. Indeed, even the problem solving process itself is a reflective cycle that closely resembles that of Action Research [22]. So, why are there so few articles about PAR and AR in PER?

One possibility, is that PER simply does not conceptualize its research as PAR even when it is PAR. It could be argued that DBER itself is built from science teaching practitioners who were/are researchers in STEM fields, deciding that they would individually - and occasionally in teams - take on the role(s) of teacher researchers in their STEM courses. Then through action research done as they taught their courses (made observations of difficulties, reflected on causes, changed curriculum or pedagogy, assessed/evaluated the student learning, and iterated again the next semester) these individuals skilled themselves in education research, designed foundational research based curriculum, and as they went about this also built the fields that are now DBER. Because of this historical context to DBER, it may be that some researchers are doing PAR without calling it PAR.

Another likely possibility is that PAR requires a relinquishing of status and control by the researchers to the participants. This may be difficult to accomplish in our fairly ridged systems of education and a slightly less "aggressive" version of PAR maybe taking place within what we call student-centered education, inquiry, course-based undergraduate research experiences (CUREs), and/or much of the reflective and/or group/team focused learning activities developed by PER over the years. Rather than going into full PAR where the choice of research topic and the products and actions of the research should be chosen by the participants. PER seems to do a "PAR light" version where the topic and product is chosen by the instructor/researcher but the actions are chosen by the participants.

Finally, it may be that Physics Education Researchers simply do not know much about PAR as a research approach and therefore do not use those terms or cite the literature. What ever the reason, it is clear PAR has much to offer PER.

IV. CONCLUSIONS

This articles provides: a brief overview of the history and definition of Participatory Action Research (PAR); reflects on PAR's utility in PER through a discussion of some of the advantages of PAR including its usefulness for teacher/faculty professional development and the alignment of PAR to large scale, educational innovation and change that the PER community has long been working towards; tempers these advantages with a discussion of challenges and limitations of PAR; and lastly examines the history of PAR in PER.

PAR offers an authentic path to connecting physics teaching practitioners and physics students with research based curriculum tailored to their needs and contexts because they create it. This paper suggests that Physics Education Researchers have been leveraging PAR and serving as unique change agents within their departments for many years even when not using the term Participatory Action Research. What might PER accomplish if it intentionally uses PAR to engage communities in change, innovation, and physics education?

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