The Changing Role of the CSET Professorate in University-Based Value Creation

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***Abstract*—As universities have continued to invest resources in economic development and entrepreneurship education, the legal and regulatory environment has been in continual change. While much of the conversation about this change has been at the administration level, particularly through offices of technology transfer and/or economic development, it also impacts the role of the CSET professorate and relevant student interactions. The CSET disciplines are among the van guard of this change given the significant potential for value added components and processes that may be commercializable. This paper provides an overview of the regulatory and pedagogical environment regarding value-creation over the past twenty years and what this means for both CSET faculty and their students. Primary concerns include understanding the intellectual property environment in research, internship, and classroom situations, the levers and impacts for evidence-based learning, and working across disciplinary boundaries.**

Keywords—Value-added; Faculty Development; Economic Development

I. Introduction

As universities have continued to invest resources in economic development and entrepreneurship education, the legal and regulatory environment has been in continual change. While much of the conversation about this change has been at the administration level, particularly through offices of technology transfer and/or economic development, it also impacts the role of the CSET (computer science, engineering, and technology) professorate and relevant student interactions. The CSET disciplines are among the vanguard of this change given the significant potential for value added components and processes that may be commercializable in their design and research purviews. This paper widens the discussion of the university-based value creation to include how students learn and the systems in which that learning occurs. For CSET faculty, experience with intellectual property and other value-creation activities traditionally supported in universities provides a mechanism to approach this broadening of thinking. While this discussion is based around the legal and regulatory environment in the United States, the paradigm shift to value creation and the potential impacts to student learning and faculty development are applicable across national boundaries.

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II. A Brief history of University-Based Economic Development

Since the Patent and Trademark Law Amendments Act of 1980 (Bayh-Dole Act) [1] and the American Recovery & Reinvestment Act of 2009 (ARRA) [2], research in Universities has become linked with economic development. This is generally understood as a process linking basic research through to the creation of jobs, as seen in Figure 1.

Basic Research → Grants →
Innovation/Invention → Industrial Partnership →
Commercialization → Jobs

Figure 1. Process Linking Basic Research to Jobs

Federal agencies such as the National Science Foundation (NSF) and the National Institutes of Health (NIH) are responsible for funding grants across the spectrum of fields and both require reporting on the creation of inventions and publications that resulted from their funding. This requirement assumes that the institution receiving the funds has the capacity to support publications **and** commercialization. Over the last decade, the federal government has passed numerous regulations and laws that require a heavy load of administrative obligations related to the management of public funds. In addition, each agency and department has developed unique rules and technological support for the submission and management of grants and intellectual property.

Taken together, this means that a research program within a university or other research institution (e.g. medical schools or research hospitals) is composed of not only the "normal" grants and contracts functions but also includes intellectual property/commercialization components, compliance components, and data management/technological components on top of what is arguably the most critical component – faculty, students, and research staff engaged in the process of creating scholarly works and conducting scientific inquiry into various topics.

In the Bayh-Dole era of intellectual property management, a shift occurred where Universities became responsible for the development of intellectual property. Needing a measurable outcome, Universities focused on counting patents and licenses as they were easily quantifiable and trackable. This proved to be the wrong measurement, as any University with enough

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funds at its disposal could patent large numbers of inventions to present a false picture of success.

The passage of ARRA created a shift in the way that intellectual property is managed within a university by its stress on the *economic impact* of the ARRA funds. Recipients of ARRA funds not only had to report any patents or licenses but also had to figure out a way to determine the economic impact of the use of those funds within their communities and State.

Universities now had to focus resources not only on patenting and licensing developments but also on supporting the development of new businesses related to the intellectual property portfolio. Business Incubators sprung up across the US at University after University. The measurable outcomes of success shifted to include jobs created, start-ups and spin-offs.

Universities then became more aware of the value of the intellectual property being created by the professorate. The America INVENTS Act reformation of the US Patent law [3] and the *Stanford v. Roche* decision [4] regarding ownership of intellectual property brought this awareness to the center of the administrative radar screen. Faced with increasing financial burdens related to intellectual property development and management, many Universities began to look at their overall approach to the traditional IP arrangements with the professorate. The advent of on-line courses played a key role in this development as converting traditional curriculum to a distance learning format opened the door for curriculum development to be considered work for hire [5] and a University could now claim primary ownership of curriculum [6].

Post-Facebook, Universities have also become aware of the likelihood that the largest intellectual property development at the University may occur amongst the student body. IP policies have now been cleverly re-written to allow students to own IP as long as no university technologies or resources were involved with the development of the IP.

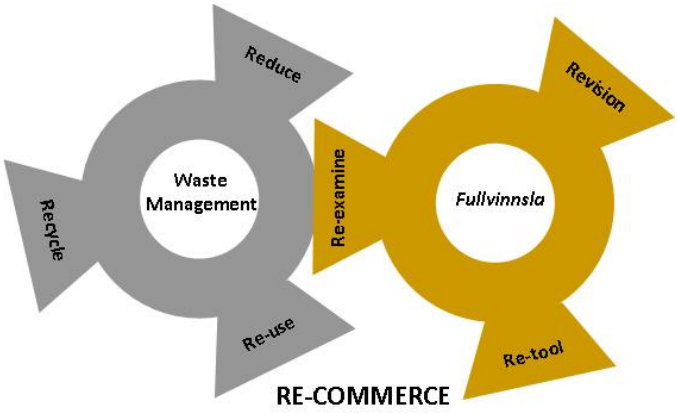

Figure 2. The re-Commerce Model [7]

Applying the lens of the re-Commerce model [7] seen in Figure 2 (approaching a situation with the rubric of re-Examine founding axioms, re-Vision the problem, and re-Tool a new solution) we now have to acknowledge that the traditional model, illustrated in Figure 3, no longer fits the full spectrum of university-based economic development or value creation. Universities must think much more broadly at what arises from the heart of academe and determine the value that is being created in every facet of the academic environment.

Invention→ Patent → License →

Commercialize to business →Jobs

Figure 3. The Traditional Invention to Jobs Model

Three areas of the intersection between the professorate and value creation will be examined in next section and be used to create a new definition of university-based value creation in the final section of this paper.

III. Intersection of the Regulatory and Pedagogical Environments

As discussed above, intellectual property, particularly around the results of research and design, have largely been the traditional starting place for considering the economic development capabilities within universities. While IP-based discussions within the university are often limited to particular disciplines and faculty-focused, they do remain part of the landscape even under value-creation thinking.

Each institution has is its own approach to IP, often including a formal policy. These approaches and policies differ widely by particular institutional cultures, the way legal counsel to the institution has interpreted state and national legislation, and the relationship between the individual and institution (e.g., student, student paid to do research or design work, faculty, staff). In addition, agreements with industry, private, and government funders may have conditions which override the normal IP assignment operations of the university.

This means, then, that the practical implications of intellectual property considerations for student learning and faculty development not only remain with the shifting perspective to value creation, they will likely need to be expanded in purview. Just as processes and policy adjustments were spurred by the post-Facebook recognition of student-generated IP, universities have begun explicitly considering IP ownership in student-developed design products and student internship opportunities. This is a model which can be built upon for implementation as we shift our view of university-based value creation to include the impacts on learning and teaching described in the following sub-sections.

A. Impacts on 'Classroom Based' Learning

Once we have accepted that students are crucial to developing value and economic security through universities, the natural next extension is to consider the classroom, here defined as learning contexts that are formal, led by someone(s) with faculty designation, and taken for academic credit. We illustrate the paradigm shift toward value creation using examples at both the course and curriculum units of analysis.

At the course unit of analysis, consider the evolution of projects in capstone design courses over the past decade. While the sources of capstone design projects continues to be dominated by industry/government sponsors and faculty research, projects generated from student ideas and potential

student-led start-up firms increased "significantly" between 2005 and 2015 [8]. This indicates an increase in the 'entrepreneurial capital', and personal-value based expectations, brought into the classroom by the students as well as adding a dynamic to capstone instructor concerns regarding the potential "over-dependence of students" on their project supervisors, resulting in a lack of motivational "ownership" of the project [9]. Similarly, classroom projects developed around student ideas adds a wrinkle to the "risk management" mechanisms, revolving around issues like the assignment of intellectual property rights and the handling of proprietary or sensitive information, universities have been instituting in response to the increasing number of industry-sponsored projects [10].

The lens of re-Commerce can also be used to reexamine the fundamental assumptions associated with the current capstone design methodology. Most of the teams are given a project with a pre-determined solution – e.g. we have an issue with X so design a Y. While it is part of engineering to "start with the end in mind" [11], Dunker's concept of "functional fixedness" [12] too often occurs within the presentation of capstone design projects. Dunker describes functional fixedness through what is known as the candle experiment: subjects provided with candles, boxes of matches, and tacks are asked to attach the candle to a vertical surface in a way that the candle can be lit. Through this and other experiments, Dunker discovers that people have a hard time viewing an object, like the matchbox, for a use other than that for which it was presented. By presenting capstone and other design activities as particular projects to be solved, we are presenting students with a set of definitions and assumptions which may vary widely from the reality of the situation or even the perceptions of the students [13].

Starting with the end in mind, when combined with functional fixedness, eliminates a large opportunity for creation and innovation. Drawing on student ideas, however, both centers the presentation of the project in a place of intrinsic motivation [14, 15] and provides a forum where the students must clarify definitions and assumptions for the instructor and the team [13]. Whether the design experience is generated from student ideas, faculty research, or real-world clients, being aware of the pitfalls of functional fixedness will encourage students to design as problem solvers, rather than solution seekers [16].

When we adjust our unit of analysis to the curriculum, the potential for value creation in both the product (e.g., the credential as well as the knowledge gained) and the process (e.g., how the needs of the curriculum are identified and the ways the curriculum is developed) become clearer.

As an analogy, think of the evolution of the mobile telephone, as illustrated in Figure 4. The needs of the users and the technological infrastructure within which mobile telephony occurs have changed radically over the past decades; some of the changes led by user input, some by gains in technology. One is extremely unlikely to see a person today walking down the street using the 1980s-style 'phone in a bag', however the basic functionality remains in current generation of smartphones. It is equally important to note that there are features in older generation models, such as the legendary indestructibility of Nokia 3310 [17], that enough users are pining for that the company is rumored to be relaunching it two decades later [18].

Figure 4. Evolution of the Mobile Phone [19]

Compare the mobile telephone, then, to the evolution of how curriculum is implemented. While discipline-based education research strives to understand both how students learn and how learning interacts with the processes and technology available, all too often faculty use the age-old pedagogical technique of "I teach the way my professors taught me" [20]. As we can learn from both evidence-based practices and the nostalgia for the Nokia 3310, just because a pedagogical tool is no longer the newest or shiniest option available, it still has features we can use and learn from. We are creating value when we put together our curriculum in different credential forms and implement it using mechanisms to increase learning among our diverse student base. In other words, not only may the resulting solution have a commercial value, but the very tool that is developed to analyze the problem may have commercial value as well.

B. Impacts on Other Learning Practices

Classrooms designed specifically for active learning as well as the concept of the inverted class room have become tools in the advancement of the exploration of new learning environments and techniques in engineering education [e.g. 21, 22]. Students in today's classes have by and large grown up within the internet of things. If they need to learn how to build a shelf or bake a cake, they don't reach for a book, they head to the internet to sites like Wikipedia and YouTube. This an element in the recent up-spike in fake news seen across social media on one hand, and also is reflected in the increased demand for on-line and self-paced learning opportunities.

Faculty are (or soon will be) adapting curriculum to incorporate new pedagogical methodologies to address these change in their student base. Since, at most institutions, the faculty are the owners of the curriculum, innovations in pedagogy and delivery styles belong to the faculty innovators. These innovations have a value of themselves and have potential for commercialization. This is very clear where institutions have chosen to hire consultants to convert

traditional curricula to new delivery methods and the contracts used to employ them are built on the work for hire model where it is clear that the University owns the eventual work product. As this trend continues, it will reach a point where more of the curriculum at use in a specific program belongs to the University and not the professors teaching the classes. It is not difficult to imagine an AI (Artificial Intelligence) being incorporated into the delivery of the University-owned curriculum eliminating the need for live instructors, altogether.

Similarly, the National Science Foundation's I-Corps-L (Innovation Corps for Learning) Program [23] explicitly works to help faculty commercialize their tested innovative pedagogical techniques. The NSF's value creation-focused program has several key differences in comparison to the university work for hire approach, including: keeping the faculty innovator in the center of the commercialization process, leveraging the strength of the NSF's peer review process to select pedagogical innovations to scale, and the goal of increasing the use of selected innovations across campuses.

C. *Impacts on Interdisciplinary Activities*

Klein's classic definition of interdisciplinary, "a means of solving problems and answering questions that cannot be satisfactorily addressed using single methods or approaches" [24], is the inescapably reality of most modern CSET challenges. Again using our lens of value creation involving both the product *and* the process by which innovation happens, we see opportunities for both students and faculty.

Industry has made it clear that a key characteristic of successful CSET professionals is the ability to work on interdisciplinary teams [e.g. 25, 26]. All too often, however, the word "interdisciplinary" is used when students from two different engineering disciplines work together on a team or when non-CSET majors are brought into a team for a specific task but are treated more like consultants than team members. Further, Lattuca et al found that "Despite the emphasis on team projects in engineering courses, such as first-year and capstone design courses, none of the instructional strategies we studied significantly related to interdisciplinary skills once other variables were taken into account" [27]. On the faculty side, interdisciplinary teams are key to solving, and acquiring the funding for, many of today's research problems [28] as well as an increasing trend in higher education teaching [29].

Whether those working across disciplines are students or faculty, they are by nature confronted with varying founding axioms and mental models regarding the work in question and the value created by the work. Founding axioms are ways of thinking that from one system or discipline are obvious, but may be neither sensible nor obvious to someone from another system or discipline [30]. Mental models are one's personal perceptions which, hopefully, are reflectively considered along with others' mental models in order to reconcile to a coherent understanding [31]. This becomes even more complex when we factor in the other stakeholders, including our administrative counterparts, who have their own reward systems, founding axioms, evaluation mechanisms, and more [30]. The framework of value creation can be used as a touchstone to create a shared understanding and shared language across disciplines, individuals, and value systems.

IV. Conclusions and New Definition of Value Creation for Universities, Faculty, and Students

Intellectual property, particularly IP which can be patented, is the most discussed and most legislated form of value created within university communities. It is, however, only the tip of the value creation iceberg. If all a university or faculty member is doing in terms of adding to the nation's economic development is paying attention to patentable inventions, the bigger opportunity has been missed. Rather, our economic development scorecard must include the impact of and on students as well as the processes we innovate for teaching and learning. **We define university-based value creation**, then, **as assessing and commercializing anything created within academe**. This may include: curricula, pedagogical innovations, novel approaches/solutions to problems, the app you develop to track your data, the data itself, the methodology used to produce a change or innovation, and much more.

This definition of university-based value creation is vague, but necessarily so. As the economy continues to shift and the 'business model' of learning follows suit, we must continue both to innovate and to define for society why our methods and credentials create a result worth the time and expense. The examples in this paper are designed to help CSET faculty position their pedagogical work within the lens of value creation as part of the larger conversation regarding the future of CSET higher education and the value of a college degree.

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