Queering methodologies in physics education research

Madison Swirtz (they/them) and Ramón Barthelemy (he/him)
Department of Physics and Astronomy, University of Utah, Salt Lake City, UT 84112

Queer theory in STEM education research is often used as a synonym for studying LGBT+ students or queer issues. However, queer theory and queer methods can be applied to discipline-based education research far more broadly. In this paper I introduce a unique perspective on "queering" quantitative and qualitative research methods and highlight some of the ways these methods are already compatible with the goals of physics education research. This will include discussions of deconstructing binaries, empowering participants in the research process, and reimagining study design to attain novel insights about the experiences of physicists.

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I. INTRODUCTION

Physics education research (PER) has been increasingly concerned with issues of equity and diversity in physics [1, 2]. While there has been a lot of good work building frameworks and trying to reimagine student learning and culture [3–6], there has been less critical attention towards the methods which underpin this research. This paper aims to take a queer lens and point it not at the participants in research, but at the research methodologies themselves. Through this researchers can analyze the underlying power structures and binaries which are reinforced via. the research questions we ask, the way we design studies, and the way we gather and interpret data.

Queer theory offers a very useful set of tools for doing critical analysis, but it is also a notoriously *slippery* field of study. It is often criticized for its resistance to creating a stable definition of itself as well as its insistence on complicating discussions without paying due attention to trying to re-adhere the pieces they broke apart [7]. While there's never a coherent definition, there is a broadly agreed upon goal of queer theory which was well- articulated by Sullivan: to queer is

> "to make strange, to frustrate, to counteract, to delegitimize, to camp up heteronormative knowledges and institutions" [8].

This tendency towards critique and deconstruction is what makes queer theory useful to apply to an analysis of research methods. This paper explains some of the common pitfalls of social science research as it pertains to binarization and the reinforcement of normative power structures, and offers tangible examples of different ways to *queer* research methods.

I'm choosing to queer the writing process by valuing honesty, authenticity, and transparent language over formality. When discussing specific papers I remain consistent with their language, but when this does not apply I use "queer" instead of "LGBT+" (lesbian, gay, bisexual, transgender). I (the first author) prefer the fluidity of this term as a self-identified queer, bisexual, and nonbinary person, but I also recognize that LGBT+ is currently the more generally accepted formal term in DBER and as such is more common to see in papers. As part of queer theory is deconstructing formality for the sake of formality, I'm choosing to use the language which is more authentic to my experiences and my communities when I can. This isn't representative of the feelings and experiences of all queer people; I'm making a choice within this inconsistency based on my experience.

II. PRODUCTIVE PARADOX

Amongst queer theorists there's a notable tension whenever a social science researcher tries to apply queer theory as a methodology, as the concept of creating data and trying to coherently analyze it can be perceived as capitulation to the academy and heteronormative structures. To count is to agree that there is a well-bounded definition, to summarize and analyze is to impose your own values onto your research participants, and to report on your findings is an attempt to assimilate yourself into the heteronormative culture of the academy [9]. As a result of this tension, many scholars argue that queering methods is an inherently contradictory phrase. To queer is to deconstruct and play, while methods restrict and demand conformity.

Ghaziani and Brim specifically frame queer methods as something which is paradoxical [9]. As a physicist, this language instantly elicits the old wisdom we often learn in undergraduate physics classes. When you encounter a paradox as a physicist, it's an indicator that either your intuition is wrong or your model is incorrect. When the constancy of the speed of light was proven it required an entirely new reconceptualization of physics in the form of special relativity. Thought experiments like the twin paradox defied common sense and deconstructed the absoluteness of simultaneity and the absoluteness of time itself. Special relativity reimagined classical mechanics not by creating issues, but by exposing the issues which already existed in the theory. Despite this, classical mechanics is still usually the first physics students learn because it's assumed to be simple enough to intuit and it is still very useful within its own contexts. Classical mechanics is demonstrably wrong, but its destruction led to its recontextualization within physics, not expulsion from it. These physics paradoxes are posited as both the downfall of old theories and the fertile soil for new ones, and this is an unquestioned good within the physics community. Special relativity was an essential piece of the puzzle in the development of physics which required us to dig deep into our own intuitions and deconstruct them to build new ones. In short, special relativity *queered* kinematics. Perhaps an even more queer contradiction in physics is that of the tension between general relativity and quantum mechanics, which lays unresolved and passionately debated with theorists constantly problematizing each other's theories on how to make it all work. Everyone agrees that the two constituent theories are extremely useful, but as a field we are still trying to move beyond both.

This paper aims to apply a similar queering process to the paradox of *queering methods* in PER by working both within and beyond conventional methods. Instead of treating this paradox as a problem to be fixed, we treat it as an opportunity for growth and change. This will be done through an exploration of papers in PER, queer theory, and related social sciences which provide concrete examples of ways to *queer* research methods.

Several of the studies used in this paper do not explicitly cite queer theory as an inspiration, and were likely not informed by this method. While there is a good methodological basis for ascribing queerness to things which were not intended to be queer [10], queer readings should not supersede the authors' methods and frameworks. Queer methods can stand on their own, but they can and should also work in conversation and tandem with other critical frameworks.

III. QUEERING QUANTIFYING

A. Useful Quantification

If there is argument about the intersection of queer theory and social science in general, there is an even larger argument about the role of quantification in queer theory. It is often wholly rejected as an un-queer method which requires limited definitions of people and categorization. There are two solid criticisms to this viewpoint which are relevant to PER.

Firstly, quantification has proven to be extremely useful in problematizing the way research is done. Although it was not explicitly aiming to use queer methods, Cid et. al. [11] utilized statistical methods and a large data set to demonstrate how PER normalizes research towards white men learning calculus-based physics at high-ranking universities, when none of these characteristics represent the majority of students who are taking introductory physics classes. This queers quantifying by exposing flaws in the assumed definition of an introductory physics student in PER.

Secondly, as transgender scholars have found, there is massive political potential in counting. Doan explicitly queered quantification when trying to find the number of people who are affected by legislation around bathrooms. By expanding her definition of transgender from people seeking sex reassignment surgery to any trans*, gender non-conforming (GNC), and intersex people, the relevant population went from 0.1% of the US to nearly 3% [12]. Doan's goal was not to assign the label of transgender to all of these people (intersex populations in particular), but to expand who we think about when we write legislation around transgender people and point out the flaws in the original legal definition of "transgender". The expansion of this definition encourages more coalition between people who may not have the same identities but are affected by the same legislation, and it demonstrates to lawmakers and activists what a large portion of the population will be affected by this legislation. This paper is a good example of how large-scale data sets can be used to reveal the incompleteness of their own definitions. More broadly, this demonstrates the importance of being explicit and intentional about how categories are defined in research.

B. Troubles With Quantification

> "Many social scientists contend that science has a method, and if you want to be scientific, you should adopt it. The method requires you to devise a theoretical model, deduce a testable hypothesis from the model and then test the hypothesis against the world. If the hypothesis is confirmed, the theoretical model holds; if the hypothesis is not confirmed, the theoretical model does not hold. If your discipline does not operate by this method [...] then in the minds of many, it's not scientific" [13]

"Physics envy" was coined by economist Philip Mirowski [14] to describe the way economics has used physics metaphors to describe human systems, and how this has harmed the ability of economics to do work which is relevant to people's lives. This term has further been applied to psychology and social sciences to describe the use of "hard science" methods in "soft science" contexts in an effort to legitimize the fields as scientific, often to the detriment of doing good research [13]. When a research community insists that every model, framework, and theory has "empirical" proof, it over-values the aesthetics of "being scientific" over collecting the data which is relevant to its research questions. In physics we are generally able to make approximations and simplifications in application to broader trends and large objects, but applying this same principle to people is not value-neutral or equally useful just because the method is more "science-like" [15]. When doing quantitative work, we need to prioritize what is useful over what is replicable and normalizable, as consistency is usually a result of flattening people's identities [16]. With this, researchers should also ask whether a quantitative analysis is best method to answer a qualitative question.

As pointed out by Traxler et al., most of the research in PER leaves biological sex and binary gender as an unstated assumption [1]. This essentialization of gender ignores the way that race, sexuality, disability, religion, and other dimensions of identity affect a person's experiences in a STEM space, as well as the complexities of biological sex and gender presentation [17]. As Cech and Waidzunas found in their qualitative work, sometimes being stereotyped as queer woman helped people gain legitimacy in STEM spaces as they were perceived as more "serious" and "capable" due to being masculinized [18], and Eglash similarly found that access to technoculture is gatekept via a type of "nerdy" gender male presentation which is restricted to white and Asian men [19]. These are "genders" which do not fit into our usual categorizations, but have large impacts on people's experiences in the field and will have an impact on quantitative results. Physics is overwhelmingly cisgender, white, and heterosexual, and as such any survey which averages over all identities other than gender will inevitably bias their results towards cisgender, heterosexual, and white populations. Due to this bias in the data, quantitative research on gender in physics often misses a lot of information and runs the risk of trying to apply "research-based recommendations" based on cisgender, white women to all women, regardless of how applicable it is to their experiences [16].

Additionally, transgender and nonbinary physicists are often excluded from quantitative analyses entirely. In a white paper written by nonbinary planetary scientists, Strauss et. al. notes how research participants are often assigned a biological sex based on their first names or data scraping, and there's little to no room for self-identification of gender [20]. Even if we expand the list of available genders and allow self-identification on surveys, we are asking research participants to discretize themselves into singular, fixed gender identities. Usually these participants are included with "women" in anal-

ysis, which implicitly defines women as "not men". This further normalizes the experiences of cisgender men, and disregards the population of nonbinary physicists as being too small— and therefore not important enough— to study. If comparing men to women with no further distinction, transgender participants who identify on the binary should not be dis-aggregated into their own category. If anonymity is a concern it is acceptable to include "nonbinary" as a category, and if the group is too small to be included in analysis this should be explicitly stated.

The only explicit example of queer-theory inspired quantitative work in PER is the *2016 LGBT Climate in Physics Report*, which blended qualitative and quantitative methods to learn more about the experiences of LGBT+ physicists [21]. While they still worked within the gender binary, they also called attention to this as an assumption of the research by explicitly defining how they use gender, sex, and sexuality, and furthermore called attention to the experiences of GNC and transgender participants via qualitative analysis within the same report. They also explicitly used an anti-deficit framework by comparing experiences within and between between LGBT+ physicists instead of comparing LGBT+ physicists to cisgender and heterosexual physicists.

In the future, quantitative work in PER should take far better care regarding the data sets used, the definitions used when creating data sets, and the underlying assumptions of lumping complex human beings into discrete bins. As Doan showed, there are ways to use national data sets to do queering work which is useful and intentional, but it requires questioning exactly what that data is, where it came from, and its limitations [12]. Beyond queering, it's a good scientific practice to critically engage with the underlying assumptions when doing any kind of research— especially quantitative work. The main research recommendations from this section are summarized in Table I.

TABLE I. Suggestions for queering quantitative research methods

Quantitative Recommendations
Define participant populations deliberately
Avoid reinforcing binary gender categories
Choose analysis methods based on research goals
Do not normalize data towards white, cisgender, heterosexual men
Collect data which includes GNC participants
Allow self-identification in surveys

IV. QUALITATIVE FUN

There exists a lack of attention to the non-generalizability of qualitative work caused by the homogeneity of academic physics spaces, with many studies neglecting to even mention participants' identities. Kanim and Cid's critique of the over-emphasis of research on a very limited demographic thus also applies to qualitative work [11]. However, qualitative research in PER generally shows more flexibility and affinity to the core ideas of queer theory. Therefore instead of restating demographic and definition concerns which were discussed for quantitative work, this section moves directly on to new ways to do research; primarily autoethnographies, phenomenology, and rethinking objectivity.

Autoethnographies are a very popular method in queer theory: where people discuss a culture or phenomenon through their own lens instead of interviewing an outside subject. One example in PER is Elby and Yerdelen-Damar's paper on breaking down the producer/consumer model of PER which falsely assumes researchers and instructors are separate populations [22]. Through this they introduce the idea of *instructionally generative fodder* whereby researchers are inspired by their research process to implement classroom changes. This type of collaborative self-analysis has great potential in PER, a field where many people do research directly tied to and inspired by their experiences in the broader physics community. Autoethnography also has a great potential for engendering emotional honesty, since participants/researchers are not necessarily looking to give a "correct" answer or maintain a professional demeanor with a stranger.

Another common queer method is phenomenological studies which focus on finding the "essence" of some phenomenon. One example in queer studies is Duran's photovoice study of a sense of belonging in queer college students of color [23]. To do this, the researcher asked the students to take pictures of the places, people, and things that made them feel a sense of belonging or helped describe that feeling, after which they did semi-structured interviews. They received images of a jar full of multicolored beads, friends' hands in a circle, and a birthday cake among others. Students described feeling double exclusion from queer spaces and PoC spaces based on their intersecting identities, and subsequently carving out smaller networks and counterpaces for themselves in non-traditional spaces. This phenomenological study queers qualitative methods by giving participants a stronger voice in their research and working to get at not just the formal structures, but the actual phenomena that make them feel a sense of belonging in college. Additionally, it includes a method of data collection which goes beyond the usual interviews and surveys.

There is an idea in PER that the researcher must be impartial and distant in order to "objectively" interpret the information they are given, but there are many studies where authors enmesh themselves into the lives of research participants to create an environment where participants trust researchers and subsequently share information more freely. In a study about queer black men at an HBCU, Patton did pre-interview meetings with most of the participants to answer questions about her positionality, methods, and underlying assumptions for the study [24]. Additionally, she was invited to events with participants several times after the interviews, going to clubs with them, having dinner with their families, and going to one of their homecoming events. This did not diminish her

work, it added richness and complexity. She was able to ask more deep and thoughtful questions during the interview, and it gave her far better insight into participants' day-to-day lives beyond the interview process. This boundary breaking has great potential in PER for pedagogical and social research. Researchers doing labs and activities with students instead of passively observing them, doing pre-interviews with curious participants, and being open about their own positionality and motivations are all great practices to engender trust and deepen data collection from participants. These recommendations and ideas are summarized in Table II.

TABLE II. Suggestions for queering qualitative research methods

Qualitative Recommendations
Do an auto-ethnography if relevant to your usual research
Gather qualitative data beyond interviews and surveys
Break boundaries between participant and researcher
Incorporate researcher and participant positionality in analysis
Prioritize empowering research participants

V. MOVING WITHIN AND BEYOND

For all its talk of eliminating binaries, queer theory still struggles with unintentionally reinforcing the "naturalness" of the straight/gay binary. Erickson-Schroth and Mitchell articulate this in their paper about queering queer theory with bisexuality [25]. According to them, as well as Ward's work on Dyke Methods [26], too much credence has been given to the idea that there are queer and un-queer people who are inherently at odds and have no overlap. Erickson-Schroth and Mitchell approach this from a bisexual perspective: by walking between gay and straight worlds but never being fully accepted in either, bisexual people face the same homophobia but are shut out from resources for gay people. Meanwhile Ward focuses more on gay men's pushback towards the idea that sometimes straight men have sex with men for heterosexual reasons, and that does not necessarily make them secretly gay or bisexual [26].

Additionally, queer theory needs to grapple with the complexities of the crumbling cisgender/transgender binary, as more people look to move within and beyond these identities in increasingly uncategorizable ways. This is an area PER can help pioneer by doing work which deconstructs rigid ideas of gender and sexuality. Much of the work on LGBT+ people in STEM is really about "LG" populations, with occasional bisexual or asexual participants. There is a need for more studies which center bisexual, asexual, intersex, nonbinary, transgender and GNC people, but also studies which call attention to the overlap and contrast between their experiences, lesbian and gay people's experiences, and cisgender and heterosexual people's experiences.

VI. CONCLUSION

Queering PER can and should go beyond contexts involving marginalized students. Concepts like breaking down the researcher/participant binary have great applications to research which involves classrooms. Additionally, the pathway into PER is still considered atypical in physics, and more autoethnographies could shed some insight into how and why academics and graduate students are increasingly choosing this field of study. Phenomenological studies could have great potential for IPER (informal physics education research) contexts to gain a better sense of the benefits and challenges conferred to participants and facilitators of informal programs. These creative ways to generate knowledge could offer deeper insights into participant experiences.

That being said, one of queer theory's strongest applications is in the study of marginalized physicists. Many studies which involve analyses of race and gender base their categorizations on large databases like IPEDS or the Unites States Census, when we know that these definitions are usually inadequate and contribute to the further marginalization of the people these studies are ostensibly trying to help [20, 27, 28]. While this may be inevitable for meta-analyses, we do not need to perpetuate it in our data collection, and should prioritize self identification wherever it is possible. Any discrete definitions of people's identities will inevitably lose information, which is why it is so important to be careful and intentional with where and why we want to discretize information. Strauss et. al. and Fernandez et. al. are both great resources on better survey methods [20, 29].

Even a good faith audience can easily look at queer theory and feel it is almost fatalistic in its contrary-ness and insistence on internal contradiction and in-fighting. If we can't ever know anything in queer theory, why try at all? To answer this I go back to my discussion of paradoxes: the boundless contradiction is interesting and inspiring, and fertile ground for new ways of doing research. Asking how we advance knowledge without setting some kind of boundaries on participants feels as nonsensical as asking how we can advance physics without fixing general relativity's contradiction with quantum mechanics. There's interesting knowledge to be found in trying to make contradictory things work together even if it fails, there's interesting knowledge to be found doing one or the other, and there's interesting knowledge to be found in attempting to probe the question. We shouldn't abandon physics just because it breaks sometimes, just as we shouldn't abandon queer theory just because it's challenging to apply.

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