



Supporting an Alternate PhD Pathway in STEM: Findings from a Qualitative Study of Students and Faculty

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Abstract

PAtENT (Pathways to Entrepreneurship) is a pilot program for an alternate pathway allowing doctoral candidates in STEM programs to satisfy capstone degree requirements by applying for patents. This model and the PAtENT program aim to bring greater alignment between doctoral degrees and the rapidly changing employment landscape, and have the potential to modernize the STEM Ph.D. In order to create flexible pathways to doctoral degrees that catalyze innovations, institutional support is needed to sustain exploratory and interdisciplinary research. A total of seven faculty and four graduate students participated in a qualitative study of PAtENT to address the overall research questions of a) what appeals to you about this alternative pathway, and b) what is needed to support alternative pathways in STEM doctoral degrees? This short paper describes the pilot program, its context, and presents findings from the qualitative study that inform next steps for all institutions interested in advancing research innovations in STEM educational practice.

Introduction

PAtENT (Pathways to Entrepreneurship) is a pilot program that allows for an alternate pathway for doctoral candidates in STEM programs at UNC Charlotte to satisfy their capstone degree requirements by applying for patents. The model and the PAtENT program aim to bring greater alignment between doctoral degrees and the rapidly changing employment landscape, and have the potential to modernize the STEM Ph.D. Programmatic and curricular innovations to the current Ph.D. model are needed to create flexible pathways to doctoral degrees and to increase innovation that more aligns with the dynamic workforce.

The current pathway model to a doctorate does not allow for differentiated backgrounds and interests of students. Should our innovations be adopted by other programs based on our anticipated findings, a separate Doctor of Innovation track might emerge as a viable alternative to the current Doctor of Philosophy track.

PAtENT Description

The overall project goal is to develop an alternate pathway for doctoral candidates in STEM programs to satisfy their capstone degree requirements that has the potential to modernize the

STEM Ph.D., bringing it in greater alignment with recent rapid changes to the employment landscape. The specific innovation involves providing as an alternative to the current practice (in Carnegie R1 and R2 institutions) of externally peer-reviewed publication(s), with an alternate capstone requirement: the development of a patentable technology as the capstone event. Yet, the external peer-review aspect is preserved, thus maintaining the academic rigor of the PhD programs. These changes are being piloted and tested in a **Pathways to Entrepreneurship (PATENT)** program, implemented in multiple STEM departments (Mechanical Engineering, Civil Engineering, Physics and Optical Science, and Chemistry) across the University of North Carolina at Charlotte (UNCC). The PATENT program has four overarching goals: 1) to develop an alternate roadmap for STEM Ph.D. students that is scalable and reflective of the evolving employment landscape and workforce needs; 2) develop an alternative roadmap for STEM doctoral students; 3) increase entrepreneurship rates among graduates; and 4) scale and propagate effective pedagogical strategies. In order to achieve these goals, the project activities include:

- Stipend Support: Participating faculty-student teams receive annual stipends to fund materials, equipment, supplies, travel to conduct research.
- Ventureprise Collaboration: Students engage with business leaders through Ventureprise, an NSF-ICorps site at UNC Charlotte. Students undergo entrepreneurial training, including investigating applications of their work, market research, and connecting with angel investors.
- Entrepreneurial Modules: Students participate in business training modules to develop entrepreneurial mindsets. These include courses on entrepreneurship developed as part of the PATENT program, specifically for students in STEM programs.

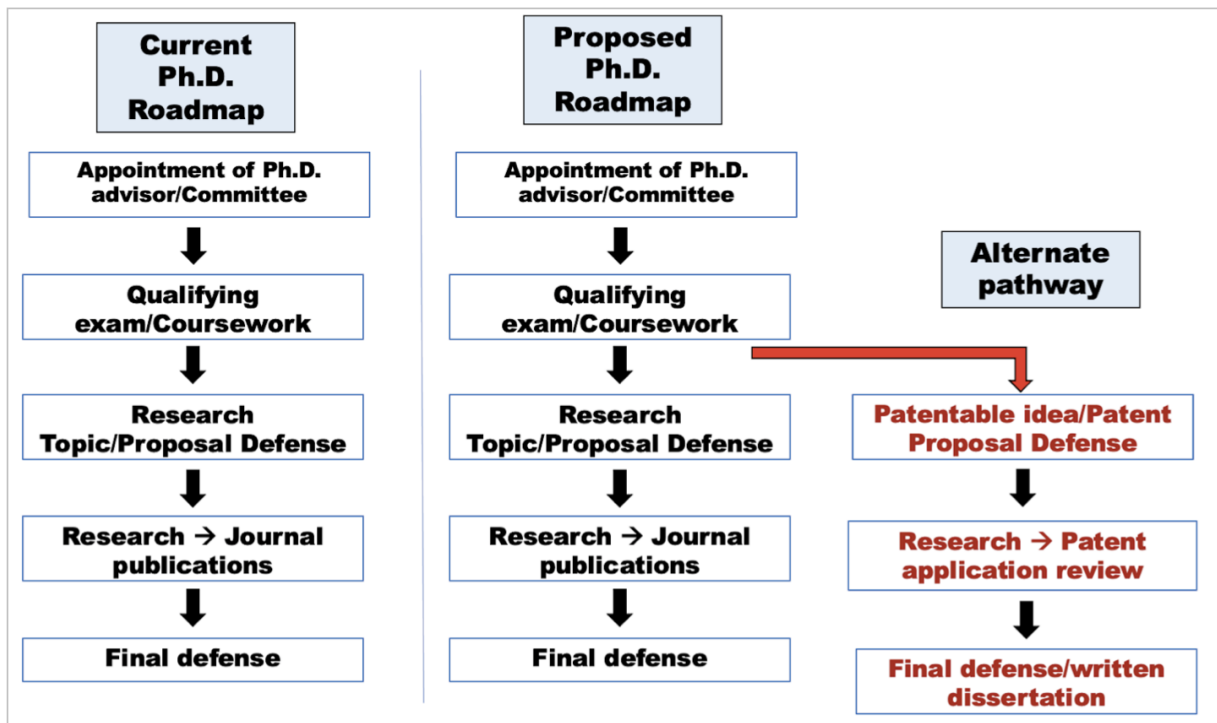


Figure 1: Comparison of progression towards PhD candidacy for the traditional and alternate roadmap of the PAtENT program

Research Questions

The following research questions are under investigation throughout this project: Will PAtENT students have a higher entrepreneurial mindset than others?; Will patent applications increase among PAtENT students compared to others at our university?; How can this alternative pathway be applied across our university and to other institutions? Our research and evaluation plans address these questions through tracking patent applications, measuring graduate student entrepreneurial attitudes (in and outside the patent pathway), curricular mapping, and qualitative study of participants. This study presents current findings from the ongoing qualitative investigation of faculty and students who engage with the PAtENT project.

Methodology

This study is a small qualitative investigation of the current students and faculty engaging in the PAtENT pathway. Three participants were invited to participate in an individual interview about their view of the pathway option. Institutional Review Board approval was obtained from the university Research Compliance Office prior to conducting the interviews, which were audio recorded and transcribed for analysis. The interview protocol was designed to gather perceptions on the overall experience in the PAtENT program, based upon the five dimensions of scale [1]. Responses were analyzed thematically from field notes [2], which is a legitimate approach given the sample size [3]. Representative quotes are provided.

Presentations were conducted at three departments outside of the College of Engineering to showcase the project and solicit feedback from faculty members about the pathway option. Additionally, the university assessment office met with the project leadership team at the start of the project to discuss the pathway model approach contribution to the university. Themes from these conversations are presented.

Limitations

This study is part of an ongoing investigation of a project in its early stages of development. The current findings, despite application of appropriate qualitative methodologies, presents a small number of participants. Until further investigations are completed, these findings are not yet representative of the project, or of all participants in the new academic pathway.

Findings

One faculty advisor to a student in the PAtENT pathway was interviewed, revealing four

overarching themes. Each theme is presented with supporting quotes.

Theme 1: PATENT students' success are mechanisms to recruit new students. The opportunity to design something for a real world application is attractive to doctoral students, and the faculty advisor observed that other students in the program were very interested in what his student was able to do in terms of applying for a patent and in collaborating with Ventureprise.

"It's attractive to think about going through a PhD program and to try out [this] into a real working prototype which is pretty rare in [my field]. We could spend many years [doing traditional research in this field]."

"My first student, who is graduating next week...he didn't want to do it, but now I've got curious students who've seen [my student's] work, and they believe, correctly so, that there is value, that this may help them with their own careers, working with industry, thinking about start up."

Theme 2: Interdisciplinary disposition is a catalyst for entrepreneurship. "Our program is interdisciplinary. Our students do a lot of different kinds of research, that model lends itself to real world applications. [In my field], we have to learn how to make a device, how to put it on a surface, and how to append it to something like a medical device. This program lends itself to an entrepreneurial mindset."

"The entrepreneurial part is natural, because we are like 'hey if we make this would you use it?' Industry has better equipment than we do in terms of scale, they have the equipment and technology to make this on a large scale, and they can tell us if it's scalable."

Theme 3: Financial support and external partnerships are essential for truly innovative research. "There needs to be more seed funding to support new pathways. And I think the university is already talking about this....how do we keep it going, which will lead to more patents, new ventures, NSF centers....I feel like that is my biggest challenge- what do I have funding for? What is safer because I know this is going to work and I can get funding for it."

"The entrepreneurial part is natural, because we are like 'hey if we make this would you use it?' Industry has better equipment than we do in terms of scale, they have the equipment and technology to make this on a large scale, and they can tell us if it's scalable."

Theme 4: Students learn entrepreneurial skills through the Ventureprise engagement. Students need to learn how to think entrepreneurially, beyond making technical products. They need to find out if their product idea is feasible and needed in the larger business community, which is part of the learning process. As a faculty advisor noted:

"My experience working with students on this track, [the program] is learning about entrepreneurship, not about if you should license this technology, but interviewing scientists and engineers, they might not need our technology- it might be cool but not useful....., So when we go to the patent committee we say it can do this and we talked to company x, y, z ...and they need it, so it gives us structure and support, gives a lot of impact to the work my students are doing."

Two PATENT students participated in interviews, with five overarching themes emerging.

Theme 1: As the students interviewed were very recently introduced to the pathway to entrepreneurship track, it was essential to record the basic understanding and familiarity of the program among the students.

"One professor explained to me that it's financial support for students with this path to help them graduate and to support their idea for patent; I've started."

"Don't know the details. Dr. [name withheld] said it was entrepreneurial; instead of papers and defense it's getting patent, sitting in on Ventureprise"

"One of my friends already did Ventureprise, she went to the national NSF-I Corps and started her own business and everything. So I was a little familiar with everything. But I was interested as well into maybe starting my own company and doing that kind of line. And also I thought you know if it is available , it is good to have. Every experience is good."

Theme 2: It is support that sustains a student on the journey they have started. Support from the program:

"Ventureprise is very helpful. Not sure yet if I have any additional biz classes. Don't have any planned out. Would be nice to have someone say these classes are good and here's why; I'd probably just want to sit in on them due to homework."

"Financial support has started."

Support from the department:

"The Chemistry Department here is relaxed and informal, everyone is ready to help, can knock on someone's door for help, why I chose UNCC; a lot of collaboration in the dept between professor to professor. Students- yeah everybody is really friendly, if I have a question about an instrument I can get help, also our instruments are nearby and we don't have funding to use them."

"From my advisor, like a lot of support because he is very experienced, he gave the idea; like mentally and financially supporting a lot."

Theme 3: Interdisciplinary collaborations and research; access to entrepreneurs is key.

"Research wise, the science side, we have a few collaborations with people, some of the dyes I'm trying to synthesize and use are being used elsewhere (U Chicago, UTK); Electrochromic Dyes- how toxic they are to cells we collaborated with Bio, also for antibacterial levels, Architecture faculty my materials might go into building materials."

Theme 4: Broad commercial applications of their work. Students have been collaborating with multiple faculty and researchers on how their work can be applied elsewhere.

"I think so yeah, related to technologies measurement of surfaces related to scanning, geography; any kind of technology, for applications mostly maybe medical."

"Architecture faculty because my materials might go into building materials. Through

Ventureprise I found out these dyes could be used for sensors (band aids, health sciences).”

Theme 5: Successful people are not gifted, they just plan, work hard towards their goal and succeed on purpose. Students have incredible ideas and are working hard to make them reality. PATENT program is a platform for those who have patentable ideas and entrepreneurial goals.

“Filed provisional patent with the university back in March, so now we are trying to figure out how to get them to get a patent; we have one company that would license it, but I may start my own company.”

“I haven’t had any experience with it yet, always in my life have thought about what new ideas can I have for this universe, kind of exciting to publish.”

The PATENT model was presented at several STEM departments across the UNC Charlotte campus, with overall feedback indicating cautious optimism. In general, the response of the faculty and administration was enthusiastic about the alternate pathway support for students’ innovation. Several noted the proposed mechanism would boost recruitment of students with an interest in entrepreneurship to the STEM programs, which has been shown based upon interviews with a faculty advisor and two students in the program. However, some departmental faculty expressed concerns regarding potential conflict of claims to a patentable idea by members of the student’s dissertation committee. For instance, if a committee member made a material suggestion that resulted in the improvement of a patentable idea, will he or she have any claim over the patent? The project team is consulting with the university’s Office of Research Commercialization and Development, and working on clarifying rules and procedures to avoid such conflicts. Additional concern was expressed regarding the timelines required for graduation through the PATENT pathway. In particular, if the university does not decide to support a patent application, will the student have sufficient time to revert to the traditional pathway, and still graduate in a reasonable time? The project team is developing a contingency plan for such cases, to be reviewed with university input.

Conversation with the University Assessment Office indicated that there is interest in creating new measurements of doctoral program outcomes, for which the PATENT pathway model offers innovative assessment options. The project has begun tracking patent applications from baseline through the project, by discipline, student and faculty, which is now available for the Assessment Office to utilize. Student learning outcomes can be developed to align with the patent pathway, and larger study of doctoral student mindsets are being informed via the PATENT surveys (which measure self- efficacy, entrepreneurialism, and other professional skills).

Discussion

Though this current research component is a small study, it is informative about the views faculty and students have about our alternate pathway for doctoral candidates in STEM programs. The research informs the project and provides a mechanism to identify and address questions from stakeholders, both faculty and students. Findings from this study are particularly relevant to goal 1 and the focus on a scalable roadmap for the STEM Ph.D. program. PATENT student and faculty

perspectives are critical to maintaining synergy for recruiting new students. Both students and faculty report the focus on design of a real world application is very appealing. A second finding related to the interdisciplinary nature of PAtENT spans all four of the program goals. The interdisciplinary nature of the program and the research to develop an application connects to the core of an alternate pathway (Goals 1 and 2) that responds to the employment landscape and workforce needs while developing an entrepreneurial mindset (Goal 3). The interdisciplinary nature of the work supports an ecosystem that draws on pedagogical strategies from multiple STEM disciplines including collaboration, hands-on research, and scientific thinking and communication. External partnerships and financial support further these elements by providing opportunities for support and partnerships that are entrepreneurial in nature, such as the Ventureprise partnership supporting development of entrepreneurial skills as well as design and testing of technical products.

Conclusion

As PAtENT continues to develop a scalable framework as an alternate pathway for engineering doctoral programs, perspectives from students and faculty are critical. These shared impressions demonstrate how this program responds to calls for graduate STEM education to evolve in addressing changes in science and engineering, the nature of the workforce, and career goals. The National Academies of Sciences, Engineering, and Medicine (2018) call for STEM doctoral programs that go beyond alignment to components of traditional degrees to expand experiences in the laboratory or fieldwork, workshops, internships and other opportunities that establishes a critical mission that will “stimulate curiosity; develop the intellectual capacity to recognize, formulate, and communicate complex problems; create an iterative approach toward solutions, drawing from discipline-appropriate quantitative, theoretical, or mixed-methods tools; make original discoveries that advance understanding; and communicate the impact of the research beyond their discipline” (pg. 105). This study demonstrates that the PAtENT program is making steps in establishing a program mission that responds to this call from the Academy to develop vibrant programs of doctoral study.

Acknowledgements

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