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INNOVATION AND INTELLECTUAL PROPERTY IN THE CURRICULUM: EPISTEMOLOGY, PEDAGOGY, AND POLITICS

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This article lays the foundation for a special issue of the journal of the National Academy of Inventors, *Technology and Innovation.* The topic of the issue is innovation and intellectual property in the curriculum and its epistemology, pedagogy, and adaptation challenges/opportunities across the academy.

INTRODUCTION

According to the National Academy of Inventors (NAI) website, "The NAI was founded in 2010 to…. **educate** and **mentor** innovative students, and translate the inventions of its members to benefit society" (1). Implicit in this mission is the responsibility of teaching students about invention, intellectual property, and commercialization thereof. This special issue of *Technology and Innovation (T&I)* provides insight into how a host of scholars practicing, researching, and teaching in the fields of innovation and invention have created specific courses and curricula to realize, in part, the aforementioned mission of the NAI.

BACKGROUND

The most recent issue of this journal addressed certain aspects of how academia is fostering educational experiences and pathways in the nascent academic domains of innovation and entrepreneurship (2). Educational contexts such as technology accelerators (3), novel master's degree curricula (4), and a focused Ph.D. innovation program (5) are described.

Beyond the academy, third parties composed of private actors are attempting to facilitate a broader understanding of intellectual property (IP) and how it impacts the lives of inventors and others (6). It is significant that these initiatives with genesis outside of the legal community do not seek to advocate for a particular kind of IP system. The various legal bar associations already do this in a manner that creates a fog of legal uncertainty that may complicate efficient commercialization (7). Such private action suggests a growing body of interest in raising the awareness of IP and commercialization in a balanced, unbiased manner. The NAI and academia in general should be good places to foster such objective awareness building.

One way to educate and mentor innovative students about IP is through formalized university curricula with commercialization and/or IP-related content. In Europe and Asia, such curricula have emerged either as courses centered on intellectual capital inside entrepreneurship programs (8,9) or as entire schools dedicated to the management of intellectual property (10).

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Note that in these newer schools of the academy, the curricular focus is not the law of intellectual property, a discipline with a distinct learning logic and traditions (i.e., study of the statutes and case law). Rather, these newer schools focus on the management or commercialization of intangible assets such as intellectual property. The establishment and recent growth of such programs are proxies for the emergent significance of these assets in global economic competition.

The logical foundations or epistemology of a subject is the product of research and educational traditions that survive the vagaries of time. Once the epistemology of a subject is established, the appropriate teaching methods and/or pedagogy can be advanced to multiple audiences and/or institutions.

Politically, new coursework with a solid epistemology and adaptable, teacher-friendly pedagogy is better prepared for institutional curriculum committees and hence is more likely to be adopted. Accessibility of such content is important because many university faculty members are not inventors. They have limited understanding of intellectual property. Further, they have little experience with commercialization and, therefore, tend to shy away from teaching it.

With commensurate curricular content accessible to all via this journal issue and other outlets (11), the NAI can indeed contribute meaningfully to all aspirations of its mission. Further, with improved understanding of IP and its role in competitive markets, the culture of the academy can be more self-supporting and responsive to the needs of society (12).

It is, therefore, the objective of this special issue of *Technology and Innovation* to investigate and illuminate the existing successful elements of innovation and IP-related coursework. Further, this issue will explore how such coursework has found its way into the engineering, management/business, and design curricula at multiple universities across the globe.

WHY THIS TOPIC NOW?

For the past 20 years, social scientists have been heralding the tectonic shift in the basis of market valuation of publicly traded firms (13). Accountants report that the valuation of tech-heavy firms traded on public exchanges has shifted during the period 1980 to 2005 from a mostly tangible asset basis (property, plant, equipment, inventory, cash) to a mostly intangible asset basis (expectation of future returns based on innovations) (13-15). By some measures, the value of contemporary technology firms such as Facebook, Google, Alibaba, Amazon, Microsoft, and others is over 80% intangible.

While this trend is most conspicuous amongst technology firms, similar shifts have been noted in other industries.

A significant component of intangible value generated by investments in basic research and development (R&D), software, and human capital can be secured as intellectual property rights (IPR) (14). Separate from the inherent private exclusionary characteristics, this form of property can be used to motivate knowledge dissemination through publication of research results in journals and elsewhere, disclosure of inventions, and pledges of patents in the public interest (16,17).

Such market actions by inventors and other agents of innovation play a role in commercialization of useful knowledge. Studying the logic of IP-related market actions helps inventors and other innovators imagine what is commercially possible and potentially viable.

With market value of publicly traded firms now dominated by intangibles and the growing activity in the pursuit of intellectual property rights, it is time to advance curricular content that helps students translate their inventions to benefit society.

TECHNOLOGY INDUSTRY MANAGEMENT

In the lead paper, "The Emergence of Technology and Innovation Management," Klaus Brockoff, professor and former dean of the WHU in Germany, reviews the full 300+ year history of technology and innovation management (TIM) as an academic and professional discipline (18).

The author carefully traces the intellectual foundations that have become part of the logic of TIM to the year 1675 when scholars identified how entrepreneurs may choose to start a new business. One choice includes differentiation based on an invention. The subsequent related scholarship includes narratives on how to use limited resources (either public of

private) together with the suggestion that innovations can drive economic growth and improve the overall human condition. The rise of formal R&D organizations within firms such as Siemens and General Electric that included patent departments indicates how TIM gave birth to the professional and academic interest in IP as an asset that should be proactively managed.

The idea of productivity gains coming from inventive activities significantly influenced the economic and business models of the third quarter of the 20th century. Further, imitation (where it is possible) is recognized as a strategic alternative to innovation. More recently, the full spectrum of IPR has been recognized by scholars as a strategic resource for managers (19).

Beyond connecting and explicating these knowledge foundations, Brockhoff points to the recent rise of TIM research funding, TIM-specific professorial appointments in the U.S. and Europe, and the growth of related Ph.D. programs, novel primary research methods, and related publishing activity in new journals and other outlets. Practitioner-focused TIM organizations in Europe and the U.S. were established about the same time. All such activities are proxies for market significance of this knowledge domain.

The ease of access to IP data as an input to TIM analysis and the growing significance of intangibles as a basis of market valuation motivated interest in the emergent discipline of IP management. The literature recognizes that it is important to link IPRs in a strategic sense to multiple fields of management (20). This makes the discipline an interdisciplinary social science. Note that the knowledge foundations and empirical methods of social scientists are different than those of physical scientists, hence the occasional tension between those who create and/or invent and those who are responsible for capitalizing on same.

By connecting the knowledge foundations of technology industry management to the growing value and awareness of intangibles and IP, Brockhoff characterizes a rich epistemology upon which to build a pedagogy and curriculum around the strategic resource that is IP.

INTELLECTUAL PROPERTY AS A MANAGEMENT DISCIPLINE

In the second paper of this issue, Holger Ernst carries the TIM explications of Brockhoff forward and describes the empirical foundations and market contexts where intellectual property has emerged as a distinct management discipline (21).

Ernst starts by briefly describing the literature that explores the market circumstances where intellectual properties (patents) are an effective instrument to secure the appropriability of new technical knowledge. He then touches on the research devoted to the role that patents play in fostering growth and economic prosperity in industries and or countries.

The aforementioned longitudinal shift in the basis of publicly traded market valuation from tangible to intangible assets is shown to correspond with increases in IP registration activities. The growing efforts to realize appropriation with these intangibles via, for example, enforcement litigation, licensing, IP asset sales, cross-licensing, securitization, freedom to operate, patent pledges, patent pooling, and investor relations has focused management attention on said assets.

The research foundation and organizational logic for the IP function within the firm is reviewed. The internal and external role of technology acquisition and use is characterized. The growing awareness of key inventors and related managerial implications are expressed. Finally, the historical change in the IP function within the firm is characterized in terms of strategy, key performance indicators, accountability, top management exposure, governance focus, orientation, organizational embeddedness, skills, methods/tools, and integration of multiple IP regimes.

Through Ernst's careful articulation of the literature and exploration of professional practice, one can appreciate the significant dimensions of the emergent IP management knowledge foundation.

INTRODUCING BROAD SKILLS IN HIGHER ENGINEERING EDUCATION USING PATENTS

Whenever a school of the academy chooses to overhaul its curriculum, there is an opportunity to develop, introduce, and nurture novel course content and teaching techniques.

In the third paper of this issue, Bekkers and Bombaerts (22) describe the development, pedagogy, and longitudinal evaluation of a novel patents and standards course sequence introduced at Eindhoven University of Technology (TU/e) during a period of large scale curricular transformation. Courses that included social science concepts such as firm strategy, user adoption, ethics, and other matters were viewed to be desirable elements of the new curriculum.

The authors trace the history of the Patents and Standards three-course sequence created, in part, to better prepare graduates to reflect on the user, society, and the enterprise (USE) during their careers. The consecutive, 11-week units address exploration, specialization, and application of patents and standards in context.

A breadth of novel pedagogical tools are used in the course, such as active classroom response (clickers), blended learning, novel guest lectures, progressive feedback assignments, role-playing games, enhanced collaboration with technical academics or patent attorneys, and reflective essays on the ethics and morals or IPRs in a given industry, e.g., pharmaceuticals.

Longitudinal data testing of student satisfaction, learning, and workload compiled and analyzed over the period 2013 to 2015 is presented and evaluated by the authors. Of all the new USE course content introduced to the TU/e curriculum during this time, the patent and standards course received the highest student satisfaction evaluation. The authors use the longitudinal data to test the assumptions inherent in their original course design to continuously improve the learning experience.

Of all the papers in this issue, Bekkers and Bombaerts present the most comprehensive explanation of how, what, when, where, and why to introduce IP-related content into an already crowded engineering curriculum.

THE UNITED STATES PATENT SYSTEM AND ENGINEERING EDUCATION

Extending the scholarship of their seminal work (23) and that of others (24-26), Garris and Garris expand the discussion of IP content in the curriculum to the senior design course context at the George Washington University (27).

After tracing the significant history of the U.S. patent system from its European roots through Jefferson, Lincoln, Edison, and beyond, the authors explore five propositions for why the patent system and its implications should be part of the pedagogy of all engineering educations. These propositions are as follows: Optimal design is an integrative process, the ethics of design in competitive industry are intricate, innovation in a litigious environment can be dangerous, patent rights are valuable assets, and the patent processes reflect the history of technology. In the discussion of each proposition, the authors use case studies to illustrate the market significance of decisions that reside within the engineering domain. To help with adoption, they suggest that each patent document (and its associated file history) serve as a prepackaged teaching case study. Hence, the available case studies across all engineering domains are plentiful.

These propositions and the associated logic can be used to traverse the politically challenging environment of the curriculum committee staffed in part by those with little experience or interest in commercialization matters.

The paper concludes with an explanation for how patents and their market implications are integrated into a 3-credit hour, senior design course in the mechanical engineering curriculum at their institution. The pedagogy for the course, format, team integration, project flow, and deliverables are characterized. The project-based format allows students to encounter ethical and other market entry challenges whereby existing patents are part of the calculus of the solution. For example, students are required to both design around a patented solution and, conversely, are required to imagine how others might design around their solution and then use the insights to inform the drafting of the patent specification. Teams work separately and secretly to enhance the competition of the course learning environment.

The 15+ years of aggregate learning that the authors have teaching this course facilitates rich discussions of a host of team dynamics and commercialization challenges and outcomes.

A COURSE ON INTELLECTUAL PROPERTY AND BUSINESS STRATEGY

Enriching this special issue, legal scholar David Orozco recounts his involvement designing, modifying, and teaching several courses at the nexus of intellectual property and business strategy (28). His narrative addresses the specifics of preparing and delivering such content for a variety of student audiences (engineering, law, management) at three different major research institutions: Northwestern University, Michigan Technological University, and Florida State University.

The consistent organizing logic used within the various course offerings is the desire to help students make connections across otherwise disparate knowledge domains (property, engineering, management/strategy). The details of the various courses, audiences, evolutions, formats, key learning objectives, and enrollments are described.

A consistent challenge for young scholars in the academy is the design and development of unique teaching content that complements and/or deepens their own scholarly research. The narrative in this paper is a window on how IP-related content gradually became integrated into the elective course offerings of a young academic during the formative stages of his career.

TRANSFORMATIVE BUSINESS STUDIES – TECHNOLOGY TRANSFER IN THE SOCIAL SCIENCES

In the final paper of this special issue (29), Magnus Gustafsson of the Åbo Akademi University in Finland extends the idea of intellectual property and technology management for the natural sciences to the broader context of knowledge transfer for the humanities and social sciences.

Introducing the concept of transformative business studies, he characterizes a research methodology that includes design science, participative action research, and actor-network theory. This kind of inquiry is conducted by both academics and professional consultants. Their interaction is motivated by the need to assure that the results are indeed transferable to commercialization agents beyond the academy.

The sufficient involvement of practitioners or consultants is necessary because the problems are complex and ill-defined. Often there exists a need for change, but few inside the firms know how to catalyze the change. Finally, organizational inertia and institutionalization are difficult to overcome by academic research results alone.

The organizational design for transformative business studies anticipates and attempts to avoid inherent disconnects between academic research and professional practice by offering a defined and clear interface.

The methodology is exercised in the context of Finnish efforts to increase the use of biogas in transportation. Significant actors in this ecosystem include truck operators, truck dealers, and integrators. Orchestrating and incenting these actors to think and behave in a different way leads to actionable knowledge, not just academically interesting knowledge. The outcome of the methodology is a continually evolving knowledge base amongst market actors that helps to define and redefine the biogas for transportation ecosystem going forward. The methodology is also being used to address challenges/opportunities in unmanned shipping, flexible power generation, and short haul shipping.

REGULAR FEATURES

This issue's USPTO commentary focuses on its 4th Annual National Summer Teacher Institute on Innovation, STEM, and Intellectual Property, where over 50 teachers learned about the intersection of innovation, technology, and entrepreneurship. The NAI Fellow Profile features Dr. Esther Takeuchi, who offers penetrating insights on the critical challenges we face in energy consumption, discusses what makes a great innovator, and shares what it means to have been responsible for saving millions of lives as a result of her research work. This issue's Innovation in Action highlights exciting technologies from Texas Tech University.

SUMMARY

This special issue of *T&I* was conceived to advance the university curricular offerings that can support the NAI's mission to "educate and mentor innovative students, and translate the inventions of its members to benefit society." The commercial logic and leveraging of intellectual property is one way to bring about knowledge transfer that benefits society.

The articles in this issue trace the epistemology of the technology and innovation management academic domain that has given birth to the intellectual property management academic and professional disciplines. The epistemologies of these fields are explored and interrogated to lay the ground work for the explication of specific engineering, management, and legal course offerings taught at leading academic institutions, such as TU Eindhoven and the WHU in Europe and George Washington, Florida State, Michigan Tech, and Northwestern Universities in the U.S.

Beyond the explicit epistemologies and pedagogies reviewed, insights for how IP-related course content has been packaged to successfully navigate and/or survive the curriculum review processes of universities are presented.

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