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RESEARCH ARTICLE

# Examining Entrepreneurship Education Program Experiences of Women Faculty Engaged in Biomedical Research

**Aida Lopez Ruiz[1] · Prateek Shekhar[2] · Aileen Huang-Saad[3] · Jacqueline Handley[2]**

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## Abstract

Although several entrepreneurship education programs (EEPs) have been created for faculty, research examining women faculty experiences participating in EEPs is minimal and particularly negligible in the context of their academic research. To address this gap, we examine women faculty's perceptions and experiences toward EEPs in the context of biomedical (BM) research. The research question examined is as follows: how do women faculty with a BM research focus experience and/or perceive EEPs? Eight self-identified women faculty who pursue B.M. research participated in in-depth interviews for this study. The data analysis drew on phenomenological experience-based qualitative research methodologies. Three key themes emerged with respect to participant experiences with and perceptions of EEPs: (1) engaging in customer discovery, (2) navigating the entrepreneurial program, and (3) facing BM specific research challenges. Customer discovery was identified as the most impactful outcome, and it pushed the faculty to explore the impact of their innovations beyond their laboratory spaces; however, the customer discovery process was challenging due to the complexity of the BM environment. Furthermore, several challenges were noted when navigating the program concerning feedback delivery and students' roles. Lastly, several BM-specific challenges were raised, specific to the lack of disciplinary diversity and post-EEP guidance on regulatory approvals and funding. We anticipate that these research-based findings will inform the continued development of EEPs that are inclusive of women STEM faculty, particularly those who are engaged in BM research. Implications for research and practice are presented in the context of the emergent findings.

**Keywords** Entrepreneurship · Diversity, equity, and inclusion · Women · Faculty

## Introduction

Over the last decade, there has been an increased interest in innovation and entrepreneurship due to its economic impact and influence on job creation [2]. Specifically, science, technology, engineering, and mathematics (STEM) disciplines have witnessed an increased interest in entrepreneurship because of the relationship between a country's innovation level and economic growth [10]. As a result, entrepreneurship has become an opportunity for universities to promote innovation within traditional academic research settings [40]. The resultant academic entrepreneurship education programs (EEPs) seek to support the commercialization of academic scientific and technological innovations [42]. The rapid growth of academic EEPs [31] presents an opportunity to broaden our understanding of entrepreneurship initiatives, specifically in support of diversity, equity, and inclusion.

Gender equality plays a significant role in both health and economic development [39], improving scientific discovery, identifying innovations, and broadening the scope of knowledge created by more diverse teams [30]. But STEM fields struggle with gender equality and women's engagement in entrepreneurship [12, 41]. Women file fewer patents, launch fewer startup companies, and get less funding than their male peers [14]. This pattern is a missed opportunity for universities because of unexploited technologies that are not translated [15]. While there has been significant growth of academic EEPs [24], and research continues to indicate gender equity plays a significant role in health and economic

✉ Prateek Shekhar
pshekhar@njit.edu

[1] Department of Chemical Engineering, New Jersey Institute of Technology, Newark, NJ, USA

[2] School of Applied Engineering and Technology, New Jersey Institute of Technology, Newark, NJ, USA

[3] The Roux Institute, Northeastern University, Portland, ME, USA

development, women remain significantly underrepresented in STEM entrepreneurship [24].

The implication of these disparities is significant for women's health, potentially limiting the translation of critical innovations, as women are more likely to pursue biomedical innovations specific to women's health than men [23]. In addition, although there is extensive literature exploring the systemic disadvantages and experiences of minoritized groups in STEM, few studies address such gaps in academic entrepreneurship, particularly for women [37]. Finally, researchers have reported that women's engagement in EEPs is significantly less when compared to men in STEM academia [7, 12].

Examination of women's experiences in entrepreneurship is limited, with research on women's experiences with academic EEPs being almost negligible. Studies that do address diversity in entrepreneurship often follow a 'deficit' model for explaining low representation, highlighting a woman's lack of confidence or entrepreneurial intent [37]. Therefore, broadening our understanding of women faculty participation in EEPs is an area needing research attention. To address this gap in the literature, we chose to unpack the perceptions and experiences of women faculty with EEPs, specifically those who pursue biomedical research. We draw on phenomenological experience-based qualitative research interviews to examine the research question: how do women faculty with a BM research focus experience EEPs?

## Background

Entrepreneurship education programs (EEPs) have significantly increased in recent years [16]. The first EEP was created at Harvard Business School in 1947 and it was called Management of New Enterprises [20]. Soon after, in 1948, Harvard University created the Research Center in Entrepreneurial History to perform research in entrepreneurship [13]. Following Harvard's example, several universities started to develop their EEPs, such as Stanford University (1967), New York University (1967), and Babson College (1968) [20].

In the recent decade, national interest in entrepreneurship education outside of traditional degree programs saw significant growth with the launch of the US National Science Foundation (NSF) Innovation Corps (I-Corps) program in 2011 [33]. The purpose of the NSF I-Corps program was to bring research from the university laboratories to the world and, consequently, broaden the impact of scientists'/engineers' inventions [33]. In these programs, by exposure to different environments outside of the laboratory and the academic community, faculty are encouraged to interact with potential customers and explore the potential needs of products rooted in their disciplinary research innovations. During its 11 years, almost 2000 teams and 1280 universities participated in the program, engaging more than 5,800 researchers [1]. Furthermore, as reported by the NSF, during the 2020 fiscal year, more than half of the teams launched startups after their participation and raised over $760 million in funding cumulatively [1].

Establishing the NSF I-Corps program and its adoption across universities rapidly disseminated a shared entrepreneurship curriculum based on Steve Blank's Lean Launch-Pad Method [4, 31]. In addition, The NSF I-Corps program supported both national and regional cohorts, initially as Nodes [17] and Sites [18] and later as Hubs [32] Success of the NSF I-Corps program also resulted in other government agencies adopting the I-Corps methodology, including, the National Institutes of Health, Department of Agriculture, and Department of Energy to name a few [8].

To participate in the national program, NSF-funded principal investigators are required to apply for the program with a team of three: the technical lead, an entrepreneurial lead, and a business/industry mentor [31]. The principal investigator serves as the technical lead bringing the NSF-funded scientific discovery. The entrepreneurial lead is a trainee, traditionally a doctoral student or postdoctoral fellow. Finally, the business/industry mentor is an external person who guides the team through the entrepreneurial process. The mentor is often an experienced industry expert who can offer insights from the commercial sector. Through their participation, teams engage in an immersive entrepreneurial program with varying lengths of time depending on the EEPs. If selected, the team is awarded $50,000 from the NSF to participate in the EEP.

Over a period of several weeks, teams are guided through the Lean Launch Pad method to explore potential business models for their innovations. Starting with customer discovery, teams, typically the entrepreneurial and technical lead, are instructed to interview 100 stakeholders to understand customer pains, gains, and work to be done [3, 4]. Performing multiple interviews with potential customers allows the teams to explore the current techniques/instruments used by the customers and the customers' needs for the teams' innovations. For each week of the program, the mentors and teaching team provide 'relentlessly direct' feedback on the interviews and guidance to find possible customers [19]. By the end of the program, teams are instructed in creating a potential business model for their invention and contemplating potential next steps. While the NSF national I-Corps program is described here in a prescriptive manner in regards with the design and execution of the program, it should be noted that the dissemination of the curriculum and methodology across institutions and regional programs is not as prescriptive. Regional and local programs often leverage the curriculum, but deliver it in different modalities and time frames, without requiring specific team formations.

## Methods

The purpose of this study is to examine the perceptions/experiences of and around EEPs for women faculty pursuing BM research. For this study, we use the Organization for Economic Cooperation and Development (OECD Definition of biomedical research):

> the study of specific diseases and conditions (mental or physical), including detection, cause, prophylaxis, treatment, and rehabilitation of persons; the design of methods, drugs, and devices used to diagnose, support and maintain the individual during and after treatment for specific diseases or conditions; the scientific investigation required to understand the underlying life processes which affect disease and human well-being, including such areas as cellular and molecular bases of diseases, genetics, immunology. [34]

Drawing on phenomenological experience-based methodologies, we use qualitative interviews to examine the research question: how do women faculty with a BM research focus experience and/or perceive EEPs? The data collection and analysis procedures are explicated below.

### Participants and Data Collection

The present study is based on a larger project that aims to address why women faculty in the STEM fields choose to engage or not engage in EEPs. The participant sample for this study were 8 self-identified women faculty who participated in at least one EEP and engage in biomedical (BM) research. For this study, an EEP included the NSF I-Corps program but was not exclusive to I-Corps. The study received IRB approval from a researcher's home institution, and appropriate guidelines were followed. Participants were recruited using a combination of purposeful sampling and snowballing [21, 36]. Purposeful sampling was first used to identify initial participants. Then, after talking to the initial participants, snowball sampling was used to identify the remainder of the participants. The sample of eight women faculty was from seven different universities in the US. All but one participant, who works at an R2 institution, as defined by the Carnegie Commission on Higher Education, are faculty at an R1 institution. The participants were appointed in five different departments (Electrical and Computer Engineering, Biomedical Engineering, Chemistry and Environmental Science, Chemical Engineering, and Immunology and Immuno Engineering). Participants' demographic details can be found in Table 1, with all names changed to pseudonyms to protect their privacy. Faculty's racial/ethnic identity was self-reported to ensure that there is no imposition on how participants identify racially/ethnically [26]. Except for one participant who engaged with more than one EEP, all participants had engaged in one EEP at the time of data collection.

**Table 1** Participants' information

| Pseudonym | Racial-ethnic identity | Pronouns | Title |
|---|---|---|---|
| Dr. A | Asian | she/her | Professor |
| Dr. B | Black | she/her | Assistant Professor |
| Dr. C | Black | she/her | Professor |
| Dr. D | Black | she/her | Professor |
| Dr. E | Middle Eastern | she/her | Professor |
| Dr. F | White | she/her | Associate Professor |
| Dr. G | White | she/her | Professor |
| Dr. H | Asian | she/her | Part-time faculty |

Participants received a compensation of $100 for participating in the study. The data were collected through semi-structured interviews to reflect on their experiences [6] regarding their participation in EEPs. Sample questions included the following: (1) Did you experience any personal or professional hurdles during your participation year that impacted your participation in the EEP? (2) What was the most challenging part of participation in EEP? (3) What types of teaching styles were you exposed to in your entrepreneurship classes? What did you like or dislike about them? (4) If you were recommending this program/course to your friends, what advantages of the program/course would you share with them? (5) What skills do you think you need to perform well in the entrepreneurship programs/courses (EEP) that you were enrolled in? The interviews were approximately one hour long and were conducted and recorded over online video platforms. After completion, the interviews were professionally transcribed.

### Analysis

We conducted a qualitative study drawing on phenomenological methods to describe the experiences of women BM-research faculty participants in EEPs. Phenomenology can be described as the study of the experiences of a particular phenomenon, explored from the perspective of who has experienced it [27, 29]. Therefore, the goal of phenomenology is to describe the experiences in terms of what and how one experienced a certain phenomenon. Hence, only the experiences related to the phenomenon of the study are considered, and any other influences were left out of the analysis [27]. In most instances, phenomenology requires many interviews. Although our study is not a true phenomenology, we rely on several aspects of phenomenology to analyze the

data since the methodological approach is suitable to answer our research questions [9]. First, to focus on experiences regarding EEP participation, the interview transcripts were 'bracketed.' 'Bracketing' is a procedure used in qualitative research to separate and suspend any preconceptions, past knowledge, and assumptions of the phenomenon of study [25, 27, 29]. In this study, the phenomenon was participation in any academic EEPs. Therefore, the result from bracketing was a description of the experiences related to explicit EEPs experiences, and emergent aspects related to them, such as discipline, gender, translation of research, challenges on EEPs, and outcomes from the program.

Second, to examine patterns in participants' experiences, we engaged in multiple rounds of data analysis of the bracketed parts of the interviews. We first used in vivo coding to form a general understanding of the data [38]. In the next step, the in-vivo codes were categorized based on conceptual similarity, generating a list of 21 codes in the final code book. Inter-rater reliability was calculated by having two researchers code the same interview transcript with the final code book and comparing codes between the two researchers. In this process, an initial 92% agreement was achieved, and a final 100% agreement was achieved over the discussion.

Furthermore, theoretical memo writing of all the interviews was conducted to trace evidence through the process and ensure the trustworthiness of the findings. The use of a memo for each participant assisted in identifying emergent aspects of participants' experiences, which were shared by all the participants and were noted as possible findings. By comparing the participants' experiences, we found that three themes were shared across all the interviews. Therefore, our findings were organized based on three emergent themes: (1) engaging in customer discovery, (2) navigating the entrepreneurial program, and (3) facing BM-specific research challenges. We developed a single case study based on Dr. F's interview to exemplify how the three different sections were present in all the interviews. Hence, a final section of the findings reiterates the lived shared experiences noted in each theme by overviewing Dr. F as an example.

## Findings

In the following section, the findings have been structured regarding the three key themes that emerged in the data (summarized in Table 2). The themes centered around the topics of customer discovery, navigating the entrepreneurial program, and facing BM-specific challenges research challenges. The similarities in the experiences of all the participants were used to elaborate and describe the essence of the phenomenon studied. By focusing on the similar experiences, we were able to unpack their 'lived' experiences and identify programmatic challenges that the faculty faced in general, and more specifically regarding their field of research, BM in our case.

We acknowledge that participants are not just 'women'; their experiences and perspectives are also informed by the fact that they are faculty members engaged in scientific research. In other words, their perspectives are situated in their BM faculty context as well as being a woman in the academic entrepreneurship space. Thus, the findings should be interpreted from a women's lens which does not manifest in silos, rather is situated within the participants' disciplinary contexts, their roles as active members of the academic and scientific community. Additionally, a single case is presented based on the experiences of Dr. F to exemplify how a single participant experienced the overarching themes in the context of her research involvement in women's health. Dr. F was the only participant from our sample with a research focus on women's health. Therefore, her experiences regarding inventions targeting women's health provide a unique perspective as a single case.

**Table 2** Summary of the findings

| Theme | Description |
|---|---|
| Engaging in Customer discovery | Engaging in customer discovery was a positive outcome resulting from participation. |
| | Conducting customer discovery was challenging due to the complexity of BM environment. |
| | Participants went beyond their laboratory spaces to understand the customer's needs. |
| Navigating the entrepreneurship program | Significant time commitment required to participate in an EEP. |
| | Excessive roughness from the EEP mentors. |
| | Expectation for the student entrepreneurial lead to become the CEO of the company. |
| | Insufficient rewards offered to students. |
| Facing BM-specific research challenges | Lack of disciplinary diversity among the mentors. |
| | Lack of direction regarding the next steps in BM entrepreneurship. |
| | Need for financial resources specific to BM research applications. |

## Emergent Themes

### Engaging in Customer Discovery

A common theme emerging from faculty's experiences in EEPs was centered around their engagement in the customer discovery process. *First*, in their interview responses, participants reported that engaging in customer discovery was one of the key outcomes resulting from their participation. Customer discovery is defined as the process of understanding the needs of potential customers and if the proposed product will satisfy the customer's needs [35]. Typically, to expose participants to the customer discovery process, EEPs engage faculty participants in activities that ask them to interact with different potential customers. This process encourages them to go beyond their research spaces (e.g., laboratories, peer communities, and research groups) to explore different real-world spaces with people that may potentially use the product the faculty are envisioning for commercialization. In our data, women faculty often reported engagement with the customer discovery process as the main outcome of their participation in EEPs. For example, Dr. H described her experiences as necessary to understand the customers and their needs. From engaging in customer discovery, Dr. H explored why customers buy a product that is not necessarily based on the technical part of the invention.

> And that's one of the valuable pieces that [EEP] provides is that [EEP] pushes you out of the labs. They push the university research out of the lab and they get them to interface with customers. And so that speaks to what I was describing earlier about that industry insights. So that's like the philosophy that [EEP] impacts on you. You really got to understand your customer and it's not just about the technical features that your product is going to deliver, but there's also social, emotional things that are involved with customer, buying decisions and all of that. It's just as important as having a technology that will perform as needed. (Dr. H)

*Second*, particularly from a BM research perspective, the findings noted that conducting the customer discovery process can be a challenge due to the complexity of the environment of the product and the low availability of the potential customers. As pointed out by Dr. E, when developing a product that will be applied by health care specialists (e.g., medical doctors), finding opportunities to interact with potential customers is scarce due to the low availability of doctors willing to engage in the customer discovery process. Thus, for faculty with a BM research focus, engaging in the entrepreneurial process is more challenging because the faculty must confront the problem of finding potential customers to interact with as they engage in the fundamental step of customer discovery, as evident in this participant's comment, "The challenges is because our customers are expert doctors, they are radiation oncologists and neuroradiologists, radiation oncologists, their average salary is $500,000 a year. Half a million, okay? And getting to talk to them, getting their time, was a huge, huge challenge" (Dr. E).

*Third*, across the analyzed interviews, several of the faculty agreed on the need to go beyond their laboratory spaces better to understand the market's needs regarding their product. Faculty reported that their perspective of themselves as academics pushed them to do research in certain areas that they were interested in. However, there was a disconnect between the needs of the possible customers and the product developed. As faculty engaged in the customer discovery process, they validated their product-market fit and consequently pursued their proposed products on the path to commercialization. For example, Dr. E confirmed the need for a product like the one they were developing in the oncology field:

> Okay. I think the most successful part is when I realized, or I got the numbers to confirm that there is indeed a need in what we are doing. That's the most successful. Before I was assuming that there was a need. I did not have the numbers and the interview that show that there is a need and I think the most successful is that almost everyone we talked to, they all said that there is a need to do better. Now, not necessarily a need for what I'm doing. In [EEP] we're not allowed to talk about our product, but there is a problem and there is a need to solve this problem in oncology. (Dr. E)

On the other hand, faculty participants pivoted in an alternate direction in scenarios in which their proposed product did not meet the market need. For example, three faculty participants (Dr. H, Dr. C, and Dr. A) realized through engagement in the customer discovery process that the product that they were proposing was not in line with what the customer needed, and therefore decided to pivot to a different direction in their entrepreneurial process, as noted in the following remark,

> They're not really looking for a detector for E- coli, they're really looking for something else. They were looking for mold, there's a lot more [inaudible]. That's how we learned it. We didn't know that until we did all of those interviews. And so that changed our direction in some ways. (Dr. C)

### Navigating the Entrepreneurship Program

Another theme emergent in faculty's responses was focused on their experiences navigating the entrepreneurship program. Particularly, several of the faculty reported the

challenges and critiques associated with the entrepreneurship program they participated in. Here, *challenges* for participation are described as the difficulties that the participants overcame during their participation in EEPs. In contrast, *critiques* are described as the behaviors/requirements from the EEPs that participants did not think were necessary and reported that they should be changed in future offerings. It is to note that while challenges and critiques were operationalized separately in the coding process, they were often closely connected and intertwined in participants' responses.

*First,* across the interviews, all the participants agreed that a major **challenge** for participating in an EEP was the significant time commitment that was required. Since all the participants were faculty members, they had to perform duties expected from a faculty member in an academic setting, including but not limited to teaching classes, research, getting external funding, mentoring students, and institutional service. For example, Dr. E pointed out the difficulties she faced when managing her time between participating in an EEP and submitting research proposals to obtain externally funded grants for her lab. When I was participating in [EEP] ... Well, the challenge is obviously the time commitment to [EEP] in parallel with my work then as ... I had to submit a grant. I had a large grant submission at the same time, so my time was limited. (Dr. E).

Furthermore, regarding time, Dr. F and Dr. C reported that they participated in EEPs because they were on a sabbatical year, and therefore had the necessary time to commit to their engagement with the EEP, as noted in the following comment, “The balance, it's always a challenge really, to put everything and balance them up. […] So I remember during my [EEP] year, I was on sabbatical. So I was able to devote my time to the project. So I was running my lab, I had students there, but I wasn't teaching.” (Dr. C).

*Second,* the excessive roughness from the EEP mentors was a common **critique** that the participants mentioned in the interviews. Participants reported that it was unnecessary and counterproductive for them. For example, Dr. A compared the unnecessary roughness experienced during the program to aggressive masculine behavior; she said,

> So there still is a very, I'll just say it, it's a very aggressive male ... And I've seen men come in who are different too. So, I don't think it's inclusive. I think it makes more sense to say these are the goals. How do you reach these goals? Right? These are the milestones; these are the goals. Even again, I watch a talk by someone who was in one of the first cohorts and she was speaking at this diversity and equity thing. And she said, 'Oh, it never bothered me, but I could see it bothering other people.' And I was like, 'That's a lie.' I mean, that's how I felt. I'm like, 'Okay, you're still buying into that being the way it should be.' So I'm not convinced that you need to be a jerk to get an outcome. (Dr. A)

Furthermore, faculty responses underscored that the excessive rough feedback of the mentors was often directed to the more inexperienced team member, who might be a student that was assigned to take the lead throughout the program, as noted in this comment:

> So they were much more about fitting what they were supposed to be doing as a site versus listening to the participants. So they were very quick to try to take down the entrepreneurial lead because they thought, Okay, this is this archetype. A know-it-all archetype. So they were actually embarrassing because they would try to take him down in a very aggressive way. (Dr. A).

*Third,* another critique that emerged was that, in some instances, EEPs appeared to be structured such that the student team member was expected to become the CEO of the company they are creating. However, faculty participants expressed their disagreement with this idea since because of the student's inexperience, specifically their lack of business experience. From their perspective, the CEO of the company should be someone with experience at leading companies and not a student, as evident in the following quote:

> Then they encouraged the young, new, let's say new graduate student, new PhD, to be the CEO of the company. So luckily [X] put a squash on that right at the beginning. He said, 'Nobody is going to look seriously at a company that has, as the CEO, a PhD in a biomedical science has no training whatsoever as a CEO.' But that's the way that the [EEP] was run. It still is run because [X] had a student who went through it recently and they told her the same thing, 'Oh, you're the CEO of this company.' And, then when they come back to the P.I.s and the P.I.s say, 'No, you can't be the CEO of this company because you have no training to be a CEO.' That creates a problem because they've been told by [EEP] that they do have qualifications to be a CEO. So [EEP] in that way is not very helpful because it sets up unrealistic expectations. (Dr. G)

*Fourth*, while the faculty acknowledged that the participation of students is crucial for building a team to join an EEP, the faculty discussed in the conversations that the rewards offered to students are often not sufficient in regard with the time and effort that is required from them in the program. Particularly, faculty participants expressed that the PhD student who often serves as the entrepreneurial lead has several other academic responsibilities (e.g., conducting research, writing papers, completing degree requirements, presenting

at conferences). Thus, there is a lack of incentive for students to participate in an EEP since their participation is likely to reduce the time that they can spend on completing their academic tasks. The faculty suggested that incentives (e.g., publishable data) to students from the program could encourage their enhanced engagement in EEPs, as noted in the following remark,

> Here are some grants in funding that you can have to go get those specific data. It becomes a win-win in the sense that a graduate student can still publish on those data. They can still put it in their thesis, but there's also data going towards showing that this technology has value. (Dr. D)

#### Facing BM-Specific Research Challenges

Lastly, a common theme that emerged during the interviews were the specific challenges regarding faculty's BM research focus that they experienced during their engagement in EEPs. *First,* a commonly reported theme emerging from faculty's experiences in EEPs was that there was a lack of disciplinary diversity among the mentors in the EEPs they were engaged in. Particularly, discussing the complexity of developing a product with a biomedical focus, several participants mentioned that there was a lack of mentors who had biomedical-specific knowledge. The low level of content-specific understanding of the mentors was specifically challenging when discussing the feasibility of transforming the faculty's research innovations into products that can be commercialized. For example, Dr. B reported that since the research innovation they were working on was based on stem cell biology, the lack of a mentor that would completely understand the technology was detrimental to the overall support and the quality of feedback they received from the mentor when examining the viability of product for commercialization, as evident in the comment below,

> Frankly, I think in the situations where these happen, I think if the person who maybe was involved knew more about Stem Cell Biology there, they would get it, they'll get why and maybe like that. I think it really comes down to perspectives. Yeah, their background. Yeah. And some people are also very quick to make judgments. So, I think, once they've decided this is the coolest part of this thing, they want to just support that. (Dr. B)

Along similar lines, Dr. G reported that there is a need in EEPs for mentors who possess an understanding of the different biomedical fields. Particularly, regarding her work in the drug development field, she pointed out that they needed specific advice from experts that was not provided during her time at the EEPs. Moreover, from her experience, she believes that drug development should be a field of its own since the advice needed is specific. Therefore, there should be a change in the way they treat drug delivery or not accept it because it cannot be treated the same way as a medical device.

> I don't know if they appreciate now that they don't have what they need for drug development, because all of these experts we're now meeting with every two weeks, they weren't optional. They're essential. And we had none of that and they don't have any people like that at [EEP] …They would have to bring in all of the expertise that [EEP] was providing and a realistic approach to, put drug development in a separate category and a realistic approach. Or maybe even not accept drug development … They're just not set up for the drug development. (Dr. G)

*Second,* when asking the participants about the outcomes of their participation and their expectations when engaging in the program, they all agreed that it was a good experience. However, participants reported that there was a lack of direction regarding the next steps that they should take on their entrepreneurial journey in the biomedical field. Particularly, the faculty noted that while a common expectation from EEP participants was that they would pursue the next steps to get their new technology in the market after engaging in customer discovery, the EEPs provided minimal guidance on the next steps after potential customers had been identified. For example, there was negligible guidance on how to get FDA approvals or what external funding mechanisms are available to take the technology to clinical trials. For instance, Dr. G mentioned how they were lost on what were the next steps and how to get to those after participating in an EEP:

> But we spent a couple of years until we joined [EEP] kind of lost in the wilderness because we didn't know how to go to Series A, we didn't know we needed an investigational new drugs application that no Series A investor was going to look at us until we had exactly a plan of how we were going to go to the clinic. (Dr. G)

*Third,* participants discussed the importance of gaining access to financial resources after completing the EEP to continue working on their entrepreneurial pursuits. This was specific to biomedical fields because the developed products that are typically applied to the human body need to pass a series of tests and studies (e.g., animal studies, clinical studies, FDA approval, etc.), before commercialization. The tests and approval process requires large sums of money. Most EEPs provide limited financial support, which is insufficient for developing and commercializing biomedical products. For example, Dr. G shared her experience with the funds given for EEPs; she said,

> But the funny thing that they did is that the way [EEP] set it up is they encouraged people who came into [EEP] to actually form a company which anybody can do. And if you compete in the innovation fund, you can get $250,000. For a life sciences project there is practically nothing you can do you with $250,000. (Dr. G)

### Overviewing Dr. F

In the following section, a single-person case is presented to exemplify the different thematic findings reported in the results section and show the reader how a woman faculty with a research focus in BM experienced her participation in the EEP. Furthermore, we decided to present Dr. F as a single case due to her research involvement in women's health. Since women's biomedical inventions are more likely to focus on women's health compared to men's biomedical inventions, overviewing Dr. F gives insight on the experiences of women's with a biomedical focus that have an invention regarding women's health. We present Dr. F's case as an example to show how the different themes (engaging in customer discovery, navigating the entrepreneurial program, and the B.M. research-specific challenges) were experienced by the faculty member.

**Dr. F Engaging with Customer Discovery** Dr. F shared that EEP participation, and the customer discovery process enabled her to interact with possible customers and obtain valuable feedback on her product, as reported in this comment, "So they promised me I will do outstanding customer discovery and I did, right? And this was my kind of realization and also kind of acceptance and I was ready to admit it. Yes, thank you, you did what you promised. So yeah, and for this I'm grateful."

However, when discussing the difficulties of talking with physicians and other medical experts, she expressed that rejection was common and that her team had to be aggressive to obtain enough interviews for the program, she said, "We were rejected a lot and it wasn't just me. It was [X] and my student, [Y]. […] So we just went there and we harassed people. Not in a bad way, but really like busy doctors and they sat down with us and let us record the conversation and shared their experiences." In summary, overall engaging in customer discovery was a valuable experience for her, but finding potential customers was challenging.

**Dr. F Navigating the Entrepreneurship Program** Dr. F pointed out that a big challenge to participating in an EEP is the time commitment, she said, "[…] but the time commitment that I had to put there and the effort I committed, I could only do it because I was on sabbatical and that's why I didn't feel so disappointed. But if it was during my teaching, it would have been just complete failure." One of the reasons for which she decided to participate was that she was on a sabbatical year and had the time to dedicate herself to the program without any other obligations (e.g., teaching, service, grant submission).

Furthermore, a common critique that emerged is the unnecessary roughness of the instructors. During her participation in an EEP, Dr. F discussed the need of the instructors to push the groups to achieve a better presentation wondering if there was a real reason behind it, and if it was necessary to be rough and not flexible, as can be observed in the following quote. "However I felt, and you never know, are they just being real teachers and they push you to become better because this is the way to make your presentation, or are they really not understanding? […] So they really pressed to fit what the requirements ... interview 200 people, follow whatever, but then they were not flexible enough"

Dr. F's experiences expose how difficult it is for faculty to participate in EEPs while covering other obligations. Furthermore, her experience with instructors' roughness was a common critique that all participants interviewed pointed out as counterproductive.

**Dr. F facing BM-Specific Challenges** Finally, when discussing the specific challenges faced when engaging a BM-specific project, Dr. F pointed out that there was a lack of fundamental understanding of the product. Although biomedical projects were grouped in a specific cohort, there is a lot of variation in the different projects. Specifically, she noted that the commercialization of a pharmacological product is different than creating a biological product. She pointed out that the lack of disciplinary diversity was a challenge that she had to face during the process, as explicated in this comment,

> [..] it comes for the lack of diversity in disciplinary diversity. So [a] product like this, maybe exactly like this, doesn't exist but I'm sure there are other things that exist that are similar. So if we had someone in that cohort who was more familiar with biological products, they probably would have helped me more.

Furthermore, Dr. F's project was focused on women's health. When discussing the lack of understanding of her product by the mentors, there was a second layer of challenge emerging due to the project being focused on women's health, and the lack of mentors who understood women's health issues. Overall, Dr. F underscored the lack of disciplinary diversity, and women in the mentoring team, which made clearly communicating her research product and its applications challenging for her. Dr. F expressed her challenge in the quote detailed below,

> […] and my stuff is so sensitive because my product is towards women and towards girls. It's like guys who

> are asking me a question like, "But this is for cancer." "No, it's not. It has nothing to do with cancer." Or, "This is for [X]." "Yeah, your wife is going to have [X] at some point and it can help." It was the lack of recognition, the lack of knowledge, the lack of highlighting the importance and actually making an effort to make it more inclusive that bothered me.

Lastly, although Dr. F described her participation in an EEP as a good experience, certain expectations were not met regarding the necessary next steps to follow after her participation. Dr. F linked the lack of direction on the further steps to take when commercializing a biomedical product to the low understanding of the mentors (due to their non-biological background). For example, an outcome that she expected from her participation was to get mentored on how to approach the FDA. However, that was not covered in the program, as noted in the following quote,

> So we got better every time and I think our final presentation was great. It was good. It was significantly better compared to where we started, but at the end, I didn't get the honest answer from those mentors because they don't work in biological sphere. They couldn't really help me with what is the next step? How do I approach FDA? What do I do?

## Discussion

The Global Entrepreneurial Monitor notes that the underrepresentation of women is particularly noticeable in early-stage entrepreneurial activities [22]. Additionally, according to the Global Entrepreneurship Monitor [24], women are not less likely to be innovative than men. Therefore, the barriers for women that lead to their underrepresentation are likely to be structural rather than a lack of innovation [24]. Wheadon and Duval-Couetil [41] also suggest that this disparity lies at the intersection of context and gender as well [41]. Given the complexities of gender inequities in STEM entrepreneurship and a general lack of attention to the underrepresentation of women in academic entrepreneurship settings [37], our study seeks to examine women faculty experiences with entrepreneurship programming, specifically in the context of biomedical research. Such EEPs are viewed as a pathway to future early-stage entrepreneurial activity, and our results have the potential to identify programmatic and structural factors that can impact our understanding of inclusivity in EEPs (summarized in Table 2).

Overall, engaging in the customer discovery process was noted as one of the key positive outcomes of program participation and, more importantly, a reason that fostered their participation in EEPs. Faculty reported that engaging in the customer discovery process taught them important insights about their markets and how to examine the need for their proposed product critically. These findings are consistent with other qualitative data collected from non-gendered [11] and racially minoritized ( [19] cohorts of faculty participating in EEPs, and are not necessarily unique to women EEP participants. Both studies note that the customer discovery process is a consistently valued learning experience, but the climate and workload are challenging [11]. However, the aspect unique to our findings is the BM-specific challenges that faculty encountered. BM faculty reported that they found the customer discovery process particularly challenging because it was difficult to find potential customers for their BM-research products. The customer segment for the BM products is often more complex than traditional products because customers are not always the end-users,the customers can be the payor such as an insurance company or hospital administrator. As underscored in Dr. E's responses, this can be challenging for faculty when engaging in customer discovery because access to potential customers, such as medical specialists, insurance providers, etc., are more limited than individual consumers. This highlights that special attention needs to be paid when engaging BM-research faculty in the customer discovery process and including training to examine other pertinent customers beyond the end user.

Along similar lines, in BM-specific challenges, faculty noted the lack of mentors who understood B.M. Typically, EEPs follow discipline-agnostic approaches for guiding participants through the opportunity identification process. However, as noted in our findings, the disciplinary disconnect between the academic group (faculty and students), and their business/industry mentor and instructors may lead to less effective guidance regarding product feasibility and how to engage potential customers. Thus, EEPs can benefit from including additional team members who understand the faculty's research or, at the minimum, are provided a working knowledge of their research. One potential solution is to engage past faculty participants as co-mentors paired with teams from similar disciplinary backgrounds. These faculty co-mentors can serve as a link between the academic group and business/industry mentor since they understand the customer discovery process from their past EEP experience and have the needed disciplinary understanding based on their academic training and/or research experience. Furthermore, as noted in the findings, the co-mentors can also guide the faculty participants regarding the next steps in obtaining resources for clinical trials and subsequently seek required approvals to bring their product to potential customers.

The other post-EEP challenge noted was the lack of direction regarding securing funding to continue working on entrepreneurial pursuits. From a BM perspective, securing funding for biomedical products is critical for faculty since biomedical develop and approvals often require significant

financial resources. In 2010, companies reported spending $31-95 Million to move a medical product, 510K, to PMA, respectively, from concept to clearance [41]. In addition, from a women's perspective, the literature has noted that women entrepreneurs are less funded than men and often have difficulty obtaining external funding to support their entrepreneurial pursuits [28]. Thus, EEPs can partner with institutional, local, and national incubators and funding platforms to assist women faculty in taking the projects they worked on through the EEP further along the entrepreneurial pathway even after the completion of the EEP experience. Discipline-oriented guidance that caters to BM commercialization needs (e.g., clinical trials and FDA approvals) may further benefit faculty engaged in BM research. Future research can examine women faculty's post-EEP experiences in pursuing funding to support their entrepreneurial endeavors. Research-based understanding of such experiences will assist in identifying programmatic, institutional, and structural barriers to attaining private or venture capital.

In their systematic review, Poggesi et al. underscore the lack of research on women's entrepreneurship in STEM academia, with only 32 papers that were relevant to the topic. Based on the analysis of the shortlisted papers, the biggest interest from researchers is directed into why women engage less in entrepreneurship and often focus on 'deficit-oriented' reasons to explain women's lower participation. Regarding EEPs, when discussing the specific case of women in STEM academic careers, researchers have noted that there is less engagement in entrepreneurial programming when compared to men [7]. Research on women's underrepresentation in entrepreneurial spaces has often been focused on women's intent in entrepreneurship [37], with almost no reports of women's experiences in entrepreneurial spaces, particularly in academic EEPs. In our findings, the roughness of the mentors was a common critique that was reported by most of the study participants. The culture of EEPs often imitates real-world entrepreneurial practices, which are likely to be rooted in the predominant masculine norms and culture. For example, attributes such as aggressiveness and roughness are likely to organically permeate into the typical pedagogical practices, making the learning environment less inclusive for participants who do not conform with the prevalent culture, women STEM faculty in our case. Thus, EEPs can critically evaluate the inclusiveness of the instructional approaches. Therefore, training for the instructors needs to be provided to create a more inclusive environment. The pitch competitions in EEPs can be designed to introduce pitching ideas in a gradual, scaffolded manner such that participants can be acclimatized to the approach.

Furthermore, it is important to note that research has shown that investors prefer pitches presented by men entrepreneurs. Therefore, female entrepreneurs are often disadvantaged when presenting their inventions [5]. This calls into question what traits are valued in pitching environments, and how those environments can be reformed to be inclusive to minoritized groups, such as women STEM faculty. Considering these findings, we encourage future research that further examines EEP pedagogy from critical theoretical lenses to identify research-based instructional practices for inclusive entrepreneurship programming in STEM contexts.

Lastly, from a programmatic standpoint, while the idea of engaging students is novel, our findings note that EEPs can better structure the role, responsibilities, and resources to engage graduate students in the program effectively. Our findings note that the faculty did not resonate with the idea that the student should be charged with serving as the entrepreneurial lead in a manner that the student is supposed to become the CEO of the future company. Also, faculty participants suggested that more incentives are needed for students to participate in EEPs since their engagement is an essential part of the training process. Doctoral students are preoccupied with coursework requirements, dissertation writing, teaching, and research assistantships. Thus, to compensate for the time and effort commitment, EEPs can explore the possibilities of providing partial (if not full) funding support to students in a manner that teaching, and research assistantships are supported. We argue that this would encourage deeper student engagement in the EEPs.

## Conclusion and Future Work

Our work contributes to an early-stage understanding of women STEM faculty's experiences with EEPs in the context of their specific biomedical (BM) research. The findings provide insights into how women STEM faculty engaged in BM-research experience EEPs and reinforce implications for developing new or revising existing EEPs to be more inclusive. The study finding significantly contributes to the delineation of BM-specific research challenges. The challenges speak to the need to evolve EEPs beyond a generalist approach that does not account for differences in faculty's disciplinary educational and research backgrounds. As currently designed, many EEPs provide foundational exposure to seeking out opportunities but do not account for the unique aspects of a discipline or industry that faculty may be targeting. Some programs have started in these directions providing more discipline-focused knowledge. However, this is not the norm. We encourage similar efforts to redesign EEPs.

Furthermore, programs often provide limited assistance on post-EEP pathways. This limitation stifles the long-term translational impact of academic EEPs. The qualitative research methods used in our exploratory work provide in-depth insights to guide future work. Also, some of the findings are not unique to female faculty and may also be

experienced by male faculty. However, we do not want to limit the results by presenting only 'women-centric' findings because the participants were both women and STEM faculty. Thus, by reporting only one set of results, we risk not presenting a holistic case where participants' identities as STEM faculty are undermined.

Our qualitative work examines the experiences and perceptions of 8 women faculty with a BM research focus and is limited regarding the generalizability of the findings. However, the lack of research in the area makes our approach suitable. For example, to conduct a large-scale survey-based study, we first need to identify the topics around which survey questions can be constructed, which can be unpacked using qualitative approaches. In other words, despite the small sample size, the findings provide several avenues for future research and examination. First, future research can examine EEPs from a discipline/industry-focused lens. Most of the research has been conducted from a discipline-neutral perspective and does not examine what faculty trained and operating in a specific discipline need to succeed in EEPs. Second, researchers can study post-EEP pathways of faculty with emphasis on barriers and affordances as they navigate university entrepreneurial ecosystems after attending an EEP. Possible directions include examining faculty's engagement with incubators and tech transfer offices, with particular emphasis on what ways and to what extent faculty's unique needs are met as they pursue entrepreneurial pathways. Third, future research can examine theoretical aspects of faculty's academic and disciplinary identities and how they manifest in an EEP setting. While it is highly likely that faculty's academic and STEM contexts may inform their perceptions and experiences in EEPs, such examinations in entrepreneurship education research are almost non-existent, warranting further investigation. Research in this area will assist in evidence-based coalescing of theoretical works from STEM and entrepreneurship education to build a thorough and holistic knowledge base for future programmatic and research efforts. Lastly, since our study has limited participants, quantitative survey-based studies can be conducted to include a larger sample. The presented findings provide directions for developing and conducting survey-based research studies.

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## Declarations

**Conflict of interest** The authors have not disclosed any competing interests

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