Entrepreneurial Science and the Training and Aspirations of STEM-Focused Agriculture Graduate Students: An Exploration

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Abstract

The academic training and professional aspirations of students enrolled in science, technology, mathematics and engineering (STEM) graduate programs in three agriculture colleges were explored in the context of the current knowledge-based economy. Particular attention was placed on how, if at all, study participants associate innovation and entrepreneurship with their research interests and intended career paths. In doing so, participant awareness of and perspective on current demands and opportunities for entrepreneurial scientists were explored. Recommendations for increasing the alignment between the so-called "knowledge economy" (Powell and Snellman, 2004) and the academic training and professional aspirations of STEM graduate students enrolled in agriculture colleges were developed.

Keywords: agriculture graduate education, innovation, knowledge economy

Introduction

The present-day global economy centers on the rapid development and dissemination of innovation (Powell and Snellman, 2004). Economists have shown within this knowledge-based economy a positive association between the competitive position of nations in world agriculture markets and investments in scientific and technological research specific to food and fiber production (Alston and Pardey, 2014; Anderson et al., 1994). Consistent with this relationship, the U.S. has strategically positioned innovation and entrepreneurship at the core of its agricultural research development policies. For example, the President's Council of Advisors on Science and Technology (PCAST) (2012) declared that investments in agricultural research should be increased to *"create opportunities for new business ventures funded by the private sector and provide the means to train the next generation of farmers and ranchers and meet the workforce demands of U.S. agriculture in the 21st century"* (PCAST, 2012, p. iii). The United States Department of Agriculture (USDA) has since allocated $75 million to establish three innovation institutes involving public-private partnerships and enhanced its Small Business Innovation Research (SBIR) program to further foster agricultural entrepreneurship (NIFA, 2015).

The diffusion of agricultural innovations within and across competitive markets is dependent on a highly trained workforce composed of professionals with both advanced scientific/technological expertise and entrepreneurial skills (Alsos et al., 2011; Murray, 2004). Indeed, the labor market demand for such diversely equipped professionals, who are heretofore referred to as "entrepreneurial scientists," is high (Alston and Pardey, 2014; Rivera and Alex, 2008). The infusion of entrepreneurial principles and practices in graduate-level science, technology, engineering, and mathematics (STEM) education is well documented (Astebro et al., 2012; Mars et al., 2008; Mendoza, 2007). The current study contributes to this body of literature by developing insights specific to how, if at all, the academic training and professional aspirations of STEM graduate students enrolled in agriculture colleges were being influenced and shaped by current workforce demands for entrepreneurial scientists.

Conceptual Framework

Two theoretical frameworks guided this study. First, the primary characteristics of the knowledge economy (innovation and entrepreneurship) (Powell and Snellman, 2004) oriented an exploration of how, if at all, an economic environment in which entrepreneurial scientists are in high demand influences the training and development of STEM graduate students enrolled in agriculture colleges. Second, the organizational premises of academic capitalism (Slaughter and Leslie, 1997; Slaughter and Rhoades, 2004) framed how, if at all, STEM graduate students enrolled in agriculture colleges are introduced (formally and/or non-formally) to the principles and practices of innovation and entrepreneurship through their programs of study.

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The Knowledge Economy

Powell and Snellman (2004) described the knowledge economy as an economic environment that is global in scale and driven by *"knowledge-intensive activities that contribute to the accelerated pace of technical and scientific advance, as well as rapid obsolescence"* (p. 199). The expeditious production and dissemination of scientific and technological knowledge is central to industrial strategy and economic development policy (local, regional, national) within the knowledge economy. Under such conditions, corporations work to rapidly generate, protect and commercialize new knowledge in order to achieve and sustain competitive positioning within relevant industries. Concurrently, public officials at various levels of government work to increase global competitiveness through the establishment of aggressive policies that incentivize the entrepreneurial application of scientific and technological innovations (Mars et al., 2014).

In the knowledge economy, innovation involves the rapid transformation of scientific and technological discoveries into novel products or processes that hold potential economic and/or social value (Baregheh et al., 2009). Symbiotically, entrepreneurship is the strategic process through which such discoveries turned innovations are positioned within relevant markets (Drucker, 2001). The dominance of the knowledge economy has resulted in innovation and entrepreneurship being central to the competitive strategies of both start-up companies and established firms, as well as a range of other organizational-types (e.g., universities, economic development agencies).

The heightened and pervasive focus on the entrepreneurial application of scientific and technological discoveries impacts academic research in a variety of ways. For example, university researchers engaged in entrepreneurial science are increasingly willing to collaborate across disciplinary lines and organizational boundaries (e.g., university-industry partnerships) (Gulbrandsen and Smeby, 2005). Cross-disciplinary and inter-organizational collaborations tend to result in greater productivity as indicated by entrepreneurial outputs (i.e., patents awarded, intellectual property licenses issued, business start-ups created) (Lin and Bozeman, 2006; Nowotny et al., 2003). However, the priority and incentives directed at entrepreneurial research with high commercial promise may constrain natural inquiry and basic (or pure) science (Schuetze, 2007). Critics have also argued that the enhanced focus on entrepreneurial science limits the scholarly exchange of ideas as researchers opt for patenting first and publishing second in order to protect the "secret sauce" of discoveries (Welsch et al., 2008).

The current study explored the potential ways in which contemporary demands for innovation and entrepreneurship influence the academic development and professional perspectives of STEM graduate students enrolled in agriculture colleges. In particular, how, if at all, the research interests and professional aspirations of these students were influenced by demands and opportunities for innovation and entrepreneurship was considered.

Academic Capitalism

Academic capitalism theory explains a myriad of implications associated with the permeation of market and market-like forces in higher education beginning in the 1980's (Slaughter and Leslie, 1997; Slaughter and Rhoades, 2004). More specifically, the theory argues the following four organizational constructs emerged within colleges and universities from the needs and demands of the knowledge economy: interstitial organizations, enhanced managerial capacities, intermediating organizations and new knowledge circuits.

- Interstitial organizations are market-facing units developed within colleges and universities to encourage and support entrepreneurial activities and initiatives (e.g., technology transfer offices, university-sponsored entrepreneurship incubators).
- The managerial capacities of colleges and universities have been enhanced through the notable expansion of a professional workforce charged specifically with managing institutionally based entrepreneurial activities and initiatives (e.g., licensing agents; corporate relation directors).
- Intermediating organizations are standalone entities external to colleges and universities that facilitate inter-organizational boundary spanning between higher education institutions and external firms and organizations (Metcalfe, 2010).
- Knowledge circuits that connect otherwise fragmented actors within and beyond colleges and universities continually emerge and evolve in response to market and market-like opportunities and demands. For example, linkages between STEM faculty and students with counterparts in entrepreneurship education centers, which are most often positioned in business colleges, are knowledge circuits that commonly develop during the creation of research-based spin-off companies (Mars, et al., 2008).

Student exposure to and/or interaction with the preceding four academic capitalist constructs provided a conceptual lens through which to recognize and more fully understand how, if at all, the knowledge economy has influenced the training and development of STEM graduate students enrolled in agriculture colleges.

Methods

General Design

The current research was conducted using a qualitative, multiple case study design (Yin, 2014). This design created the opportunity to achieve greater analytical depth and breadth through the exploration of a single phenomenon across separate settings with common characteristics (Creswell, 2007; Miles and Huberman,

1994; Stake, 2006). The central phenomenon explored here was the influence of the workforce demands for entrepreneurial scientists within the knowledge economy on the academic training and professional aspirations of STEM graduate students enrolled in agriculture colleges at three public land grant universities (LGUs). The inclusion of three similar, yet separate settings allowed this phenomenon to be considered beyond the context of a single agriculture college. Accordingly, the trustworthiness and transferability of the results were enhanced (Lincoln and Guba, 1985). The study was determined by the researcher's home university to be exempt from institutional review board approval and oversight.

Site Selection

The three agriculture colleges included in this study were purposefully selected according to the following three criteria recommended by Miles and Huberman (1994): 1) relevancy of setting, 2) occurrence of activities and/or or processes reflective of the topic of study and 3) accessibility of key informants. First, each of the three agriculture colleges was considered to be a particularly relevant setting based on being located within a LGU. LGUs share an institutionalized mission to foster community and economic development through the discovery and dissemination of scientific and technological knowledge. While this mission is mostly acted on through education and outreach activities, the diffusion of innovations through entrepreneurial initiatives is increasingly common within LGU's (Glenna et al., 2007; Mars, 2014). The study was thus enriched by the organizational proximity of each of the three agriculture colleges (and associated LGUs) to the knowledge economy. Second, all three of the agriculture colleges enrolled graduate students in a range of STEM-related programs of study. Third, final site selection was made after adequate access to key informants (i.e., STEM graduate students enrolled in agriculture colleges) and supporting data (e.g., program descriptions, curricula) was confirmed.

Qualitative research does not generate generalizable results. Instead, such research aims to develop new insights and propositions on phenomena to in turn be considered in settings similar to those included in a particular study (Merriam, 2009). The purposeful development of conceptually relevant variation between cases is one strategy for enhancing the transferability of qualitatively generated insights (Onwuegbuzie and Leech, 2007). The geographic diversity of the selected sites included in this study helped capture the national landscape of STEM-focused graduate education in agriculture colleges. This geographical breadth also helped position the study in the broader context of the previously described national economic strategy to remain competitive within the knowledge economy. The three sites ultimately selected are referred to by the following geographically descriptive pseudonyms: Southwestern University (SU), Middle University (MU) and Eastern University (EU).

Participant Selection

The participant sample was purposively developed in part using a theoretical-based sampling strategy reflective of the primary constructs of the knowledge economy (innovation and entrepreneurship) and its influence on agricultural industry and enterprise (Onwuegbuzie and Leech, 2007). The sample was thus limited to agriculture graduate students enrolled in STEM-focused programs of study. Additionally, a maximum variation sampling strategy (Patton, 2015) was used to increase the likelihood of the sample including agriculture graduate students from a range of STEM-focused programs of study and with a diverse set of experiences and perspectives specific to innovation and entrepreneurship.

Participant recruitment began with the department heads and/or graduate directors of the STEM-focused departments within each of the three agriculture colleges distributing an open invitation to participate in the study to all graduate students via departmental email listservs. Students interested in participating in the study contacted the researcher directly via email. In turn, these students received a more detailed description of the study and its protocol. The researcher next individually confirmed with each interested student his or her enrollment in a STEM-focused program of study located within the agriculture college at his or her respective university. Participant interest, both academically and professionally, to agriculture was also verified. Ultimately, 24 graduate students representative of nine STEM-focused fields of study participated in the study. The sample was composed of nine women and eight men with 62.5% of the participants being at the doctoral level and 37.5% being at the master's level. Fifty-four percent of the participants were at EU, 25% were at SU and 20.8% were at MU. To protect anonymity, each participant was assigned a pseudonym that reflected his or her gender (Table 1).

Table 1. Participant Sample

Participant Name (Psuedonym)	University (Psuedonym)	Program of Study	Degree Level
Adam	EU	Conservation Ecology	Doctoral
Alvin	EU	Animal Sciences	Master's
Bill	EU	Horticulture	Doctoral
Carly	MU	BioChemistry	Doctoral
Carmin	SU	Soil Sciences	Master's
Chelsea	EU	Animal Sciences	Doctoral
Chester	SU	Environmental Sciences	Master's
Donna	EU	Natural Resources	Doctoral
Edward	MU	Plant Sciences	Master's
Elizabeth	SU	Natural Resources	Master's
Emma	EU	Animal Sciences	Doctoral
Gabriella	MU	Animal Sciences	Doctoral
Kevin	EU	Conservation Ecology	Doctoral
Kylie	EU	Animal Sciences	Doctoral
Luke	SU	Natural Resources	Doctoral
Madison	EU	Animal Sciences	Master's
Mason	MU	Wildlife Ecology	Master's
Nicholas	SU	Natural Resources	Doctoral
Nolan	EU	Animal Sciences	Master's
Oliver	SU	Natural Resources	Doctoral
Owen	MU	BioChemistry	Doctoral
Paul	EU	Wildlife Ecology	Master's
Tyler	EU	Conservation Ecology	Doctoral
Zachary	EU	Animal Sciences	Doctoral

Data Collection and Analysis

Data were gathered primarily through semi-structured interviews with each of the 24 participants. An interview protocol was designed to thoroughly explore with the participants how the knowledge economy and academic capitalism influenced their academic training and professional aspirations. The protocol was developed using the previously outlined principles of the knowledge economy (i.e., innovation and entrepreneurship involving scientific and technological research) (Powell and Snellman, 2004) and the organizational constructs of academic capitalism (i.e., interstitial organizations, enhanced managerial capacities, intermediating organizations, new knowledge circuits) (Slaughter and Rhoades, 2004). More specifically, participants were asked to do the following: 1) discuss their scholarly interests and career goals, 2) define entrepreneurship and innovation, 3) relate entrepreneurship and innovation to both their scientific/technological fields of study and career goals and 4) describe how, if at all, principles of entrepreneurship and innovation had been embedded (formally, non-formally, informally) in their academic training and/or professional experiences. The protocol was piloted with three agriculture graduate students enrolled in STEM-focused programs housed in the agriculture college at the researcher's home university. The feedback gained was used to refine the focus and wording of the interview questions. The length of the interviews varied from 37 to 92 minutes. A third party service used audio recordings to transcribe each interview verbatim. Relevant curricular and programmatic documents at the departmental, college, and university levels (e.g., syllabi, course and workshop descriptions, campus event materials) were also collected and analyzed to confirm and enrich the findings revealed through the interview data (Miles and Huberman, 1994).

Following the recommendations of Miles and Huberman (1994), a structured coding framework was developed using the principles of the knowledge economy (Powell and Snellman, 2004) and organizational constructs of academic capitalism (Slaughter and Rhoades, 2004). The framework was then used to guide the deductive analysis of the data, which occurred at both the idiopathic and nomethetic levels (Gelo et al., 2008). Idiopathically, patterns and trends specific to individual participants were uncovered. Nomethetically, sample-wide (and thus inter-site) patterns and trends specific to the integration and permeation of innovation and entrepreneurship in STEM-focused graduate education within agriculture colleges were uncovered. The data were also inductively analyzed to illuminate any patterns or trends relevant to the study, but not captured by the structured coding framework (Strauss and Corbin, 1998).

The qualitative researcher is the central instrument for bringing meaning to data. As such, the knowledge, experience, and perspective of the researcher relevant to the phenomenon of interest heavily influence the qualitative research process (Chavez, 2008). This researcher leveraged nearly a decade of experience in developing and teaching interdisciplinary-based innovation and entrepreneurship courses within and outside of agriculture colleges to enhance the richness of the findings. This researcher's well-established scholarly focus on innovation and entrepreneurship education brought further depth and perspective to the analysis. However, this researcher's positionality to the topic of focus also threatened to bias the analysis. Accordingly, trustworthiness was further established through member checking and the triangulation of the interview and document data (Berg and Lane, 2014). Idiopathic and nomethetic analysis also brought greater richness and overall credibility to the findings (Gelo et al., 2008), while the creation and maintenance of an audit trail increased dependability and conformability (Lincoln and Guba, 1985).

Findings and Discussion

Participant Awareness: Knowledge Economy

The students were overall equally receptive to university- and industry-based career paths. Kevin, a Ph.D. student in Interdisciplinary Ecology at EU, captured this openness to multiple career paths when stating, *"I'm pretty much open to anything. Working for the government, for the public sector, working for the non-profit sector, or for the academic sector will be options that I will contemplate equally."* Such receptivity was not driven, however, by the recognition of the demand for and strategic importance of entrepreneurial science within the knowledge economy. Students instead believed that compared to academia, industry would provide greater access to the resources necessary to pursue fruitful scientific and technological research and associated projects. For example, Nolan, a master's student in Animal Sciences at EU with plans to pursue a doctoral degree, stated, *"I'd like to stay in academia but if I had an opportunity in industry to work with research, I would definitely go too. I think industry has the money for research!"* In general, participants considered careers in industry based more on a perceived sense of certainty and security rather than on an intrinsic drive to engage the knowledge economy through entrepreneurial activities.

Gabriella, Owen and Tyler were the only three study participants with some level of interest in becoming an entrepreneur. Gabriella, an animal sciences doctoral student at MU, and Owen, a biochemistry doctoral student at MU, were also the only participants with direct experience working in an entrepreneurial environment prior to entering their graduate programs. Owen's experience working in a biotechnology start-up introduced him to the "world of entrepreneurial research" and shaped his goal of becoming an entrepreneur. He was keenly aware of the demand for entrepreneurial scientists across various industrial sectors, as well as the availability of government subsidies to support research-based biotechnology start-ups. He stated, *"I'm not going to write grants all day and be restricted in what*

I want to do because of its [university] bureaucracies. I'd much rather on my own go after SBIR grants that the government is throwing at entrepreneurial techies." Gabriella worked for a consulting firm that supported university technology transfer activities prior to beginning her doctoral program. Similar to Owen, Gabriella's interest in entrepreneurship was driven by a desire for scientific autonomy. She had distaste for the constraints placed on researchers within established firms that typically conform to industry trends. She commented, *"Based on what I have seen, there aren't many interesting new strategies for incorporating science into the [cattle] industry. I think I could do more cutting edge stuff on my own."* Owen was also disenchanted by the prospects of working within a corporate-sponsored laboratory. He said, *"Even in industry there are too many rules and constraints. The current economic environment is perfect for someone like me with advanced training, creative ideas, and the drive to be my own success story."* The third student with entrepreneurial intent was Tyler, a conservational ecology doctoral student at EU. He had no entrepreneurial experience, but perceived entrepreneurship to be a pathway to self-determined success. He stated, *"I see people start businesses or come up with an idea to fit a market niche and then they're able to empower themselves and overcome their own economic lot that they were basically dealt in life… This inspires me."* The entrepreneurial awareness of these three participants was spawned from industry experience and/or personal observations rather than directly from the influences of the knowledge economy on their academic training and professional development.

With the exception of Gabriella, Owen and Tyler, the study participants had given little direct thought to the concept of entrepreneurship and its intersection with scientific and technological research. However, the participants did consistently describe entrepreneurship as a general process involving individuals that autonomously start and operate businesses. For example, Carley, a biochemistry doctoral student at MU, indicated *"an entrepreneur is someone who has made opportunities for themselves… like someone who starts a company or something like that to make a profit on their own."* Elizabeth, a natural resources master student at SU, described entrepreneurship as *"having the freedom to make money by turning nothing into something."* Likewise, Zachary, an animal sciences doctoral student at EU stated, *"the way I see it, it's [entrepreneurship] dependent on the person, the individual. It's almost like an instinct to see and act on business opportunities."*

Overall, study participants identified creativity, novelty and the usefulness of discovery as the primary attributes of innovation. According to Carmin, a soil sciences master student at SU, innovation is *"the ability to create something robust but new and useful for technology and society."* Adam, a conservation ecology doctoral student at EU, echoed a similar understanding when indicating innovation involves *"creating a novel and creative approach to look at an issue or address a problem*." Participants also consistently associated innovation with research and discovery. For example, Tyler stated, *"innovation is coming up with new models or tweaking old models to provide additional insight into phenomena that we want to research."* Similarly, Emma, an animal sciences doctoral student at EU, linked innovation to her research activities in the following way: *"I feel like the research I do is to figure out and develop new things that could potentially work better than what currently exists. This is innovation."* She went on to say, *"after the scientist innovates and creates something that works, then entrepreneurs step in and put it [discovery] out there in the market."* Thus, participants viewed innovation as an important attribute of their current research activities and future scientific or technological careers. However, they also made a distinction, whether directly or indirectly, between the scientific process of research and the subsequent commercialization of innovative outputs. This distinction suggests participants were as graduate students isolated from both the entrepreneurial opportunities and demands of the knowledge economy.

Participant Awareness: Academic Capitalism

While all study participants recognized an intersection between innovation and their roles as scientists and technologists, only three viewed themselves as emergent entrepreneurial scientists. Considering the importance of scientific and technological entrepreneurship to competitiveness within the knowledge economy, this general pattern was somewhat surprising. However, participant awareness of and engagement in academic capitalism (or lack thereof) as graduate students sheds some insight on this finding. Specifically, participants were mostly distanced from the influences of academic capitalism and thereby the entrepreneurial opportunities and demands of the knowledge economy as experienced from within higher education.

None of the participants had experience interacting with market-facing interstitial units (e.g., technology transfer offices, university-sponsored entrepreneurship incubators) at their universities. Similarly, none of the participants indicated having interactions with university professionals charged with facilitating academic entrepreneurship (e.g., patent licensing agents). No references to university resources relevant to academic entrepreneurship were included in the 47 syllabi analyzed as part of this study, nor were such resources prominently featured on departmental or agriculture college websites. Thus, participants had minimal exposure to and consequently little awareness of entrepreneurial resources located within campus-wide interstitial units.

Participants received some non-formal training on intellectual property (IP) protection. However, this training was not specific to protecting the economic value of discoveries through entrepreneurial strategies (e.g., patenting, copyrighting). Instead, faculty mentored students on establishing and guarding the academic

value of novel data. For example, Bill, a horticulture doctoral student at EU, reported, *"Faculty in the division talk to us about it [IP protection], but not so much in terms of entrepreneurship. More like a moral or academic conduct issue, you know, avoid certain people who might steal your ideas or data."* Similarly, Chester, an environmental sciences master student at SU, stated, *"My thesis advisor tells all of us in the lab to be careful of where you post things or if you present at a conference, don't just give all your data away before publishing it."* The common association of IP protection with scholarly positioning extenuated the divide between the academic experiences of the participants and the entrepreneurial underpinnings of the knowledge economy.

Participants were alert to the availability of courses related to innovation and entrepreneurship that were offered outside of the agriculture colleges at each university. Examples of the topics addressed through such courses included IP protection, technology commercialization and strategic communication. Campus-wide announcements and word of mouth shared between students alerted the participants to the availability of these courses. For example, Bill stated, *"I saw a flyer for one or two [interdisciplinary IP courses] being offered through the law school. I don't believe that any similar courses are offered directly through us [agriculture college]."* Tyler was made aware of a graduate certificate offered through the business college during an informal conversation with other students. He stated, *"They [business college] offer a certificate in entrepreneurship to graduate students that are not studying business… I don't know a lot about it or if it is even relevant to my career."* Without faculty guidance, the study participants were only vaguely aware of the various entrepreneurial learning opportunities available at their universities and even less certain of the relevancy of these opportunities to their scientific and technological careers.

Participants did regularly observe and participate in interdisciplinary collaboration within the three agriculture colleges. For instance, Owen, a biochemistry doctoral student at MU, described benefiting from the diverse range of expertise he had access to through collaborations between the microbiology and plant sciences department. He stated, *"It's [departmental expertise] almost 50-50, people working on plants and then people working on human health and disease and then just a couple of random people are working with bacteria… ultimately, it [interdisciplinarity] is beneficial for everybody."* Conversely, participants made far less mention of interdisciplinary activities and experiences that transcended the boundaries of the agriculture colleges. Participants also made no mention of having access to any entrepreneurial knowledge circuits that may have intersected their departments, colleges, or universities. In short, participants were mostly isolated from the organizational attributes and activities of academic capitalism and, more broadly, the knowledge economy.

The participants in the current study indicated being largely isolated from the entrepreneurial opportunities and demands of the knowledge economy. Such isolation was revealed through two central findings. First, participants had little awareness of the entrepreneurial potential underlying their scientific and technological training and research. While participants commonly associated innovation with their academic interests and activities, they did so specific to discovery and the advancement of knowledge through traditional academic channels (e.g., peer reviewed publications). Moreover, only three of the 24 participants identified entrepreneurship as a relevant component of their current and future scientific and technological career aspirations. Second, participants were mostly distanced from the four organizational structures of academic capitalism, which Slaughter and Rhoades (2004) argue tie colleges and universities to the knowledge economy. Next, several key recommendations for increasing the alignment between the knowledge economy and STEM graduate education in agriculture colleges are provided.

Faculty members in agriculture colleges are encouraged to engage their graduate students more directly in their own entrepreneurial activities and industry collaborations; albeit in a judicious manner that considers potential conflicts of interest associated with the faculty-student dynamic (Mars, et al., 2008). Such engagement does not inherently imply faculty pushing their students toward entrepreneurial and/or industrial career paths. Instead, the inclusion of graduate students in entrepreneurial activities and industry collaborations is an opportunity for faculty to further mentor their students on scientific entrepreneurship and the relevancy of research and discovery to the knowledge economy (Mendoza, 2007). Without such faculty mentoring, graduate students are likely to overlook or unnecessarily discount potential career opportunities within industry and other entrepreneurial-type environments (e.g., start-up companies). Also, greater involvement in entrepreneurial activities and industry collaboration under faculty supervision would further prepare students to independently generate research funding. Indeed, the capacity to generate research support using entrepreneurial strategies (e.g., competitive positioning, resource acquisition, stakeholder mobilization) is advantageous to students intending to pursue academic careers within colleges and universities that are increasingly resource strapped.

University-wide entrepreneurship education is also a promising approach to introducing agriculture graduate students to innovation and entrepreneurial leadership. Entrepreneurship education is now an interdisciplinary field that transcends the boundaries of the business schools in which the underlying curricula are typically located (Levenburg et al., 2006; Solomon, 2007). Less formal, yet meaningful learning opportunities relevant to the knowledge economy are also available through programs sponsored by interstitial units such as technology transfer offices and university-sponsored entrepreneurship incubators (Stephan, 2001; Siegel and Phan, 2005). Examples of such programs include workshops on topics such as IP protection and start-up

funding allocation strategies, as well as guest lectures by entrepreneurs and executive leaders from a range of agricultural and life sciences (and other relevant) industries.

Entrepreneurial learning via the interstitial units and managerial capacities developed and enhanced through academic capitalism would also provide STEM graduate students enrolled in agriculture colleges access to more diverse knowledge circuits. The knowledge circuits attributed to academic capitalism are interdisciplinary and inter-organizational (e.g., university-industry connectedness) in nature (Slaughter and Rhoades, 2008). Observing and/or participating in these knowledge circuits, which typically do not directly intersect formal classroom settings, would thus increase student exposure to and understanding of the cross-sector and multi-disciplinary nature of research and development within the knowledge economy.

Summary

The current study is not intended to critique the influences of the knowledge economy and academic capitalism on agriculture colleges or to encourage a market fundamentalist approach to agriculture research and instruction. Instead, the purpose is to provide an initial understanding of how, if at all, STEM graduate students enrolled in agriculture colleges relate their academic training and professional aspirations to the knowledge economy. Indeed, the pros and cons of overlaying graduate education in agriculture colleges with market-based principles and practices warrant debate. However, such debate is beyond the scope of this study. Accordingly, scholars are encouraged to further pursue the relevant issues and concerns through objective research and constructive dialogue.

The implications of the knowledge economy on the academic training and professional aspirations of agriculture graduate students in non-STEM programs of study (e.g., agribusiness, agricultural education and leadership, rural sociology) should also be examined. Such research should raise awareness of how entrepreneurship and innovation influence the preparation of not only those students preparing to be leaders in agricultural-based industries, but also those pursuing careers in community development and education. Future research on the intersection of the knowledge economy and undergraduate education across the agriculture disciplines is also encouraged.

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