The Process and Curriculum of Technology Transfer

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What Is Technology Transfer?

Technology transfer is a process in which knowledge, cost, risk, and benefit are shared among various economic entities in modern human society (Song, 1998). These economic entities include the inventors who are the creators and intellectual owners of the intellectual properties that comprise the actual inventions; the legal owners of the inventions who can be the inventors and, sometimes, the inventors' employers and/or the assignees; the manufacturers and the commercial distributors (who are sometimes the inventors themselves), who convert the invention into a tangible commodity; and, finally, the users of the inventions including governments and private entities as well as individual consumers of the general public (Song, 1998).

Why Technology Transfer?

We continue to live in an era where knowledge is created, updated, and shared commercially as any other commodity. In fact, knowledge is deemed as a great source of business power, and the "management of knowledge" is of serious concern to leaders in industry today (Greco, 1999). From both an American and global perspective, the transfer of knowledge, most commonly the new findings and discoveries associated with rapidly changing technologies, has assumed greater importance than ever before (Anonymous, 1998; Walumbwa, 1999). The need for technology transfer as a professional practice as well as an academic discipline for faculty and students in technology studies can be examined in terms of (a) professional obligations and (b) legal mandate and socioeconomic significance. This may, in turn, create a new paradigm shift in evaluating faculty and student scholarship.

Professional Obligations

Technology faculty and students majoring in technology are key human resources in carrying out the mission of a university, that is, to transmit (via teaching and learning), create (via research), and apply (via public service) knowledge. The transmission, creation, and application of knowledge are interrelated, and many institutions would even prefer a synergistic relationship where the whole becomes greater than the sum of the individual parts. The increasing emphasis on research sometimes raises the issue of added responsibility for universities in terms of serving the community by communicating the results of their research efforts expediently, particularly those findings that could positively impact the lives of people.

The following examples of 1998 and 1999 award-winning research in the nation's prestigious annual Collegiate Inventors Competition (1999; also earlier known as the B.F. Goodrich Awards Competition) shed some light on potential societal and economic implications of university research:

- Amtek Phase-Change Incubator for Use in Areas Without Electricity
- Twistmaster, a Jar-Opening Device for People with Disabilities
- Pendeo-Epitaxial Growth of III-Nitrides for Use in Microelectronic Devices
- Luminescent Quantum Dots for Ultra-Sensitive Biological Detection
- Planing Hull Catamaran Designed to Plane on the Water Rather Than Displacing It
- A New Dynamic Random Access Memory (DRAM) Cell
- Phosphouminoglycosides: Potentially Curative Strategies of Chemotherapy for End-Stage or Hormonally-Refractive Cancer
- Jeep Rear Suspension
- Method and Apparatus for Selectivity Inhibiting Activity in Nerve Fibers

Although the inventions profiled in the Collegiate Inventors Competition represent only a small sampling of research at our universities, the national stature of the award reflects both the range of academic disciplines and the magnitude of their potential social and economic impact.

The Legal Mandate and Socioeconomic Significance

Technology transfer has become more relevant to university faculties and students since 1980 when the Bayh-Dole Act (P. L. 96-517; subsequently amended in P. L. 98-620), passed by Congress in 1980, established a uniform federal patent policy that encourages universities to retain title to inventions even though they are developed through governmental funding. The Bayh-Dole Act is the single most significant stimulant to university technology transfer activities. Historically, about 60% of all university research funding comes from government sources (Thayer, 1992). The universities are mandated to file patents on inventions they elect to own, while the government retains march-in-rights and a nonexclusive license to practice the invention throughout the world. More information on the Bayh-Dole Act and subsequent legislation may be accessed via the Internet from http://web.mit.edu/osp/WNW/cogr/cogr.html (The Council on Governmental Relations, 1993) and http://www.ucop.edu/ott/tech.html (Office of Technology Transfer, 1998).

Most recent statistics indicate that more than 7,000 invention disclosures per year are being filed by individual faculty members at U.S. universities, resulting in more than 5,000 patent applications per year by the universities. Subsequently, more than 2,000 licenses and/or options per year are executed, yielding an annual royalty income of approximately $300 million for the inventors and their universities nationwide (Song, 1998). The financial implications of new discoveries and inventions continue to be a major force in promoting continuous expansion of the research function at U.S. universities and, for that matter, universities worldwide (Anonymous, 1999; Bell & Sadlak, 1992; Blumenstyk, 1998; Kenward, 1986; Sales, 1997; Waugaman, 1990).

Technology transfer and commercialization, facilitated by the Bayh-Dole Act, have positively impacted the lives of the general public in several ways. New drugs, medical treatments, building materials, consumer products, diagnostic devices, and innovative application software are just a few of the products that started as ideas in university research laboratories and now touch our lives daily (Northwestern University Infrastructure Technology Institute, 1998).

The success of the Bayh-Dole legislation is reflected in the number of patents awarded to universities annually before and after the bill was passed. A decade after the bill was passed, about 1,600 patents were issued annually to university inventions as opposed to only about 250 prior to the legislation (Office of Technology Transfer, 1998). In 1996 alone, 248 start-up companies were formed because of new technologies transferred from university inventions (Song, 1998). The wealth-generating potential for faculty research is one of several important reasons why most universities nationwide have established their own offices of technology transfer (OTT) to handle faculty and student inventions.

Faculty and Student Innovation and Creativity: Need for a Paradigm Shift

With rapid advances in technology, particularly with the proliferation of computer-based applications, scholarly and creative work can emerge in a format that is not universally perceived as being conventional. A number of higher education institutions continue to have a restrictive definition of scholarly work, often limited to journal publications, books, and selected conference proceedings and presentations. The current generation of faculty and students have the resources and opportunity to bring forth their creativity and innovation in the form of other copyrighted materials including computer programs and computer-based instructional materials on CD-ROMs and the Internet as well as patents, trade-marked laboratory materials, and technical processes deemed as trade secrets. For a long time, the American public has acknowledged inventors' rights to benefit from their creativity as society continues to benefit from their new discoveries (Fleming, 1991). University faculty and student inventors are no exception.

Technology Transfer Process for Faculty and Student Inventors

Faculty members and students in technology studies are most likely involved in the technology transfer process as either the inventors or Intellectual Property (IP) consultants. Figure 1 is a flowchart that includes three major actions (A1, A2, and A3) and seven decisions/determinations in a typical technology transfer process involving university faculty and students, where D1 is a legal and ethical decision by the inventor based on the inventor's employment conditions; D2 is a personal decision by the inventor based on the inventor's knowledge of, interest, and confidence in pursuing the technology transfer process as the intellectual property owner; D3 is a research, technological, and business decision by the inventor's based on the nature of the invention itself and its potential market

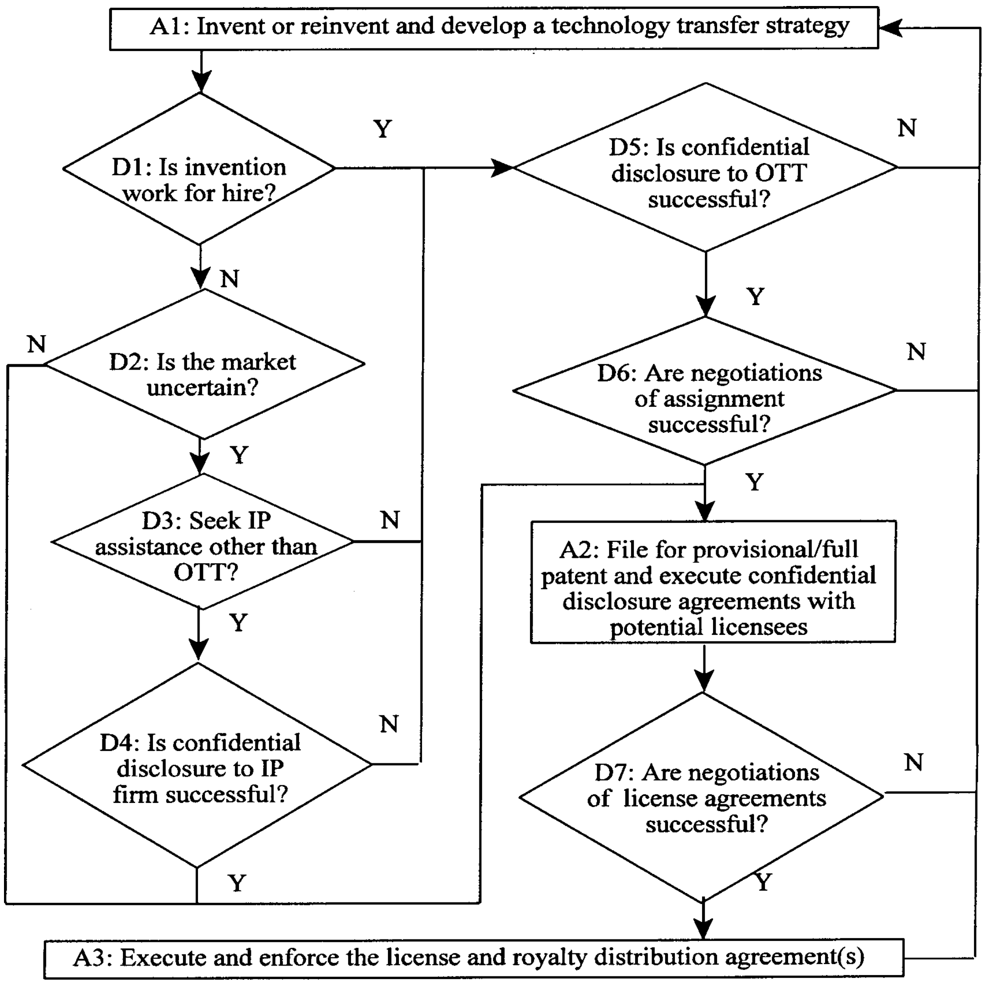

Figure 1. Technology transfer process for faculty and students in technology studies.

analysis; D4 and D5 are determinations of the matching of interest, resources, and perceptions between the inventor and potential assignees of the invention; D6 is a determination of an appropriate match between the inventor and the potential assignees in terms of their interest, resources, and perceptions of the invention itself and its potential market; and D7 is the determination of a match between the owner of the invention (either the inventor or the assignee at this point) and the potential licensee in terms of interest, resources, and perceptions of the invention itself and its potential market, as well as production and marketing costs, market uncertainty, and royalty rates, all being a function of time within the life of the technology.

Intellectual Property Rights and Infringement Issues

The intellectual property rights and infringement issues in the case of a patent are thorny in technology transfer processes. Generally, the inventor owns the intellectual property residing in his or her invention unless the invention is part of the work for hire. If an employer contracted the work, he or she is the owner of the intellectual property or the patent for the invention. In all the cases, the inventor's name will be listed as the inventor in a patent certificate, on which the ownership will also be specified. An infringement of the patent occurs when a patented technology is used for commercial purposes without the authorization of the patent owner.

Patent infringement cases can be normally settled in or out of a federal court. Remedies are determined by the estimate of the actual monetary loss to the patent owner due to the infringement. The principles of microeconomics and market research data are often considered in the determination. Considering that an invention is patentable in the United States only if it is novel, nonobvious, and useful, a patent infringement case always involves the question about whether the patent is valid in the first place. The risk and costs involved to a patent owner in a patent infringement case are often considerations that lead to a settlement outside the court. Interested readers may visit http://www.ceet.niu.edu/faculty/song/tco for more information and references on the thorny issue of intellectual property rights and infringements.

Need for a Technology Transfer Curriculum

Aristotle (384-322 BC), the Greek writer and philosopher, once said that an exclusive sign of thorough knowledge is the power of teaching. Successful technology transfer practice draws upon the knowledge and skills from a variety of disciplines including but not limited to technology, business, law, and liberal arts and sciences. Technology transfer is implicitly interdisciplinary, lying on the border of many traditionally divided academic territories. It is not surprising that very few universities offer a course exclusively devoted to technology transfer. As business-oriented technical professionals, industrial technology educators are among the most qualified professionals capable of teaching courses that exclusively address the essentials of technology transfer. At the same time, current market trends also suggest that our graduate students should possess adequate skills to work in today's virtual and real "global villages" where technology transfer is ubiquitous. Therefore, a course in technology transfer as a core requirement appears to be a timely addition in all graduate degree programs in technical studies and allied areas.

Previous research has called for an expansion of the content base even among those few schools that currently do offer a course in technology transfer or closely related area (Johnson, Gatz, & Hicks, 1997). A significant number of graduate (master's and doctorate level) programs exist in industrial technology, industrial education, technology education, and related fields; yet, very few programs offer a course in technology transfer, particularly with an emphasis on universities as the "creators and exporters of technology." The issues of technology transfer are of high relevance even among community colleges across the nation (Bragg et.al., 1991; Spaid & Parsons, 1993; Sugarman, 1992). The proposed university course could be tailored to meet the needs of faculty and administrators at community and other junior-level colleges. Because programs leading to terminal degrees in technical studies often include preparation of future community college educators as a major goal, we have here another good reason to offer a course in technology transfer.

A Feasible Technology Transfer Curriculum and Its Clientele

The diverse range of topics embraced by technology transfer makes it a rather complex subject matter for undergraduate instruction. Therefore, it should be taught only as part of the graduate curriculum. A one semester class that meets for three hours every week should provide a reasonable platform for educating technology studies majors in the essentials of modern-day technology transfer. The unique aspect of our course proposal is the emphasis on topics that are likely to help students during their academic as well as lifelong careers. Our course consists of three modules that may also be treated as three stand-alone courses, each worth one semester hour of credit. These modules should be taught in sequence for maximum effectiveness. It should be recognized that one-credit courses (nicknamed "sprint courses") can often find their way into a curriculum and be implemented with more ease than a typical three-credit course (Bardes, 1996). The modules are (a) General Concepts, Practice, and Procedures of Technology Transfer; (b) Engineering Economy and Market Research in Technology Transfer; and (c) Case Studies of University Faculty and Student Inventions.

Module 1—General Concepts, Practice, and Procedures of Technology Transfer will develop a historical backdrop focusing on the economic and social impact of technology development and transfer in the United States. The overview will include an introduction to federal, state, and local development strategies and initiatives, and will discuss issues involved in policy development and benchmarking. Concepts and procedures for assessing/

identifying originality, utility, nonobviousness, and the level of "proof of concept/reduction to practice" required for patenting and prototyping of inventions will be covered. Information presented in Module 1 will be organized to provide both a historical perspective of the innovation/transfer process and a contextual framework and continuity for the information presented within the other modules. Internet tools for patent searches along with the fundamental concepts and procedures of intellectual property protection will also be presented.

Module 2 —Engineering Economy and Market Research in Technology Transfer will introduce strategies for invention market research via a computerized database and market survey procedures, computerized statistical and cash-flow modeling of inventions, decision making (involving risks and uncertainties), decision-making trees, and contemporary strategic planning/decision-making tools to be used in the technology transfer process.

Module 3—Case Studies of University Faculty and Student Inventions will include cases of student inventions in recent American history involving all areas of science, engineering, and technology. Each case will be revealed in terms of the inventors' personal and academic background, the fundamental science, engineering, and technology principles involved, and the existing and/or potential scientific, economic, and humanistic impacts. The socioeconomic relevancy of undergraduate science, engineering, and technology courses will be discussed, and the student inventors will serve as role models for all undergraduate science, engineering, and technology students nationwide. The case studies should be developed via a systematic literature review and news screening of the past decade, complemented by a fresh survey of U.S. universities currently published by the Association of University Technology Managers.

Curriculum Clientele

The audience for this course should be graduate students or senior undergraduate students having outstanding credentials. Majors from several disciplines including general sciences, engineering, technology, and even liberal arts, fine arts, and social sciences will learn something valuable from the proposed course. A patent may be obtained on an idea that has its roots in almost any subject ranging from algebra to zoology. A quick navigation to the IBM Patent Databank will reveal the fact that a large percentage of the U.S. patents issued in the past 20 years consist of inventions in the field of humanities and arts (IBM, n.d.). Innovative and practical ideas stretch across traditional disciplinary boundaries and, accordingly, the topics included in the proposed technology transfer course should be of interest to diverse groups across college campuses.

The proposed technology transfer curriculum will stimulate the appreciation, understanding, and enthusiasm of undergraduate students from various disciplines for technology innovation, development, and transfer process, and also show how they can become personally involved. The singular feature of academic diversity of the technology transfer course should attract significant attention and enrollment to the field of technology studies, a field which is interdisciplinary by nature and still deserving of its own unique academic and professional niche.

Implications and Questions to Technology Studies as a Discipline

Georg Hegel (1770-1831), a German philosopher, once observed that just as we do not need to be shoemakers to know if our shoes fit, it is not necessary for us to be a professional in order to acquire knowledge in matters of universal interest. A case may be established that knowledge of technology transfer is a matter of universal interest. This article along with the curriculum it proposes to faculty and students in technology studies aims at improving the preparation of future technology educators and practitioners by offering an opportunity to understand effective strategies to transfer ideas. Since no single academic group has, so far, made large-scale claims on its exclusive rights to "technology transfer," this is an opportunity waiting to be exploited by faculty affiliated with technology studies. There is no telling how long this opportunity could last. If faculty members and students in technology studies become more active players in technology transfer as inventors, intellectual property managers, and technology transfer educators, wouldn't the status of technology studies as a discipline be elevated to the next higher level? William Gull once remarked that the road to medical knowledge is through the pathological museum, and not through an apothecary's shop (Wilkins, 1991). Perhaps the road to technical knowledge is through the patent database, and not through a school laboratory. This may be especially true to the future scholarship of faculty and students in technology studies.

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