Examining the STEM Institution and Imagining the Beginnings of a Revolutionary Praxis Through the Queer Perspective

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Madeleine Jennings, J.S. Deese, and Participants

“I feel like if you change that core [capitalist] part of the system itself, that [change] will fundamentally reverberate throughout it.”
-Alexandra, Participant

Abstract
The STEM institution in the United States has grown and evolved within the context of the capitalist society that it is embedded in. Scholars from the fields of education, gender and sexuality studies, and ethnic studies have adopted anti-capitalist frameworks which examine how American society’s educational, economic, and social systems have developed in ways that harm marginalized groups. These groups include the Gender, Romantic, and Sexual Minority (GRSM) community, Communities of Color, people living with disabilities, and women. This paper adopts an anti-capitalist and critical lens specifically through the use of Foucauldian analysis of power dynamics to examine how four GRSM people who experienced the STEM educational and industrial institutions conceptualize revisions to that institution through the radical lens of their queerness. Two participants left the STEM institution due to discrimination based on their GRSM experiences, whereas the other two are still embedded in engineering environments. Each participant describes their experiences with power and privilege with regard to their subjectivities and those of their superiors, as well as reimagine the STEM institution through the beginnings of a revolutionary Queer praxis (or, theory into practice).

Introduction
Historically, the STEM institution gained traction during World War II when the United States was in need of engineering and weapons research in order to establish itself as a global power [1]–[4]. This capitalistic history of STEM is still present today, and asserts itself through a persistent meritocratic and apolitical climate in STEM environments. This environment serves to effectively discourage any critical curriculum or discussion that is not centered around mathematics, science, or economics, due in part to the apolitical and meritocratic history within the STEM institution [5], [6]. Additionally, research that focuses on inclusion and diversity seems to pinpoint ways in which the institution is exclusionary, and often does not propose thorough systemic solutions to the issue [7], [8]. In addition, researchers in the field of STEM education have not extensively utilized frameworks useful for critiquing the institution through an explicitly anti-capitalist lens, instead preferring other critical frameworks to examine the institution, such as liberal feminism [6] and social capital theory [9]. This body of work is growing, however, and critical frameworks have proven quite useful so far in identifying
mechanisms with which the STEM institution upholds racist, patriarchal, and otherwise “traditional” ideals. However, their implications typically do not expand beyond institutional policy reform in favor of offering global, systemic solutions to change the structure of the STEM institution to solve these issues.

In addition to the scarcity of tangible, globally systematic solutions, the body of work addressing the enhancement of inclusivity in STEM focuses heavily on analyzing the experiences of marginalized communities that are cisgender (e.g. white women, people of color, cisgender gays and lesbians). These analyses are often made through liberal or systems-focused frameworks, largely ignoring the Gender, Romantic, and Sexual Minority (GRSM) community (See Gold, 2019 [10]) for more information on the GRSM community; Be advised that ‘I’ refers to the first author of this paper, and that I use ‘GRSM’ and ‘queer’ in place of LGBTQIA+. It is my belief as a queer individual myself that these terms more accurately encompasses the diversity within the community to which it refers). According to a recent poll, nearly 5% of the United States population identifies as something other than cisgender or heterosexual, which corresponds to over 16 million Americans [11].

Despite this statistic, however, the first paper on the queer STEM experience was published a little over a decade ago, meaning that research about this community remains disturbingly sparse [7]. The queer community is diverse, spanning all ethnic and racial communities, socioeconomic statuses, ability/disability statuses, genders, and more. Although there is an increasingly vibrant body of literature surrounding the issues with enhancing inclusion and diversity in STEM in terms of sex, race, and ethnicity, the GRSM community remains absent from a majority of this research; particularly the Trans* and Gender Nonconforming (TGNC) community, and queer people of color (QPOC, [12], [13]). Given the scarcity of research on GRSM people within the STEM institution, even less is known about how being GRSM compounds issues that have already been explored with respect to any other salient intersectional identities, such as race, ethnicity, gender identity, class, and disability.

One vehicle of marginalization is the establishment and maintenance of hegemonic and meritocratic power structures. Foucault [14], [15] describes power as a miscible, dynamic, and subtle force that plays out everywhere, especially in hierarchical institutions such as education. These power structures serve to subjectify individuals into ideologically dominant and stereotyped norms and practices, such as gender performance, heterosexuality, and nationalism [16]. This process of subjectification creates a totality within society – a system of norms and behaviors that must be adhered to in order to survive in a capitalist society – making ideological norms and practices extremely difficult to escape.
An antithesis of Foucault’s conceptualization of power and domination is queer theory. Although difficult by nature to define, queer theory can be described as the study of the rejection or subversion of subjectifying, oppressive capitalist norms, often through the critique of normative gender and sexuality and the intersections of race, class, and disability [16]–[18]. Revolutionary time – or time spent subverting interpellating norms through whatever means available – is a tool that the marginalized communities can use to cope with power structures and marginalization. Often, revolutionary time can include the mobilization of activists against marginalizing forces, such as the International Women’s Strike on March 8, 2017 [19]. However, revolutionary time can take the form of daydreaming about a queered future on company time or pushing against institutional norms which bar marginalized groups such as the GRSM community from engineering institutions.

This qualitative study utilizes the stories of four GRSM individuals who are currently or who used to be pursuing an education/career in STEM. Using aspects of queer theory, Foucauldian analysis, and revolutionary time, this study aims to answer the following research questions: What is the nature of the GRSM experience with power and privilege within the STEM institution? How do GRSM individuals imagine a revolutionary praxis for STEM? Each participant gives an account of their experiences within the STEM institution as well as ways that they envision revolutionizing the STEM institution to become liberatory for the GRSM community, among other marginalized groups. Finally, it should be noted that I intentionally include each participant as a co-author. This acknowledges and attempts to dispel the power dynamics present in a researcher/participant relationship, as well as allows my GRSM participants to take ownership of their own experiences and stories. Multiple participants acknowledged their co-authorship and/or story-sharing as part of their healing process with regard to the trauma that STEM culture had inflicted upon them, as well.

**Conceptual Frameworks**

**Researcher Subjectivity**

Like any individual, I belong to a set of communities and hold a number of subjectivities, both known and unknown to me at this time. The subjectivities that I am most aware of, or that best describe me, would be that I am a white, queer-identifying, genderfluid, disabled person that grew up middle class, who is an engineer-turned-social scientist and researcher, and who strives to be an activist for marginalized communities (especially the queer community). Additionally, I have recently developed an interest in queer, Marxist, anarchist, and feminist philosophies. These philosophies inform my belief that the lack of research proposing revolutionary, systematic changes to the STEM institution – combined with the lack of representation of marginalized communities within STEM – is a function of the capitalist nature of the STEM institution. I believe that a fundamental restructuring of the STEM institution is necessary in order to make it hospitable for marginalized communities, and for the technical
innovation that it produces to serve society instead of the interests of capital. This, I feel, can be accomplished in part through “small numbers” research [20], which revolutionizes traditional sampling restrictions that can silence already marginalized voices and produce rich, detailed accounts of the mechanisms of marginalization embedded in the fabric of society. Through the stories valued in small numbers research, we can develop a revolutionary curriculum and pedagogy as a community to better serve society. Adopting queer theory as well as critical, anti-capitalist frameworks for this project help provide the tools to critique the STEM institution as being the ideal environment for maintaining heteronormative, homophobic, and patriarchal ideologies, as well as to propose revolutionary ways to dismantle this ideological aspect of STEM.

Foucauldian Power Dynamics

Stemming distantly from Marxist economic theory and philosophy, Foucauldian analysis focuses on the immiscible dynamics of power through an anti-capitalist lens. Foucault, a French philosopher active during the AIDS crisis, discusses class and identity struggles as power dynamics, which he calls “biopower.” Similarly, “biopolitics” is the management of the people through the manufacture and dispersal of social norms, which create inherent power structures [14]. Importantly, Foucault defines these power dynamics as being faceless; they are not attributable to any one individual, class, political party, or global power, and are instead propagated initially through the ruling class at the time. Althusser [21], a philosopher in conversation with Foucault at the height of his scholarly activity, explains that these power structures are upheld through publicly disseminated social “superstructures” in a process called social reproduction.

The superstructures that Althusser refers to consist of institutions such as education, industry, police and the military, discourse, politics, law, and socially accepted ideology in general. Foucault [14], [15] explains that the way that these ideological apparatuses are enforced is through the constant impression of surveillance and punishment, which is referred to as the panopticon theory. The panopticon is a hypothetical prison concept, introduced by Jeremy Bentham in 1791 [22], in which a guard is able to see every prisoner at all times, but the prisoner cannot see the guard. This creates the illusion that each prisoner is being constantly surveilled, thus efficiently enforcing the desired behavior. The same effect of obedience is achieved in the real world through the minutiæ of everyday life. For example, binary gender norms are enforced through gendered language, social expectations, the erasure of genderqueer individuals from history, and discourse found in popular media that enforce these arbitrary norms. Failure to conform to these norms leads to punishment through social ostracization or threat of physical violence. For this paper, I focus primarily on the aspect of punishment that the participants experienced due to their nonconformance, as well as how they subtly rebel against these punishments.
**Queer Theory**

Queer theory is derived from Marxist thought and continues to evolve from poststructural theorists such as Foucault [14], Butler [16], Muñoz [23], and is rooted deeply in anti-capitalist sentiments. Other queer theorists examine social and power structures through the lens of queerness, otherness, and marginalization, such as Johnson [17], who relates his Blackness and his queerness through his grandmother. Poststructuralism and queer theory also share roots in Marxist critique and analysis [24]. Queerness is inherently an unstable concept, constantly shifting as societal norms shift. It is influenced by how history manifests itself in everyday norms through historical materialism [25]. Therefore, queer theory aims to understand what made and continues to make identity what it is, what defines it, and what governs those definitions, as well as how to subvert those governing forces for the purpose of liberation.

One way that queer theory defines queerness is through “what is essential to the dominant and unqueer… queer theory argues that there is beauty, power, and truth, even magic where dominant culture and its authorized language posit only ugliness, impotence, and falsehood [26].” This definition of queer theory describes how queerness celebrates otherness and subversiveness, thus providing an asset-based framework with which to analyze the queer perspective within the STEM institution, as well as a guideline for introducing revolutionary, subversive praxis into the STEM institution.

**Revolutionary Time & Alternative Futures**

The ideological pillar of the capitalist “superstructure” – as opposed to the military, state, or political pillars – is most vulnerable to revolutionary change [21]. Revolutionary time is the active refusal to be productive for the capitalist regime, instead focusing on resting, re-educating, mobilizing, and enacting counter-ideological movements [19]. Revolutionizing institutional powers begins with engaging in personal revolutionary time, such as imagining alternative futures. The conceptualization of alternative futures may take multiple forms, such as Black radicalism [27], [28], queer futurity [23], and crip or disability futurity [18]. Imagining alternative futures is a form of revolutionary time, as it directly subverts productive time and benefits the working class and marginalized individuals as opposed to the ruling class.

**Methods**

*Investigative Context & Participant Recruitment*

Due to the nature of the population that this study seeks to understand, as well as the need for “small numbers” research [20], [29], it is qualitative in nature. Consistent with the critical frameworks chosen for this study, methods were informed by queer theory, Marxist critique, and revolutionary time. This study aims to answer the following research questions: *What is the*
nature of the GRSM experience with power and privilege within the STEM institution? How do GRSM individuals imagine a revolutionary praxis for STEM?

Originally, recruitment for participants was to take place at Arizona State University’s Ira A. Fulton Schools of Engineering. Participants being considered were graduate or undergraduate engineering students who belong to the GRSM community in some way (with the exception of Allies). However, recruitment efforts were hindered at ASU due to the COVID-19 pandemic response. Recruitment efforts were therefore expanded to consider GRSM students or professionals who study/studied or work/worked in STEM fields. These participants were recruited from across the country via online outreach on Facebook. Participants were recruited through convenience sampling and through announcements in various GRSM Facebook groups. Overall, four participants were recruited. The following section serves to profile each participant.

Participants

- Alexandra is a white, demisexual, lesbian woman, who studied engineering at a community college prior to her transition. She also has autism and ADHD. She left engineering when she realized that she would either have to pursue it after she had fully transitioned, or not transition in order to pursue engineering. She is now a senior pursuing a degree in women and gender studies at a large, public university in the southwestern United States. She notes that she is uncomfortable with the qualifier “trans,” and prefers to identify as a demisexual lesbian woman.

- Mathiae is a white, genderfluid transmasculine person who identifies as aromantic and asexual. Mathiae uses neopronouns and will be referred to as ze/zir/zirs throughout this paper. Ze studied mathematics and physics at a small, public university in the southern United States, but switched to history after a transphobic professor discriminated against zir in class, and little was done by the university administration to remedy the situation.

- Solomon identified verbatim throughout their interview as white, agender, asexual, aromantic, autistic, and as having bipolar disorder. They are also autistic. Solomon uses they/them pronouns. They are currently working as a mechanical engineer at a large automotive company and cannot be out at work for fear of being fired.

- Adrian is a white, bisexual, cisgender woman who works as a software engineer at a large tech company in the southern United States. She is married to a cisgender man and has a child. She is not out at work as bisexual, despite corporate and federal non-discrimination policies.

Data Collection

To facilitate a good rapport and trust with my research participants, I held short, 10-20-minute individualized, non-recorded meetings via phone or Zoom with each participant to introduce
myself, the purpose of the research, and to review the consent form. This meeting also served to familiarize each participant with the interview protocol, which helped them to produce thoughtful responses that better addressed the research questions, while also allowing them to provide feedback or ask questions regarding the research project. I also took this opportunity to learn how the participant identifies, and let them pick a pseudonym that aligns with their preferences. Finally, I shared my own story as a queer engineer with the study’s participants to neutralize some of the inherent power dynamics at play within the researcher/participant interaction [29].

Following this introductory meeting, one 45-60-minute semi-structured interview was held for each participant. Each interview was recorded, transcribed for coding, and scrubbed of identifying information, such as their location, school, or company. Although I was searching specifically for evidence of power and privilege structures stemming from capitalist ideology within the STEM institution, I designed the interview protocol specifically to not mention these concepts. Instead, I asked open-ended questions that allowed the participants to discuss aspects of their identity and story that were important to them, which in turn allowed participants’ stories and experiences to illuminate capitalist structures of power and privilege within the STEM institution without explicitly pointing them out. As such, the initial protocol and probing questions did not address identity or power structures, instead honoring each participants’ own experiences. I believed that this would help to mitigate the power imbalance between researcher and participant, as this protocol allowed the participant to tell the story that was most important to them and did not lead participants to answer in ways that they felt were mandated by the purpose of the research.

This initial pilot protocol was tested on a colleague. However, my colleague and I found it difficult to facilitate deeper conversations without the use of language that considered identity. Identity, through the lens of a Foucauldian analysis, is a tool used to subjectify individuals under oppressive social norms. As a result, I initially avoided conversations around identity. However, conversations surrounding identity are mainstream and were well understood by the participants. As a result, I added identity-specific interview probes to allow for deeper conversations regarding each individual’s particular identities. This enabled me as the interviewer to address the unique aspects of my participants’ subjectivities that they felt were relevant to their experience, including stories regarding neurodivergence and disability, or stories about experiences that they had with power and privilege outside of the STEM institution. This addition also prevented the accidental creation of a monolithic participant by creating an opportunity to honor each participants’ unique qualities and traits. The finalized interview protocol and probing questions are below:

Interview Protocol:
1) Can you please describe for me how you came to pursue STEM, and any challenges and successes you may have faced thus far?

2) Can you describe a time in your program or workplace where something happened that made you feel unsafe or uncomfortable?

3) Could you describe a time when a person in power acted as an advocate or an ally to you or somebody in your community?

4) If you could change STEM to be more inclusive to people like you and me, what would you change?

Probing Questions:

a. You mentioned _______ earlier. Can you tell me more about that?

b. You mentioned that you identify as _______. Can you explain more about how that experience affected you with regard to that identity?

b. Can you explain what you mean by __________?

c. Can you explain how you felt when that happened?

Data Reduction & Analysis

Similar to Pawley’s [29] methods for protecting participants, I sent each participant their anonymized transcripts to allow them to retract any other information that they wished. Additionally, I allowed each participant to pick their own pseudonym. This tactic was chosen to help align the power dynamic present between researcher and participant, as well as to protect the participant. Interestingly, a number of the participants chose to use their own names. To protect their anonymity, I will not distinguish which participants chose pseudonyms and which did not, again utilizing Pawley’s “group immunity” strategy. To further align the power dynamics between researcher and participant, I offered each participant the opportunity to co-author on this project. This was in an effort to acknowledge the ownership of their own stories that each individual offered as well as to acknowledge each participants’ contribution to the larger research project. Additionally, some participants expressed that explicitly acknowledging the ownership of their story through co-authorship or through using their real names helped them heal from the trauma that they had faced within the STEM institution. Only one participant asked to co-author, under the pen name J.S. Deese, which helps protect their anonymity through the same “group immunity” strategy mentioned above.

Once each participant confirmed their transcript, I began the coding process, referencing coding strategies discussed in Saldaña [30]. I began with holistic coding, due in part to the diverse experiences that my participants shared with me. My objective was to capture encapsulating themes that arose from the data, while still respecting the sanctity of each participants’ story and remaining aligned with my framework. To accomplish this goal, holistic coding involved aspects of in vivo, narrative, and initial coding. This resulted in approximately sixty thematic codes.
Code-mapping was utilized to organize first-cycle codes into loose themes, and then later, into more structured categories. This resulted in approximately twenty codes. Finally, axial coding was used to further unify data that were separated during first cycle coding and compile major thematic codes into a codebook. I emerged with eight major themes within this codebook, six of which are discussed in this paper: STEM Ideology, Power Hierarchies, Allies, The Ultimatum, Coping Strategies, and Suggestions. The two codes that are not discussed in this paper are “I chose engineering because...” and Notable Quotes. Throughout the coding process, memoing was utilized to help conceptualize findings within the chosen frameworks.

**Limitations**
This study serves as a pilot. As such, analysis is limited by the number of participants that I was able to recruit. Additionally, I was unable to recruit GRSM participants who reside at marginalized intersections of race and ethnicity. I suspect that this difficulty was due in part to the systemic discrimination that happens within the STEM institution, which may prevent GRSM people of color from pursuing it in the first place. The lack of racial and ethnic diversity among the participants could also be due to my own identity as white, as well as other issues that arose with recruiting due to the COVID-19 crisis. Given the nature of the framework, a different analysis method, such as discourse or narrative analysis, would have been more appropriate for the data. This was an exploratory study, however, and coding helped deepen my understanding of patterns within the queer experiences in STEM.

**Validity**
Using Walther et al.’s [31] framework for achieving validity in engineering education qualitative research, I present multiple means with which validation was achieved throughout this project. By being a member of the GRSM community myself, this study possesses some aspect of communicative validity [32]. This presents me with the ability to filter my participants’ stories through my own experiences and knowledge about the community, positioning me as an individual with enough experience and community-specific knowledge to conduct research with this community. I also was forced to navigate challenges within the STEM institution as a direct result of my identities as queer and disabled, thus deepening my understanding and empathy with my participants’ experiences.

With this mentioned, I am aware that my subjectivities as someone within the community that I am researching could present a quality threat to the findings of this research. To mitigate this threat, I engaged in memoing processes to help me to reflect upon all of the ways in which my subjectivities could influence the findings. Additionally, I engaged in a “critical friends” protocol with trusted mentors and colleagues to ensure that my framework was appropriate, my analysis methods were sound, and that my findings were representative of what the data present [33].
Results & Discussion

STEM Ideology

A recurring theme among all four participants was the reflection upon and discussion of toxic culture due to problematic dominant ideologies within the STEM institution, and particularly within engineering. Interpretations of the dominant ideology varied in epistemological depth between participants, with the most surface-level analyses being relegated to the discussion surrounding the gender imbalance within STEM, and the most in-depth discussions relating explicitly to the capitalistic philosophy of STEM being the source of its poor and unwelcoming culture for marginalized communities. Overall, the queer perspective surrounding the STEM ideology seems to be that STEM is societally regarded as masculine, rigid, heteronormative, entrepreneurial, and not particularly socially aware. This finding is consistent with much of the work regarding STEM’s (and particularly engineering’s) chilly climate for minority or marginalized communities [34]–[36]. In turn, participants feel that the societal values placed on the STEM institution are what attract individuals who tend to conform to these ideological norms, and in turn, are what makes them feel like they themselves must conform to these norms. Alexandra describes this phenomenon:

And I just – I do agree that [engineering had] like, um, it was definitely like, a societal kind of pressure, and expectations. Like, I would say that through the professors – I guess, like, if we’re gonna talk about power dynamics that, like, the professors, as well as – I think the reason the ex-military, you know, now that I'm thinking about it, the ex-military guys – I think the reason they intimidated me, too, is because – One, [societal norms are] drilled into them through the military. But also, they were older, and so they kind of also – Kind of held like, a little bit of a, like – More than just a peer, like, presence. And so like, both through the professors and some of those students, those were like, the male role models, kind of that, like – Like, I think subliminally, like, you're supposed to adhere to, and it's expected that you adhere to be like them... In my personal life, as well as, um, like, in other instances. Like, people would frequently, like, think I was, like, a gay dude or something and, like – And so I would constantly, like, overcompensate for that. Like, I took up, like, shooting as, like, a hobby, and took up several other things that I don’t even get involved in anymore. Paintball and stuff. And, like, those were the things I would, like, be pushing, like, heavily, and talking about all the time and stuff around those kinds of guys to kind of just, like – Like, bond somehow over those things. And I think, like – I think without realizing it, basically just kind of, like, trying to emphasize the, like, “No, no, like, I'm not queer. Like, don't worry about that,” type of thing.

All of the participants mentioned some form of subjectifying norm which served to marginalize
them within the STEM institution, consistent with a Foucauldian analysis of the ideological pillar of the capitalist superstructure. These norms often resulted in a decision that each participant had to make – which served a “gatekeeping” and censoring function within the STEM institution – that I coded as “The Ultimatum.” The Ultimatum is marked by a choice where the participant is inundated into STEM culture and realizes that in order to remain in STEM, they must sacrifice some aspect of their identity in order to fit in. If they are not comfortable with this sacrifice, they make the decision to leave STEM. When Alexandra and Mathiae were faced with the Ultimatum, both decided to leave the STEM institution in order to be out and more fully themselves. Both participants are currently pursuing degrees in the humanities, and they both expressed relief at being able to be more themselves in their programs.

Solomon and Adrian, however, remained within the STEM institution when faced with The Ultimatum, and must remain closeted at work to prevent adverse repercussions. Both participants expressed some form of distress, with Solomon mentioning that they are constantly misgendered and deadnamed, and Adrian mentioning that she cannot be honest about her sexuality at work without feeling like she would be sacrificing upward momentum in her career. This type of pressure to remain closeted or perform a certain gender identity in the workplace is consistent with other works that investigate the GRSM STEM experience in the workplace [34], which corroborates that compartmentalizing one’s queer and STEM identities can create or exacerbate mental health issues such as anxiety and depression [37]–[39]. Connecting this finding with the framework, the pressure to conform to heteronormative and cisgender requirements in the workplace is enforced through the threat of punishment or losing one’s job. This phenomenon can be compared to the analysis of a panopticon culture, which creates an illusion of surveillance and a requirement to conform, at the risk of being punished.

**Power Hierarchies**
The largest and most pervasive theme that emerged between each of the four transcripts was the presence of power hierarchies or imbalances within the STEM institution, often resulting from aspects of the STEM ideology. Power hierarchies manifest from imbalances of power, which stem from capitalist institutional, societal, or structural sources. I defined capitalist institutional powers as the power that derives from a large institution, such as a university system or a corporation. Societal power structures derive from what is deemed as “acceptable” within a capitalist society, including concepts like gender norms, heteronormativity, and neurotypicality. Structural powers derive from interactions that are hierarchical or structural in nature, such as a student interacting with a professor or administrator, or an employee interacting with a boss or with HR. These three types of power sources often interacted with each other, making them difficult to separate into distinct codes. For example, Adrian describes an instance of all three
types of powers. She explains not feeling safe to come out at work as bisexual, despite corporate anti-discrimination policies:

*I know that there wouldn't be a consequence [to coming out at work] as far as, like, I wouldn't lose my job. Because they do – We have trainings that specifically say not to harass people. The same that large corporations do. But I do feel like I might lose some of the help that I feel like senior women are willing to give me... But, um, I just don't know how it would affect the politics of, like, me getting from entry-level to, like, a more senior position. Um, there aren't any – As far as I know, like, any openly gay women in senior positions in my company. They're all married to men. Um, and I'm married to a man. So, if they think that I'm like them, I know that they'll continue to help me in the way that they already have. So, I don't want to burst their bubble.*

This excerpt illuminates how, despite institutional power structures seemingly protecting her in the event that she comes out at work, Adrian still feels like she would be punished for not conforming to societal and structural norms within the workplace. Solomon describes this same phenomenon at their company, calling it “*that whole rainbow capitalism thing,*” otherwise known as pinkwashing. These norms exert power by mandating heteronormative and gender-binary behavior by anybody who wants to progress professionally, effectively forcing Adrian and Solomon to remain closeted. This is an example of an interpolative norm, which is an ideological norm that is readily adopted and accepted by most of society, and which serves as the basis for which discrimination takes place [21]. As is the nature of interpolative norms, most of these power imbalances were informal in nature. Another example of this was uncomfortable interactions with classmates, as Alexandra describes:

*I had like, several friends I had made in the engineering program who like, as I associated more with my queerness, just like, basically expressed like, extremely like, homophobic views. Um, I remember one instance when I just jokingly posted a, uh, image of just two men kissing on my Facebook and one of the guys [in the program], um, completely freaked out and, like, was just – Went on this, just, like, very homophobic tirade on my Facebook about it, and I was just like, “Oh my gosh, like, is this really happening right now?”*

Part of the experience with power hierarchies that many participants had was with allies in the space they were navigating. Each instance that a participant described was marked by the presence or absence of an ally, which tended to have an affect on the outcome of the situation. For example, Solomon described struggling with bipolar disorder and autism during their
capstone project, which nearly made them fail the course. They explained that their undergraduate mechanical engineering department’s head intervened on their behalf and “pulled some strings” to help them successfully complete the semester. This intervention, combined with other institutional and structural support systems that they encountered, enabled them to successfully graduate and become employed. Conversely, the lack of allies caused Mathiae to leave zirs mathematics and physics program. Ze decided to leave zirs mathematics and physics program after a professor responsible for teaching a bulk of the mathematics coursework humiliated zir in class for being transmasculine. Following this incident, Mathiae described administrators who performed allyship well. Still, when presented with the decision of whether to remove the transphobic and abusive professor, they elected to preserve that professor’s spot. Mathiae explains:

*I didn’t have any support in that class, no. But I did have another professor that I talked to about it, and it was confidential and everything. And she was super nice about it. Super – Super comforting. And I also went to the chair of my department. And he was comforting about it, but – And they did an investigation on that [transphobic] professor for a whole multitude of reasons. Him being transphobic towards me was just a part of that. And nothing, from my knowledge now, nothing ever came of it. Because he is an older professor, and there were instances where he would trail off in conversation, he wouldn’t complete lectures, his grading was incomplete. And so, he was investigated for that. And then during that investigation, the transphobic comments came up. But later on, I was informed that nothing – Like, he’s still a professor there. Nothing has changed. His position has not changed.*

Allyship towards the GRSM community is an example of institutional and structural power. When handled correctly, it can be a useful tool to help level power imbalances between students and faculty or employees and bosses. However, allyship and trust can be abused by administrators and professors, as exemplified by Mathiae’s story. The department chair seemingly had enough evidence to remove an ineffective and harmful professor from a position of power but elected not to do so. This decision resulted in an incredibly harmful outcome for Mathiae, who expressed a great deal of concern for incoming mathematics students who might share a similar identity to zir. Ze also mentioned that the decision to leave mathematics had an adverse effect on zirs relationship with zirs family, who strongly desired for Mathiae to pursue a STEM degree. The culmination of trauma that ensued from this incident exacerbated by the ineffective “allyship” displayed by the administration weighed so heavily on Mathiae that ze became observably upset during our interview.

*Coping Strategies*
Navigating power structures within the STEM institution had an adverse effect on the participants’ mental health. In order to cope with the trauma inflicted, or even to avoid trauma in the first place, participants explained a number of coping strategies that they incorporated while navigating the STEM institution. Mostly, participants explain that they remain closeted at school or the workplace, citing that they did not want to put forth the emotional labor required to come out. Alexandra and Mathiae left the STEM institution altogether for this reason, but not without lasting trauma. Mathiae explains:

[Thinking about leaving mathematics is] just like, really painful for me. Because, like, in that class, specifically, there are some teenagers and young adults – There's a local high school that also went to that four-year university. And they were like, 17, 18-year-olds that were seniors in high school. And I'm just worried that I wasn't the only one. And I have a pretty thick skin most of the time. I just like – Recollection on it later bothers me a lot. And I just don't want other people to have left their math degree because of him (the transphobic professor). There's like, four or five math majors that left their degree because of him, and, yeah, they all had other reasons, but I was a bit – Mine was a different case. And it's not that – I, like, I still love math. Like, it's something I always loved. But I just don't want people my age or younger to go through something like that.

Solomon and Adrian are still part of the STEM institution and are working as engineers. Interestingly, both Solomon and Adrian mentioned that their employers have “rainbow organizations” that support GRSM people within their respective companies. However, the presence of these organizations does not make either participant feel more comfortable coming out at work due to perceived power structures originating from colleagues, bosses, or other societal norms. Both participants stay closeted for fear of losing their jobs or limiting upward mobility. To cope with being closeted in the workplace, both participants are vocal about their identities in their personal lives. However, Solomon explained that even though they have support outside of work, they still feel the urge to move on to a more accepting environment:

Uh, but I think I've overheard stuff like, them saying like, transphobic comments. Just like, like, he-she, you know, calling somebody a he-she... Which, like, it could be worse, but like... It could be a lot better. So, I know that I'm searching for jobs right now... But when I was – I was like, 'Okay, I'm gonna find a place and make sure that when I go there, I'll out myself at the start. Like, I'll sign the contract, they'll like, hire me and I'll – I'll out myself.' Because I won't be able to handle being misgendered the entire time. And [I'll] see what happens from there. Um, yeah, hopefully, it could be progressive, but I wouldn't be able to, like, mentally handle being misgendered for another job.
Overall, participants overwhelmingly discussed the need to stay closeted as they navigated the STEM institution. Many of them find support outside of the workplace with friends, therapists, online forums, and sometimes family. However, the process of compartmentalizing one’s life to conform to workplace norms has been shown to have adverse mental health repercussions. Despite pinkwashing performances by corporations and institutions, all participants felt subjected to conforming to heteronormative, cisgender ideologies or behaviors in the workplace [40].

**Queer Revolutionary Praxis**

Recent work in engineering education has documented the meritocratic and apolitical climate within STEM as being a source of social disengagement [5]. STEM curriculum purposefully focuses on the importance of technical knowledge and “rigor,” placing social sciences and humanities at a lower level of importance [41]. This can result in STEM graduates who are ignorant of the social implications of their design, and who derive their success from corporate benchmarking. Often, a participant mentioned that engineering students would rather remove humanities classes in favor of more engineering or math. A direct example of the repercussions of this institutional neglect of humanities in STEM is ableism in engineering design. The specific example that was given by Solomon was privatized scooter sharing apps reducing accessibility for disabled people on public sidewalks. They explain why the emphasis on humanities might help teach STEM students to consider the human factor in their design:

> Um, well, it's the same things where it's like- because we need to understand diversity and inclusion. And then my idea of it stops there. Because it's like, I just like, I know that I want it in there. Because I know so many people who are so focused on the math that like – I know, I've seen like, petitions posted on [my University's engineering] meme page that are like, 'Hey, let's have a petition to have fewer Humanities classes in the engineering program.' Like, that's the opposite direction! There needs to be more! We do the same exact math, just in different ways, in so many classes... A huge thing about design is that people don't realize that other people are having to interact with this design. Consumers are using this... So, if there was something that got them to really – Like, if there was, like, an engineering design class that was like, Engineering for People – Like, have a class that's saying, ‘This is how you engineer things for the consumer...’ I don't know the specifics, but [here's a] totally revolutionary idea... Teach people empathy.

Interdisciplinarity repeatedly surfaced as a theme within recommended suggestions to revolutionize STEM. Some participants believed that providing opportunities to work with other
engineering disciplines could help diversify ways of thinking within the STEM educational institution, perhaps leading to more socially aware scientists and engineers. Indeed, interdisciplinarity can help to engage learners in creative and critical thinking processes [42], [43]. Alexandra, who left engineering for women and gender studies, reconceptualized interdisciplinarity within STEM to include critical race theory:

There's actually a professor here. Um... She teaches one of the, um, the feminism sci-fi course, and um, she's a former engineering student because she wanted – Um, and she's very much in the interdisciplinary aspect of it. And um, it's just, it's very fascinating because um, she's very big on like, talking about how like, the things minorities have done within like, the community within engineering and like, feats that have been done and changed and um, yeah. It was just, it was really cool. Because originally, she’d gotten an aerospace engineering degree. And then it was like, oh, at the time women couldn’t fly, you know, like, planes and stuff – like especially Black women and like, and um, and so she was like, “Screw this,” and went back for her – I think she ended up going for justice studies or something. I don't know what it would be called at the time. But um, but yeah. Anything incorporating a lot more of that into things.

Imagining a revolutionary curriculum for STEM was a thematically common trend among many of the participants. My participants and I suggest that the reconceptualization (or queering) of what it means to be an engineer or a scientist must happen in order to revolutionize the STEM institution. This revolutionary change requires a fundamental ideological shift in how STEM is researched, taught, and executed, with a focus on community, mutual aid, and social support, instead of capital accumulation. In other words, my participants advocate for queering STEM.

Conclusion
Prior work on the GRSM community in STEM, and particularly engineering, is slow to catch up to diversity and inclusion literature that has been published in the field already regarding sex, race, and ethnicity. Much of the work on GRSM people in STEM is largely seminal or flagship in nature, and offers only a baseline understanding of what life is like for (usually) only a subset of GRSM engineering students [44]. Works like these outline that GRSM people in STEM (although focusing primarily on lesbian, gay, and bisexual people [7]) are generally less respected, feel isolated, and are less healthy than their cisgender, heterosexual counterparts in STEM and much of this health discrepancy is due to the explicit marginalization and discrimination of this community. The findings of this study seem to corroborate prior work regarding the GRSM STEM experience.
Literature exploring the GRSM experience in engineering education seems to focus on establishing the fact that discrimination occurs on the basis of gender identity and sexual orientation in many STEM settings, including at universities [34]–[36] and in the workplace [39], [40], [45]. However, works on inclusion and diversity within the STEM institution rarely adopt key anti-capitalist critical frameworks such as queer theory or Marxist critique. In addition to corroborating findings from the broader body of literature, this paper seeks to encourage a more critical and revolutionary way of examining and critiquing the STEM institution. This manuscript provides a brief outline of the theoretical context for why adopting critical frameworks are necessary for inciting revolutionary change within the STEM institution, supported in part from empirical evidence and prior literature.

In an effort to begin to initiate a revolutionary praxis within STEM, I ask readers to engage in revolutionary time to critically examine their place within the STEM institution, as well as how their discipline contributes to capitalist accumulation and the subjugation of marginalized communities. The reader may consider the following questions:

- In what ways does my STEM discipline center capital or profit over the needs of society? Who benefits from the ways in which capital is centered, and who suffers?

I ask this question to engage the community in a broader conversation about how the STEM institution actively harms queer people who attempt to navigate it. In many of the cases that the participants outline, the STEM institution seemed to be more concerned with producing results and profit than working to ensure that those who wanted to succeed in STEM could indeed do so. Solomon also points out in the example of the rentable motorized scooters that corporatizing technological advances has a direct implication on broader societal issues, which often harm marginalized communities.

- How have I been complacent in perpetuating power structures or repressive ideologies? Who has been most affected by this complacency within society, the workplace, the classroom, etc.?

The readers may deduce from the stories of my participants that successfully navigating the STEM environment without lasting health or career repercussions requires one to at least partially subscribe to its ideological and epistemological underpinnings. As researchers who have navigated the STEM environment well enough to engage with this paper, my concern is that we have internalized many of the harmful ideologies and epistemologies that are the foundation to a successful (e.g., imperialist, capitalist) American STEM enterprise. I ask this question to help alert readers to any uninterrogated, non-critical biases they may have as they engage with their research.
How can I begin to dismantle dominant capitalist ideological structures within my STEM environment, research, or classroom? How can I mobilize others to do the same?

This question is difficult for me to provide a generalized answer for, precisely because it is so contextual. Although STEM epistemologies are largely informed by Western thought, the intensity of these epistemologies varies by discipline and sub-discipline. Engineering, being a field of study with the worst rates of representation among all STEM disciplines, has a very different “mood” or “climate” than nursing, for example. Thus, mobilization towards revolutionary change may look different for each environment. However, my participants’ engagement with other people and resources helped them develop mobilization and radicalization strategies for themselves or for STEM. Beginning to have conversations with others who share your experiences (e.g., other queers, QPOC, women, disabled people, marginalized community, etc.) about the role of STEM and your role within STEM can help spark ideas for inciting revolutionary changes.

**Implications & Future Work**

Prior works in fields such as engineering education have begun to focus on the GRSM community in STEM environments. Although this work is clearly valuable as it establishes a basis of understanding for this community’s experience in engineering, few of these works seek to understand the experiences of GRSM people in STEM through frameworks that have been created for the express purpose of understanding queerness. Furthermore, these works do not typically identify solutions with which to systematically and culturally dismantle repressive institutions that affect the GRSM STEM community. Therefore, I suggest that a more critical analysis of the STEM institution be adopted in inclusion and diversity research that focuses on STEM’s role within a capitalist society. This work should also seek out systemic, revolutionary solutions from the communities that are actually affected by these systems, such as the GRSM community in STEM. Each participant in this study engaged in revolutionary time during their interviews, in which they critiqued the STEM institution and imagined alternative futures in which it better served the GRSM community (and society as a whole).

Due to the nascency of the body of work on the GRSM STEM experience, this work primarily serves two purposes – to diversify the body of literature surrounding the GRSM STEM experience, as well as to introduce an explicitly anti-capitalist critique of the STEM institution. Further work on this topic is required to establish competency regarding the GRSM experience within the STEM institution, as well as the suitability of, specifically, anti-capitalist critique in STEM education research. Finally, expanding research on the GRSM experience in STEM helps to normalize the presence of this community within the STEM institution, perhaps creating an opportunity for the adoption of a more inclusive STEM culture. This work serves as a pilot study, which will inform much of my future work, including my dissertation. I intend to continue
investigating the experiences of marginalized communities, and particularly the GRSM community, within the STEM institution through a post-modern, queer, and critical lens.

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**References**


