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Lessons Learned in Adopting a New, Patent-Based Doctoral Pathway Model

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Abstract

This Work in Progress paper describes the lessons learned from a new pathway for doctoral candidates in STEM programs allowing capstone degree requirements to be fulfilled by research culminating in a patent application. The Pathways to Entrepreneurship (PAtENT) model aims to bring greater alignment between doctoral degrees and the rapidly changing employment landscape. Given that seventy percent of PhDs exit academic careers within three years [1], creating doctoral pathways that align with multiple career options is an imperative. We describe the PAtENT model, rationale and goals. Components of the pilot program will be explained through a curriculum alignment describing key activities that respond to recommendation for STEM graduate programs identified by the National Academies of Sciences, Engineering and Medicine [2]: developing scientific and technological literacy and conducting original research; and developing leadership, communication, and professional competencies. After two years of development and implementation, we are also able to discuss lessons learned and strategies for scaling the model. We present findings from students in the program and a reflective interview of the project leadership team. In order to adopt this innovative education model, students, faculty, and universities need understanding of career pathways and opportunities beyond traditional academic pursuits.

Introduction

We formed the Pathways to Entrepreneurship (PAtENT) graduate education model to address the need to develop and train advanced engineering students in the art of entrepreneurship. Workforce estimates show that only 10% of doctoral graduates in STEM overall obtain a tenure-track position [3]. Most doctoral scientists and engineers obtain employment in the private sector rather than in education [4], and increasingly as entrepreneurs. A wide range of skills and knowledge is required in order to succeed in industry, such as leadership, communication, and teamwork skills [5] as well as development of understanding of business, social, and ethical contexts within STEM [6]. Traditional graduate programs fall short of preparing students for multifaceted careers in the current landscape of rapidly evolving technology and scientific knowledge [2]. The PAtENT model provides a framework to engage engineering doctoral students in entrepreneurship throughout their academic work and not as an addendum to it. In this Work in Progress paper, we describe the program curriculum, management and evaluation structure, the launching activities, and provide project lessons learned over the course of the first two years in the project's life cycle.

The PAtENT project has been developed and applied in multiple STEM departments in the College of Engineering at the University of North Carolina Charlotte (UNC Charlotte) through a National Science Foundation award. UNC Charlotte is an ideal location for this novel model of graduate education, because the institution is a large, research institution that is situated in an urban region with significant entrepreneurial activity. There is more entrepreneurial activity per capita within this region than elsewhere, providing an environment rich for student entrepreneurship. In a national study of 166 public and private universities, UNC Charlotte was ranked third in a peer group with similar research programs in entrepreneurial activity [7]. When adjusted for the scale of programs offered, Charlotte was ranked eighth for startups, and 15th for invention disclosures [7]. Since 2017, UNC Charlotte faculty and students have been awarded 98 patents and launched 17 startups. UNC Charlotte faculty were also ranked 10th in the 2022 Global University Entrepreneurship Productivity rankings published by the Texas Christian University [8].

PAtENT Model

The PAtENT model applies a student-centric approach to focus the educational emphasis toward the development of entrepreneurial skills necessary to engage in the modern and rapidly changing technical workforce. A flexible, alternative pathway is offered instead of the traditional graduate program, that does not add time to completion nor reduce technical rigor. The model design adheres to the core elements identified as essential for doctoral education, which are to develop scientific and technical literacy, leadership, communication and professional competence, and catalyze original research [2]. Students, and their faculty advisors, who choose the alternative pathway, are able to select a commercial idea/patent proposal in lieu of the traditional dissertation proposal. They then proceed with their original research, submitting a patent application, and defending the proposal submission.

The goals of the PAtENT pilot program are as follows. The program goal is to create an alternate pathway for doctoral students in STEM domains to pursue entrepreneurship, through a patent proposal, that addresses the workforce landscape. The research goals are to understand the conditions that develop entrepreneurial mindsets in doctoral students, and how the PAtENT model can be scaled within our university and to others.

PAtENT Curriculum

The curricular pathway is designed to be integrated into the doctoral degree program. Rather than operating as a standalone, extracurricular model, the PAtENT model allows students to opt into entrepreneurial coursework that counts toward their degree. Students whose preliminary research demonstrates potential for patenting can choose the PAtENT pathway in consultation with their dissertation committee, and enroll in doctoral level entrepreneurial courses. The patent proposal and application serves in lieu of the proposal and dissertation. Thus, the core elements of STEM doctoral education are delivered, while satisfying the multiple requirements and needs to address the evolving workforce through this student-centered program.

The entrepreneurial coursework is provided through the College of Business and Ventureprise, a center for innovation and research commercialization and an NSF I-Corps site. These resources provide students with mentorship expertise for university-based startups as they offer classes, workshops and bootcamps to develop and scale commercial enterprise. Students choosing the PAtENT pathway are able to select from this range of options in the College of Business and Venturprise to complement their project foci.

Curriculum mapping identifies the experiences (i.e. the actual curriculum) in comparison with the core elements of quality STEM education Ph.D. programs from the National Academies study [2], so that educational experiences are purposefully and logically structured, and also allow for documentation of key program components. Current work is primarily focused on phase one of the process: identify processes and skills emphasized; essential concepts and topics; products and performances [9]. This documentation will ultimately go through multiple reviews and become a critical artifact in program review and refinement. Current highlights of the curriculum mapping include specific program components mapped to each of the core elements. Figure 1 provides illustrative examples.

Competency	Program Components
Develop Scientific and Technological Literacy	• Required to enroll in two courses offered by College of Business on Entrepreneurship and Innovation, such as Entrepreneurial Decisions
Conduct original research	• Student presents research idea to Committe • If Passed, student presents to full Patent Committee • If Approved, a provisional patent application is submitted • Student drafts the technical description of the full patent application
Develop leadership, communication, & professional competencies	• Required to enroll in Graduate Business courses • Or participate in Venturprise training modules

Figure 1. Examples of Curricular Mapping to National Academies of Science Core Educational Elements

PAtENT Management and Evaluation Structure

The Project Leadership is structured into three teams: Management & Administration, Recruitment & Scalability, and Research & Assessment. The leadership team meets biweekly to share updates, insights, and discuss progress. Each sub-team presents updates. Strategy, direction and course corrections if needed are also discussed.

The approach to the research is guided heavily by applying the five dimensions of scale [10]: depth, sustainability, spread, shift and evolution. These dimensions are also important for a continuing evaluation of the program, which is guided by a developmental evaluation approach [11]. Depth measures relate to the quality of the program. Sustainability measures focus on participation in the pilot track. Spread involves scale to other institutions. Shift centers on the evolution of the model with various departments and evolution measures learning across all components of the program across multiple contexts. The data collection is ongoing, qualitative and quantitative, and captured from key stakeholders. Faculty who lead the project, faculty who are advising students in the program, and students are key stakeholders. Students who are in the program are surveyed and interviewed, and students not in the program are invited to participate in surveys. Interviews and initial survey results have been published elsewhere [12].

Launch Initiatives

During the first two years of the PAtENT project, primary activities have centered on recruitment, marketing, and investigating student and faculty perceptions about the program. The year one focus was on relationship building with campus resources and community, and establishment of data measurements and collection plan. The management team collected responses from faculty about project status for potential doctoral candidates, and finalized student cohort one. Additionally, the team connected with the Ventureprise and the Business School to form the partnership across colleges. University collaborations were embarked upon with the Graduate School, the Office of Assessment, and STEM departments through meetings.
The recruitment team developed sustainable recruitment strategies to build a student pipeline, especially for under-represented students in STEM. To connect with other institutions potentially interested in the PAtENT model, marketing strategies were also developed. A website was developed and dissemination planning at conference venues was planned. The research team devised a data collection and management plan, defined the comparison student group for study, and created instruments for measurement. Baseline instrumentation including a student survey and university and national benchmarking data began. The first year activities culminated in summer 2021 with attendance at the ASEE meeting (summer 2021), engaging the first student cohort in Venturprise training, and participation in the NSF IGE annual meeting.

The second year project focus has remained on recruitment for cohort two. Reaching out to faculty about potential student interest was a key activity. The research activities launched in year one and continue into the second year. A student survey of entrepreneurial mindset was distributed to capture baseline student attitudinal data across Engineering, Business and Computing students on campus for comparison groups. This survey is administered at intervals throughout the project cycle to measure change in PAtENT students compared to other students, and to determine if coursework is well suited for entrepreneurial attitudes. Interviews of PAtENT students and faculty were conducted [12]. Additionally, a focus group was conducted with the project leadership team to reflect upon project success and challenges to be addressed. These lessons learned are shared following description of the methodology.

Participation in the PAtENT pathway option to date has included six faculty and eight students (half of whom are female). While this is a small number compared to the total number of doctoral students in Engineering (Fall 2022, the most recent available term had 206 doctoral Engineering students enrolled), the interest expressed during student orientations has been accelerating for newly enrolled students. Making a pathway shift during one's degree pursuit may feel disruptive to current students, yet appeal to the newly enrolling students who are launching their careers.

Methodology

The leadership team was interviewed in Fall of 2022, with an evaluation approach known as the 'critical friend' [13]. The focus group protocol was designed so that overall impressions with the program development and evolution were explored, based on the five dimensions of scale in the program evaluation model. The interview was conducted during a project leadership meeting, audio recorded and transcribed for analysis. Responses were analyzed using a comprehensive process to identify evolving themes, using both inductive and deductive processes to extract information and compare evidence [14], [15]. This approach is appropriate given the small sample size (n=4). Representative quotes are included to provide a rich description of perspectives.

Lessons Learned

The lessons learned across the leadership team revealed the following themes. There were **perceived barriers** among faculty and students. **Operational obstacles** were another theme. Additionally, **institutional challenges** were noted. These lessons learned are described by these themes.

<u>Perceived Barriers</u>. When initially presented to faculty, whether in departmental or individual meetings, initial concerns stemmed from the misperception that the PAtENT pathway would

require additional time for doctoral students to complete their degrees. The pathway design replaces the dissertation proposal and defense with a patent application proposal and defense, and fits into the doctoral degree pathway within the same timeframe. An additional concern voiced by the faculty, and also by students, was concern about getting Graduate School approval, and the publication record of doctoral students. Doctoral programs require publications as part of the degree, and publishing research that is related to patentable ideas can be tricky, if not impossible. "Grad students want publications." However, a main premise of the PAtENT model is that patented research and ideas presents a wealth of career opportunities beyond academic careers, making publication records less significant within the knowledge innovation workforce. The project leadership team noticed reticence among students and faculty to engage in a pilot program that has not produced large cohorts in its first two years. Interestingly, yet unsurprisingly, the patent pathway appeals to certain disciplines over others. "The hard sciences like Physics seem most interested in this model. Computer science faculty were not as interested as we had anticipated, which upon reflection, is likely due to the research domain. One cannot patent an algorithm."

Operational Obstacles. There are notable operational challenges for the model. The leadership team acknowledged that there is a lagging delay for recruiting students from undergraduate and masters programs into the PAtENT program, because these potential students have to matriculate through degree programs. There are certain socio-cultural and economic contextual realities enmeshed with recruiting undergraduate students into doctoral programs that are not easily addressed. "Students want to get out and earn a living." To address this, the team is adjusting its strategy to include targeted marketing for undergraduate and masters students. Polls about interest levels among these students will be a component of the marketing so communications can be directed to an interested pool of potential students. Additionally, the pandemic occurred during the launch of the program such that recruiting efforts were stalled.

Institutional Challenges. The leadership team collaborated with the Graduate School early on in the project, and established the pathway model approval process. However, the university process requires that both the patent office and the graduate school approve student progression through doctoral milestones. Having two institutional offices direct dissertation matriculation does add a layer of administration for students and their faculty advisor. To address this issue, the leadership team has included a strategy for collaboration with the patent and graduate school simultaneously so that the administration can be better coordinated and aligned, to increase efficiency for students.

Conclusions and Next Steps

The PAtENT model is a flexible, hybrid approach to the program model to accommodate the three publications rule from the institution. As stated by a project team member: *"The original* *vision of this project was to provide an alternate route for graduate students to see if this could somehow attract students who would not usually consider doing a phd; a different picture of what a phd could be; to attract students who were not looking at this as a career option."* The leadership devised the pathway allowing students to: publish one or two papers; then enroll in relevant entrepreneurial coursework or Venturprise programming, to address faculty and student concerns about additional time to degree and publication records. The prominent lessons learned were in recruitment strategy pivots. The leadership noted that "Face to face recruiting works well with students, and student groups, and individual faculty meetings work best because we can alleviate their concerns by answering questions directly and immediately." However, this activity is time consuming and resource intensive. The next year will devise a recruiting strategy that can be efficiently scaled, and to reach into the undergraduate and masters degree students with quick interest polling. Additionally, the team "employs a strategy of following up with faculty who have filed patent applications recently."

Project leadership discussed the mindset shift required among students, faculty and the institution, to become fully aware of the innovative potential of the PAtENT model. Thinking beyond university postdoctoral employment is a big change. As one team member stated insightfully, "If this model is to take hold, we need a cultural change." Through this realization, the leadership team has begun inviting colleagues from R1 universities to discuss how they catalyze entrepreneurial mindset among students and faculty. We anticipate further study of how this pathway model impacts recruitment of new students and how it may enhance university partnerships with industry.

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