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REVIEW ARTICLE

THINKING ABOUT WAYS TO CLASSIFY INNOVATIONS IN TECHNOLOGY

***Harvey Hyman**

Florida Polytechnic University, 4700 Research Way, Lakeland, Florida 33805

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ABSTRACT

This paper reports on a small study designed to inform about how we might classify technological innovations by categorical groupings. We begin with a foundational discussion of the constructs of interest: technology, innovation, invention and entrepreneurship. We then theorize about how innovative efforts might be classified in terms of their impact on the technological user. A pilot study is conducted using 50 self-identified entrepreneurial technologists. The results of the study produced four emergent categories for classifying innovations: substitute, alternative, replacement and extension. We present the descriptions of the categories based on the responses from the study and close with a discussion on proof of concept and feasibility in the solution as described by the participants in their interviews.

INTRODUCTION

Ben Franklyn once said that "When you're finished changing, you're finished." Technology and change seem to go hand-in-hand. When we think of changes in technology, how do we recognize the impact on our way of doing things? How do we understand and assess the nature of innovation in technology?
In this paper, we present a discussion on the topics of *technology* and *innovation*. We begin with defining technology and innovation by their conceptual use and historical evolution. We then investigate technology and innovation through the constructs of invention and entrepreneurship, and conduct a small pilot study to determine how these constructs might fit into the conceptual understandings of technology and innovation in their modern usage. Lastly, we report on the findings of the study and present to short a discussion on the descriptive categories discovered.

Research Question

When we think about technology, we often refer to various techniques and elements of the scientific method and how it can be applied to solve problems. Sometimes we apply this task to the business environment, other times we use management tools and strategic concepts applied to design and development as a solution to a business problem. But, how should we think about the overarching landscape and theoretical concepts of technology and innovation? In this paper we explore the research question: How can we classify innovations in technology? We begin with the historical reference and operational definition for technology.

Corresponding author: Harvey Hyman
Florida Polytechnic University, 4700 Research Way, Lakeland, Florida 33805

Technology

The modern conventional definition for technology is "*the application of scientific knowledge for practical purposes."* An alternative definition is "*science or knowledge put into practical use to solve problems or invent useful tools*." Yet another definition for technology is "*the application of science, especially to industrial or commercial objectives."*(These descriptive definitions represent a consensus of definitions from a variety of open sources: Merriam-Webster, Wikipedia, Dictionary.com, Business Dictionary.com, Oxford Dictionaries.com)

The significant phraseology to note above is *application, knowledge, and science*. Notice how these definitions highlight the application of science or knowledge to business (industry, commercial). If we explore the etymology of the word technology, we see that it comes to us from the Greek words *techne* meaning *art or skill*, and *ology* meaning *learning or study of*. So in the literal sense, technology is the study of art or skill, or the learning of art or skill. In its contemporary usage, technology is associated with tools, machinery, automation, procedures and methods for humans to gain leverage or advantage in use or skill. Engineering is the discipline that primarily claims ownership over the study and

design of technology and its application. We often think of engineering as the design and build of physical things. However, in the modern application of technology, especially *information technology*, engineering is extended to additional domains such as software engineering, computer engineering, and system engineering. The study of the development and application of technology relates to the human ability to control and adapt to the natural environment around us. If we extend this definition to the *business environment*, technology can be operationally defined as a *tool, technique, or procedure designed to improve performance*, by efficiency or effectiveness, in the process to which it is applied.

Innovation

Stephen Hawking once said that "Intelligence is the ability to adapt to change." Some might link intelligence and the ability to change, to innovation.So what is innovation, how does it relate to technology, and how do both of these concepts fit into a framework? First let us define innovation. Innovation can be defined in several ways. It is one of those ambiguous concepts that, like tofu, tends to take on the flavor of whatever is applied. One view of innovation is "*the introduction of something new."* An alternative view is *"a new idea, method, or device*." Yet, another view of innovation is simply the one word description "*novelty*." (These descriptive definitions represent a consensus of definitions from a variety of open sources: Merriam-Webster, Wikipedia, Dictionary.com, Business Dictionary.com, Oxford Dictionaries.com)If we apply the paradigm of design to innovation, then we should view innovation applied to the business process in terms of its value added proposition – its ability to solve a business problem. In that light a working definition for innovation can be: "*translating an idea or invention into a good or service that creates value*."

In the context of design and a framework, we might view *innovation* as it relates to *technology* by its application and influence. If we view technology as the prime mover, the foundation of science and knowledge applied to a process with the goal of improving that process, then innovation might be described as the evolution of developing new forms of technology to increase our mechanical advantage to achieve our goals. Our goals are often measured as increased performance by greater effectiveness (producing more) or better efficiency (producing cheaper) (Linton, Jonathan, 2007). Clearly, the obvious meaning of innovation or innovating is in the *creation* of something new. But, the new development is not limited to a clean slate invention. Some of the best examples of innovation are improvements to current offerings. From this perspective, we can view innovation as a new thing itself, a new design of a thing, a new feature or capability of a thing, or simply a new way of doing the same thing. The emphasis here is on the creativity and novelty, and the value of the proposed novelty. When we think of innovation as a new or novel thing or way of doing something, we might think of technology as a blank art canvas, and innovation as the paint or drawing applied to the canvas. The paradigm of design and the framework of the science of design becomes the frame of the canvas and the display apparatus to hang it upon.

Entrepreneurship

The label entrepreneur is given to an individual who "*organizes, manages, and assumes the risks of a business or enterprise."*(These descriptive definitions represent a consensus of definitions from a variety of open sources: Merriam-Webster, Wikipedia, Dictionary.com, Business Dictionary.com, Oxford Dictionaries.com) Two elements that seem to be most commonly associated with an entrepreneur are *risk* and *initiative*. The term entrepreneurship is commonly defined as "*the process of starting a business or new endeavor."* (These descriptive definitions represent a consensus of definitions from a variety of open sources: Merriam-Webster, Wikipedia, Dictionary.com, Business Dictionary.com, Oxford Dictionaries.com) Under this definition it seems that risk, although not directly mentioned, may in fact be assumed. It is interesting to note that, whereas the entrepreneur is described as the person who starts a business and is willing to risk loss in order to make a profit, the description of entrepreneurship is more closely aligned with the process of starting a business, the development of a business model, and the acquisition of resources (Priem *et al.,* 2011).

Invention

The construct of invention shares some overlapping characteristics with innovation. For example, one definition for invention is "*a product of the imagination*" (Bijker, 2009). An operational description for invention is "*a new scientific or technical idea, with the ability to be demonstrated*." – This may sound most similar to design in terms of the demonstration of feasibility in the solution. An alternative description is "*a new device, method, or process developed from study and experimentation*" or "*a device or process that has been created or made up*." – This might sound reminiscent of the framework of design and the application of the scientific method to a problem. If we look to U.S. Patent Law for guidance, then an invention is *a new, useful process, machine, or improvement that did not exist previously, is not obvious, and is unique* (http://www.uspto.gov/patents-getting-started/general-information-concerning-patents#heading-2). Under this usage an invention is distinguishablefrom *ordinary mechanical skill or craftsmanship*.Whichever variation of definition or description for invention we may choose, we need to consider how these specific choices frame our thinking and portrayal as an innovation relates to the particular technology identified, within the environment as defined.

Pilot Study Conducted

We conducted a study of 50 self-identified entrepreneurial technologists. The participants of the study were selected from various technology companies along Florida's "I-4 Corridor." The study consisted of a series of semi-structured interviews during which participants were asked about how they define technology, entrepreneurship and innovation. The participants were also asked to use descriptive characteristics to explain how innovations impact existing technologies and how people use them. The participants ranged in age from 27 to 54, with the majority being between 35 to 45 years old. There were 40

males and 10 females in the study. All participants except one, had at least a bachelor degree, over half had a master degree, and 5 had a PhD degree. The participants' responses were coded using three independent reviewers not part of the study. A Principle Components Analysis was conducted resulting in four classification groups. In the next section, we report the four categories that emerged from the analysis of the interviews and we provide descriptions for the groups based on the responses from the participants.

"Dynamics": Substitute, Alternative, Replacement, Extension (SARE)

When we interviewed the participants, a consistent description used was the term "dynamics" when explaining innovation and technology, and the effects of each upon the marketplace and society. The results of the study suggest that the impact of a particular innovation, as it takes the form of a specific application of technology, can be described by its effects using four categories: *Substitute, Alternative, Replacement*, and *Extension*. These categories might help explain how a new technology in the form of an innovation is adopted for use by the consumer of the technology. We found that the acronym SARE is a good way to remember the four categories as described in this section. When we think of an innovation offered as a substitute we are considering a scenario whereby the legacy technology is still current and serves the purpose and intent of the end-user. *The new innovation is an equivalent technology*. This means that there is no discernable improvement in performance or in application of the new technology. The technology is offered to take the place – substitute – for the legacy technology, but without a value added proposition, the adoption of the new technology is predicted to be quite slow. In this scenario, substitution is slow to take root, but eventually gains traction as the legacy technology begins to age and lose perceived value.

Early adopters, who are motivated to possess the most current technology are the best influencers for this category. Without significant and meaningful advantage in use, the early adopters are the most likely candidates to keep the innovative offering alive in the marketplace. Think of this classification describing a new way to do the same thing. An innovation offered as an alternative suffers from a similar lack of significance as that offered as a substitute. The main distinction between a substitute and an alternative is that technology offered as *a substitute is largely a replication of the legacy features and functionality, merely with updated presentation*; whereas a technology offered as an *alternative is intended to be a distinct, different method* to compete against the legacy form. Technology offered as an alternative to a legacy will typically have features and functions presented in an unusual or unconventional manner – offering a uniquely different way of achieving the same task as the legacy. Think of this classification as a better way to do the same thing.

Technology offered as a replacement is comprised of a distinct and significant improvement over the legacy technology. In this instance there may be new features and functions, or a new process or method. A replacement technology might represent an improvement in performance, durability or other form of value, making it a more attractive choice to adopt over the legacy. Think of this classification as an improved way of doing the same thing, such as the latest version of a smart phone or other device. Technology offered as an extension carries the greatest impact of the four categories of innovation. An extension technology offers *new ways of doing new things*, *previously unavailable*. We see this in devices containing new features and functions, more powerful abilities, additional capabilities, extended boundary conditions, longer lifetimes, new environmental parameters, significantly different physical properties (such as lighter or stronger materials), and an overall comprehensive robustness not previously available in the legacy technology. Extension technologies tend to be *breakthrough inventions*. Think about the internet, email, Facebook, or texting. Each one of these technologies presented a new way to perform a communication activity that previously did not exist. Extension technologies share similar characteristics with replacement technologies, but set themselves apart in that they typically are more robust or unique in their approach, when compared to replacements.

Proof of Concept and Feasibility

We found that the participants in the study were very interested in the feasibility of an innovation and its proof of concept. Many of the participants indicated that "a truly new invention or innovative technology has to overcome several hurdles," the most significant of which include "raising enough capital to complete the development process" and "bringing the product or service to market." The four classifications (substitute, alternative, replacement, extension) consistently emerged in our conversations with the participants, and were often associated with "an entrepreneurial effort" and understanding "how the innovation can be best explained to potential investors, marketers and customers alike," and help to "determine how to position or brand the item." Several participants mentioned the design of the prototype, or minimum viable product (MVP), that demonstrates feasibility in the solution:

"Okay, so you built the working demo; you even drafted a white paper explaining the underlying concepts; used a rigorous scientific methodology to support your results with evidence, now what?"

"How do you get someone to give you the necessary capital to get to the next step?"

"What are the questions you need to address to get your innovation to market?"

Responses from the interviewees also revealed items needed to be established for an innovation capable of being produced: *technical status, technical risk, and hires*.

Hires refers to the description and explanation about who is in and who is out; who is part-time and who is full-time; *who* is running *what* at the company; and there better be a company – no corporate structure, no business entity, equals no money from investors. Several participants suggested that there needs to be a management team in place, and they better have bona

fide skills and accomplishments at bringing a product such as this to market. Several also mentioned the saying that "you bet on the jockey, not on the horse." Meaning, the technology may impress, but your management team better also impress. When in doubt, choose great management over great concepts. A great entrepreneur will make a good idea into a great reality. An average entrepreneur will make a great idea into a mediocre reality, if at all.

Technical status refers to a clear demonstration of where we are in the lifecycle process. There is also aneed to understand whether the innovation is fundamentally defensible. Meaning, is this patentable, or do we have a viable trade secret? How are we able to prevent others from easily replicating our invention?

Technical status includes a deep internal analysis and explanation of our use of funds: How much have we spent so far, and on what? What is our specific revenue model for the vertical space that we are targeting? We also need to explain why no one else in our market is doing this, and what prevents someone else from doing this? For that matter, what market are we operating in? We need to define these issues to understand ourselves, before we can go making a pitch to others.

Technical risk refers to the simple question of *what do we need to make this work*? How sound or proven is the underlying technology that we are relying upon? What is our ability to build the product? Are there any assumptions about our supply chain that we need to know? What are the dependencies and sequences of actions that affect our ability to deliver the product to market? How stable is the product, our operation, our management team, our development lifecycle, and our market?

Finally, many of the participants indicated that we need to understand and be able to explain: (1) who our customers are, (2) what our sales model is, (3) why they will pay what we think they will pay, (4) how will we be able to maintain these relationships, and for how long? Lastly, several of the more experienced interviewees suggested that, in addition to a functioning prototype serving as a proof of concept for the innovation, we may also need to establish a cadre of beta customers to serve as a proof of concept for the revenue model.

Conclusion

This paper presented a discussion on how we might think about classifying categories of innovations in technology. We presented a discussion on the constructs of innovation, technology, invention and entrepreneurship, and we reported on a pilot study of 50 self-identified entrepreneurial technologists and described the results from the study. Our next steps will be to expand the study to see if we can generalize our results to a larger technology community and further explain ways to classify innovations in technology. We welcome feedback on our discussion presented here.

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