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Applied and Use-Inspired Research in the College of Technology: A Rationale for Defining a Research Domain

Introduction

The College of Technology at Purdue University is in some respects in a unique position in that it offers very large diverse programs of study at both the undergraduate and graduate levels. Purdue University is a research-intensive university that is nationally recognized in Engineering, Technology, and the Sciences. In the last few years research funding at Purdue has increased at a high rate due to the efforts of our present and immediate past presidents of the university and our faculty who have embraced the strategic plans which guides the research growth. The College of Technology is expected to engage in funded research and contribute to the overall growth of funded research at Purdue University. The College of Technology has seized this opportunity to grow research and increase the enrollment of graduate students and graduate curricula. In doing so it has become necessary to clearly define our research domain to differentiate and identify overlaps with existing engineering and science research domains. This paper provides an intellectual and philosophical basis for defining a research domain for technology and engineering technology and states a position on the role of research in engineering technology.

Historical Context of Research

To understand the roles and goals of research in the United States and its institutions of higher education, one would have to begin with the influences of ancient Greek culture. To broadly understand and appreciate the role of research it is recommended that the reader refer to Stokes[1]. Although Greek culture did not have an equivalent for science, they did develop scientific inquiry. They were able to regard the world as a natural system governed by general and discoverable natural causes and to leave the gods out. They believed that natural causes could be explained by rational inquiry.

The other major contribution to our modern view of research was the Greek's philosophic motive of severing "inquiry" from "use" which was strongly reinforced in Greek civilization by the consignment of the practical arts to people of lesser class and manual labor to slaves. As a result, practical utility was rejected as a legitimate end of natural philosophy and this became the core belief in the Platonic and Aristotelian systems of thought. Plato's ideal Republic radically separated those engaged in philosophic inquiry from those engaged in the manual arts by assigning a more exalted position to philosophic inquiry. This thought set in motion a tension that remains today between *pure* and *applied research* or research to gain *new knowledge* and research for practical *use*.

The views of the Greek philosophers towards scientific inquiry have been challenged throughout the ages. Challenges started most notably by the Hippocratic physicians of ancient Greece who sought knowledge to better practice medicine. Later, Francis Bacon's expressed the view that techniques were knowledge rather than fruits of knowledge. However, there have also been many more defenders of the linear approach to research who claim that applied or use-based research flows from basic research, including the most influential person in the United States regarding research during his time, Vannevar Bush. After the recognition by our nation's leaders for the important role that research played in World War II, Bush was commissioned by

President Roosevelt to submit a report recommending how research should be supported by the Federal government in peacetime. His subsequent report titled *Science, the Endless Frontier*, has as its first canon that basic research is performed without thought of practical ends.[2] Its second canon states that basic research is the pacemaker of technological improvement.[1] The final piece of the puzzle that led us to where we are today has its roots in the Grinter report released in the late 1950's that advocated a more science-based engineering curriculum which eventually led to the creation of engineering technology programs that retained much of the applied and lab-based approach to teaching engineering concepts and principles.[3]

Basic vs. Applied Research

Bush's views continued the tension between basic and applied research in our nation. However, you can find throughout history examples of applied or use inspired research that actually contributed to our basic understanding of nature. Louis Pasteur is a classic example of a noted scientist that wanted to understand fundamental laws of nature but he was inspired not through his desire to create new knowledge but to solve practical problems related to specific diseases. Pasteur's work is an example of the rise of a new scientific discipline, microbiology, in the late 19th century that was a new branch of inquiry created out the effort to cure diseases and not purely for the quest for fundamental knowledge or understanding. This is an example of *use-inspired basic research*.

Of course there is much pure research that is undertaken without regard for use or application. A classic example is the work of Niels Bohr's work in physics on the structure of the atom which can be classified as *pure basic research*. Research that is the furthest removed from pure basic research is the type that was undertaken by Thomas Edison. Most people are familiar with Edison's classic work on finding the best material to use as a filament for a light bulb. Edison had no desire to understand the science underlying his discovery during his quest to make a working light bulb. In fact it was left to other scientists to consider its more fundamental implications for the Edison Effect which eventually led to a Noble prize for Rosenberg and Thompson for discovering the electron. Edison's research can be categorized as *pure-applied research*. A great deal of modern research belongs in this category and is extremely sophisticated although narrowly targeted on "immediate" applied goals. The immediacy of the research is a distinguishing characteristic of the research that is of primary interest for technology and engineering technology programs.

Pasteur's Quadrant Model of Scientific Research

Stokes[1] advocates that from these three forms of research you can create a model to better understand and explain the goals and roles for various forms of research. Stokes calls his model Pasteur's Quadrant Model of Scientific Research. Figure 1. This model represents the 3 forms of research that are commonly undertaken and described above. The model is a good representation for the types of research but does not depict the interaction between the quadrants that actually occurs when one engages in research. This interaction is a very important concept to better understand the overlapping nature of research between and across disciplines and academic departments in higher education.

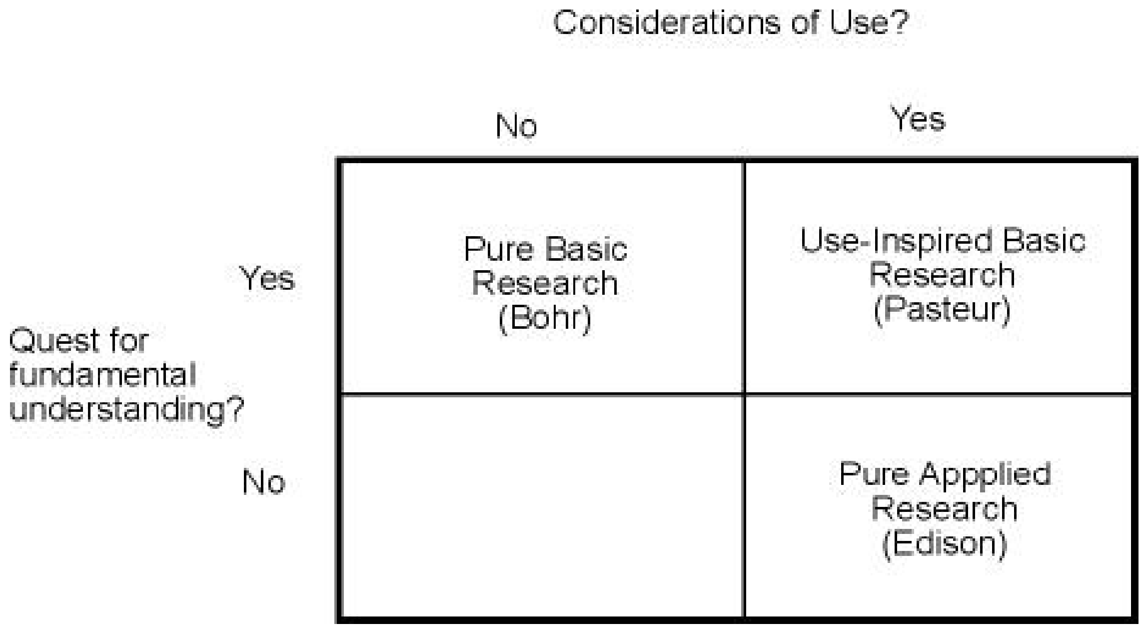

Figure 1 Quadrant Model of Scientific Research[1]

Pasteur's Quadrant Model of Scientific Research can be modified to represent the more dynamic nature of research and the interaction that can occur between pure basic research, use-inspired research, and pure applied research. Stokes[1] proposed such a model and it is represented in Figure 2. This model addressed the clear need to represent the dual, upward path as interactive but semiautonomous. Science often moves from existing to a higher level of understanding through pure research where technology has little influence. Technology often moves from an existing to an improved capacity by narrowly targeted research, or by engineering or design changes, or by simple tinkering at the bench, where science has little influence. However, each of the paths is at times generally influenced by the other, and this influence can move in either direction, with use-inspired basic research often serving as the connecting role.

A Revised Dynamic Model of Research

The dynamic nature of research is also referred to as *translational research*. The traditional boundaries among basic research and use-oriented research are yielding to a single, continuous, bidirectional spectrum commonly termed translational research. Translational research is the bridge from discovery to delivery and back indicating the interplay between basic and applied research.

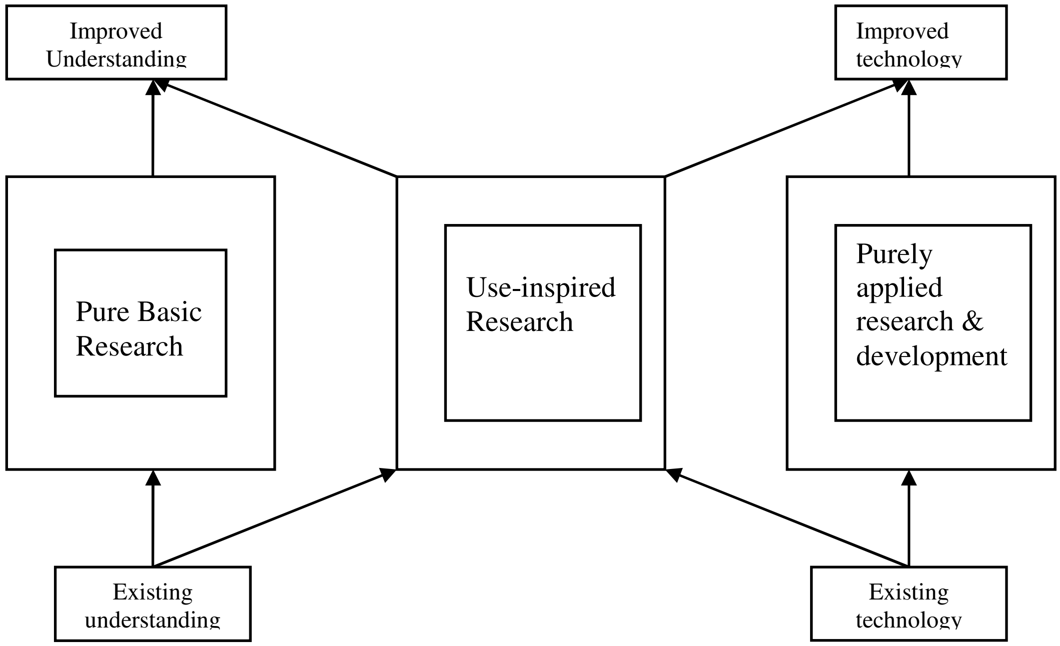

Figure 2 A Revised Dynamic Model of Scientific Research.[1]

The Role of Technology Disciplines in Research

So what roles in research should faculty and students pursue in colleges of technology and engineering technology? When looking at Pasteur's quadrant or the Revised Dynamic Model and with an understanding for the historical context and definition for each quadrant, it is clear that the faculty and students in technology should be focused on research that falls within use-inspired basic research (Pasteur) and pure applied research (Edison). This research is inspired for a *practical* end that aligns perfectly with *technology* as a discipline.

Faculty in technology engaged in discovery have many opportunities to engage in research which is *use*-inspired; that is with a specific end goal in mind that will solve problems or enhance existing techniques and processes. Faculty in technology engaged in discovery have many opportunities to engage in research that is purely *applied* in nature where the specific goal is to apply technology in novel ways to solve problems, extend existing technology, or create new technologies. Technology faculty have the knowledge and professional obligation to pursue use-inspired and pure applied research as leaders in their discipline. All this can be done in a scholarly manner and in many cases following the same rigor and publication standards one would employ when engaged in pure basic research.

Very rarely would technology faculty directly engage in pure basic research although technology faculty could have a very important supporting role, such as providing the underlying information technology infrastructure to collect and analyze data produced through an experiment or computer simulation or through improved instrumentation used to collect and analyze scientific data. Use-inspired basic research is undertaken to understand fundamental laws and principles but the inspiration of such research is not to create new knowledge but "to solve practical problems". This particular domain of our research is shared with many other disciplines, such as engineering and science, so you will find overlap at times but also opportunities for collaboration. Pure applied research is furthest removed from pure basic research and is characterized as being extremely sophisticated and narrowly focused on immediate results. Technology's role in research is primarily focused on pure applied research but there is some overlap with other disciplines including engineering and science, which also offers additional opportunities for collaboration.

Our strength in research is related to pure applied research projects in each of our technology domains in colleges of technology and engineering technology. There are opportunities for research in all traditional technology departments that is unique although related to disciplines and departments outside the colleges of technology. Our strength in pure applied research originates from the skills and talents of our faculty that are primarily rooted in our desire to engage in problem solving that will produce immediate results. In most cases we apply our skills and talents to solve immediate problems or enhance existing techniques and processes for business and industry. We also engage in the novel applications of new knowledge generated in other disciplines or emerging technologies to solve problems or to create new products, patents, and copyrights, create new business opportunities, or improve techniques and processes.

Harris[5] refers to technology's role in research as the scholarship of application. The scholarship of application bridges the gap between theory and practice. It is action-based research that involves problem identification and resolution. Many technology faculty are adept at this type of research which in many cases is funded by business and industry. Although some could view this as service, in technology this action-based or pure applied research is scholarship if pursued to that end through paper publications and presentations; dissemination and peer review. The "new knowledge" or discovery would be in the improved process, new patent or copyright, novel use of existing technology, or other technological advances. Discoveries related to pure applied research could result in innovation. In a few cases there could be new businesses created or new products, which is innovation. As research in technology matures and gains momentum, innovation will become a common output of the research. Since the national labs and universities produce most innovation in this nation[6], technology programs have the potential to become a leading source of innovation on university campuses.

Another research strength in colleges of technology and engineering technology relates to STEM education. Our programs have a long and rich history of being excellent teachers of technology and there are opportunities to extend that talent into research. Research into the development, evaluation, and implementation of the teaching of technology is a strength that we must further define and develop. This is not so much the science of learning, which is primarily the domain of education and psychology, but the application of the science of learning to teach and learn technology. We also have opportunities to engage in the novel application of information technology and cyberinfrastructure to teaching and learning that could be of benefit to all disciplines preK-18. Related to this is an opportunity to lead in research and development of best practices for professional and adult education for business and industry (workforce development).

A research strength that could emerge in the near future relates to technology and policy. As leaders of technology as a discipline there is an opportunity to engage our citizens and government in the development of sound policy decisions and informing the general public about existing and emerging technology.

Modern technology and engineering technology programs have their origin in many of the emerging technologies from the past 2 decades. Modern programs include departments or areas of study related to information technology, nanotechnology, biotechnology, product lifecycle management, and advanced manufacturing. These emerging areas in technology programs provide many opportunities for use- and pure applied research. Funding for the research can come from NSF, NIH and business and industry. Traditional engineering and science research is primarily funded from government foundations and government agencies. Technology programs will find funding through the same government foundations and agencies but a larger part of their research portfolio will come directly from business and industry. The nature of our research strengths and interest in pure applied research provides many opportunities to engage in research projects with business and industry.

A good example of a pure applied research project with industry conducted at Purdue University in the College of Technology can be found in Hudecki[7]. This paper described in detail a pure applied research project funded by a major aerospace company. The research project succeeded in automating a tedious engineering design problem for the design of jet engine turbine blades. The research resulted in a 99% time savings in the design of the turbine blade which reduced the design time from days to a few minutes. This research was funded by industry to solve an immediate problem with the solution put into use by the company resulting in significant time and cost savings. This is the type of research that technology and engineering technology faculty can engage in on a regular basis.

Summary

This paper outlines and defines the research domain for technology as use-inspired and pure applied research. This type of research is actively being conducted at Purdue and elsewhere in the nation. It is time for technology and engineering technology programs around the nation to engage in a serious discussion of our role in research. As a discipline we have much to contribute to our nation's economic vitality through our unique role as leaders in pure applied research. We have been dormant for too long in defining our role in research and in taking an active position in research. We must fully embrace our roles in academia and take our place as active and important contributors of research in higher education if we are to remain a relevant and vibrant discipline.

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