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Technology from the Perspective of Society and Public Interest

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TECHNOLOGY FROM THE PERSPECTIVE OF SOCIETY AND PUBLIC INTEREST

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To my beloved family, Jiyoung and Jane

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PREFACE

After 10 years of working in managing national researches on technology, I found myself in the states of complacency and sloth. I was seized with despair and the despair, in a sense, was the origin of this study. Now, I know that the despair was not about the emotions, but about the notion of absolute passivity presenting in the domain of technology. For 10 years, I had witnessed technology being appropriated by the state bureaucracy and being developed only for the sake of experts themselves or business interests. The public was excluded and the efforts to strive for the essence of technology were nowhere to be seen.

Historically, technology used to be degraded of labor that was assigned to lower class people of a society. Such a phenomenon that the exercise of metaphysics or aesthetics surpassed the physical or technical exercise could be found in common both in the Christian tradition of the West and the Confucian tradition of the East. Through the modern era, technology was conceived as peripheral to science and, even today, technology is still confused with science. However, technology stays within the life-world and, thus, connotes real values. There is no doubt that technology is a major source of power and wealth in the present age. Inherently, technology favors interests of certain groups of a society and, necessarily, impinges the others'. In the crux of the matter lies the value-ladeness of technology. The multiple value structure of technology causes conflicts among values. Schuurman worries that "we shall be blind to the essence of technology if - as very often happens - we regard technology as a neutral means that man can either use or misuse" [1, p.101]. As long as technology is not neutral and accompanies practical decisions and actions, policy is concerned; the public is concerned.

Feenberg says, "my goal is to develop an account of collective action in the technical sphere" [2, p.105]. As shown in his description of the co-construction of technology and society, the two domains are paradoxically intertwined: "the public is constituted by the technologies that bind it together but in turn it transforms the technologies that constitute it" [3, p.13]. If the public is excluded from the domain of technology, in the same context, technology would maintain only limited amounts of representativeness of a society. Consequently, both technology and society will be perverted and mutilated. Sandel calls for the active participation of the citizen to construct the society, which is pertinent to human well-being [4]. Technology is not an exception. The social values embodied in technology are the reason that technology should be engaged by the public. And the engagements should be sublimated into democratization of technology, which is to be realized by the activities of engraving universal human values and public welfare into the mechanism of technology development. Technology is everywhere interacting with every aspect of our lives. Aristotle's *technē* and *phronēsis* are now assimilated to each other. As Winner says, "technology is a word whose time has come" [5, p.4]. Until public interest is incorporated into technology, my itinerary to the essence and democratization of technology will continue.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CD	Compact Disc
DOS	Disk Operating System
DV	Dependent Variable
EPT	Engineering Philosophy of Technology
FTP	File Transfer Protocol
HPT	Humanities Philosophy of Technology
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IRB	Institutional Review Board
ISO	International Standards Organization
ITEA	International Technology Education Association
IV	Independent Variable
KMO	Kaiser-Meyer-Olkin test
LP	Long Play or Long Player
MOS	Metal-Oxide Semiconductor
MPEG	Moving Pictures Experts Group
MPPC	Motion Picture Patents Company
PATT	Pupils' Attitudes Toward Technology
PC	Personal Computer
SCOT	Social Construction of Technology
STEM	Science, Technology, Engineering, and Mathematics
STS	Science, Technology, and Society
TAM	Technology Acceptance Model
TTL	Transistor-Transistor Logic
URL	Uniform Resource Locator
WLCS	Work Locus of Control Scale

ABSTRACT

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The ultimate goals of this study were to determine ways to reconcile technology with public interest and to understand the relationship between what we know and how we feel about technology. To achieve the goals, related literatures were reviewed; the mechanism of technology development was described with empirical data; and human perception of technology was tested with a survey. The duality of technology that implied technological inherencies of technical reason and social meanings was the principle assumption of the study. Neutrality of technology becomes a myth with the presence of social meanings embodied in technology. Given the huge impact of technology on human societies, the absence of neutrality is, in turn, attributed to the necessity for policy.

Analyses of eight empirical cases of technology in history based on the method of grounded theory provided core categories of technical progress, economic values, and social inclinations. Upon the core categories and concepts corroborated by the cases, the mechanism of technology development appeared to be a concatenation of the interactions between technical progress and social demand of either economic values or social inclinations. Technology that is pertinent to public interest, in this context, will be possible if a social inclination toward public interest can be built. The state can shape a social inclination of the kind and intervene in the mechanism of technology development. Furthermore, such an intervention could be accelerated by the potency of the collective actions of citizens. If successful, technology will incorporate the social value of public interest and the paradigm of technology will embrace it.

Survey responses indicated that the biggest misconception of technology was in the concept of technological knowledge, which especially was supposed to be distinguished from scientific knowledge; technology was perceived to have a distinctive kind of knowledge and to be practical, but still to be a part of science pursuing the knowledge of nature. Technology still seemed to be a mere part of science with more emphasis on practical purpose in everyday life, which was concurred with the term applied science. The respondents agreed on the idea of value-ladeness of technology and, thus, necessity for human control over technology. However, they appeared to have relatively passive attitudes toward technology. The conflict between the necessity for control and the paucity of faith in the ability to control technology by themselves must attribute respondents' dependency toward experts. The correlation between understanding of technology and will to control technology was statistically significant but weak. The control variables of academic affiliation and department were found to have significant effects on the results.

CHAPTER 1. INTRODUCTION

Humans living in a technological world are often swayed by such misgivings; "will humans be able to control future artificial intelligence?" or "is it acceptable for humans to engineer the genome?" The prodigious properties of modern technology attenuate people's belief in the ability to control technology. From the moment that you turn off the alarm of your smart-phone in the morning, you spend your time upon the plethora of technologies with or without your own intention. A lot more times than you assume it might be, you hardly ever recognize the existence of technology. Without careful deliberations about technology, it will be impossible for humans to retain the ability to control technology.

Political emphasis on STEM (science, technology, engineering, and mathematics) education and enormous efforts of many distinguished scholars exploring the relationship between society and technology have drawn more attention from public in recent decades. National surveys, however, still indicate the public does not have clear awareness of the discipline of technology. Given the impact and power that contemporary technology wields within a society, fundamental considerations and discreet awareness of technology become more crucial than ever before in the human history for a undistorted and healthy relationship between society and technology.

1.1 Scope

Since the Industrial Revolution, the wave of social and technical modernization has swept the world into a contemporary era. Today, humans are confronting ever more overwhelming technologies all through the fields of medicine, energy, transportation, communications, robotics, etc. Social and technical discourse and debates on new technologies with mass popularity or economic ramification abound. However, a fundamental consideration about technology itself and a comprehensive approach to figuring out the relationship between technology and society remain still rather esoteric to scholars.

To establish a platform and path that could lead the public to the essence of technology, this study begins with recapitulating preceding contemplation on technology or "philosophy of technology", especially from Martin Heidegger's concept of *Ge-stell (enframing)* to critical theory of technology developed and succeeded by Herbert Marcuse and Andrew Feenberg. Meanwhile, distinctive traits of modern technology are elicited. Also an attempt to articulate the discipline of technology is placed mostly upon Carl Mitcham's work.

Covered in latter chapters, the concept of human will toward technology is drawn out of former studies and manipulated to refine the concept of democratization of technology that has been surfaced by scholars like Feenberg and Langdon Winner. Finally, a descriptive relationship between technology and society that mechanizes technological formulation and social attunement is introduced as a guidance to enhance technological democratization.

1.2 Significance

A Harvard philosopher Michael Sandel calls for the active participation of the citizen to construct the society, which is pertinent to human well-being [4]. Technology is not an exception. Even for those who are opposed to such perspectives of technical determinism or technocracy, there is no doubt that technology is a major source of power and money in the present age. The social values that technology connotes are the reason that Feenberg, in response to the myth of technical neutrality, argues that technology is to be controlled by citizens and exclaims the legitimacy of citizen involvement in technology [2].

If the mechanism through which a technology forms and interplays with a society can be described successfully, technology would be able to incorporate public participation in a systemized manner and technology policy would be executed on proper spots of intervention. Consequently, these interventions would lead humans to a technologically democratized society that can assure public redemption of technology from those groups of experts, politicians, and commercial behemoths.

1.3 Research Question

The research questions of this study were:

1. How can technology be developed toward public interest? (Qualitative)
2. What is the relationship between understanding of technology and its discipline and human attitude toward technology? (Quantitative)

1.4 Assumptions

The following assumptions were inherent to this study:

- There is a distinctive domain of technology discipline that is distinguished from science.
- Technology connotes social meanings as well as technical reason, thus, is value-laden and subject to be controlled.
- Technology develops out of various causes including technical and social ones.
- The public has the right to choose the technology that they use and the right should not be encroached by any specific population of a society.
- Unfettered or inappropriately treated technology can be a threat to public interest and public interest should be protected from such a threat.
- There is a need to figure out the mechanism of technology development, with which humans can preside technology in accordance with public interest.
- The research methods adopted for this study were appropriate to elicit the answers for the research questions posed.
- The survey questionnaire was properly constructed to measure the respondents' perception of technology.
- The respondents of the survey were accurate and honest concerning their own perception of technology.

1.5 Limitations

The following limitations were inherent to this study:

- Geographically, this study was limited to the West Lafayette area in the state of Indiana, where the Purdue University located.
- The study was limited to the availability of preceding theories and findings that were relevant to the discipline of technology and the relationship between technology and society.
- The study was limited by the amount of historical events of technology that could be accessed and studied via either printed or electrical version.
- The study was limited by the amount of cooperation of undergraduate and graduate students at the Purdue Polytechnic Institute enrolling in 2016-2017 academic year.

1.6 Delimitations

The following delimitations were inherent to this study:

- The study utilized the facilities available at the Purdue University in West Lafayette, Indiana.
- For quantitative approach, the study focused on undergraduate and graduate students enrolling in the Purdue Polytechnic Institute during 2016-2017 academic year.
- The study was conducted at the level of comprehensive discipline of technology and was not focused on any particular kind of engineering technology.
- The study was focused on the technology of the modern and contemporary era.

1.7 Definitions

In the broader context of the study, definitions of the following terms are:

Axial Coding: A set of procedures whereby data are put back together in new ways after open coding, by making connections between categories. This is done by utilizing a coding paradigm involving conditions, context, action/interactional strategies and consequences [6].

Category: A classification of concepts. This classification is discovered when concepts are compared one against another and appear to pertain to a similar phenomenon. Thus the concepts are grouped together under a higher order, more abstract concept called a category [6].

Coding: The process of analyzing data [6].

Concepts: Conceptual labels placed on discrete happenings, events, and other instances of phenomena [6].

Core Category: The central phenomenon around which all other categories are integrated [6].

Dimensions: Location of properties along a continuum [6].

Discipline of Technology: The field of study of technology, which, as being distinctive from that of science, mainly deals with, but not limited to, the reification of technology and the relationship between technology and society.

Duality of Technology: The insight initially introduced by Jean Baudrillard, which refers to technical functionality and social connotations that technology incorporates. In the first place, technology has functions and they account for the most part of its existence. But in reality, technology connotes a myriad of reflections stemming from the association with other aspects of society [7, 8].

Engineering Philosophy of Technology & Humanities Philosophy of Technology: Two strains of philosophy of technology that Carl Mitcham named mainly based on distinctive approaches to technology. Mitcham argues that the former focuses on describing technology itself while the latter has emphasis on the impacts of technology on society or vice versa. Some scholars call them "analytical" and "continental/critical", respectively [9].

Epistēmē: An ancient Greek that refers to generalized scientific knowledge or pure theory that does not incorporate practical world [9–11].

Ge-stell(Enframing): Heidegger's concept explaining the phenomenon (mode of revealing) that "sets upon man to order the real world as technological materials (standing-reserve)" [12, 13].

Open Coding: The process of breaking down, examining, comparing, conceptualizing, and categorizing data [6].

Philosophy of Technology: A term coined by Ernst Kapp in 1877 to refer to systematic reflection on aspects of technology to elicit concepts that technology connotes both inherently and socially [14–17].

Phronēsis: An ancient Greek that refers to moral knowledge, prudence, and practical wisdom, which is about understanding the implications, and making the right choices [10, 11, 18].

Poiēsis: An ancient Greek that refers to the practical activity of human production [16].

Properties: Attributes or characteristics pertaining to a category [6].

Proven Theoretical Relevance: Indicated that concepts are deemed to be significant because they are repeatedly present or notably absent when comparing incident after incident, and are of sufficient importance to be given the status of category [6].

Selective Coding: The process of selecting the core category, systematically relating it to other categories, validating those relationships, and filling in categories that need further refinement and development [6].

Technē: An ancient Greek that refers to the knowledge or discipline associated with a form of *poiēsis*, which is concerned with knowing how to make something [10, 16].

Technology: A distinctive discipline of human intellect that accompanies procedures and systems to fulfill practical needs of humans [9, 17, 19, 20].

Technical Codes: Feenberg's concept that implies the realization of a social interest or ideology in a way that is congruent with a technical specification [2, 8].

Technology Development: A socio-technological phenomenon that shows a series of technological events such as invention, adoption, diffusion, modification, transition, and even obsolescence in a society.

Transactional System: A system of analysis that examines action/interaction in relationship to their conditions and consequences [6].

1.8 Summary

Chapter One stated the problem and presented the scope, significance and research questions of the study. The chapter also provided a list of assumptions, limitations and delimitations. The next chapter explores relevant literature elucidating the topics of the discipline of technology, philosophical reflections on technology, values and ethics of technology, and the relationship between technology and society.

CHAPTER 2. LITERATURE

Since the inception of human history, people have lived upon technologies from a stone ax to an electric car. For a welter of time, however, only a relatively small amount of scholarship has been achieved in the field. Genuine study solely contributed to the discipline of technology is limited. Even now, technology study is commonly perceived as peripheral or confused with science [21].

Under such a stark situation, this chapter is to look through previous studies about technology. Both perspectives of engineers and philosophers are in consideration. Topics of defining, delineating, and coping with technology proceed.

2.1 Approach to the Review

The goals of this review are to formulate a reasonable body of technology and build a platform to articulate the essence of technology, with which a rational path to further action on technology can be introduced. Consequently, selective sources are focused and interdisciplinary works that are believed to be pertinent to the discussion are borrowed without hesitation.

2.2 Discipline of Technology

Today, humans are living with ever more advanced technologies in history and the fact renders technological conceit. Most people think or pretend to know technology. Without serious contemplation of technology, however, the knowing turns out to be ambiguity. Rapp says this situation of ambiguous understanding happens similarly to those highly generalized concepts, such as ‘politics’ or ‘society’ [17]. Nevertheless, understanding the discipline of technology as well as technology itself is a *sine qua non* for further immersion in technology. Otherwise, it will be impossible for humans to retain the ability to handle technology properly [21].

> Today's attempts to develop a prescription for a democratic, sustainable technology are hampered by a lack of clarity in ideas about the nature of technology itself [22, p.170].

2.2.1 Defining Technology

The public is likely to consider technology as mere forms of artifacts that are results of applied scientific knowledge [15]. The belief is not true, of course, but experts and scholars also admit the difficulty of drawing a precise definition of technology. "Given the manifold determinants of technology, it is unreasonable to expect universal agreement upon any one definition" [17, p.23]. Technology is considered to be indexical, which takes its meaning from its uses [23].

2.2.1.1 Etymology

The word technology has its origin in ancient Greek, *technē*, which refers to the knowledge or discipline associated with a form of *poiēsis*, which refers to the practical activity of human production [16]. Hence, etymological meaning of technology is necessarily related to the historical hermeneutic of *technē* and *poiēsis*.

According to Mitcham, *technē* was commonly translated as human activities of "art", "craft", or "skill" [9]. *Technē* also conceived facets of *epistēmē*, that was systematic or scientific knowledge, but the knowledge is applied rather than theoretical. At the same time, the fact that, for ancient philosophers like Plato and Aristotle, *technē* was believed to be theoretical as knowledge, thus, rather science of production than art or skill is noticeable [24]. The limited practicality here attributes to the concept of *phronēsis* as acting itself in comparison to knowledge of acting.

Technē is considered to be logical: to Plato, *technē* refers to "all human activities that can be talked or reasoned about - all activities that are neither spontaneous nor the result of some unconscious drive or intuitive perception" [9, p.118]. Aristotle defines *technē* as "a habit (or stable disposition to act in a specific manner) with a true *logos* concerned with (or ordered toward) making (the human production of material objects)" [9, p.120].

Poiēsis, as producing, is subordinate to *praxis*, that is, practical action [18]. Historically, as being considered as handiwork, *poiēsis* used to be degraded of labor that was assigned to lower class people of a society. Such a phenomenon that the exercise of metaphysics or aesthetics surpasses the physical or technical exercise can be found in common both in the Christian tradition of the West and the Confucian tradition of the East. Jauss, however, notices degrees of perfection in *poiēsis*, and through the state of perfection, *technē* can reach its highest realm of art and virtue [18].

According to Herschbach, the English term "technology" used to have a limited meaning of "the application of science (knowledge) to the making and use of artifacts" [25, p.32]. But as technology develops, the linkage of formal knowledge and technology is emphasized. Technology, in the contemporary age, associates with the distinctive knowledge and logical activity of human beings to make something with degrees of perfection. Characteristics of technology are explored further in later chapters.

2.2.1.2 Contemporary Understanding of Technology

To historians of technology, the word "technology" is generally used to refer to "making activities, or knowledge of how to make and use artifacts, or the artifacts themselves" [9, p.116]. More specifically, technology has been defined as: "transformation of nature through the intellect (Heinrich Beck)", "everything that gives a corporeal form to human will (Max Eyth)", "reality derived from ideas, through purposeful forming and processing of natural resources (Friedrich Dessauer)", "the general term for all objects, procedures, and systems, which are produced for the fulfillment of individual and social needs (Klaus Tuchel)", etc. [17, pp.33-35]. Among definitions, Ferré is considered to define technology well: "practical implementation of intelligence" [19, p.26]. The State of Indiana, in its announced standards for technological literacy, defines technology as "the modification of the natural environment in order to satisfy perceived human needs and wants" [20, p.7].

Definitions of technology may change as technology evolves. Nowadays, the grasp of cutting-edge technologies over society aggravates the misconception of technology. Especially, objects with high-tech features are considered as technology in many cases [26]. Without awareness of everyday technologies, however, the public's involvement in technology is distant [27]. Consequently, the misconception of technology will keep aggravating and technological matters will be left to small groups of experts and politicians. The presence of such a threat is why even contemporary definition of technology cannot be confined to new technologies and should be discussed on comprehensive basis.

Upon preceding and contemporary contexts regarding definitions of technology, this study perceives technology as a distinctive discipline of human intellect that accompanies procedures and systems to fulfill practical needs of humans. To solve practical problems and serve human needs, says Pool, "technology combines the physical world with the social, the objective with the subjective, the machine with the man" [28, p.15].

2.2.1.3 Technology vs. Science

As mentioned already, Aristotle construes *technē* as "art" or "technical skill" that is concerned with "bringing something into being", and distinguishes it from *epistēmē* that enjoys the primacy of being eternal and scientific [11, p.121]. Much like the distinction between engineering and physics, technology is applied and involved in making things while science pursues universal laws. "The two forms of knowledge are interrelated, and they overlap in practice, but they are discrete" [10, p.10].

The fact that technology associates with making things or *poiēsis* differentiates technology from science which associates with *physis*, the nature. While technology deals with the essence, science the existence [16]. De Vries finds the distinction between science and technology in different purposes of those disciplines. According to him, science seeks knowledge about reality while technology tries to change reality to meet human desires, that is, science is problem-oriented and technology is solution-oriented [15].

Although many people identify technology with applied science, Vincenti shows that the contribution of science to technology is very limited. He argues that the most knowledge of technology comes from other sources than science and even when transferred from science, the knowledge often needs to be transformed by engineers [29]. For Rapp also, progress in science is necessary but not sufficient to realize technological procedures and systems [17]. MacKenzie and Wajcman claim: the misconception that technology is dependent on science is largely attributed to the second half of the nineteenth century when science and technology were closely connected. Science and technology, however, have not always been connected and the contribution of technology to science is as much as the contribution of science to technology [30]. However, the debate on whether technology is applied science or not is still frustrating as evidences for both sides of pros and cons can be found easily [15]. Apparently, the question still remains as an *aporia*. Table 2.1 shows major distinctions between technology and science.

Table 2.1. *Technology vs. Science*

	Technology	Science
associates with:	*poiēsis*, the practical activity of production	*physis*, the nature
deals with:	the essence	the existence
tries to:	change reality to human desires	seek knowledge about reality
is:	solution-oriented	problem-oriented

2.2.2 Constituents of Technology Reification

Heidegger suggests Aristotle's *four causes* of material, formal, final, and efficient to be involved with the ancient craftsmanship [12, 13]. "The four ways of being responsible bring something into appearance. They let it come forth into presencing", says Heidegger [12, p.9]. Among many scholars, efforts to formulate the constituents of modern and contemporary technology have been made. For this study, the way to the discipline of technology is guided mainly by analytical works of Friedrich Rapp and Carl Mitcham as they are found to maintain the commonality and concatenation of thoughts of the kind.

[gold + cup-shape + sacrificial rite + goldsmith = chalice]

Figure 2.1. Four Causes of Aristotle and Craftsmanship [12]

Rapp tried to figure out some common features that technology exhibits regardless of diverse circumstances. He believed that those features would make possible a "supra-historical structural description of technology". He says that technology is combinations of techniques (or procedures) and technical objects [17, p.25].

Technology = Technique (procedure) + Technical object

And out of the technique, which refers to "the individual technical means themselves, the actual application processes", two more aspects of technology emerge: knowledge and activity [25, p.32].

Technique = Knowledge + Activity

Thus, three features of technology, that is, knowledge, activity, and object, are drawn. Coherently and expectedly, those three features are also present in Mitcham's proposition.

Among various and cumulative considerations about technology, Schuurman distinguishes technological forming and designing that contribute to fabrication of technological objects and Carpenter also compartmentalizes the body of technology into object, knowledge, and process [1, 9, 31]. McGinn stresses technology as a form of human activity [32]. On such basis, Mitcham articulates three fundamental modes of technology: knowledge, activity, and object [9]. In addition to those three concepts, Mitcham accepts the suggestion of McGinn that properties of technological material outcomes “may in a sense be said to be due to the volition of the practitioner” and includes the concept of volition [32, p.182].

As a result, four constituents of technology reification, that is, objects, knowledge, activities, and volition, had been identified as shown in Figure 2.2 and Mitcham calls these “four different modes of the manifestation of technology” [9, p.160]. The diagram portrays how a technology is reified out of abstract knowledge and volition in a simple manner. Although Mitcham admits that his framework is yet provisional, it holds meaningful significance in conceptualizing the process of technology reification as a considerable body of previous studies in the field is subsumed under the framework.

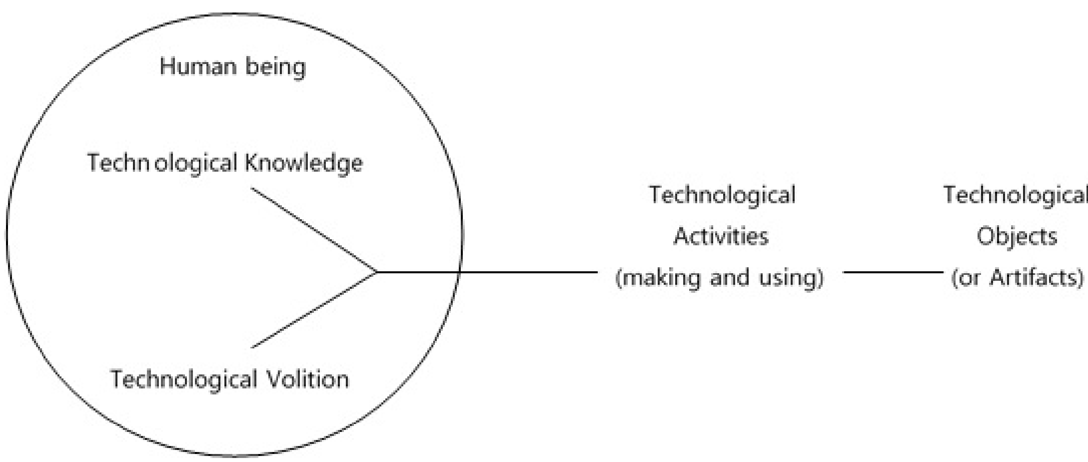

Figure 2.2. Modes of the Manifestation of Technology [9, p.160]

2.2.2.1 Technology as Objects

Technology as objects is the most immediate and common response when someone is asked about technology and can include all material artifacts with human fabrication [9, 15]. According to Dipert, the objects can be divided into an instrument, a tool, and an artifact; when we use a natural object for any practical purpose without modification of the object, it is an instrument. If a modification is added, it is a tool. Then an artifact can be marked when it displays its own purpose or function *per se* [33]. From mundane to cutting-edge, technological artifacts are everywhere in our lives. Due to the knowledge-intensive characteristic of modern technology, the concept of artifact explains technology as objects well.

According to Mitcham, there have been two basic social responses regarding technological objects: socialist response and Luddite (artifactist response) [9]. The former shares the belief that social problems are not caused by technological objects, but by the social context that these objects inhabit while Luddites inculpate objects themselves. Though, it has to be noted that Luddites are not inherently anti-technology and they focus on consequences of technological inventions [9]. Technological objects can be used in accordance with the ways that designers initially intended, that is, proper function, but at the same time, they can be used in different ways, that is, accidental function. Here, the ambivalence of technological objects is held [9, 15].

The relationship between technological objects and human capability has been examined by Ihde and McLuhan. Ihde argues that tools or instruments have a simultaneous amplification/reduction structure through which extend and also restrict human capability [34]. Mcluhan calls this phenomenon the laws of enhancement and obsolescence. For him, "any new technique or tool, while enabling a new range of activities by the user, pushes aside the older ways of doing things" [35, p.99].

2.2.2.2 Technology as Knowledge

Technology as knowledge is based on the idea that technology is a discipline with a distinct kind of knowledge [9, 15]. Ryle introduces two types of knowledge, that is, "knowing-that" and "knowing-how". Knowing-that is the knowledge that can be expressed in propositions such as scientific knowledge and knowing-how cannot be [36]. In the condition of proposition-based, knowing-that could be well fit into what Audi defines knowledge: "justified true belief" [37, p.220]. Technological knowledge, however, is definitely the type of knowing-how. Technological knowledge is neither proposition-based nor belief-based. According to de Vries and Mitcham, technology is solution-oriented and deals with more practical matters as it aims at changing reality to fulfill the needs and desires of humans [9, 15, 38].

Herschbach introduces three forms of technological knowledge: descriptive knowledge, prescriptive knowledge, and tacit knowledge. Descriptive knowledge is close to (applied) scientific knowledge that describes things as they are, such as material properties. Prescriptive knowledge is about “what has to be done in order to achieve the desired results”, which can be achieved through the successive efforts to obtain “greater effectiveness, such as improved procedures or operations”. Tacit knowledge is implicit in activity and embedded in individuals. As being transmitted from one individual to another by working together, tacit knowledge is seen to be immanent in skilled workers and engineers, and highly required even in the high-tech industries [25, pp.34-35].

The knowledge of technology is distinctive from the genuine implication of *epistēmē*, which refers to generalized scientific knowledge or pure theory that does not incorporate practical world, as *technē* is involved with the knowledge of making things in *praxis*, the practical world. [9–11]. Jauss also elucidates different kinds of knowledge: *technē*, *phronēsis*, and *epistēmē*. According to him, *technē* is acquired knowledge while *phronēsis* and *epistēmē* are moral knowledge and theoretical knowledge, respectively [18]. Unlike other knowledge, acquired knowledge is employed for the purpose of making based on anterior certainty and practicality.

Aristotle, however, shows a firm distinction between the man of *technē* and the man of mere memory or experience. He argues that the man of *technē*, that is, technological knowledge, knows the why and the cause while the other does not [24]. Under the Aristotelian scheme, both *technē* and *phronēsis* are distinguished from *epistēmē* for being practical than theoretical. Remaining changeable and uncertain to cope with the real world never yield knowledge of the eternal. But, *technē* and *epistēmē* do share the common ground to be capable of being taught and learned [24].

Under the introduction of modern technology, the separation between theory and practical production is unclear, says Dunne, “scientific information about the world contains technical imperatives: the formulae for the new technology and modes of production no longer reside in the rules of craftsmen but rather in the corroborated findings of scientists" [24, p.175]. Of course, this does not imply that technological knowledge becomes identical to scientific knowledge. But this implies that the feature of modernization caused inexorable changes in the relationship between these two categories of knowledge.

2.2.2.3 Technology as Activities

> All [technological] artifacts owe their existence to having first been thought out by man and then systematically and suitably made. Thus it was only natural that philosophical reflection first focused on two indispensable prerequisites to the emerging machine technology, namely, the creative act of invention and the role of the engineer [17, p.4].

The fact that technology associates with *poiēsis* presents human activities as a constituent of technology. *Technology as activities* refers to designing, making, using, and assessing as the main activities in technology [15]. To a certain extent, it can also be explained with the basic types of human behavioral engagements that include crafting, inventing, designing, manufacturing, working, operating, and maintaining [9]. Regardless of taxonomies that can be brought here, the concept is lucid: through proper technological activities or/and processes, human volition with technological knowledge becomes the artifacts with intended functions.

As mentioned earlier, human activities of production or *poiēsis* had been conceived traditionally as handiwork for lower working class of a society. But Karl Marx reevaluated human labor as a 'concrete activity' that is "the true productive activity and placed above all theory and all political and communicative action" [18, p.600]. In fact, with introduction of the Industrial Revolution and accompanied autonomous machine technology, activities of making has made a transition from the labor intensive handicraft to the knowledge intensive complex system. Accordingly, there has been a major shift in professional and social status of technological activities as well as, like Mitcham notices, the shift from artistic design to engineering design [9]. Through the degree of advancement and complexity, handiwork of "toiling against a resistant nature" has been promoted to professional activities of inventing and creating out of considerable intellect [18, p.591].

Comparing to ancient times showing the dominance of artistic design, today, in most cases, technological activities are construed as engineering [9]. And engineering is always struggling with various internal and external values, such as efficiency and public interest. The struggles imply that *Technology as activities* also connotes ethical and practical judgments of engineers. Practical judgments are made upon the questions of internal values of technology while ethical judgments are made upon external values. More discussions about the values of technology and corresponding judgment of engineers are followed in later chapters.

2.2.2.4 Technology as Volition

Technology as volition is about the notion that technology is part of human will, and therefore, it is value-laden [15]. And the notion now turns to be rather philosophical than technological. Technology is the intrinsic matter to humans. Rapp introduces three main motives for humans to develop technology: basic human need to survive, desire for power and control, and desire for the intellectual capacities [17]. Those desires of humans are associated with volition. To a simple notion, volition is thought to be the initiation of human intention and activities. According to Ryle, volition is the outputs of internal forces and is not the subject of being voluntary or involuntary [36].

Mitcham analyzes technology as volition in three senses: technological desire, technical motivation or movement, and consent to technology. Interrelations of the senses refer to a technological imperative; technological desires engender motivations, and through the creation of objects, knowledge, and activity, finally, consent to technology completes the feedback process of technology [9].

Volition, as a highly subjective and psychological concept of human mind, can be criticized to be inappropriate to reify technology. Ambiguity of abstraction remains in the concept of volition. “Volition is the most individualized and subjective of the four modes of manifestation of technology”, says Mitcham [9, p.250]. Nevertheless, human mind takes the role in technology and the role can be explained adequately only by various social elements. While technical reasons or internal values constitute technology, so do social or external values of technology.

As long as it incorporates human will, technology as volition is also related with human control over technology. As potence of technology increases, stronger ability of intelligent control is required. According to Mitcham, the intelligent control of technology depends on "knowing the right direction and goal of technology, knowing the consequences of technological actions, and acting in accordance with those two types of knowledge" [9, p.260]. And a critical issue of *incontinence* happens when people do wrong to satiate their desires even though they know that it is wrong. Sometimes the will breaches the rationality or reasonableness of human action and technology as volition can account for such phenomenon [9, 11].

When the idea of technological neutrality as pure means to human ends is rejected, human will and the intelligent control of technology become significant. Here, the concepts of human will and control in relation to technology are quite new and should not be subject of being considered in traditional circumstances. As the act of technology has been transited from craft to knowledge intensive, new approaches to the concepts are required. "It is perhaps permissible to suggest that the pursuit of efficiency or the will to control might even be termed a historically unique volition that can be associated with technology in a new way", says Mitcham [9, p.259]. More discussions about the relationship between human will and technology are followed also in later chapters.

2.2.3 Reflections on Technology

The history of technology began no later than the initial appearance of mankind. Thus, it is reasonable to say that thoughts about technology have existed for a long time as human history. To the perspective of contemporary scholarship, however, systematic reflections on technology are generally dated from the work of a German philosopher Ernst Kapp, in which he coined the term "philosophy of technology (*philosophie der technik*)" in 1877 [9, 19]. Since then, with enormous development of technology, more

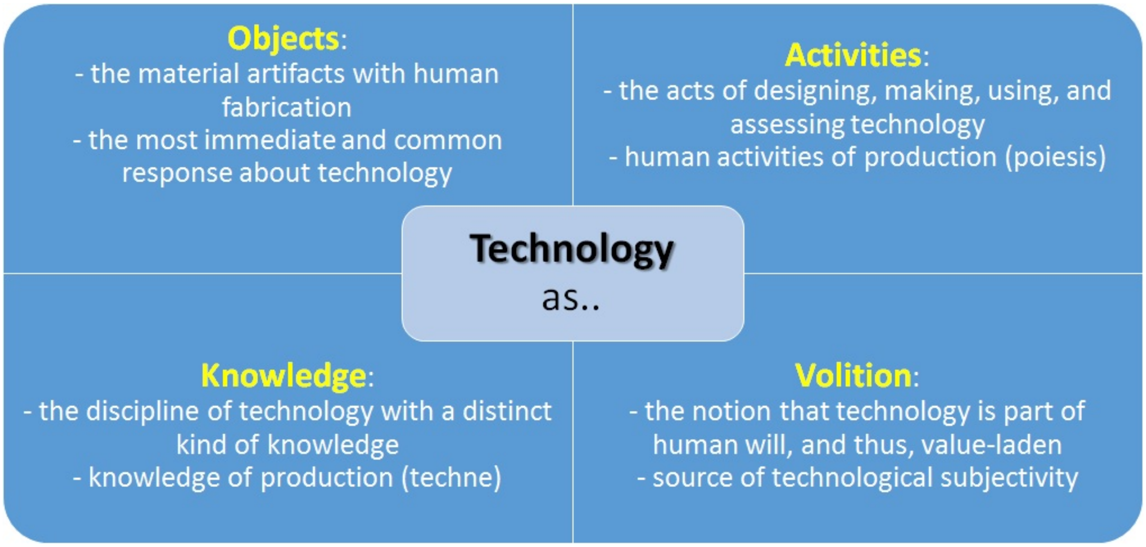

Figure 2.3. Four Constituents of Technology Reification [9]

attention of scholars has been paid to technology and their studies are now subsumed under the term.

2.2.3.1 Philosophy of Technology

Deleuze defines philosophy as the art of forming, inventing, and fabricating concepts, which means, eventually, philosophy of technology is about eliciting concepts that technology connotes [14]. Traditionally, a lot of scholastic efforts have been made upon establishing philosophy of technology in accordance with legitimate fields of philosophy: ontology, epistemology, methodology, metaphysics, and ethics and aesthetics [15].

According to Schuurman, when philosophical reflections on technology began to appear, the goal was rather to secure the independent domain of technology than to perform the structural analysis of modern technology [1]. Due to frequent encroachment of science and economics, technology was not been paid enough attention by general philosophers. They underestimated the social significance of technology, and then, reduced it to a mere science. Furthermore, philosophers and engineers were not familiar with each other and did not communicate, either. Consequently, thoughts of these two groups were so disparate and a certain degree of heterogeneity still runs down the field [1].

From the view points on modern technology and its relation to society, Schuurman distinguishes two groups of modern philosophers of technology: transcendentalists and positivists [1]. Transcendentalists like Jacques Ellul posit passivity and technological pessimism, and thus, they are inclined to reject mechanical modern technology. While they try to strive for a supra-historical humanistic understanding of technology, they are not likely to have clear distinction between science and technology. On the other hand, positivists like Karl Steinbuch believe that technological development is the source of cultural progress, and thus, technology is at the center of their technocratic view [1]. Regretfully, however, Schuurman argues that neither group of those philosophers is able to suggest an universal explanation of the relation between humanity and technology [1].

Within the same context, there has been tensions between being technical and social, or internalist and externalist through the history of technology. While internalist studies focus on making and using of technical artifacts, externalist studies focus on the influence of technology [9]. Likewise, in contemporary philosophy of technology, the whole work can be divided into two strains; de Vries calls them “analytical” and “continental/critical”. He argues that the former aims to conceptualize technology and its discipline while the latter is more interested in making values regarding technology [15]. Alternative names for those two strains of philosophy of technology are “engineering philosophy of technology (EPT)” and “humanities philosophy of technology (HPT)” that Mitcham introduces. Identically with de Vries’s idea about analytical and continental, the former focuses on describing technology itself while the latter has emphasis on the impacts of technology on society or vice versa [9, 15]. Through this study, terms of Mitcham will be used for the reason of semantic clarity.

Although engineering philosophy of technology is firstborn strain in the field of philosophy of technology, it has drawn comparatively less scholastic or public attention so far and has not established as many theories as its counterpart, either. De Vries puts the unpopularity down to peoples tendency to prefer social and cultural aspects to genuine concepts of technology. But the very existence of technology has its origin in technical aspects. He asserts that humanities philosophy of technology is “philosophy about technology” and through the “empirical turn”, more emphasis has to be made on “philosophy of technology” that can provide answers for practitioners [15, p.6]. Mitcham also emphasizes the importance of real world engineering experience and criticizes humanities philosophy of technology for overlooking it [9].

Humanities philosophy of technology is said to be developed mainly by those philosophers without an engineering or natural science background and, thus, concentrates on the society that inhabits technology rather than technology itself [15]. For the reason, Mitcham criticizes the strain for having humanities stand on the center to conceive technology [9]. Such inherited inclination may weaken belonging philosophers insights into the discipline of technology. But, it does imply significant meanings to both technology and society. In fact, as technology develops apace, being either engineering or humanities in the field of technology study seems trivial and the borderless collaboration of two strains becomes an inevitable corollary. Furthermore, with the presence of volition within reification of technology, two strains of philosophy of technology, engineering and humanities, can share a meaningful intersection. Even in engineering philosophy of technology, human will could not be excluded from forming a technology.

Those humanities philosophers of technology believe that socially specific values are embodied in technology and deal with the question of technological means to social ends [16, 39]. Along with respect to the role of human action toward technology and the neutrality of technology, Feenberg summarizes the varieties of theory of those philosophers as Table 2.2.

2.2.3.2 Critical Theory of Technology

Among various theories, this study focuses on the Critical Theory in accordance with the propositions that technology is value-laden and subject to be controlled by humans. Specifically, the ideas of Feenberg that can be traced down from Heidegger and Marcuse are explored for two major reasons; first, the concept of de-worlding or instrumentalization process of technology is most appropriate to describe the

Table 2.2. *The Varieties of Theory [2, p.9]*

Technology is:	Autonomous	Humanly Controlled
Neutral (complete separation of means and ends)	Determinism (e.g. traditional Marxism)	Instrumentalism (liberal faith in progress)
Value-laden (means from a way of life that includes ends)	Substantivism (means and ends linked in systems)	Critical Theory (choice of alternative means-ends systems)

comprehensive phenomenon of contemporary technology; second, Feenberg's suggestion for democratization of technology is the ultimate destination of this study.

As marked in Table 2.2, critical theory of technology posits the beliefs that technology is not neutral and, thus, needs human intervention. Accordingly, the first step to embrace the theory is to reject the neutrality of technology. Inherently, especially in contemporary societies, much of technology development favors interests of certain groups of a society, and in turn, impinges others', sometimes including public interest. So far, such a characteristic of technology development has been likely to be perceived as an accidental consequence [40]. The traditional assumption of technological neutrality or rationality by which technology development can be explained solely with efficiency or other technical reasons has formed modern technocratic falsity and diffused social indifference to making technological decisions. Feenberg calls this the "innocence of technology" meaning that technology, as the means to the social ends, "cannot be blamed for the particular uses to which it is put" [41, p.36]. But critical theory of technology rejects the assumption and suggests an alternative view:

> The Critical Theory school formulated the most influential statement of the alternative position, arguing that while technology serves generic ends such as increasing the power of man over nature, its design and application serves the domination of man by man. In this sense, the *means* (technology) are not truly "value free" but include within their very structure the *end* of furthering a particular organization of society. In sum, technology is *political* [40, p.18].

Critical theorists argue that technical rationality itself is socially relative and embodied with diverse social values and economic interests [40, 41]. Feenberg attributes this contamination of technical sphere to the capitalist production system in which separated workforces and markets are automatized with atomized individuals. He sees the separation of labor, consumption, and social decision making as the underlying problem [40]. "Weber's account of science and technology as nonsocial and neutral, which Habermas shares, masks the interests that preside over their genesis and application," says Feenberg [2, p.161]. Marcuse also notices the dissipation of technological neutrality by saying that technical principles formulated in abstraction are soon to be social when they enter reality [42]. Once technology is turned to be value-laden and to connote social values, the next step is to distinguish between the two spheres of technology, that is, "technical reason" and "social meanings".

2.2.3.3 Duality of Technology and Instrumentalization

As early as in the time of ancient Greece, Aristotle implied the ambivalence of technology with the distinction between 'technique' and 'praxis'. In the same context, scholars of critical theory share the insight of Baudrillard, "duality of technology", which refers to technical functionality and social connotations that technology incorporates. In the first place, technology has functions and they account for the most part of its existence. But in reality, technology connotes a myriad of reflections stemming from the association with other aspects of society [7, 8]. Of importance, the duality of technology introduces a dichotomous world that consists of two spheres: Marcuse calls them "the natural world of science" and "the lifeworld of experience"; Habermas "the system" and "the life world" [43, 44]. Latour also makes a similar recognition by introducing "sociogram" and "technogram" as social interests and technical configurations respectively that construct technologies. According to him, a specific technology can be understood at the intersection of the two facets [45]. Those two spheres are very constituents of technological being that cannot be separated by subjectivity or objectivity [8]. And this technological world becomes systemized by Feenberg's processes of "de-contextualization" and "re-contextualization", that is, the "instrumentalization" of technology.

Before going further into the instrumentalization of technology, a retrospection on Heidegger is indispensable. Although Heidegger's affiliation to Nazism deteriorates his reputation, at least his insights into technology still have tremendous influences on contemporary scholarship. Specifically, Heidegger's academic contribution to Feenberg can be found in the concepts of de-worlding and *Ge-stell (enframing)*.

According to Heidegger, technology is "a mode of revealing" [12, p.13]. And the acts of revealing are distinguished into "bringing-forth" in premodern society and "challenging-forth" in modern society. This is where modernity isolates social aesthetic and ethical values from *technē* and creates dehumanizing threat of modern technology pursuing technical perfection only [8, 12]. Here, the concept of *Ge-stell* aggravates the isolation well by reducing nature as mere objects of modern technology. Waddington explains *Ge-stell* as "the phenomenon that sets upon man to order the real as standing-reserve", while "standing-reserve" implies the status of nature as material objects with disposability of modern technology [13, p.569]. By reducing nature as objects of technology, process of de-worlding happens and with *Ge-stell*, interplays between society and technology become immanent in the being of technology. Heidegger asserts that the *Ge-stell* "distorts the appearing and ruling of truth" [1, p.107].

Figure 2.4. Heidegger's challenging-forth and standing-reserve [12, 13]

Heidegger's insight of *Ge-stell* let him explorer deeper into the dualism of subject and object:

> What is central is the existence that precedes thinking and is present in it. Heidegger begins by looking behind the positions of Descartes, Kant and Husserl. In them he discerns a dualism: the (thinking) subject stands over against the objects to be known [1, p.95].

Accordingly, Schuurman asks to be aware of the subjectivity of technology:

> We shall be blind to the essence of technology if - as very often happens - we regard technology as a neutral means that man can either use or misuse [1, p.101].

Apparently, both Heidegger and Feenberg tried to find the essence of technology from outside of technical rationality, that is, in contexts of society and technology. But, Heidegger attributes an autonomous logic to technology and stands on "substantivism" [46]. Heidegger holds emphasis on exploitation and destruction of humanities and natural orders. To a certain extent, he calls for returning to a premodern society by abandoning modern technologies. Heidegger's passivity and failure to provide reliable alternatives germinated discontent of Marcuse. Marcuse also deplored dehumanization of modern technology but, he believed in possibility of redesigning and controlling technology to properly serve human needs [43].

> Marcuse does not propose a conversation with nature but argues for a technology developed and applied with understanding of the inherent potentialities of its medium, the raw materials and context it presupposes. Such an approach would bear a certain resemblance to aesthetic practice, and would promise a new type of technology that does not conquer nature, but reconciles human beings with the natural environment in which they live [40, p.32].

Finally, Feenberg comes up with an alternative. Feenberg, through his instrumentalization theory, sublimates his predecessors' reflections on technology into an impervious analysis and provides a significant initiative to the alternative, democratization of technology. "The duality of function and meaning underlies the 'double aspects' of the instrumentalization theory", says Feenberg [8, p.174]. According to him, the essence of technology has two aspects of functional constitution and realization, which he calls "primary instrumentalization" and "secondary instrumentalization", respectively [2, 8].

Feenberg explains; in primary instrumentalization, processes of "de-contextualization", "reductionism", "autonomization", and "positioning" happen to ensure technical functionality. Natural objects are de-worlded, simplified to fit designated qualities, and assigned technical features. Till this primary level, technical rationality presides the processes. Hence, technological neutrality still holds and pure individual objects are produced. During secondary instrumentalization, processes of "systemization", "mediation", "vocation", and "initiative" happens to integrate functionality with its human and natural environment. In this secondary level, the rule of "technical codes" presides the processes. Technical codes imply the realization of a social interest or ideology in a way that is congruent with a technical specification [2, 8]. Feenberg elucidates technical codes with the concept of Gilbert Simondon, "concretization", which implies "designs that accommodate a wide range of influences and contextual factors" [8, p.215]. Table 2.3 briefly shows Feenberg's instrumentalization theory. Vertical axis represents the distinction of de-contextualization (de-worlding) and re-contextualization (re-worlding) while horizontal axis represents primary and secondary instrumentalization.

Table 2.3. *Instrumentalization Theory [2, p.208]*

	Functionalization	Realization
Objectification	Decontextualization Reduction	Systemization Mediation
Subjectification	Autonomization Positioning	Vocation Initiative

The facets of duality of technology can be enumerated along with the phases of instrumentalization as in Figure 2.5.

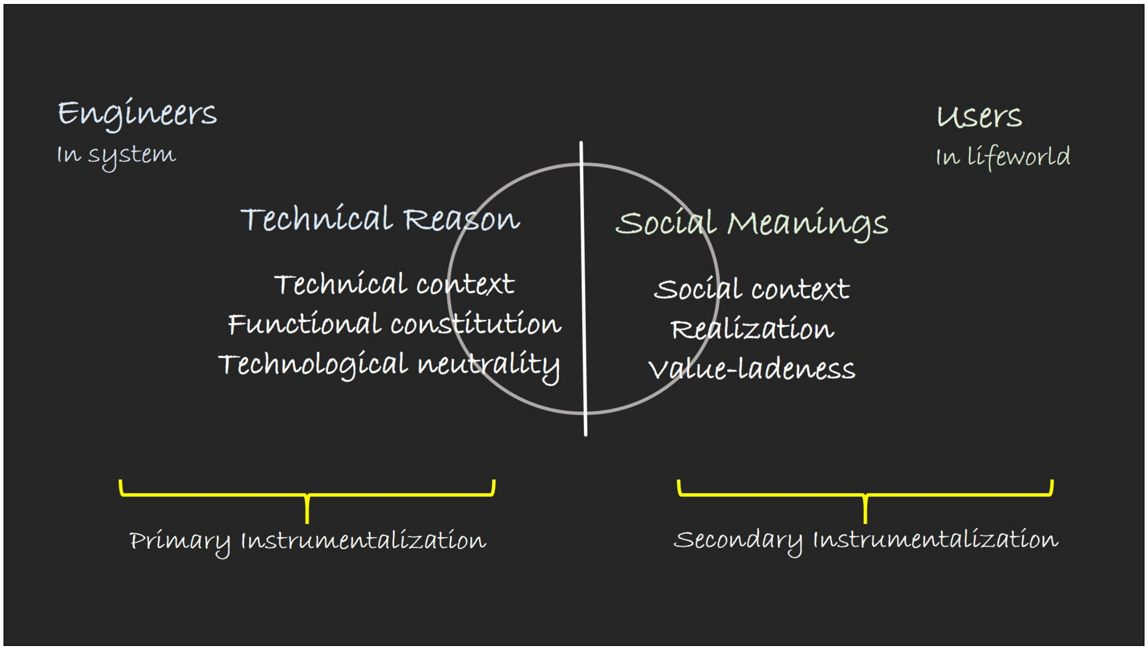

Figure 2.5. Duality of Technology [2, 8]

2.3 Values of Technology

"Incontinence", in moral philosophy, is the term indicating "a hiatus between knowledge and action" [9, p.259]. As technology develops, humans are equipped with more power and ability and, thus, new potentialities are released into the real world. Without conscientious awareness of technology use and its consequences, however, the power and ability would rather become a social calamity. The ambivalence of technology holds here. Nevertheless, humans need technology and reducing the discrepancy between what we know and what we do in the technological sphere remains critical.

In the crux of the matter lies the value-ladeness of technology. The multiple value structure of technology causes conflicts among values and renders such questions: "what kind of values does technology connote?" "what values override others?" and "how should we deal with the values?" Certainly, efficiency or other technical reasons cannot answer the questions in full. Consequently, the endeavor enters the domain of ethics that deals with the values of technology.

2.3.1 Axiology of Technology

> Values are not the opposite of facts, subjective desires with no basis in reality. Values express aspects of reality that have not yet been incorporated into the taken for granted technical environment. That environment was shaped by the values that presided over its creation. Technologies are the crystallized expression of those values [3, p.12].

The study of values of technology posits the denial of technological abstractness and neutrality. There were several attempts to identify and distinguish the values of technology. Gonzalez introduced three possible levels of analysis: “axiology of technology in general” for the values in any form of technology, “axiology of specific technology” for the values that belong to a specific technology, and “axiology of the agents developing technology” for the values that are accepted by designers and engineers [47, p.12]. Another distinction that focused on the life cycle of a technology was also made as “the construction of a technology” and “the application of a technology” [47].

Basically, the distinctions of both cases are subsumed under the dichotomous view on technology, that is, the duality of technology. In this regard, this study proceeds with the taxonomy of van de Poel that shows a clear demarcation between the two spheres of technology. He elucidates the values of technology as in “internal” and “external” values [48].

2.3.1.1 Internal Values of Technology

Internal values of technology are commensurate with technical reason of the two spheres of technology. Van de Poel defines them as the values “that are perceived by engineers as internal to engineering practice and that do not, or at least seemingly do not, refer to broader social goals and values” [48, p.32]. These values are endogenous for a technological being and contribute to its functionality [47]. The examples of technical perfection, efficiency, effectiveness, and reliability are categorized as this type.

Engineers' enthusiasm for technical perfection must be the purist motivation of technology development. Although technical perfection in itself is not supposed to be judged by moral criteria, it has been accompanied by numerous negative effects of technology in history. Wernher von Braun, the famous rocket engineer who made the first manned flight to the moon possible, was a member of Hitler's SS during the World War II. While he was making German missiles and U.S. space shuttle, his only purpose was in pursuit of the engineering perfection. But his indifference to the social consequences of his work shows well why engineering ethics is needed [48].

Efficiency, as the most technical value, is believed as the foundation of technological neutrality. Efficiency can be said to be the ratio between the amount of function fulfillment and effort where the amount of function fulfillment stands for the effectiveness. Engineers are likely to suffer from the conundrum of efficiency and effectiveness. Nevertheless, with these values, they maintain competitiveness and technical breakthroughs can be achieved. Mitcham defines engineering design as "a systematic effort to save effort" [9, p.225]. The problem is that efficiency is context-dependent and circumstantial. Winner also mentions that historically, technologies have not always increased efficiency [49]. Of important note, technology have required occasional sacrifices of efficiency. He emphasizes the importance of paying attention to the meaning of activities such as design and arrangement in evaluating technology.

2.3.1.2 External Values of Technology

As the values that are commensurate with social meanings of technology, external values are defined as the values "that are related to effects of technology on other practices" [48, p.33]. These values are pertained to many facets: aesthetic, social, cultural, political, economic, etc [47]. The examples of safety, health, and sustainability are categorized as this type.

"Engineers shall hold paramount the safety, health, and welfare of the public" [50]. The first rule of practice of the National Society of Professional Engineers (NSPE) arouses attention to the external values of technology. People's safety and health must be considered when engineers practice their knowledge or create a technology. Otherwise, the results can be disastrous and this is why blind enthusiasm of engineers must be alerted. To a certain extent, the values of safety and health constitute public welfare. Given that the ultimate goal of technology is public interest and welfare, these values of technology can be the second to none. Sustainability is mainly about the environmental responsibility [48]. The environmental exploitation of modern and contemporary technology had been connived by capitalism and now, it became a subject to be condemned by the conscientious citizens of a society. Recently, capitalism itself seems to depend more on environmental values for the profitability [2].

The two spheres of technology are not close systems. Likewise, the two types of technological values are not exclusive. Internal values are transformed to external values by engineers and designers. Reciprocally, external values are conveyed to internal values again by users and societies.

2.3.1.3 Values of Information and Communications Technology

The values of information and communications technology (ICT) can be specified further. Among many values that Neira presents, there are accessibility and versatility for the internal values of ICT. Accessibility refers to both physical and cognitive meanings. The first generation computers, for example, were not only too expensive to own personally but also too difficult to operate for the lay persons. Then, the accessibility was reinforced with the commercialization of desktop computers [51]. Versatility is concerned with the intermediary roles of ICT. Occasionally, the users employ ICTs for different purposes other than the intended ones. The Internet, for example, was invented initially for the exchange of information among experts with geographical constraints. But later, it has been the locus of virtual communities in which lay users pursue a lot more functions than just exchanging dry information.

Davis introduces two external values of ICT that are considered to be foremost when users choose technologies to adopt: perceived usefulness and ease of use. According to his Technology Acceptance Model (TAM), these two external values determine individual's behavioral intention to use a system as described in Figure 2.6 [52].

Later, with Venkatesh, he adds some interrelated social values such subjective norm and job relevance to affect people's decision to choose certain systems [53].

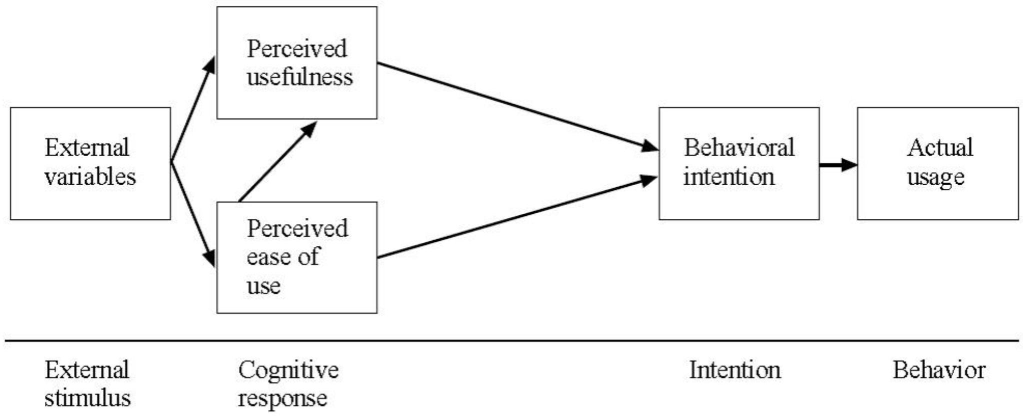

Figure 2.6. Technology Acceptance Model (TAM) [54, p.20]

Friedman and van de Poel also mention 12 values to be especially important in the domain of ICT [48, 55]. Among them, values like ownership and property, privacy, universal usability, informed consent, and identity are noticeable. Besides, an increasing number of recent debates and studies on information security suggests another external value of ICT.

Table 2.4. *12 Values of ICT [55]*

human welfare, ownership and property, privacy, freedom from bias, universal usability, trust, autonomy, informed consent, accountability, identity, calmness, environmental sustainability

2.3.1.4 Examples: Technologies for Social Values

Mesthene tells that technology can contribute to the social values either "by bringing some previously unattainable goal within the realm of choice" or "by making some values easier to implement than heretofore" [56, p.76]. Especially, ICT, with the internal values of accessibility and versatility, has the absolute strength in performing intermediary roles for the universal values of technology, that is, public interest and welfare.

Unlike U.S. or other developed countries, poor people in many underdeveloped countries cannot afford traditional bank services. So the movement of micro-finance such as Grameen Bank in Bangladesh made a global sensation. And there is a case that the mobile technology plays a major role in the movement. M-PESA, meaning “mobile cash”, is an innovative money transfer service via mobile phone text message for Kenyan unbanked population. A mobile phone user can send any amount of money directly to another mobile phone user with the service. The M-PESA account at Safaricom, the communication service provider, replaces the traditional bank account. Users can deposit or withdraw at any designated dealers in the neighborhood [57]. With M-PESA, those people in Kenya are now able to enjoy a nationwide financial system and, as a result, their economic welfare has been improved.

Mobile phone text message is also used for public health in Kenya. There was a clinical trial in which HIV infected adults were treated with the antiretroviral therapy (ART). During the treatment period, some of the patients received mobile phone text messages once a week from the medical clinics and were asked to respond with how they were doing with the therapy. For comparison, patients’ adherence to the therapy was significantly improved with the text messages [58].

2.3.2 Technology and Ethics

> The paradox of technology is that it is always praised for its functional utility, or always held in contempt because of its irritating neutrality, although it has never ceased to introduce a history of enfoldings, detours, drifts, openings and translations that abolish the idea of function as much as that of neutrality [59, p.255].

Technology is not a mere means to an end and its values are involved directly or indirectly with the formulation and changes of a society. Accordingly, engineering is seen as the application of related knowledge that has to be accompanied by the exercise of judgment of engineers [60, 61].

Heidegger argues that technology is "a mode of revealing", and the acts of revealing in modern society isolates ethical values from the genuine technology that originates in ancient *technē* [8, 12]. To Aristotle, *technē* connotes human expertise in production, thus, professional ethics is inherent in technology [11]. Intentional effort to redeem ethical values is required.

2.3.2.1 Ethics

> The *Ethics*, however, is a work of practical science. What that means is that the characteristic aim of studying ethics is not the acquisition of knowledge about action but action itself. [11, p.xxvii].

To some scholars, ethics is necessarily irrational and arbitrary due to "its impossible conceit of impartiality" [62, p.103]. Humans, however, still need ethics for a practical reason: to find a path to the correct decision out of conflicting values. Vesilind defines ethics as "the study of systematic methodologies which, when guided by individual moral values, can be useful in making value-laden decisions", where the moral values are "those standards or patterns of choice that guide us toward satisfaction, fulfillment or meaning" [63, pp.290-292]. For Gonzalez, ethics is related to the "justification of human activity" and morals is conceived as "the study of the actual way of behavior of individuals, groups and societies" [47, p.16].

There are two major types of modern ethical theories: deontology and consequentialism [64]. Deontology is basically about right and wrong. In deontological ethics, people are expected to abide by particular rules and fulfill obligations. Codes of ethics of many organizations are good instances of deontology [63, 64]. Consequentialism, on the other hand, focuses on the consequences of an action. This type is largely favored by utilitarian economists as they emphasize choices to obtain the greatest amount of utility [64]. Due to the emphases on results and goals, consequentialism takes the approach of teleology in a wider spectrum [65].

2.3.2.2 Ethics of Technology

Some scholars say that Aristotle's primary concern regarding to ethics is "human expertise rather than moral excellence" [11, p.xxxviii]. Such emphasis of being practical to ethical issues of technology implies the essence of technology. Along with the values, ethics of technology can also be analyzed upon the idea of duality of technology. That is, two types of ethical issues that are involved with either technical reason or social meanings can be identified. Congruently with the premise, Gonzalez names them "endogenous" and "exogenous" ethics of technology [47].

Endogenous ethics of technology deals with the internal values of technology. The value of efficiency, for example, is a matter of technical reason and initially immune to ethical considerations. But when humans take it for the creation of a technology, it enters an ethical setting [47]. There is the notion that engineers have to be aware of their engagement in ethics as early as they act on technical reason. Even though they stick to abstract knowledge and processes of engineering, their will is already influenced by the society that they inhabit.

Exogenous ethics of technology, on the one hand, deals with the external values of technology. When a technology is invented and introduced to a society, ethical considerations regarding the values of safety and health, for example, take place in addition to other legal and regulatory ones. The exogenous perspective of technology ethics appears to be diverse among societies as the criteria of acceptance of technological values depend on diverse historical, cultural, and/or religious backgrounds [47]. A technology can be ethically right to use in a society while it is not in another, like the automobile in Amish communities.

Mitcham calls for a new approaches to ethics of technology in two respects; He believes that the traditional analyses failed to adequately account for human will toward technology and the relationship between various human institutions and technology [9]. Mitcham's concept of a duty *plus respicere* refers to "a professional obligation to expand design thinking in order to take more aspects of reality into account" [66, 67, p.113]. Ihde's notion of the "designer fallacy" saying that "a designer can design into a technology, its purposes and uses" also implies an engineer's professional responsibility to the society that he or she inhabits [68, p.121]. Ethics of technology is in need of further deliberations that can incorporate the complex characteristics of technology itself as well as the interrelation between technology and society.

2.4 Technology Development

As early as the 1950s, a French sociologist Jacques Ellul described the relationship between technology and society as one-way influence in which technology dominates social life [69]. But, de Vries asserts that "technology is totally a human-originated phenomenon and therefore, humans have full control over it". He says that the problem is just people's indifference, neglect, and dependency on experts [15, p.77].

Based upon the words of Marcuse and other postmodern thinkers, Feenberg denies the single path of technical rationality for technological development and calls for philosophical reflection on social control [2, 43]. Here, social control means human intervention in technology. While Marx stresses that technology is thought to obviate the need for political ideas and practices, social values embodied in technologies denies the instrumentalism of technology [39]. Rather, technologies are "frameworks for ways of life" that are in desperate need of human intervention [16, p.14].

2.4.1 Drivers of Technology Development

Humans rely on technology to fulfill their practical needs of everyday life. Thus, the basic motive for technological reification or invention must be the desire to overcome the limitations of human faculty. Rapp introduces three main motives for humans to develop technology: basic human need to survive, pursuit of power and control, and extension of intellectual capacities [15, 17]. Obviously, humans have been inventing and crafting tools for the ultimate purpose of survival against harsh nature. Those tools are mainly aimed at amplifying physical abilities of humans. Then, with the accumulation of intellect and capital, the intermediary role of technology as means of power and control that support social systems and hegemony is emphasized. The emergence of sophisticated and complex modern technologies now blurs demarcation of means and ends of technology. Consequently, technology *per se* becomes a constituent of society, in which technology affects all [21].

Autonomous modern technologies diffused two deterministic beliefs in technology development: "technical necessity dictates the path of development, and that path is discovered through the pursuit of efficiency" [2, p.77]. Thus, technical rationality engaging with perfection and efficiency was believed to be the pure driver of technology development. But, Feenberg sees technology development as "the passage from abstract technical beginnings to concrete outcomes" and refuses the beliefs [40, p.44]:

> We have the same kind of problem in understanding the development of technology that Kuhn had with scientific development: progress is not reducible to a succession of rational choices because criteria of rationality are themselves in flux [8, p.37].

Instead, as Kuhn takes the notion of "paradigms", Feenberg introduced the concept of the technical codes that reflects social values [8, 70]. Within the context of contemporary societies, technology development is not driven only by efficiency or other technical reasons but also by various social motives, and occasionally, these social motives even require sacrifices of efficiency itself [49]. The fact constitutes under-deterministic character of contemporary technology. Unlikely to existing theory of modernity, efficiency does not solely account for the path of technology development, but many social forces play together in the path [8]. From this point, further analyses of technology development emerge.

Regarding instrumentality of technology, questions of technological means and ends still remain in the center of technological discourse especially in regard to humanistic and ethical issues. Regarding the concept of the "system" and the "lifeworld", in which technical rationality and social meanings of technology are juxtaposed, Habermas elucidates two spheres that technology connotes. Technical rationality enables a technology to function properly in technological ways, but at the same time, every technology has social meanings in the context of a society [44]. These two spheres are present again in Marcuse's concept of the "natural world of science" and the "lifeworld of experience" [43]. Feenberg calls them the "technical context of rationality" and the "lifeworld context of meaning" that are "radically different but essentially interlinked" [8, p.168].

Table 2.5. *Drivers of Technology Development*

Two Spheres of Technology	(Habermas) *System / Lifeworld* (Marcuse) *Natural World of Science / Lifeworld of Experience* (Feenberg) *Technical Context of Rationality /* *Lifeworld Context of Meaning*
Values of Technology	Internal Values / External Values

These two spheres of technology represent the duality of technology which has been introduced earlier in this study, and it seems certain that, in fact, both are strong drivers of technology development. The concept of two spheres of technology, or duality of technology, is also commensurate with two types of technological value: internal and external. Sometimes, technology develops in pursuit of internal values such as efficiency or/and technical perfection. At the same time, technology is also pursued for the sake of external values such as money and power. For both cases, apparently, human will to technology matters.

2.4.2 Human Will and Technology Development

> Human action is ultimately not determined by reason. There is something more fundamental, more basic, more real - namely the will. This is witnessed by the fact of incontinence; knowing what is good on a rational level, human beings nevertheless often do something else. The challenge of such a phenomenon is heightened by the manifestation of technology as volition. [9, p.266].

The presence of volition as a constituent of technology reification provides two strains of philosophy of technology, engineering and humanities, with a meaningful intersection. Even in engineering philosophy of technology, human will could not be excluded from forming a technology, but presides the creation and adoption of technology. By designers, engineers, and users, not only technical reason but also social values are employed in technology. In humanities philosophy of technology, the implications of human will in technology are even greater. They put more emphases on the interplay among humans, societies, and technologies.

Within ethical settings, Aristotle considers being incontinent as doing something wrong by desire although he or she knows that it is wrong [11]. Given the potency of contemporary technology, the problem of incontinence is a real threat to public interest. The threat becomes critical as technology advances. Thus, intelligent human control over technology is required. According to Mitcham, there are three preconditions for the full exercise of such intelligent control: "(1) knowing what we should do with technology, the end or goal toward which technological activity ought to be directed; (2) knowing the consequences of technological actions before the actual performance of such actions; and (3) acting on the basis of or in accord with both types of knowledge - in other words, translating intelligence into active volition" [9, p.260].

As mentioned earlier, the acts of intelligent control are to be based on rational and neutral decisions at least when engineers and designers stay within the internal values of technology. When the external values of technology intervenes as it happens all the time in real world, however, situation gets more complex. One instance of entangled values of technology and human manipulation can be found in technology entrepreneurship.

2.4.2.1 An Example: Technology Entrepreneurship

The economic potentiality stemming from the social values that are immanent in technologies makes technology a great opportunity for entrepreneurs. Technology entrepreneurship germinates in this potentiality. As the acts of spontaneous creation and economic utilization of technology, in a sense, technology entrepreneurship is a legitimate apparatus that rationalizes the pursuit of social goals through technology. Mitcham's analyses of technology as volition, that is, desire, motivation or movement, and consent, are all present in technology entrepreneurship. Furthermore, in fact, the acute tension and ambivalence between technology itself and its society, that is, the critical interaction between the two spheres of technology, can be found.

Since the 1960s, the shift in U.S. policy in favor of intellectual property and technological advancement expanded federal financial support for university research [71]. Although empirical evidence of direct effects on the increase in university entrepreneurial activity is inadequate, the Bayh-Dole Act of 1980 provided incentives for universities to enhance commercial exploitation of their technology [72]. Nowadays, universities with high technologies and young engineers and scientists are the foundation of technology entrepreneurship.

After reviewing 93 journal articles written about technology entrepreneurship since 1970, Bailetti proposed a definition of technology entrepreneurship:

> Technology entrepreneurship is an investment in a project that assembles and deploys specialized individuals and heterogeneous assets that are intricately related to advances in scientific and technological knowledge for the purpose of creating and capturing value for a firm [73, p.9].

Technology entrepreneurship is distinguished from other entrepreneurship types in its dependency toward scientific and technological change [73]. The opportunities are fostered through scientific or technological innovations in technology entrepreneurship. Certainly, technology itself constitutes the core of technology entrepreneurship [74].

The case of Silicon Valley and Route 128 shows the dependency well. With a torrent of military spending during the Cold War and ample supplies of talented manpower from distinguished universities around, both regions became the centers of electronics entrepreneurship. But out of serious setbacks due to changes of the international situation in the mid 1980s, they experienced different fates. Silicon Valley was based on the semiconductor, which were used in every electronic product while Route 128 on the minicomputer, which were relatively limited in use. Consequently, Silicon Valley could be able to enjoy the prosperity of today [75].

Here, technical perfection or advancement cannot solely explain the counter results of the two regions. The success or failure of a region cannot be attributed to a single element of technical reason or social values. Both spheres of technology or both types of internal and external values that technology connotes are intermingled and affect each other. Feenberg calls for the necessity to distinguish between “the objective knowledge of nature embodied in technologies and the form of its concrete social realization in this or that actual technological device” [40, p.34]. He asserts:

> The process of invention is not however purely technical: the abstract technical elements must be inserted into a context of social constraints which defines their functional environment and their relation to other technologies. Technologies, as developed ensembles of technical elements, are thus greater than the sum of their parts. They meet social criteria of purpose in the very selection and arrangement of the intrinsically neutral elements from which they are built up [40, p.34].

Apparently, Heidegger’s aspiration for “free relation to technology” is obviated in the field of technology entrepreneurship. No absolute “free will” exists, either. Technology entrepreneurs spare no effort to manipulate and control technology better than contenders. Success and failure largely depend on how good they are at discerning and realizing social values in technology as much as on how good they are at technology itself. Human will presides the creation of technology. By designers, engineers, and users, not only technical reason but also social values are employed in technology. And an entrepreneur orchestrates all the resources and processes to accomplish desirable “concrete” outcomes.

2.5 Technology and Society

Heretofore, the duality of technology that consists of the two spheres of technical reason and social meanings has been elucidated. According to scholars of the field, it is certain that technology stays in between theory and practice. Feenberg defines the relation of the two spheres of technology as "an entangled hierarchy" and argues that the two spheres must be understood together as a whole [8]. He concludes:

> Technical creation involves interaction between reason and experience. Knowledge of nature is required to make a working device. This is the element of technical activity we think of as rational. But the device must function in a social world, and the lessons of experience in that world influence design. [...] [There is] no inviolate god creating technology and society from the outside [8, pp.xvii-xxiii].

Since Aristotle's notion of practicality of technology, Dunne assumes that "the gulf which had separated theory and production for the Greeks is now eliminated" and says, "*praxis* is assimilated to technique" [24, p.175]. Unlike the ancient time in which scientists of *epistēmē* could be distinguished from craftsmen of *technē*, in the modern societies, technological values are permeated everywhere and even control the framework of scientific knowledge [24]. The intrusion of social meanings to technical reason or mingling of the two spheres of technology has been stimulated by modern technologies and defines the relationship between contemporary technology and society.

2.5.1 Being Aware of Value Conflict in Technology

The conflict between internal values such as effectiveness and efficiency is a usual phenomenon for engineers and can be solved or compromised within the sphere of technical reason. When the external values are associated with the conflict, however, situations become ethical. The first step for engineers to be responsible and ethical is to be aware of these situations happening in the real world.

The first commercially-produced bicycle, the hobby horse or "pedestrian accelerator", was popularized in England in the late 1860s. As shown in Figure 2.7, the earlier bicycle of that time had two wheels of similar sizes so that a rider could balance easily. Then, the bicycle was began to be used in racing sport and it brought innovations to bicycle design and technology [76]. To add more speed, the front wheel got bigger and the rear wheel smaller than the earlier ones as seen in Figure 2.8.

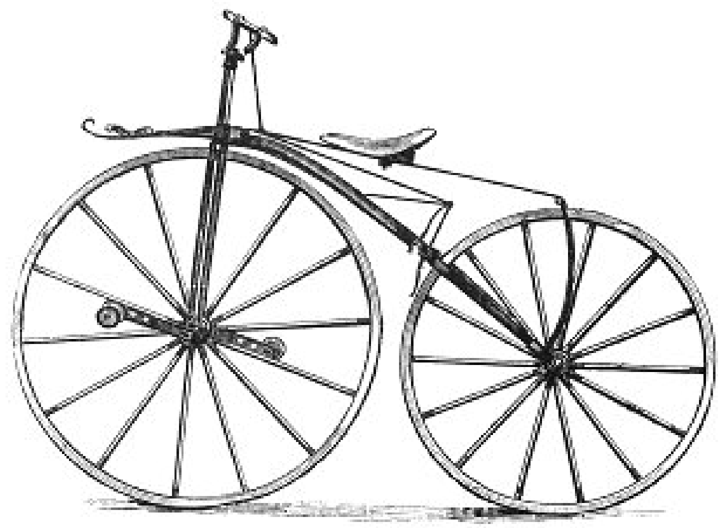

Figure 2.7. Earlier Bicycle (www.historywebsite.co.uk)

Figure 2.8. Racing Bicycle (thegraphicsfairy.com)

New materials other than wood and metal were employed. Instead, as a result, riding a bicycle became rather acrobatic activity requiring higher skill of balancing of professional athletes [76]. The question is what the bicycle is used for: racing or transportation? There is conflict between the values of speed to demonstrate athletic prowess and the safety to travel a long distance. The invention of bicycle rendered new values in a society and the social values steered the development of bicycle in that society.

Even today, for example, the conflict can be witnessed in sweatshops of some underdeveloped countries mainly in Asia and Central-South America. The young women hired by multi-national clothing companies work more hours and are paid a lot less money. Working conditions are often found to be harsh and dangerous. So the sweatshops are condemned by protesters in developed countries. Here, technology, in combinations of economic interests, is implicated with the violation of human welfare again. Meanwhile, engineers also need to be cautious about the ambivalence of a social phenomenon, especially when they decide someone else's welfare. On the contrary to one's paternalistic prejudication, these young women may prefer working at sweatshops to living in rural villages. Getting out of the extreme poverty could be closer to their welfare than having no chance [77, 78].

The case of surrogacy requires another contemplation of what is ethical. As technology advances, human ability to intervene in procreation increases. As a result, the surrogacy contract between different groups of people becomes prevalent in contemporary societies. If the welfare of both the rich who want babies and the poor who want financial rewards are fulfilled, can commercialization of childbirth be conceived as ethical? Or is surrogacy to be criticized for degrading women by instrumentalizing their bodies and for violating human dignity? Certainly, some values override others [4]. And of course, most values can change as societies change.

2.5.2 Policy Need in Technology

When we admit the fact that there are more than a single path of efficiency or technical rationality for technology development, and when we admit the duality of technology, neutrality of technology becomes a myth. Given the huge impact of technology on human societies, the absence of neutrality is attributed to the necessity for policy and regulation [21].

As Latour expresses technology as a “parliament of things”, contemporary technology, in certain aspects, became a source of domination, social struggles, and conflicts of interest [79]. Furthermore, technical prowess of our time resulting in cutting-edge technologies surpasses systematic readiness to govern them [56]. Winner views technology as “ways of building order in our world” [49, p.58]. Societies choose structures for technologies and reciprocally, technologies manipulate every corner of societies. He repeats a maxim running down the strain: “what matters is not technology itself, but the social or economic system in which it is embedded” [49, p.53]. Inherently, technology causes value conflicts. And the conflicts are to be solved by social means of agreement and decision. The reason that policy is needed in the field of technology lies in the fact.

Through the recent history of mankind, science and technology have been revered for enhanced productivity and material prosperity. Under the Capitalist system, its exploitation of the nature and human lives has been connived. Schuurman argues that politics is led by the ideology of science and technology, and as a result, leaves no room for the democratic consideration about technology development [1]. The public is excluded from the process of technological decision making and enforced unilaterally to adapt to new environments created by the decisions.

Heidegger condemns technological exploitation of the nature and humans. He believes that modern science and technology does not, of itself, ensure the enhancement of human justice or happiness, but can be instrumentalized for the domination of nature and human beings themselves [24]. Marcuse and Habermas emphasize the necessity of establishing the guidelines for technology development that are congruent with democracy [1]. Now, the discussion enters the milieu of public interest out of the relationship between technology and society.

2.6 Technology and Public Interest

> [The market] is a useful means of facilitating the flow of goods from producer to consumer; but it becomes a social evil when it is allowed to govern the technology of production [80, p.223].

Mesthene argues that the role of technology policy is to ensure equal distribution of the opportunities created by new technologies to all segments of population of the society [56]. *Public interest in technological perspectives is basically about opening the path and sharing the benefits of technology development*. If technology is governed only by a profit system, public good will be encroached [21].

Knowledge intensiveness and complexities of contemporary technologies render structural restrictions on the citizen participation in technology and perpetuation of social tendency toward dependency on experts. As technology advances, lay people confront higher barriers to technological affairs. But any decisions about technology eventually affect every member of a society and therefore, every member of a society has a right and duty to be directly involved in making those decisions [49]. Searching for the ways of governing technology and protecting public interest in the processes of technology development is necessary.

Harris defines the public in the aspects of technology as "any person or group vulnerable to the effects of technology, through lack of political or financial power, information, technical training or time for deliberation" [61, p.322]. And at least in the domain of technology, engineers are responsible for the public's vulnerability:

> When a class of experts becomes divorced from the public needs they are called upon to serve, then, says Dewey, their knowledge is private knowledge. As far as the public is concerned, this is no knowledge at all [81, pp.99-100].

One of the duties and privileges of engineer is to realize social values out of technical reason, that is, the external values of technology out of the internal values.

2.6.1 Aspirations for Self-Management

> I would hate to think that my work as a writer could not be done without a direct dependence on strip-mined coal. How could I write conscientiously against the rape of nature if I were, in the act of writing, implicated in the rape? For the reason, it matters to me that my writing, is done in the daytime, without electric light [82, p.282].

Modern technology consolidated technocracy in which social polarization was aggravated. To a certain extent, Heidegger's apprehension of exploitation of humanities and destruction of natural orders was realized. As a result, social movements denying materialization and utilization of such inviolate values for technocratic ends set by small groups of technical experts, politicians, and corporate behemoths held. Earlier, Feenberg introduced the French May Events of 1968 as an example [2];

As a series of civil unrest erupted with nationwide demonstrations, labor strikes, and occupation of universities and factories, the French May Events went out of control of the government. Termination of the regime of de Gaulle and diffusion of New Leftism in European and other western countries, however, were not only achievements of the movement. At the same time, the movement was led by students and workers to redeem their dignity. It was not just a socialist protest against capitalist control of the economy and nation, but a collective rejection of technocracy and administrative bureaucracy in which the public became a subject to be ruled passively by technical imperatives [2]. What people wanted was a society of self-management, through which they could redefine the idea of progress. They wanted the progress to be what they wanted it to be [2].

Heidegger's ideal of a "free relation to technology" advocates a non-addicted selective acceptance of a technology so that one can be free of its existence at any time. He warns that unconditional acceptance of modern technology will have people be subjugated to technology and exploited [12]. According to Thomson, the Amish people seem to be closest to the ideal. He praised the Amish people for realizing Heidegger's ideal by leaving their cellular phones in the outhouse overnight, for example [46]. The lesson that the Amish people implies here is the exertion of control over technology. They do not insist unconditional denial of modern technologies, but try to optimize technical functionality with their cultural values. They actively regulate the technologies to use as well as when, how, and why they use the technologies. The Amish people believe technology is value-laden and thus, can be a potential disruption to the prime values such as simplicity and humility of their culture and communities [83]. The Amish way to deal with technology is an action striving for technologically independent society, in which people can choose and manage their ways of living for themselves.

Again, in the center of the question lies technological neutrality. Those people who believe the neutrality hold instrumentality of technology and concede a society is immune to technologies that inhabit it. Rapp argues, however, modern technology with overwhelming power requires human control [17]. Mitcham also warns that uncontrolled power will bring a disaster. Technology is not neutral any more [9]. But in contrary to reality, the public is more likely to leave technological affairs in the hands of experts [2]. De Vries deplores that the problem is not human ability to control over technology but public indifference toward technological decisions [15]. It is time for public to destroy the old beliefs of technological development led and decided by engineering necessity and efficiency. Given the power and influence that modern technology bears to the lives of people, technology must be conceived as a social institution to democratize as well [2].

2.6.2 Citizen Participation and Democratization of Technology

> The modern world develops a technology increasingly alienated from everyday experience. This is an effect of capitalism that restricts control of design to a small dominant class and its technical servants. The alienation has the advantage of opening up vast new territories for exploitation and invention, but there is a corresponding loss of wisdom in the application of technological power [8, p.xvii].

Sandel calls for the active participation of the citizen to construct the society, which is "pertinent to human well-being" [4]. Technology is not an exception. Even for those who are opposed to such perspectives of technical determinism or technocracy, there is no doubt that technology is a major source of power and money. The reason that technology is to be involved with the citizen can be found here. But again, knowledge intensiveness and complexities of contemporary technology inevitably bring greater dependence on the experts and limited devices. And this is a critical impediment to the citizen's understanding and participation in technology [49, 56]. Then, how can it be resolved? The answer is simple: at least in regard to making technological decisions that may affect the society, experts have to share their knowledge and information with the public and the citizens have to request legitimate opportunities to be informed and participate in the process [21].

Unlike many experts of other domains, technology experts or engineers show a paucity of occupational exchanges with the public, and even seem to enjoy their own esoteric world of technical jargon. If technology experts are not open to the public, however, technology is likely to be steered by the demands of money and power, and the isolated community of experts is likely to be perverted, too. Eventually, not just the citizens but also the experts will be mutilated [8].

> Enlarging citizen participation promises to provide an adequate ways for (democratic) societies to cope with the effects of existing technologies and to improve mechanisms for anticipating and evaluating particular consequences of new technologies [84, p.248].

Those scholars who emphasizes citizen participation in technology or technological decision making are agreed on the idea of "democratization of technology". *Democratization of technology is about redeeming the social values of the public and put them back in technological orders and, thus, incorporating public interest into technology* [8]. Democracy is to empower legitimate participation of the citizens in constructing social structures and technology itself is a social structure [85]. Hence, technology is subject to be democratized and the citizens have to be given the legitimacy to manage their technologies for themselves. Democratization of technology can happen in various phases of technology development such as designing, adopting, using, and assessing. Some empirical examples can be found;

Famous Dutch Science Shops originated in the early 1970s. These Shops nested in universities and were operated by faculties and students with various scientific expertise to share their knowledge and intellectual properties with the public. The goals were "to reorient science toward the social needs of workers and disadvantaged groups" and to fight the interest of social behemoths [84, p.253].

The dispute over Minnesota's new power-line is often compared to the MacKenzie Valley Pipeline Inquiry. Both happened in the 1970s, these two socio-technological events epitomize how the process of technological decision making can be more democratic in a given structure of society. In Minnesota, U.S., the utility companies to construct new transmission lines across the state and farmers to protect their farmlands from any potential dangers could not reach an agreement. The state authorities and businessmen defined the crux of dispute as the health and safety effects of direct current power-line and confined the issue to scientific resolutions. Blaming the conflict on farmers' ignorance of science, they adduced some results of research and pushed ahead the construction. But the farmers and protesters condemned the decision as misusing science to confuse matters and lacking true understanding of the essence of the conflict, that is, the real life world of local farmers [86].

On the contrary, even in the context of the global "energy crisis", Tom Berger, the chair of the MacKenzie Valley Pipeline Inquiry of Canada, tried to understand both direct and indirect influences that the gas pipeline across northern territory would have on the ways of life of the region. He tried to weigh the testimony of both experts and lay people and encouraged understanding between non-indigenous and indigenous people. Public awareness and support formed and as a result, a ten-year moratorium on the construction was recommended [85, 87].

2.7 Summary

Chapter Two provided a brief summary of relevant literature that gave ideas on the discipline of technology, values and ethical issues of technology, the relationship between technology and society, and policy need in technology. Technology had been defined and the constituents of technology reification were introduced. Discipline of technology, consequently, could be seen as the field of study of technology, which, as being distinctive from that of science, mainly deals with, but not limited to, the reification of technology and the relationship between technology and society. Also, the concept of duality of technology, which consisted of the two spheres of technical reason and social meanings, was delineated to describe the relationship between technology and society as well as suggesting the momentum to deliver a new way of dealing with technology. The next chapter goes further about empirical measuring the related concepts and examining hypotheses.

CHAPTER 3. FRAMEWORK AND METHODOLOGY

Regarding methodology, the study proceeded forward two major goals that would lead to answers for the research questions: (1) figuring out the mechanism through which technology develops and (2) measuring the relationship between understanding of technology and will or attitude toward technology. These goals posited the assumptions that human intervention in technology, that is, participation in the process of technology and control over technology, is critical to direct technology toward public interest, and once the mechanism of technology development is described successfully, human intervention in the domain of technology can be executed in more efficient and effective ways. To be clear, the term "technology development" in this study refers to a socio-technological phenomenon that shows a series of technological events such as invention, adoption, diffusion, modification, transition, and even obsolescence in a society.

> Once we know that one kind of issue leads to changes in another, we can put mechanisms in place to deal with those changes. It is a precept - a working principle [10, p.11].

3.1 Structure of the Study

As mentioned earlier, the study bore two questions: (1) how technology can be developed toward public interest and (2) what is the relationship between understanding of technology and human attitude (will) toward technology. In response to the research questions, the study employed mixed methods of qualitative and quantitative approaches. According to the incompatibility thesis, combining qualitative and quantitative methods is inappropriate due to epistemological differences. Denzin, however, believes methodological eclecticism to be an essential characteristic of mixed methods research; Researchers can gain deeper understanding of a phenomenon by selecting and integrating appropriate techniques from multiple methods [88]. Pawson also considers an inquiry as "an amalgam of principle and practice" [89, p.55].

As shown in Table 3.1 below, a qualitative study was conducted based on the methods of grounded theory, phenomenology, and phronetic generalization to describe the mechanism of technology development. And a quantitative study was conducted as well with survey questionnaire for the other research question. As post-positivists emphasize, one major role of the researcher must be "promoting dialogue and engaging with diverse perspectives, often through the use of multiple methodologies" [10, p.10]. So was this study.

Table 3.1. *Structure of the Study*

Research Topic	Mechanism of Technology Development	Relationship between Understanding of Technology and Attitude toward Technology
Research Approach	Qualitative	Quantitative
Methods	Grounded Theory, Phenomenology, Phronetic Generalization	Survey Questionnaire

3.2 A Qualitative Approach: The Mechanism of Technology Development

The merit of a qualitative approach is to stay closer to the empirical world. For this study, a qualitative approach was to figure out the mechanism through which technology develops. Among a number of methods of the approach, grounded theory, phenomenology, and phronetic generalization were utilized. The rationale of employing a qualitative approach for the topic was the underlying assumption in technology: in the essence of technology, the duality of technical reason and social meanings exists. With the interplay between the two spheres of objectivity and subjectivity, technology including its development is an interwined and multifaceted matter that inhabit human societies. Therefore, increased depth of understanding of the practical cases and situations was preferred to the statistical generalizability.

When one focuses only on technological inherency of abstract knowledge and technical functionality, he or she would be able to follow the positivists' view that reality is fixed and truth is unique [90]. When one focuses on the relationship between technology and society, however, multiple versions of reality await. The research anticipated by the study was rather guided by the constructivists' view that people construct the multiple realities and those constructions affect their lives and interactions with others [91]. The mechanism of technology development was to be identified base on the ground of constructivsm that pursues the epistemological considerations focusing individual perception, then on the ground of constructionism that pursues the collective meanings of actual phenomena [91, 92].

Adhering to the constructivists' view, however, did not necessarily imply the denial of empirical truths in technology, but the acknowledgment of social influences in technology. As Thomas Kuhn argues that the paradigms of scientific knowledge are socially constructed, no knowledge can be abstract from human environment in any absolute sense [70]. In this regard, view points of the study were consistent with postmodernism and human beings became a major variable acting in the domain of technology.

3.2.1 Mixed Qualitative Methods

Upon those guidelines, methods of grounded theory, phenomenology, and phronetic generalization were borrowed. More details of each method and how it was employed to fit into the context of the study are followed;

3.2.1.1 Grounded Theory

> Once concepts are related through statements of relationship into an explanatory theoretical framework, the research findings move beyond conceptual ordering to theory. [...] A theory usually is more than a set of findings; it offers an explanation about phenomena [93, p.22].

Ultimately, the goal of this qualitative study was to build an explanation about how technology develops. Thus, the study was about the mechanism of technology development that consisted of various concepts subjugated to the essence of technology. Basically, qualitative grounded theory shares the constructivists' view on the world, but at the same time, the theory strives for objectivity to provide researchers with some standardization and rigor [91]. Glaser emphasizes that grounded theory, as a total methodological package, is "a specific methodology on how to get from systematically collecting data to producing a multivariate conceptual theory" [94, p.836]. Regarding to this contradiction of subjectivity and objectivity, Charmaz warns that "a constructivist grounded theory may remain at a more intuitive, impressionistic level than an objectivist approach" [95, p.526]. This study conceives the hindrance and, as Patton concludes, defines grounded theory as fundamentally incorporating objectivity while still maintaining constructivists' insight [91]. Grounded theory requires to be systematic and creative simultaneously:

> It is important to maintain a balance between the qualities of objectivity and sensitivity when doing analysis. Objectivity enables the researcher to have confidence that his or her findings are a reasonable, impartial representation of a problem under investigation, whereas sensitivity enables creativity and the discovery of new theory from data [93, p.53].

According to Patton, the focus of grounded theory is not on the content of theory, but on the process of generating theory. It takes the researcher to the results and findings that are closer to the empirical world [91]. Unlike deductive generation of theory based on *a priori* assumptions, grounded theory is rather *a posteriori*, in which concepts and underlying pattern are elicited out of data. Thus, the method is constantly modifiable as data accumulate and collection and analysis of data coincide [91, 94].

Grounded theory is an inductive methodology for sure, but Glaser admits that some deduction is present also. He argues that the deductive strategy of theoretical sampling can enhance systematic collection of data to compare. "Deductions for theoretical sampling fosters better sources of data, hence better grounded inductions. This is a pattern of reverberating induction fostering deduction and so forth," says Glaser [96, p.43].

Patton explains that there are three kinds of qualitative data collection: "(1) in-depth, open-ended interviews, (2) direct observation, and (3) written documents" [91, p.4]. Unlike many other qualitative inquiries, the study did not collect data by either interviews or observation. Instead, various written sources about practical and historical cases that were related to technologies were employed for constant comparison and analysis.

From the scholarship of critical theory of technology, theoretical concepts and statements were considered to facilitate collecting data as well as to understand and systematically interpret what was happening beyond what was seen in the domain of technology. At the same time, having a specific strain of literature to guide the inquiry was also worrisome as it could impose biases and stunt the advantage of grounded theory approach. To mitigate such worries, the inquiry stayed within practical cases and any existing concepts were reconsidered toward a new set of explanation.

Grounded theory proceeds with multiple works: data collection, constant comparative analysis, coding, memoing, sorting, theoretical outline, and writing, through which conceptualization of the data into categories and their properties, overall integration, and formalization of a substantive theory can be achieved out of ambiguity and confusion [96, 97]. Due to the aspect that this study was conducted with a preliminary literature review and specific research topics, it might not be fully complied with the methodology of grounded theory. However, strengths of grounded theory, that is, the freedom of conceptualization leading to a theory and methodological rigor rooted in systematic analysis of practical data enriched the study.

3.2.1.2 Phenomenology

> We must start from what is known. But things are known in two senses: known to us and known absolutely [11, p.6].

Among various phenomenological approaches, commonality lies in "a focus on exploring how human beings make sense of experience and transform experience into consciousness, both individually and as shared meaning" [91, p.104]. While grounded theory still maintains the attention to objectivity, subjectivity is mainly emphasized in phenomenology. According to Patton, there are two implications of the phenomenological perspective: the first one is knowing what people experience and how they interpret it while the other one is methodological [91]. Within the same context, the study was conducted with such a phenomenological perspective, but again, did not committed effort directly to relative techniques such as participant observation or in-depth interviewing that are normal in conducting phenomenological inquiries.

The mechanism of technology development in this study was to be built upon congruent theoretical achievements of various scholars and secondary data of practical cases were to be analyzed. Thereby, the scope and result of the study would not be confined to a person or small group of people. Though, the phenomenological perspective, inclusive of phenomenological philosophy and analysis, was important for the study to deal with people's experiences with the domain of technology and to discern the interplay between the two spheres of technology.

> One can employ a general phenomenological perspective to elucidate the importance of using methods that capture people's experience of the world without conducting a phenomenological study that focuses on the essence of shared experience [91, p.107].

3.2.1.3 Phronetic Generalization

Fischer asserts that "the social sciences, as empirical sciences of society, largely have failed" [98, p.129]. The notion here is about "usable knowledge". The major problem, Spicker says, is that the social sciences "generalize about the wrong sort of thing" [10, p.10]. The idea of phronetic generalization begins with acknowledging the failure of existing social sciences and eager for the pragmatic research. Due to the fallacy of causal explanation of social phenomena and the difficulties of direct application of social science to social policy, Gans argues that a policy oriented social science is needed [99].

Aristotle warns: The belief "that a set of true and universal principles is somewhere waiting to be found" could be an illusion [11, p.xxxi]. Habermas queries, "how can the promise of practical politics be redeemed without relinquishing, on the one hand, the rigor of scientific knowledge?" [24, p.173]. As long as the concern associates the life-world of human beings and incorporates social values, the wish to find an absolute principle or generalization could be a fancy illusion for social scientists. In this regard, phronetic generalization can be a reasonable alternative.

As *technē* corresponds to technology and *epistēmē* to science, Flyvbjerg calls for *phronēsis* in social science. In comparison to other kinds of knowledge such as *technē* and *epistēmē*, *phronēsis* usually refers to wisdom, prudence or judgment [10, 100]. Like Noel expresses the concern with the question, "What should I do in this situation?" [101], *phronēsis* is about "understanding the implications [of an action], and making the right choices" [10, p.11]. *Phronēsis* emphasizes flexible and practical judgment of action that can cope with uncertainty and variability of the real life-world [10, 102].

Feenberg stresses the importance of considering circumstantial differences even in rational procedures:

> But critical theorists [of technology] argue that rational, technically efficient procedures may differ greatly in different forms of society. The notion that rationality is socially relative makes sense only if one recognizes the extent to which rational procedures and practices embody social values and economic interests [40, p.20].

Likewise, Spicker argues that "the generalizations are about experience - about what happens - rather than about theoretical relationships", which emphasizes the circumstantial understanding of experience [10, p.14]. He introduces three characteristics of phronetic generalization; first, *phronēsis*, as to guide action, is approximate; second, *phronēsis*, as being understood in a specific context, is particular; third, phronetic generalization is done by "cross-referring (or triangulating) experiences from different sources, without eliminating inconvenient data" [10, p.15]. Phronetic generalization is similar to grounded theory in the aspect that it has to be tolerant of uncertainty and ambiguity.

3.2.2 Conduct of the Inquiry

The major components of qualitative research, Strauss and Corbin introduce, are the data, analytic and interpretive procedures, and written and verbal reports [6], and this inquiry complied with the components. While the inquiry followed the procedure of grounded theory developed mainly by Barney Glaser and Anselm Strauss, critical views from phenomenology and phronetic generalization were also reflected throughout the procedure, especially in analysis and coding.

Basically, the inquiry proceeded with a principle assumption: the mechanism through which technology develops can be described within concepts that can be interpreted with and subsumed under the duality of technology and critical theory of technology. Hence, as Glaser and Strauss note that the method of grounded theory can be employed for either verification or generation of a theory [103], the inquiry first began as an attempt to verify the existing theories of the duality of technology and Feenberg's instrumentalization.

3.2.2.1 Guiding Criteria

Accordingly, although this qualitative inquiry is inductive, decent previous scholarship of critical theory of technology was referred. As Strauss argues, the aspects of deductions permitted by propositions can steer data collection into a further induction [6]. To guide the inquiry to the way that was pertinent to related propositions and beliefs, some criteria could be set on the mechanism of technology development;

- The mechanism should not be confined to a particular technology, but should be able to embrace any technology in general.
- The mechanism should be vindicated with academic achievements of the field, especially the scholarship of critical theory of technology.

- The mechanism should be pertinent to the concept of duality of technology, especially the premise that social meanings as well as technical reason affect the way how technology develops.
- The mechanism should be able to describe the interactions between technology and society.
- The mechanism should be corroborated by practical cases of technology in social contexts.
- The mechanism should maintain theoretical flexibility that can incorporate circumstantial differences.
- Based on a qualitative approach, the mechanism pursues deeper understanding of underlying relationships or patterns in practice.

3.2.2.2 Procedures

> We like to think of grounded theory as a *transactional system*, a method of analysis that allows one to examine the interactive nature of events [6, p.159].

As mentioned previously, actual conduct of the inquiry conformed to the procedure of the method of grounded theory: data collection, analysis through constant comparison and coding, memoing and sorting, and writing up a theory.

Data collection was performed by theoretical conceptualization and sampling, which were constant back and forth considerations between deductive and inductive approaches. Conceptualization was built on the literature scrutinized in Chapter Two, specifically out of the critical theory of technology and the concepts of duality of technology. Through conceptualization, theoretical sampling became possible and samples were collected on the basis of proven theoretical relevance. With the term "proven theoretical relevance", Strauss and Corbin indicate certain concepts that are considered to be significant because "they are repeatedly present or notably absent" during comparisons of cases [6, p.177]. The literature provided theoretical sensitivity, which enriched awareness of the subtleties of the meaning of data. Theoretical sensitivity was a critical attribute to develop categories and their relationships out of phenomena, and also constituted the quality of grounded theory that could incorporate the insights and perspectives of the other methods of phenomenology and phronetic generalization.

Like other grounded theory studies, analysis of the data was performed by a technique called "coding". While emphasizing constant comparisons among concepts, categories, and also cases, there are three major types of coding: open coding, axial coding, and selective coding. During the process of open coding, the collected data was broken down, examined, compared, conceptualized, and categorized within each case. Attempts of labeling phenomena, naming categories, and developing corresponding properties and dimensions were made.

After open coding, connections were drawn among categories that were found in each case. This process of axial coding aimed to analyze and reconstruct the relationship among categories and their subcategories. The paradigm model shown in Table 3.2 had been utilized to enhance systematic understanding of the cases. With the paradigm model, multiple activities of analyzing categories such as the hypothetical relating of subcategories to a category, the verification of those hypotheses against actual data, and the further development of properties and dimensions of categories and subcategories were made simultaneously. Overall, as Strauss and Corbin emphasize, there was a "constant interplay between proposing and checking" [6, p.111].

The process of coding was completed with selective coding, in which the core categories were selected and their relationships were validated. At this phase of the inquiry, comparisons on the level of inter-cases were made. Categories, subcategories, and properties of all cases were compared together and building of the mechanism of technology development initiated. The techniques of memoing and sorting of grounded theory were employed through all types of data coding. In fact, while conducting the inquiry, ordinal distinction among phases or techniques were found to be vague. Rather - much like the inquiry itself went back and forth between deductive and inductive approaches - the inquiry stayed in any phase or ran any technique simultaneously along with necessity in striving for the mechanism of technology development.

Table 3.2. *The Paradigm Model [6, pp.96-99]*

(A) CAUSAL CONDITIONS:
Events, incidents, happenings that lead to the occurrence or development of a phenomenon.

↓

(B) PHENOMENON:
The central idea, event, happening, incident about which a set of actions or interactions are directed at managing, handling, or to which the set of actions is related.

↓

(C) CONTEXT:
The specific set of properties that pertain to a phenomenon; that is, the locations of events or incidents pertaining to a phenomenon along a dimensional range. Context represents the particular set of conditions within which the action/interactional strategies are taken.

↓

(D) INTERVENING CONDITIONS:
The structural conditions bearing on action/interactional strategies that pertain to a phenomenon. They facilitate or constrain the strategies taken within a specific context.

↓

(E) ACTION/INTERACTION:
Strategies devised to manage, handle, carry out, respond to a phenomenon under a specific set of perceived conditions.

↓

(F) CONSEQUENCES:
Outcomes or results of action and interaction.

3.2.3 Data Collection

Data collection in grounded theory begins with concepts. With concepts, one can continue to question and examine a phenomenon in the form of propositions. Propositions, in turn, guide data collection in deductive ways that eventually lead to further induction as well as testing of the propositions. [6]. Theoretical sensitivity can also be enhanced by *a priori* hypotheses. Thus, data collection of the inquiry required a preceding process of conceptualization.

3.2.3.1 Conceptualization

The principal assumption or hypothesis run through the inquiry was that the mechanism of technology development could be described within the concepts of duality of technology. Therefore, the anticipated mechanism of technology development that predicated upon the concepts of duality of technology had been built as shown in Figure 3.1. The duality of technology, as a core characteristic of technology, implied technological inherencies of technical reason and social meanings.

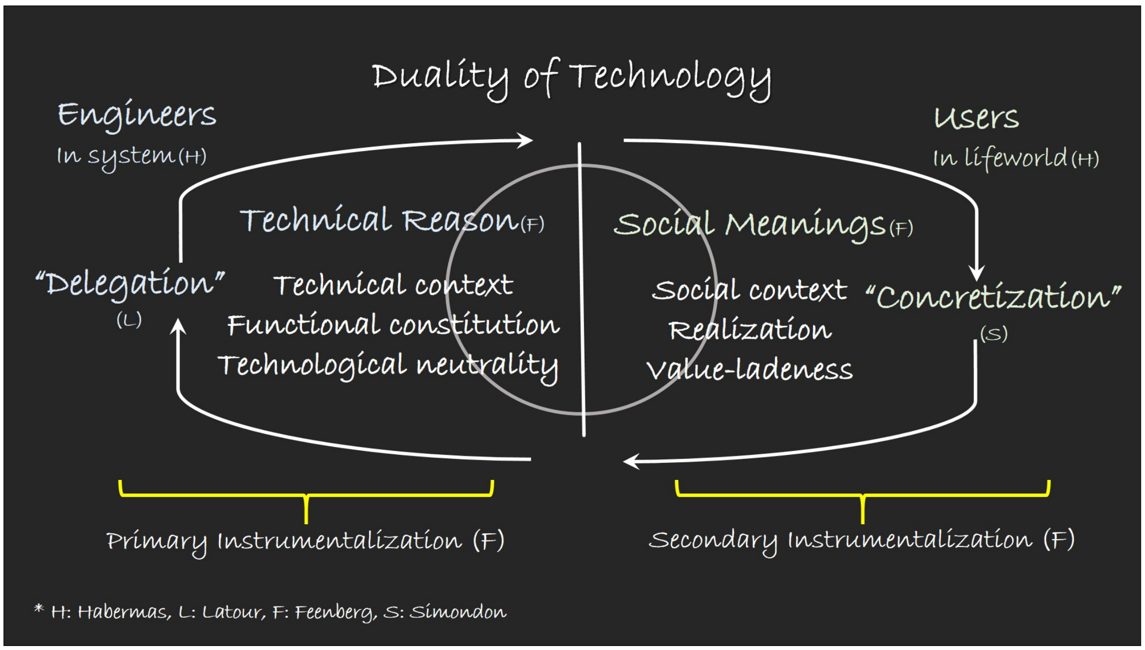

Figure 3.1. Theoretical Conceptualization for Sampling and Coding [2, 8]

The anterior phase of technology development was commensurate with Feenberg's "primary instrumentalization", where designers and engineers assign technical reason to technology. Levels of human knowledge, experience, and skill affect the completion of a technology [2, 8]. Concepts of technical context, functional constitution, and technological neutrality that were examined in the literature are subsumed under the concept of technical reason.

Engineers, as inventors and manufacturers, wield the potency within the process and technology reflects their will. Even during this process, however, the will is not the free will of engineers. To a certain extent, they are obliged to the society that they inhabit and the social meanings and values of the society are “delegated” to technology. The concept of delegation is introduced in Latour’s delegation theory. An automatic door closer, for example, implies a social norm to keep the door close and the designer assigned it to the device [104].

The posterior phase of technology development is commensurate with Feenberg’s “secondary instrumentalization”, where, in short, a technology is socialized and incorporated in a society. Here, society should not be identified with the market, but it represents broader contexts of human life world that are interlinked to each other. External values preside the phase and concepts of social context, realization, and value-ladeness are subsumed under the concept of social meanings. Feenberg introduces the concept of “technical codes” to describe the realization of a social interest or ideology in a way that is congruent with a technical specification [2, 8].

Unlike the other phase, users play major roles during the posterior phase. Lay users purchase, adopt, use, and assess technologies. Consequently, Simondon’s concept of “concretization” emerges to accommodate the responses of users in societies. Through this phenomenon of reconciling multiple interests in technology, users or the general population participate in the process of technology development [8]. Sometimes, unintentional and/or unanticipated social ramifications of new technologies are witnessed. Table 3.3 adumbrates the two phases of technology development that were drawn from the reviewed literature.

3.2.3.2 Theoretical Sampling

> Yes, to be sure grounded theory is an inductive methodology, but there is some deduction in grounded theory. Theoretical sampling is deductive. It is the carefully grounded deduction from an inducted category or hypotheses of where to go next for data to compare [96, p.43].

Unlike a quantitative inquiry in which sampling is supposed to be done in a way that can represent the entire population to be generalized, the concern in grounded theory

Table 3.3. *Anticipated Two Phases of Technology Development [2, 8]*

Anterior Phase	Posterior Phase
(Primary Instrumentalization)	(Secondary Instrumentalization)
Process of technical reason and functionality	Process of socializing
Domain of engineers / designers Technology is neutral. “Delegation” occurs.	Domian of users / general population Technology is value-laden. “Concretization” occurs.

is with “representativeness of concepts”. Based on theoretical relevance, sampling in grounded theory keeps looking for evidence of a significant presence or absence with the data. In principle, grounded theory does not pursue generalization but specification. Grounded theory aims to specify “the conditions under which our phenomena exist, the action/interaction that pertains to them, and the associated outcomes or consequences”. The theoretical formulation of the inquiry is expected to apply to certain situations and circumstances studied under the inquiry but to no others [6, p.191]. Within this context, grounded theory shares an emphasis of phronetic generalization, that is, circumstantial understanding of a phenomenon. If technical reason solely constitutes technology, and thus technology is neutral, a technological phenomenon should be generalized with a universal explanation. But technology is not neutral due to embodied social meanings, and circumstantial understanding becomes inevitable.

A set of secondary data had been collected for the inquiry. Historical events of technology documented in forms of journal articles and scholastic books had been gathered and analyzed. For a certain aspect, the criteria of selecting a sample case accommodated the perspective of social construction of technology (SCOT), developed by Bijker and Pinch, to ensure the presence of social meanings that associated technology. Among various interactions between technology and society witnessed in a case, various understandings of technology as well as involvement with technology of different groups of people could be discerned with interpretive flexibility. The process of theoretical sampling should be well planned but still with some degree of flexibility [6]. After all, the utmost importance lay on representativeness of related concepts, which was verified with evolving theoretical relevance.

The point at which a researcher can stop collecting data in grounded theory is called theoretical saturation. Generally, a grounded theory research pursues theoretical saturation of each category. Strauss and Corbin list the conditions of saturation: "(1) no new or relevant data seem to emerge regarding a category; (2) the category development is dense, insofar as all of the paradigm elements are accounted for, along with variation and process; (3) the relationships between categories are well established and validated" [6, p.188]. In fact, collection of data had been continued through all phases of the inquiry. After each case was collected and categories were drawn out of it, repetitive testing of the case and categories was done to decide the theoretical relevance. Consequently, sampling and analysis were in tandem so that analysis could guide the way of sampling. Cancellation and selection of a sample case happened all the time.

3.2.3.3 Sample Cases

Historical cases of technology collected and analyzed in the inquiry were summarized and documented chronologically in Appendices A to H. Those cases were intended to retain mundane to revolutionary technologies, from the seventeenth century's mechanical to the twentieth century's computer technology. Due to the availability of written documents upon mature investigation, cases were centered around technologies of the modern and postmodern eras, which were conceived as the most radical and dynamic periods in human history of technology. Stories borrowed for this study did not necessarily cover every fact or episode of subject technologies, but were edited in the ways that were pertinent to the study. Lastly, given that many of existing documents of technology written from the perspectives of STS study or SCOT are weighted toward social factors, a case maintaining balanced and unbiased description of technological factors was preferred. Table 3.4 shows the list of sample cases.

Table 3.4. *Sample Cases of Qualitative Inquiry (Appendices A to H)*

CASE 1: Mechanical Clocks
CASE 2: Early Bicycles
CASE 3: Motion Pictures
CASE 4: Mass Production
CASE 5: Fluorescent Lamps
CASE 6: The Télétel (Minitel) of France
CASE 7: Personal Computers
CASE 8: On-line Music

3.3 A Quantitative Approach: Human Attitude toward Technology

While the qualitative inquiry was grounded on the philosophical reflections of technology in a society, mainly endorsed by critical theory, the quantitative inquiry stayed within the discipline of technology and examined the relationship among the four constituents of technology reification that Mitcham identified, that is, technology as objects, knowledge, activities, and volition.

Taking a close look at each of the concepts made the existence of human volition noticeable. Technology as volition, as a constituent of reifying technology, could be differentiated from the others in the aspect that it was more about human mind and thus, subjective. While other concepts could be translated into how much you knew which stood for the objectivity of technology, volition could be translated into how you thought and felt which stood for human intentions in technology. Hence, the concepts of technology could be reorganized with the term, understanding of technology that incorporated technology as objects, knowledge, and activities collectively and referred to the level of people's understanding of technology and its discipline. Figure 3.2 shows the reorganized structure of the constituents of technology.

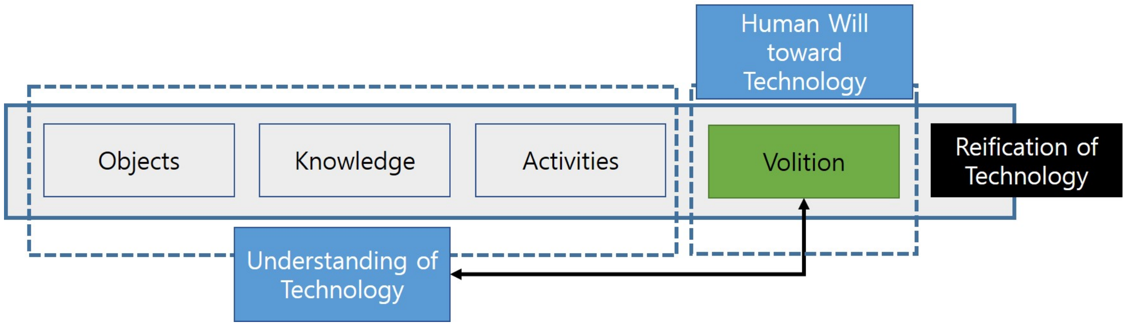

Figure 3.2. Reorganized Structure of the Constituents of Technology Reification

3.3.1 Hypothesis

The research question tested by a quantitative approach in this study was "the relationship between understanding of technology and human attitude (will) toward technology", in which the understanding of technology referred to the level of people's understanding of technology and its discipline while human attitude was about the notion that technology is part of human will and culture and, therefore, humans can control technology. When understanding of technology referred to understanding of technology as objects, knowledge, and activities, it could be hypothesized that those who have higher level of understanding of technology would more likely to have higher level of will to control technology.

The basic assumption of the inquiry was illustrated in Figure 3.3. When the understanding level of technology goes higher, the fulcrum shifts to right, and consequently, human will to control technology gets bigger with the same amount of human intervention. Technology as volition acts on both sides of the leverage; as human intervention on the left and as human will to control technology on the right.

3.3.2 Measurements

The summated rating scale format of Rensis Likert was used to measure the levels of understanding and human will for the vantages that Spector mentions; First, it can have

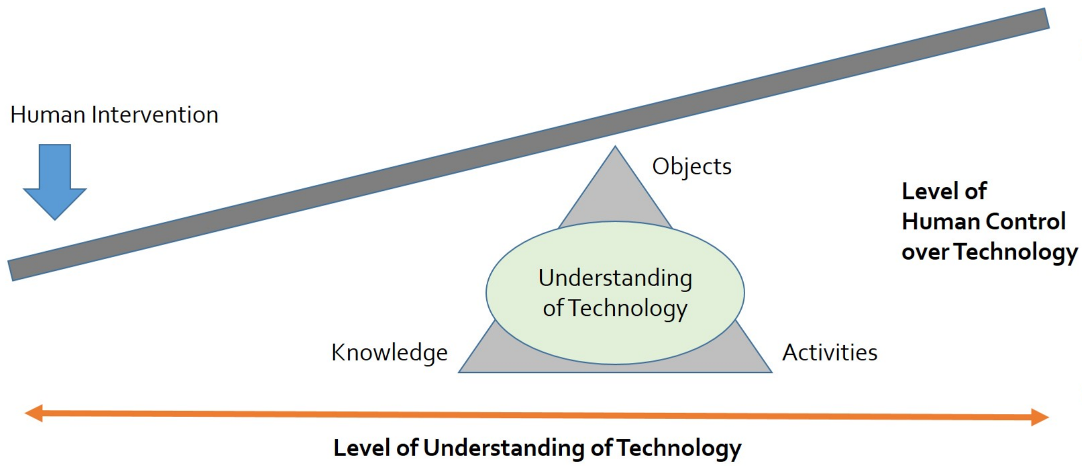

Figure 3.3. Basic Assumption of the Relationship between Understanding of Technology and Attitude toward Technology

good reliability and validity. Second, it is relatively easy to develop. Third, it is usually easy for respondents to complete the survey [105]. Specifically, except for the statements that stood for each concept, the Work Locus of Control Scale (WLCS) of Spector had been adopted. There were six bipolar response choices of agreement from "disagree very much" to "agree very much", and the values from one to six were given respectively: 1 = disagree very much, 2 = disagree moderately, 3 = disagree slightly, 4 = agree slightly, 5 = agree moderately, 6 = agree very much. As Blair et al. recommend, midpoint choices of "do not know" or "neutral" had been purposely excluded to prevent insensitive and dummy responses attenuating the relationship between variables [106].

The independent variable was "understanding of technology" and two to three measure items were drawn from each concept of technology as objects, knowledge, and activities that had been elucidated in Chapter Two. Dependent variable was "human attitude (will) toward technology" and multiple scale items were drawn mainly from the concept of technology as volition that also had been elucidated in Chapter Two. Control variables were age, gender, and academic affiliation; Age was asked in ranges from "19 or younger" to "40 or older", while gender and academic affiliation were in categories.

Generally, younger people are considered to be more familiar with technology than older people. Also, the field of technology has been a traditional domain of the men, thus, gender is highly expected to have the net of effects on both independent and dependent variables. Academic affiliation is expected to have implications on the level of understanding of technology. All the response choices were checked to be exhaustive and mutually exclusive.

Sixteen items in total, ten for independent and six for dependent variable, had been generated from conceptual definitions of the variables. To be sure that each scale item was conveying correct meaning of corresponding concept, a review by expert in the discipline of technology had been done. A nationwide survey conducted by Gallup under the auspices of International Technology Education Association (ITEA) also had been referred and as a result, a couple of elaborate statements that implied certain concepts better had been borrowed [107]. Related studies of Pupils' Attitudes Toward Technology (PATT) and Technology Acceptance Model (TAM) were also reviewed to check the comprehensibility of statements [52, 108]. Measure items for independent and dependent variables were as Tables 3.5 and 3.6.

Although already proven scale of WLCS was adopted, reliability and validity would be tested again as measuring statements had been replaced. Item analysis using Cronbach's alpha would be run to ensure the reliability and factor analysis would be performed for the validity. Items 1, 3, 5, 6 and 8 of independent variable and items 2 and 5 of dependent variable were reverse statements as they conveyed negative meanings to corresponding concepts and, accordingly, were coded in reverse order.

3.3.3 Data Collection

Data collection began with deciding survey population and how to sample the population followed by constructing the questionnaire. Basically, the process of data collection in this quantitative inquiry was conducted within the geographic and systematic boundaries of Purdue University, West Lafayette, while fully utilizing its resources.

Table 3.5. *Measure Items for Understanding of Technology (IV)*

1. Technology is present ONLY in the forms of physical object. (Objects)
2. Every technological object has its own purpose(s) of human need. (Objects)
3. In ancient times, technology did NOT exist. (Objects)

4. There is a distinctive kind of technological knowledge. (Knowledge)
5. Technology is a part of science. (Knowledge)
6. The knowledge of technology is the knowledge of nature. (Knowledge)
7. Technology is more about everyday life than scholarly research. (Knowledge)
8. The term "scientist" refers to a person who is good at technology. (Knowledge)

9. Human activities of designing is a part of technology. (Activities)
10. Technology develops upon human engagement. (Activities)

Table 3.6. *Measure Items for Attitude (Will) toward Technology (DV)*

1. Human will is a part of technology.
2. Technology determines how people live.
3. Technology is subject to be controlled by humans.
4. The results of the use of technology can be harmful to human beings.
5. Technology is value-free, thus, neutral.
6. I can decide whether to accept or deny a technology on my own.

3.3.3.1 Survey Population and Sampling

Target population of the survey consisted of the students of the Purdue Polytechnic Institute (College of Technology) and population units were individuals. Specifically, the population was restricted to the Polytechnic students who were enrolling in either undergraduate or graduate courses as of the spring semester of 2017. There were rationales that these boundaries of target population had been set: intimacy, proximity, and accessibility. First, since the study was about human attitude toward technology, intimacy with technology and proximity to technology might affect the dependent variable regardless of the independent variable, respondent's level of understanding technology. Hence, the possibility of bias was minimized by restricting the target population only to Polytechnic students who were assumed to be relatively homogeneous in the level of intimacy and proximity regarding technology. Second, as the survey would be conducted on-line using emails, high level of computer and Internet affiliation of the Polytechnic students was expected to contribute to higher response rate. Third, to proceed only with enrolling students would give the survey higher accessibility to the population as those students were physically bound to university and supposed to check their emails on a regular base.

According to "Data Digest", the official data collected and maintained by Purdue University, a total of 3,988 students were enrolling in the college as of the spring semester of 2017. As shown in Figure 3.4, there were 614 students in graduate level (376 men and 238 women) and 3,374 students in undergraduate level (2,744 men and 630 women). Although it was not be possible to obtain the whole directory of the Polytechnic students that was the target population, upon approval of the Institutional Review Board (IRB), the questionnaire had been emailed to the students by each department office and academic advisor. The respondents were asked to click a URL (Uniform Resource Locator) that led to the survey questionnaire produced electronically by the Purdue Qualtrics system. As the student data was tightly retained by the college and each department, problems of ineligibles, inaccuracies, omission, and duplication were relatively negligible. Because the survey questionnaire was to be distributed to every member of the population, sampling was not required. As a result, any possible bias stemming from sampling was canceled out.

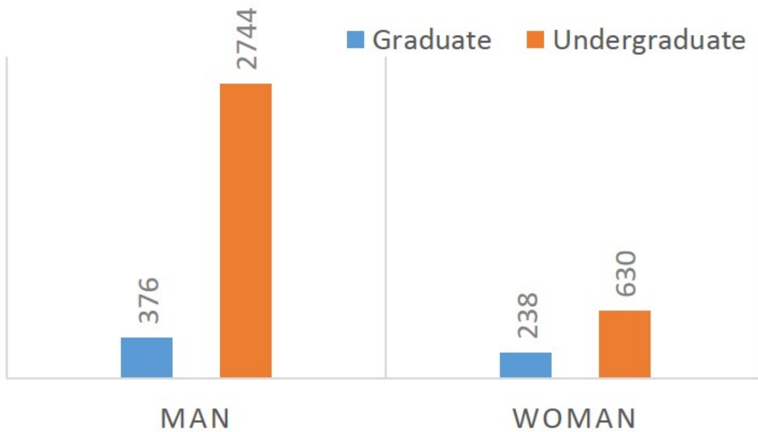

Figure 3.4. Survey Population

3.3.3.2 Survey Questionnaire

Purpose of the questionnaire was to operationalize the concepts of understanding of technology and attitude toward technology. To the initial questionnaire, two rounds of respondent debriefing had been performed. The first round was performed face-to-face with five Polytechnic graduate students including two men (in Ph.D. course) and three women (one in Ph.D. course and two in master's course) after they had finished answering the questionnaire. Debriefing was focused mainly on figuring out any comprehension problems due to highly conceptual characteristic of the scale. Fortunately, respondents' levels of comprehension turned to be fine enough as three of them answered the questions did not have difficulties in understanding at all, one "a little", and one "somewhat". The second round of debriefing had been performed with two male Polytechnic graduate students with the questionnaire revised upon former feedbacks. Additional rewording had been made to the scale items in consequence.

Some ancillary questions including the control variable, age, gender, and academic affiliations were followed the scale. Each control variable was considered to have effects on the relationship between the independent and dependent variables, and to have implications for further extension of the study.

Overall, the concept measurement scale (Section A) preceded ancillary questions (Section B) to induce more of respondent's attention to the former. For the first part of questionnaire, there were survey information and eligibility filtering questions. The information sheet answered for questions that respondents might have prior to participation, that was, purpose of research, procedures, duration of participation, risks, benefits, compensation, confidentiality, voluntariness, contact information, and informed consent. The filtering question asking if the respondent was a Polytechnic student was to block out the problem of ineligibles by stopping the respondent if she or he would choose "no". And also, there was one more question for eligibility filtering to cancel out the possibility of duplication problem. Since the survey was to be conducted on line using emails, repetitive distribution of questionnaire would be placed to ensure higher response rate and, on the one hand, it was possible to cause duplication of response. Again, to conduct the survey on-line, the electronic version of questionnaire was created, and it is believed to have contributed to enhanced control over filtering questions and easiness for respondents to complete the questionnaire. The survey questionnaire is attached in Appendix I.

3.3.3.3 Gathering Responses

The survey aimed to measure human perception regarding technology and, thus, dealt with human subjects. Accordingly, the IRB (Institutional Review Board) approval was pursued through the Purdue University Human Research Protection Program and obtained as in Appendix J.

After the IRB approval, the questionnaire was distributed to the population via email. The URL linked to the electronic questionnaire created and hosted by the Purdue Qualtrics system was sent with a participation request of Appendix K through department offices and academic advisors of the Purdue Polytechnic Institute (College of Technology). The questionnaire was created to be compatible with both computers and smartphones. With the system, response rate was being monitored in real-time and additional distributions of the participation request were asked of the departments with relatively low response rates.

Responses had been gathered and recorded by the system during the period from the 20th of February to the 7th of March. By the end of the period, a total of 387 responses had been collected with a response rate of 9.7 percent. As data collection was done for the whole population, there was not a chance of sampling bias, but the possibility of response bias still existed.

3.4 Summary

Chapter Three has explained the methodology adopted to this study. For the study, both qualitative and quantitative approaches were employed. Mixed methods of grounded theory, phenomenology, and phronetic generalization were elucidated for the qualitative inquiry. For the quantitative inquiry, a survey was conducted. A detailed description of survey population, sampling, building a questionnaire, conducting a survey, and collecting the data was present.

CHAPTER 4. ANALYSES AND RESULTS

As emphasized in Chapter Three, the goals of this study were to figure out the mechanism of technology development and the relationship between understanding of technology and attitude toward technology. These goals were set intentionally to lead the ways to (1) serious contemplation of the discipline of technology and (2) the attunement of technology toward public interest. Upon the framework and methodologies chosen for the study, collected data were analyzed and results of the inquiries are delineated in this chapter.

4.1 The Mechanism of Technology Development

If the mechanism through which a technology emerges and interplays with a society can be described successfully, technology policy will be able to be planned and executed in a more efficacious and systemized manner. Furthermore, proper interventions in the mechanism would lead to a technology that incorporates public interest.

As explained in Chapter Three, the first step of analyzing data was coding. Figuring out categories and their relationships through coding is described well in the following words of Glaser:

> As the researcher constantly codes, analyzes and theoretically samples for more data, the latent structural pattern of the substantive theory emerges. That is, one of the categories seems to be consistently related to many other categories and their properties over and over. This category soon becomes classified as the core category, because most other categories are related to it. This core category provides and becomes the latent structure of the theory as Lazarsfeld termed it. He showed it over and over by running core indexes against all other data and finding a preponderance of relationships with them in a pattern [96, p.26].

Again, all types of coding, that is, open, axial, and selective coding were employed simultaneously as well as techniques of memoing and sorting. With a social phenomenon, one could get a mere sense of what is going on beyond what is seen, but the sense comes in a state of being opaque. With categories and their properties and dimensions, a systematic analysis on a phenomenon is enabled and reification of the sense that one is given from a phenomenon becomes possible. While coding, the paradigm model was utilized for each case as shown in Appendix L. Among them was the following;

Table 4.1. *Example of the Paradigm Model Analysis - Mechanical Clocks*

(A) CAUSAL CONDITIONS:
- Flaws and inaccuracy of existing clocks.
 (sundials, water clocks, sandglasses, incense clocks)
- Religious piety and importance of timely prayer.

↓

(B) PHENOMENON:
- Introduction of mechanical clocks to society.

↓

(C) CONTEXT:
- Increased accuracy.
- Increased market demand for mechanical clocks.

↓

(D) INTERVENING CONDITIONS:
- Even more increased accuracy with the invention of pendulum clocks.
- Limits of handcraft manufacturing system.

↓

(E) ACTION/INTERACTION:
- Development of the precision machinery using machine tools.

↓

(F) CONSEQUENCES:
- Stimulating the inventions of various scientific instruments that led to the Renaissance.

As shown in Table 4.1 above, through the paradigm model analysis, a phenomenon of technology conveyed by the case could be located in a series of social and technological situations and events.

4.1.1 Core Categories of Technological Phenomena

While defining the relationships among those situations and events, major concepts were found to be categories. And the categories were accompanied by properties and dimensions. Categories, properties, and dimensions by each case were analyzed as shown in Appendix M. As a result, after repetitive comparisons among cases and their categories, core categories with proven theoretical relevance were found and could be named as “technical progress”, “economic values”, and “social inclinations”.

4.1.1.1 Technical Progress

Every case showed a phenomenon of introducing a new technology to society. And every new technology of the sample cases was preceded by relevant technical achievements; mechanical clocks were possible to be made upon advanced metalworking of the escapement; bicycles upon carriage- and blacksmith-shop technology; motion pictures upon phonographs; mass production upon interchangeable parts, sheet steel punch and press work, and assembly lines; fluorescent lamps upon incandescent lamps; the Télétel upon telecommunications technology; personal computers upon personal calculators and microprocessors; and on-line music upon digital recording and computer networks. Existing technology achieved by technical progress of earlier periods was found to be an important precondition of new technology.

Hughes introduces the term “reverse salients” to describe an area “where the growth of technology is seen as lagging”, and argues that efforts to correct reverse salients attribute to innumerable inventions and developments of technology [30, p.11]. Comparatively bigger size of digital sound before MPEG, for example, confined the medium of recording and sharing music to the CD. But with constraints of space and time that were inherent in the CD, like its predecessors, the cassette tape and the LP for analogue sound, the music industry could not satisfy social inclination toward the Internet and personal computing until the invention of digital sound compressing technology opened a new era of on-line music.

Modifications of a technology were often made to enhance functionality or efficiency. When people were enthusiastic about a new sport using a new technology, the high-wheel bicycle with enhanced speed was designed. As technology of the fluorescent lamp had matured, the high-efficiency daylight fluorescent lamp was manufactured. This was not the end of story. Those new technologies, in turn, appeared to be preconditions of following technologies. Contributions of mechanical clocks to precision machinery, for example, was considered to eventually have led the inventions of mechanical instruments such as telescopes and microscopes, which brought the new philosophies of scientific inquiry to Europe before the Renaissance.

Certainly, technical progress presided a phenomenon of any case and it constantly appeared throughout a phenomenon. Technology acted as a cause, an aggravator, a mitigator, or a solution of a phenomenon as progress was made. Various categories found in the process of open coding could be sorted into a core category of technical progress as shown in Table 4.2.

Table 4.2. *Categories Pertaining to Technical Progress*

Time Keeping, Machine Making, Application, Riding, Playing Movies, Product Quality, Telecommunications Network, Computing, Audio Compressing

4.1.1.2 Economic Values

Along with technical progress, presence of economic values such as marketing, management, maintenance, and service was constantly acknowledged. Those values were found even in the case of the Télétel of France that had been led by the government. The importance of economic values was observed to increase as a case was closer to the present era. Especially, the property of profitability along with market size appeared to be pervasive.

For numerous cases, economic values motivated technical progress; the profitability of racing bicycles based on social popularity intrigued high-wheel designs.

The high cost of constructing and maintaining national telecommunications infrastructure pushed introduction of new services utilizing the infrastructure. Economic goal of maximizing profits with maximized productivity and minimized production cost was achieved with mass production. Profitability of personal computing attributed to increasing demand of individuals let companies develop personal computers. Meanwhile, the fact that religious piety, instead of an economic one, was a precondition for mechanical clocks was noticeable. Religious piety must have been just as important in the European Middle Ages as economic values in contemporary capitalist society.

Likewise, a technology itself was likely to involve elements of economic enhancement; the high-efficiency daylight fluorescent lamp was advertised as being "three to two hundred times as much light for the same wattage" comparing its predecessor, the fluorescent tint lighting lamp, and as being "most economical" to use. Research on compressing audio data began to find a technological solution to broadcast with less bandwidth under the scarcity of available frequencies.

Also, many of the intervening conditions to a new technology were attributed to economic values; an increase of market competition among producers was usual after successful commercialization of a new technology, as clearly shown in the cases of motion pictures and fluorescent lamps. Modifications of technology were required to respond to the changes in market as a technology was not evaluated solely upon the degree of technical functionality or perfection, but together or even more with marketability. Sometimes, technology was directed to the way in which economic values of certain groups could be secured. The high-intensity daylight fluorescent lamp was a choice of the Mazda companies and the utilities to secure their market share and profits against a new competitor, Hygrade Sylvania. Neither technical context nor market demand was responsible for the change. Those categories that could be sorted into a core category of economic values were shown in Table 4.3.

Table 4.3. *Categories Pertaining to Economic Values*

Marketing, Management, Maintenance, Service

4.1.1.3 Social Inclinations

There were several categories found not to belong to either technical progress or economic values: sporting, filming contents, community resource, and on-line network. They were rather infrastructure or environment in which technologies and economic values germinated. Popular sporting events employed bicycles as a novel means of a racing sport. Success or failure of the motion picture industry did not depend on advanced instruments but on filming contents in which famous celebrities acted on diverse culture. One of the critical factors that made personal computers possible was said to be the spontaneous activities of user groups. Invention of the digital audio compressing technology was mainly due to the social and technological environment in which people were enjoying personal computing and interactions through the Internet. In case of the Télétel, there was a strong political drive to overcome national concern of falling behind in information technology.

Those categories were not involved directly with achieving technical progress or realizing economic values. Rather, they were certain kinds of social inclination that could be interpreted as a trend of the time. The fact that those categories were also the historical events that attributed many parts to social and technological aspects was not deniable. At least in each phenomenon of the sample cases, however, they could be distinguished from the other core categories. Consequently, the third core category was found to be social inclinations that contained such categories shown in Table 4.4.

Table 4.4. *Categories Pertaining to Social Inclinations*

Sporting, Filming Contents, Community Resource, On-line Network

4.1.2 The Paradigm Model of Technology

As Feenberg implies with the concept of "technical codes", both spheres of technical reason and social meanings of the duality of technology could be inferred from core categories of technical progress, economic values, and social inclinations; Technical progress was commensurate much with technical reason and the others with social meanings. Those core categories interacted consistently throughout phenomena. One became a cause of others and then, was caused by others. Technical progress emerged out of economic values or vice versa. Social inclinations sometimes accounted for technical progress or economic values. Economic values created by technical progress eventually triggered another technical progress. The core categories were intertwined with multilateral relations. Upon the paradigm model analyses on the sample cases and core categories drawn out of them, the paradigm model of technology could be proposed as shown in Table 4.5.

Table 4.5. *The Paradigm Model of Technology*

(A) CAUSAL CONDITIONS:
- Technical progress.
- Social demand (mostly, economic values).

↓

(B) PHENOMENON:
- Introduction of a new technology to society.

↓

(C) CONTEXT:
- Increased technical ingenuity.
- Increased social satisfaction.

↓

(D) INTERVENING CONDITIONS:
- Social responses to the technology.

↓

(E) ACTION/INTERACTION:
- Modifications of technology to cope with social responses. (technical or/and social)

↓

(F) CONSEQUENCES:
- Transition to another phenomenon of technology.

Around a central phenomenon, multiple interactions among core categories were found. A new technology equipped with increased technical ingenuity or/and social satisfaction was invented out of core categories. Then, the technology was embraced by various social responses and modifications, either technical or social, of the technology were made to cope with social responses. During these interactions of technology and society, technology was seen to evolve or develop into another technology. Eventually, the phenomenon was succeeded by another phenomenon of technology.

The idea of "technological paradigm" is considered to be an analogical extension of the scientific paradigm of Thomas Kuhn in terms of that "particular technical achievements have played a crucial role as exemplars, as models for future development" [30, p.9]. Technology stays within a paradigm and its development is made out of the paradigm. MacKenzie and Wajcman argue that the paradigm of technology is different from technical trajectory that simply follows an internal logic [30]. Various social values and demands such as economic values and social inclinations as shown in Table 4.5 interact with technological trajectory. The discrepancy between technological paradigm and technological trajectory is attributed to the fact that technology *per se* is a social artifact. And the fact accounts for the presence of economic values and social inclinations as core categories with technical progress.

4.1.3 The Mechanism of Technology Development

> It is important to understand that as your theory evolves, you can incorporate seemingly relevant elements of previous theories, but only as they prove themselves to be pertinent to the data gathered in your study [6, p.50]

As mentioned earlier in Chapter Three, the inquiry first began as an attempt to verify the existing theories of the duality of technology and Feenberg's instrumentalization with the method of grounded theory. And as proved with the analyses so far, the concepts of duality of technology, that is, technical reason and social meanings, were found to constitute technological phenomena in the forms of core categories of technical progress, economic values, and social inclinations. Likewise, "delegations" of social values to technology were witnessed in transitions of existing technology to new ones. Technologies were also "concretized" in response to the social demand. The elements of the duality of technology and Feenberg's instrumentalization were verified by data of the sample cases. But at the same time, the elements were not sufficient to explain the entire mechanism of technology development and theoretical extension was inevitable.

The mechanism of technology development described with core categories and concepts corroborated by the sample cases could be drawn based on the paradigm model of technology as shown in Figure 4.1. The duality of technology presides over shaded area on the left with technical progress and social demand, which stands for economic values and social inclinations. Social responses and modifications of a technology lead the way to another round of the mechanism. The phenomena of concretization and delegation happen through the mechanism as the outcomes of interactions between technology and society. A technology reaches its transition point through concretization, and the point is succeeded by a new technology through delegation. On the bottom line, the mechanism incorporates the phases of technology development: invention, adoption, diffusion, modification, transition, and obsolescence.

The mechanism of technology development turned out to be a concatenation of the interactions between technical progress and social demand. Apparently, repetitions of the mechanism will constitute technological paradigms. Then, how can technology be driven toward public interest? Technology that is pertinent to public interest will be possible if a social inclination toward public interest can be built and applied to the mechanism as social demand. Not surprisingly in capitalist societies of today, economic values rather than social inclinations worked as social demand in the mechanism for most of the sample cases studied in this inquiry. A few exceptions were found in the cases of mechanical clocks and the Télétel; Mechanical clocks were known to be invented out of religious piety and importance of praying on time. The reform of the national telecommunications infrastructure of France were led by a strong political drive.

A technology that is driven by the state concerning development is military technology. For military technology, economic values are abstained and the social value of national security is emphasized. The emphasis becomes a social inclination to work in the mechanism of technology development. Certainly, economic values are present also in the field of military technology, but those values are created by the state. Military technology

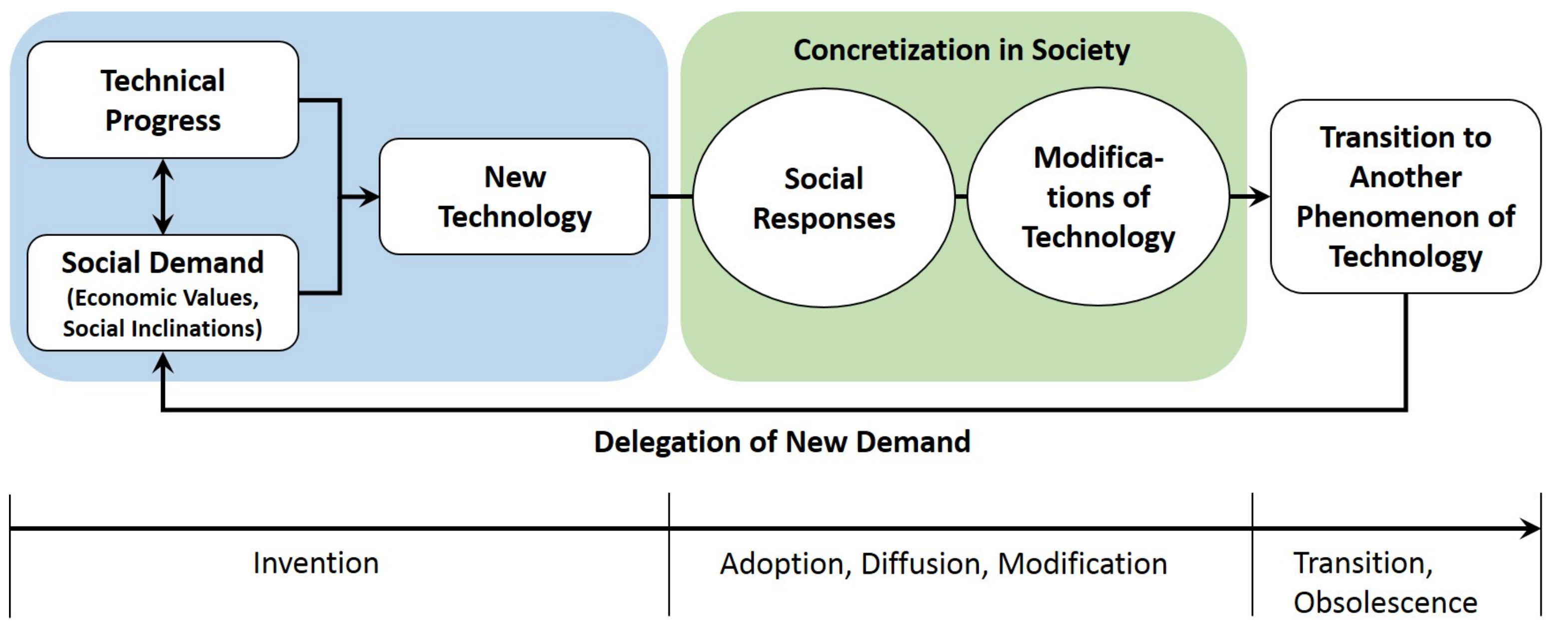

Figure 4.1. The Mechanism of Technology Development

suggests an analogy to public interest in technology. The state can shape a social inclination toward public interest and intervene in the mechanism of technology development. As seen in the case of personal computers, such an intervention could be accelerated by the potency of the collective actions of citizens. If successful, technology will incorporate the social value of public interest and the technological paradigm will embrace it.

4.2 Human Attitude toward Technology

Analyses on survey responses were conducted along with three major steps; first, the demographics of respondents were taken into account; second, the respondents' perception of technology was analyzed with each scale item. The perception of technology refers how the respondents understand technology and its discipline, and where they stand on technology; third and finally, the relationship between two variables of the perception, that is, understanding of technology (IV) and attitude toward technology (DV), was examined to verify the hypothesis: "those who have higher level of understanding of technology would more likely to have higher level of will to control technology".

4.2.1 Demographics of Respondents

The survey has four demographic questions asking age, gender, and two types of academic affiliation. The demographics of 387 respondents were as the following;

Age groups of '19 or younger' and '20-24' shared more than 70 percent of the respondents. Given that about 85 percent of the population was in undergraduate level, students of those age groups were considered to show comparatively low response rate. Women appeared to have higher response rate comparing to their counterpart by sharing one-third of the respondents. In the population, women represented less than 22 percent.

	Frequency	Percent	Cumulative Percent
19 or younger	59	15.2	15.2
20-24	229	59.2	74.4
25-29	39	10.1	84.5
30-39	44	11.4	95.9
40 or older	16	4.1	100.0
Total	387	100.0	

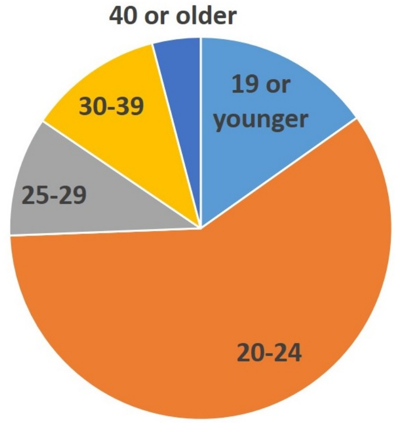

Figure 4.2. Demographics by Age

	Frequency	Percent	Cumulative Percent
Man	258	66.7	66.7
Woman	129	33.3	100.0
Total	387	100.0	

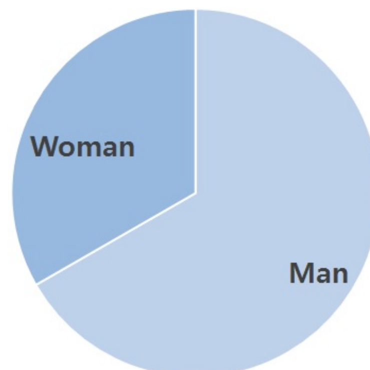

Figure 4.3. Demographics by Gender

	Frequency	Percent	Cumulative Percent
Freshman	45	11.6	11.6
Sophomore	58	15.0	26.6
Junior	84	21.7	48.3
Senior	84	21.7	70.0
Master's student	66	17.1	87.1
Ph.D. student	50	12.9	100.0
Total	387	100.0	

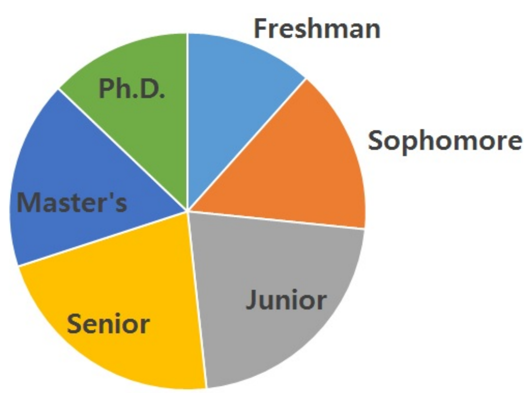

Figure 4.4. Demographics by Academic Affiliation

	Frequency	Percent	Cumulative Percent
Aviation and Transportation Technology	5	1.3	1.3
Computer and Information Technology	141	36.4	37.7
Computer Graphics Technology	35	9.0	46.8
Construction Management Technology	65	16.8	63.6
Engineering Technology	82	21.2	84.8
Technology Leadership & Innovation	57	14.7	99.5
Transdisciplinary Studies	2	.5	100.0
Total	387	100.0	

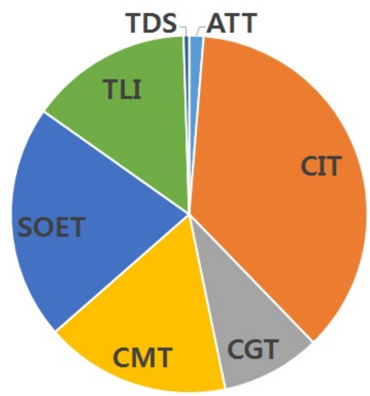

Figure 4.5. Demographics by Department

As anticipated with the age distribution, 70 percent of the respondents was in undergraduate level. Again, given the proportion in population, graduate students appeared to have higher response rate. The number of respondents at the department of Computer and Information Technology was bigger than any numbers of the rest. Departments of Aviation and Transportation Technology and Transdisciplinary Studies shared negligible proportions.

4.2.2 Respondents' Perception of Technology

As mentioned in Chapter Three, there were sixteen scale items for the survey: ten for the independent variable and six for the dependent variable. The scale consisted of four subscales that implied each mode of technology reification, that is, technology as objects, knowledge, activities, and volition. Response analyses were made with subscales for technology as objects, knowledge, and activities to discern respondents' understanding of technology and its discipline (IV), and for technology as volition to discern respondents' attitude toward technology (DV).

4.2.2.1 Understanding of Technology and its Discipline

The first three items (Figures 4.6–4.8) implied the concept of technology as objects, which was relatively typical and familiar. Responses for all items appeared to be much congruent with the concept. More than 82 percent conceived that technology could be intangible, and even more respondents acknowledged teleologic perspective of technological presence for fulfilling human need. Most of the respondents agreed that technology did exist in ancient times. The common misconception of technology that people come up with high-tech material objects when they are asked about technology was not inferred from the respondents.

	Frequency	Percent	Cumulative Percent
Disagree very much	156	40.3	40.3
Disagree moderately	107	27.6	68.0
Disagree slightly	58	15.0	82.9
Agree slightly	39	10.1	93.0
Agree moderately	22	5.7	98.7
Agree very much	5	1.3	100.0
Total	387	100.0	

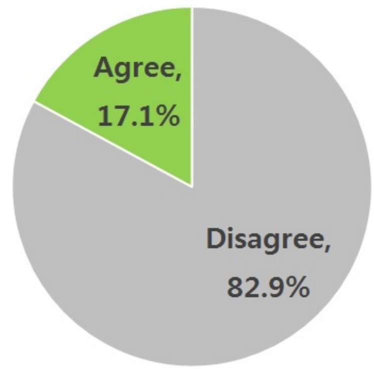

Figure 4.6. A1. Technology is present ONLY in the forms of physical objects.

	Frequency	Percent	Cumulative Percent
Disagree very much	9	2.3	2.3
Disagree moderately	25	6.5	8.8
Disagree slightly	22	5.7	14.5
Agree slightly	97	25.1	39.5
Agree moderately	138	35.7	75.2
Agree very much	96	24.8	100.0
Total	387	100.0	

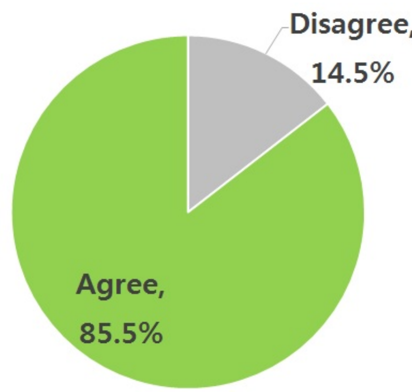

Figure 4.7. A2. Every technological objects has its own purpose(s) of human need.

	Frequency	Percent	Cumulative Percent
Disagree very much	265	68.5	68.5
Disagree moderately	70	18.1	86.6
Disagree slightly	30	7.8	94.3
Agree slightly	9	2.3	96.6
Agree moderately	8	2.1	98.7
Agree very much	5	1.3	100.0
Total	387	100.0	

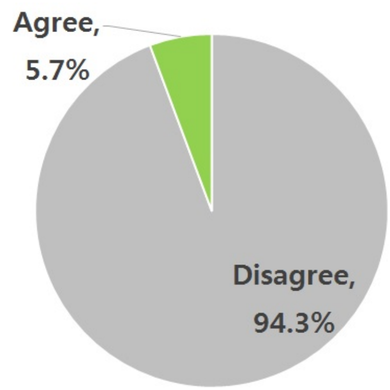

Figure 4.8. A3. In ancient times, technology did NOT exist.

The next five items (Figures 4.9–4.13) were to measure respondents' understanding of technology as knowledge that referred mainly to the idea that technology was a discipline with a distinct kind of knowledge, which especially could be distinguished from knowledge of science. More than 70 percent admitted the presence of technological knowledge as a distinctive kind. About 64 percent placed emphasis on technological practicality and about 80 percent answered that technology was different from the domain of scientists.

But responses for items 5 and 6 were quite provocative and paradoxical. Most respondents did not have a clear distinction between technology and science by saying that technology was a part of science. Furthermore, about 70 percent believed that technology was the knowledge of nature. Technology was perceived to have a distinctive kind of knowledge and to be practical, but still to be a part of science pursuing the knowledge of nature. Even though the respondents were all students of technology, they were having a hard time positioning the domain of technology. Technology still seemed to be a mere part of science with more emphasis on practical purpose in everyday life, which was concurred with the term, "applied science". Though, further investigation with multiple scale items would be required to decide whether the respondents implied subordination of technology to science or just deep relationship between the two by agreeing the item statement, "technology is a part of science". Also, responses to item 6 are possible to have been influenced by common perception of the term, 'knowledge', which has a strong implication of *physis*, the nature.

	Frequency	Percent	Cumulative Percent
Disagree very much	14	3.6	3.6
Disagree moderately	29	7.5	11.1
Disagree slightly	68	17.6	28.7
Agree slightly	127	32.8	61.5
Agree moderately	120	31.0	92.5
Agree very much	29	7.5	100.0
Total	387	100.0	

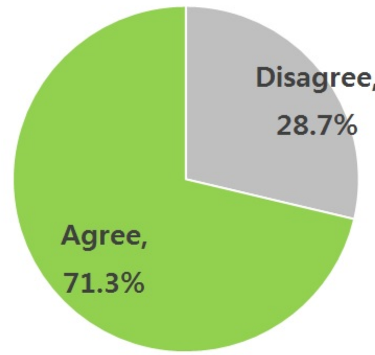

Figure 4.9. A4. There is a distinctive kind of technological knowledge.

	Frequency	Percent	Cumulative Percent
Disagree very much	4	1.0	1.0
Disagree moderately	7	1.8	2.8
Disagree slightly	16	4.1	7.0
Agree slightly	55	14.2	21.2
Agree moderately	135	34.9	56.1
Agree very much	170	43.9	100.0
Total	387	100.0	

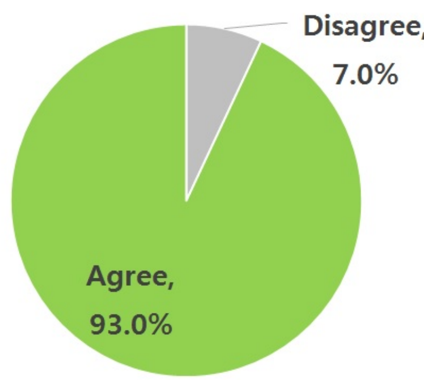

Figure 4.10. A5. Technology is a part of science.

	Frequency	Percent	Cumulative Percent
Disagree very much	8	2.1	2.1
Disagree moderately	42	10.9	12.9
Disagree slightly	72	18.6	31.5
Agree slightly	130	33.6	65.1
Agree moderately	96	24.8	89.9
Agree very much	39	10.1	100.0
Total	387	100.0	

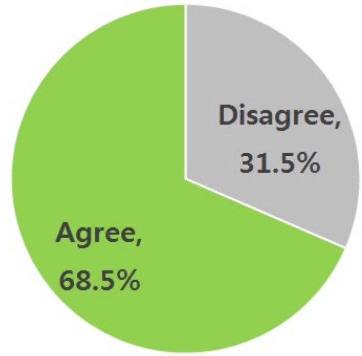

Figure 4.11. A6. The knowledge of technology is the knowledge of nature.

	Frequency	Percent	Cumulative Percent
Disagree very much	15	3.9	3.9
Disagree moderately	49	12.7	16.5
Disagree slightly	76	19.6	36.2
Agree slightly	88	22.7	58.9
Agree moderately	110	28.4	87.3
Agree very much	49	12.7	100.0
Total	387	100.0	

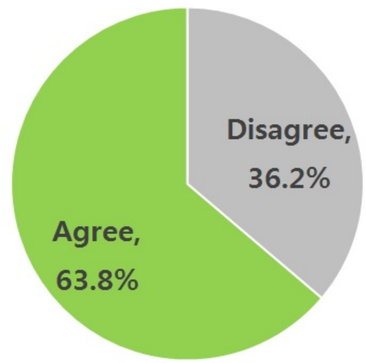

Figure 4.12. A7. Technology is more about everyday life than scholarly research.

	Frequency	Percent	Cumulative Percent
Disagree very much	68	17.6	17.6
Disagree moderately	128	33.1	50.6
Disagree slightly	112	28.9	79.6
Agree slightly	56	14.5	94.1
Agree moderately	15	3.9	97.9
Agree very much	8	2.1	100.0
Total	387	100.0	

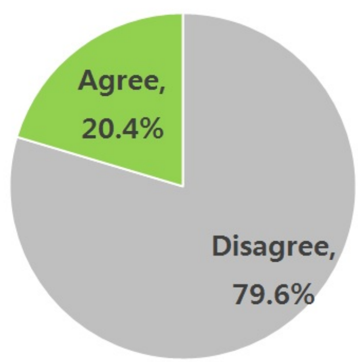

Figure 4.13. A8. The term “scientist” refers to a person who is good at technology.

Items 9 and 10 (Figures 4.14–4.15) were asking about technology as activities. More than 90 percent of the respondents accepted activities of design as a part of technology and believed human engagement to be a constituent of technology development. By maintaining the idea of human activities in technology reification, respondents appeared to have a sense of technological activities or *poiēsis* pursuing *technē* in comparison to scientific activities pursuing *epistēmē*.

	Frequency	Percent	Cumulative Percent
Disagree very much	1	.3	.3
Disagree moderately	12	3.1	3.4
Disagree slightly	17	4.4	7.8
Agree slightly	110	28.5	36.3
Agree moderately	157	40.7	76.9
Agree very much	89	23.1	100.0
Total	386	100.0	

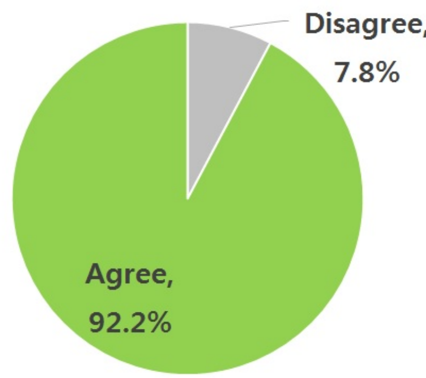

Figure 4.14. A9. Human activities of designing is a part of technology.

	Frequency	Percent	Cumulative Percent
Disagree very much	2	.5	.5
Disagree moderately	11	2.8	3.4
Disagree slightly	16	4.1	7.5
Agree slightly	69	17.8	25.3
Agree moderately	172	44.4	69.8
Agree very much	117	30.2	100.0
Total	387	100.0	

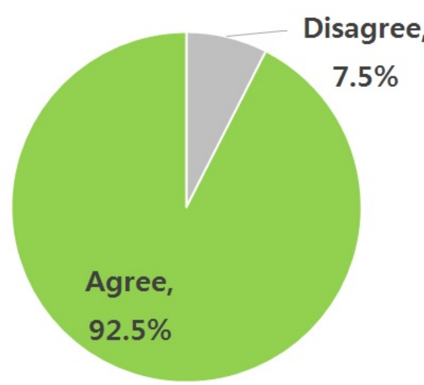

Figure 4.15. A10. Technology develops upon human engagement.

4.2.2.2 Attitude toward Technology

To measure respondents' perception of technology as volition or respondents' attitude toward technology, six items were employed (Figures 4.16–4.21). About 80 percent acknowledged human will in the domain of technology. More than 80 percent said that the use of a technology could be harmful to humans, and thus, technology was subject to be controlled by humans. Accordingly, about 80 percent did not see technology as being value-free or neutral. But, less than 70 percent answered that they could decide acceptance of a technology on their own, and most provocatively, more than 85 percent believed that technology determined how they lived.

So, the respondents overcame the myth of technological neutrality and agreed on the necessity for human control over technology. However, they appeared to have relatively passive attitudes toward technology. They still seemed to be permeated with technological determinism or technocracy that was originated from autonomous and prodigious modern technology. The conflict between the necessity for control over technology and the paucity of faith in the ability to control technology must attribute respondents' dependency toward someone else such as experts or politicians. Given that the respondents were students of technology including those in graduate courses, the implication is quite critical.

	Frequency	Percent	Cumulative Percent
Disagree very much	20	5.2	5.2
Disagree moderately	15	3.9	9.0
Disagree slightly	43	11.1	20.2
Agree slightly	105	27.1	47.3
Agree moderately	136	35.1	82.4
Agree very much	68	17.6	100.0
Total	387	100.0	

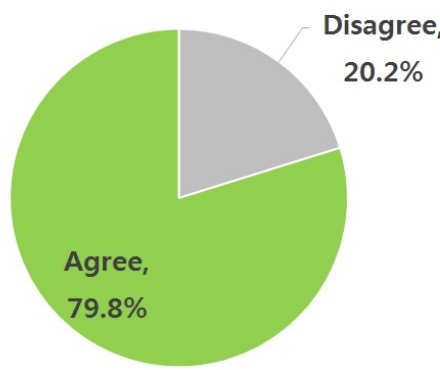

Figure 4.16. A11. Human will is a part of technology.

	Frequency	Percent	Cumulative Percent
Disagree very much	6	1.6	1.6
Disagree moderately	22	5.7	7.2
Disagree slightly	28	7.2	14.5
Agree slightly	84	21.7	36.2
Agree moderately	119	30.7	66.9
Agree very much	128	33.1	100.0
Total	387	100.0	

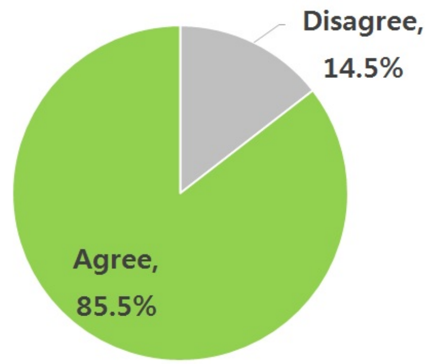

Figure 4.17. A12. Technology determines how people live.

	Frequency	Percent	Cumulative Percent
Disagree very much	3	.8	.8
Disagree moderately	20	5.2	5.9
Disagree slightly	36	9.3	15.2
Agree slightly	92	23.8	39.0
Agree moderately	150	38.8	77.8
Agree very much	86	22.2	100.0
Total	387	100.0	

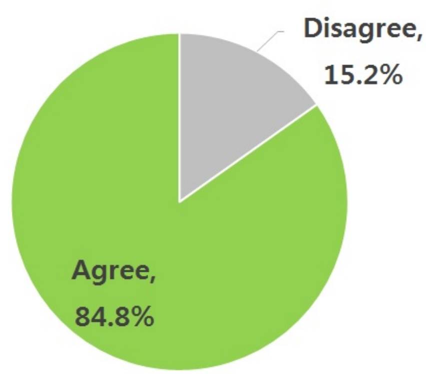

Figure 4.18. A13. Technology is subject to be controlled by humans.

	Frequency	Percent	Cumulative Percent
Disagree very much	9	2.3	2.3
Disagree moderately	30	7.8	10.1
Disagree slightly	35	9.0	19.1
Agree slightly	108	27.9	47.0
Agree moderately	101	26.1	73.1
Agree very much	104	26.9	100.0
Total	387	100.0	

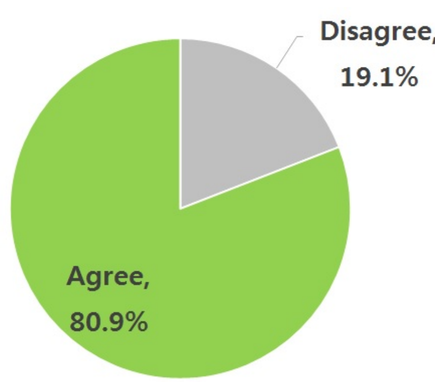

Figure 4.19. A14. The results of the use of technology can be harmful to human beings.

	Frequency	Percent	Cumulative Percent
Disagree very much	74	19.1	19.1
Disagree moderately	132	34.1	53.2
Disagree slightly	102	26.4	79.6
Agree slightly	46	11.9	91.5
Agree moderately	17	4.4	95.9
Agree very much	16	4.1	100.0
Total	387	100.0	

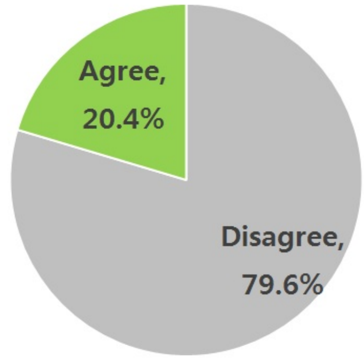

Figure 4.20. A15. Technology is value-free, thus, neutral.

	Frequency	Percent	Cumulative Percent
Disagree very much	13	3.4	3.4
Disagree moderately	49	12.7	16.0
Disagree slightly	63	16.3	32.3
Agree slightly	81	20.9	53.2
Agree moderately	97	25.1	78.3
Agree very much	84	21.7	100.0
Total	387	100.0	

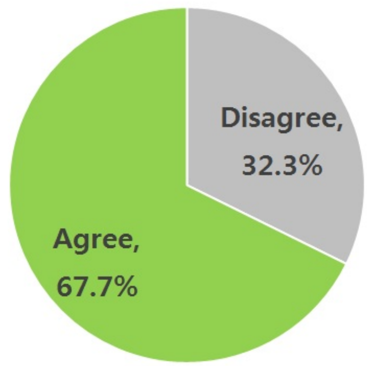

Figure 4.21. A16. I can decide whether to accept or deny a technology on my own.

4.2.3 Reliability and Validity

Recoding the responses to those item statements in semantic reverse direction was necessary before any further analysis. So, the values of items 1, 3, 5, 6 and 8 of independent variable and items 2 and 5 of dependent variable were recoded in the completely opposite order of the remainder: 6 = disagree very much, 5 = disagree moderately, 4 = disagree slightly, 3 = agree slightly, 2 = agree moderately, 1 = agree very much. Then, internal consistency of the scale was checked to assure reliability and coefficient alpha (Cronbach's alpha) turned out to be 0.241, which was too low to test the hypothesis. Consequently, the process of item analysis had been conducted.

4.2.3.1 Item Analysis

Through an item analysis, those items that are not consistent with the scale can be found and eliminated [105]. In fact, initial coefficient alpha without recoding the items with reverse statements was much higher (0.525). Without recoding, however, the values would cause conceptual conflicts within the scale and violate major theoretical assumptions of the study. Spector warns that "the item analysis should not be used to determine the direction in which items should be scored" [105, p.34]. The first round of item analysis calculated with all sixteen items indicated three items that ran against the construct of scale: items 5 (A5) and 6 (A6) of independent variable and item 2 (A12) of dependent variable as shown in Appendix N. As one might expect, those items were pulled to the opposite direction of the concepts with provocative responses and were all in reverse wording as shown in Figures 4.10–4.11 and 4.17.

Hopefully, the inconsistency of those items might have reflected respondents' deep misconception about technology. According to Spector, however, it could be caused also by either poorly written sentences with ambiguity or respondents' incapability of understanding [105]. The items possibly conveyed some highly conceptual meanings with relatively ambiguous words. After eliminating those three items, coefficient alpha was 0.472 and indicated one more item that ran against the construct: item 8 (A8) of independent variable. Without the four items, at last, coefficient alpha reached 0.519 as shown in Figure 4.22, which was considered to be reasonable to test the hypothesis.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.519	.553	12

Figure 4.22. Reliability Statistics

Although the coefficient 0.519 did not meet the tacit reference level of 0.7 to be acceptable, there were several rationales for conceding the relatively low level of alpha.

First, the reference level of alpha is Nunnally's personal advice that is not based on either empirical research or clear logical reasoning. Thus, the reference level is circumstantial to a certain extent [109]. Second, given the small number of items used to measure multiple constructs covering wide breadth of concepts, even alphas lower than 0.7 can be reasonable to accept. Cronbach's alpha has a fundamental assumption of uni-dimensionality that scale items measure only one latent variable or dimension. And a large number of redundant items contributes to higher alpha by averaging out the error of low correlation among items [105, 110]. The survey scale conducted for the inquiry, however, consisted of just sixteen items operationalizing and measuring multiple different concepts. Lastly, increasing alpha to a certain level by deleting items causes decrease in diversity of items and harms validity of the survey [109].

4.2.3.2 Factor Analysis

Validity is about interpreting what the scale items represent. After the item analysis above, a factor analysis had been conducted to examine validity of the scale. With correlation matrix shown in Appendix O, the Pearson correlation coefficient between all pairs and the one-tailed significance of these coefficients were checked. No singularity appeared in the data and the determinant value was 0.352 (> 0.00001), which was good enough to accept. The KMO (Kaiser-Meyer-Olkin) value was 0.673 (> 0.5), which meant that the sample was adequate, and the Bartlett's test was highly significant with the value smaller than 0.001. Therefore, factor analysis for the data appeared to be appropriate [111].

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.673
Bartlett's Test of Sphericity	Approx. Chi-Square	397.054
	df	66
	Sig.	.000

Figure 4.23. KMO and Bartlett's Test

With the component analysis and the scree plot shown in Appendix P, three components were found to have an eigenvalue greater than 1, which indicated the existence of three major factors of the scale as Kaiser recommended [111, 112]. Then, the rotated factor matrix was examined with loading sizes greater than 0.4. According to Field, comparing to a normal factor matrix, factor rotation makes interpretation considerably easier by clarifying loading size [111]. As shown in Figure 4.24, three major factors were scattered over items, which appeared to be quite different from the initial construct. Upon considerations over belonging items, the first factor could be labeled as "application of technology", which implied teleological perspective of technology; the second factor contained the items that were associated with "production of technology"; the items that constituted the third factor could be interpreted as the practical implication or effect of technology, that is, "implications of technology". Accordingly, scale items for each factor were reorganized as in Table 4.6.

Table 4.6. *Reorganized Items by Major Factors*

Factor	Scale Item
Application of Technology	A13. Technology is subject to be controlled by humans. A4. There is a distinctive kind of technological knowledge. A2. Every technological object has its own purpose(s) of human need. A16. I can decide whether to accept or deny a technology on my own.
Production of Technology	A11. Human will is a part of technology. A9. Human activities of designing is a part of technology. A10. Technology develops upon human engagement. A1. Technology is present ONLY in the forms of physical object. A3. In ancient times, technology did NOT exist.
Implications of Technology	A15. Technology is value-free, thus, neutral. A14. The results of the use of technology can be harmful to human beings. A7. Technology is more about everyday life than scholarly research.

The factors or latent variables drawn out of the process of factor analysis represented the production, application, and practical implications of technology, which

Rotated Component Matrix[a]

	Component		
	1	2	3
A13. Technology is subject to be controlled by humans.	.616		
A4. There is a distinctive kind of technological knowledge.	.566		
A2. Every technological object has its own purpose(s) of human need.	.520		
A16. I can decide whether to accept or deny a technology on my own.	.516		
A11. Human will is a part of technology.		.631	
A9. Human activities of designing is a part of technology.	.414	.616	
A10. Technology develops upon human engagement.	.436	.615	
Reverse of A1		.560	
Reverse of A3		.544	
Reverse of A15			.619
A14. The results of the use of technology can be harmful to human beings.			.587
A7. Technology is more about everyday life than scholarly research.			-.505

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

Figure 4.24. Rotated Factor Matrix

were also meaningful concepts for the study. Based on the result of factor analysis, to a certain extent, the scale could be said to have failed to measure the concepts in the forms of initial theoretical distinctions, such as objects, knowledge, activities, and volition. Those theoretical distinctions as well as the distinction between the independent variable and the dependent variable were highly conceptual and thus, somewhat contrived. Obviously, the respondents had perceived those concepts conveyed by an on-line survey in the ways that they were more familiar with so that the discrepancy between asking and answering occurred. The discrepancy, however, did not necessarily impose failure on the survey because those latent variables themselves still implied the concepts and assumptions of the study. After all, they all implied respondents' perception of technology. Therefore, reorganizing the scale items in accordance with the conceptual distinctions of the respondents and testing the relationships between those new variables should be worth of testing.

4.2.4 The Relationship between Understanding of Technology and Attitude toward Technology

Before dealing with the newly found variables of application, production, and value-ladeness of technology, the relationship between understanding of technology (IV) and attitude toward technology (DV) was examined provided that the initial concepts were still measured by the factors analyzed.

The correlation between two variables was statistically significant at the 5 percent level of alpha. Thus, the hypothesis, "those who have higher level of understanding of technology would more likely to have higher level of will to control technology", was supported by the data. But, the Pearson correlation coefficient was 0.275, which was quite low. The R-square was as low as 0.076 meaning that only 7.6 percent of the variation in the level of will to control technology was accounted for by the level of understanding of technology. The slope was gradual as shown in Figure 4.26.

While constructing the measurement scale, the control variables of age, gender, academic affiliation, and department were expected to have effects on the independent and dependent variables. To decide a proper method of analysis on the effects, the assumptions of the one-way ANOVA, that is, the normality and homogeneity of variance were tested at the 5 percent level of alpha. As shown in Appendices Q and R, the tests of

		DV Mean	IV Mean
Pearson Correlation	DV Mean	1.000	.275
	IV Mean	.275	1.000
Sig. (1-tailed)	DV Mean	.	.000
	IV Mean	.000	.
N	DV Mean	387	387
	IV Mean	387	387

Figure 4.25. Correlation between IV and DV

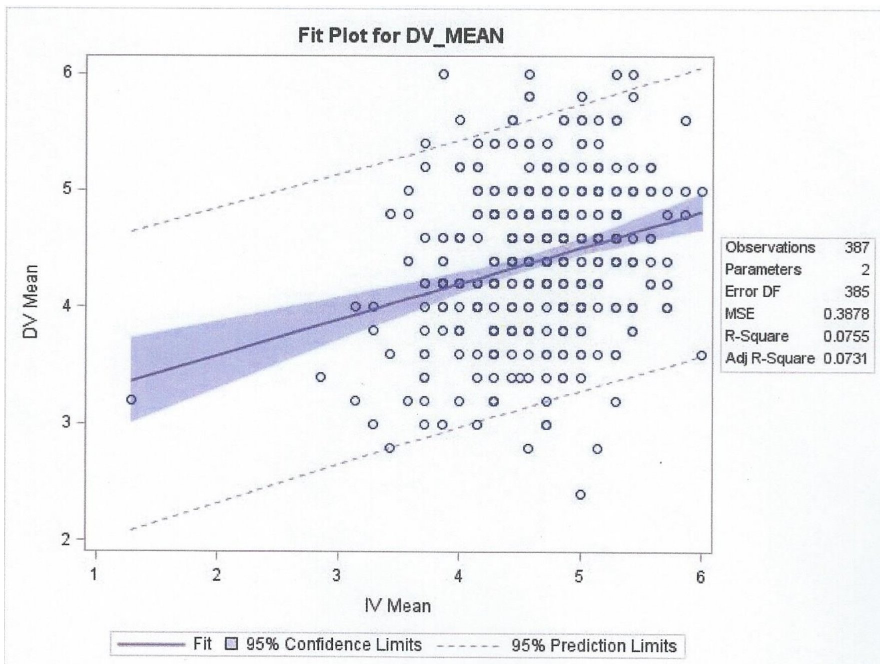

Figure 4.26. Fit Plot for DV

normality and Q-Q plots of the variables rejected the normality of data distribution. The test of homogeneity of variances also indicated some significant differences between the variances as shown in Appendix S. Consequently, as both assumptions were violated, an alternative method was preferred and the Kruskal-Wallis test was employed for further analysis. The Kruskal-Wallis test is a non-parametric version of the one-way ANOVA without assuming the normal distribution of the data. Although some scholars argue that the one-way ANOVA is robust under certain degrees of assumption violation, there are evidences showing that such violations invalidate the use of the ANOVA [113, 114].

As shown in Appendix T, the test indicated that only the independent variable had significant differences between the groups of academic affiliation ($p = 0.018 < 0.05$). To figure out specific groups of academic affiliation that were significantly different from each other, the Mann-Whitney U test with two independent samples was performed. Mostly, the Ph.D. students were different from all the other groups except for the sophomores and master's students at the statistically significant level as shown in Table 4.7 ($p < 0.05$). The sophomores were different from the seniors and the master's students were not different from any group of students. As shown in the means plots of Figure 4.27, the Ph.D. students were more likely to have higher level of understanding of technology than the freshmen, juniors, and seniors.

Table 4.7. *Differences between Groups of Academic Affiliation for IV (* $p < .05$*)*

	Sophomore	Junior	Senior	Master's	Ph.D.
Freshman	.082	.371	.992	.369	*.010
Sophomore		.234	*.025	.443	.213
Junior			.248	.915	*.015
Senior				.240	*.002
Master's					.052

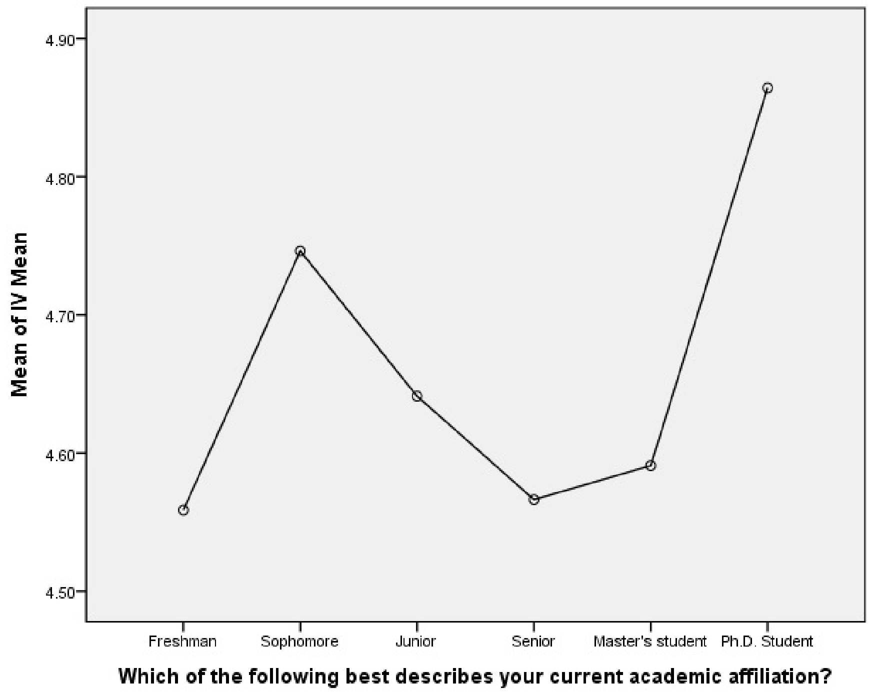

Figure 4.27. Differences among Academic Affiliations for IV

4.2.5 The Relationships between New Variables

For the last part of the study analysis, the relationships between new variables that had been extracted with factor analysis were examined. As mentioned already, the respondents appeared to have perceived the initial concepts conveyed by the survey questionnaire in their own conceptual frame that was typical and familiar. Along with reorganized factors and scale items shown in Table 4.6, the relationships between the application of technology and production of technology, application of technology and implications of technology, and production of technology and implications of technology were tested. All the correlations between new variables appeared to be statistically significant at the 5 percent level with gradual slopes as illustrated in Figure 4.28 and Appendix U.

The Kruskal-Wallis test shown in Appendix T indicated that the control variables of the academic affiliation and department had significant differences for the production of

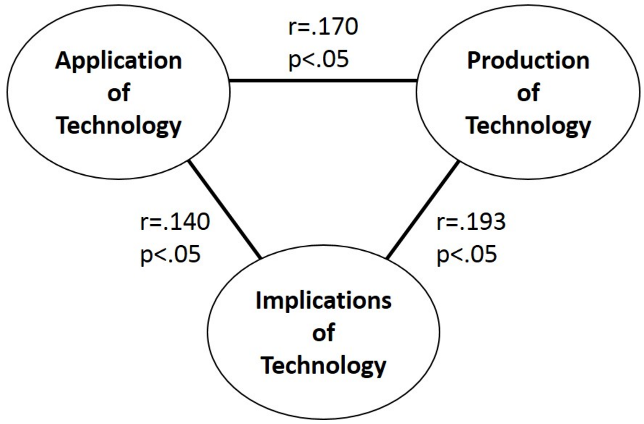

Figure 4.28. Correlations between New Variables

technology ($p = 0.009 < 0.05$, $p = 0.006 < 0.05$). According to the Mann-Whitney U test shown in Table 4.8, the freshmen and seniors were significantly different from the master's and Ph.D. students. The freshmen were also different from the sophomores. As shown in Figure 4.29, the master's students and Ph.D. students were more likely to agree with the concept of production of technology than the freshmen and seniors.

Table 4.8. *Differences between Groups of Academic Affiliation for Production of Technology (* $p < .05$)*

	Sophomore	Junior	Senior	Master's	Ph.D.
Freshman	*.007	.051	.159	*.007	*.003
Sophomore		.272	.052	.876	.860
Junior			.320	.215	.218
Senior				*.034	*.019
Master's					.993

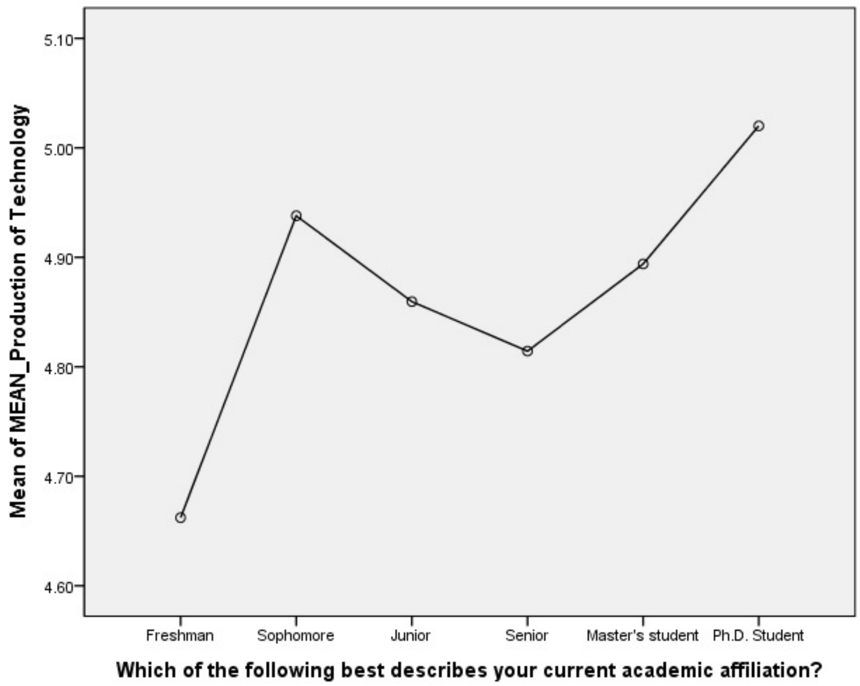

Figure 4.29. Differences among Academic Affiliations for Production of Technology

As shown in Table 4.9, the department of Computer and Information Technology was significantly different from Construction Management Technology and Technology Leadership and Innovation ($p < 0.05$). Also, the department of Computer Graphics Technology was significantly different from Construction Management Technology, Engineering Technology and Technology Leadership and Innovation ($p < 0.05$). As shown in Figure 4.30, those students of the departments of Computer and Information Technology and Computer Graphics Technology were more likely to agree with the concept of production of technology that implied human engagement in technology and diverse forms of technology reification than those students of the other departments.

Table 4.9. *Major Differences between Groups of Department for Production of Technology (* p < .05)*

	Construction Management Technology	Engineering Technology	Technology Leadership & Innovation
Computer & Information Technology	*.008	.159	*.024
Computer Graphics Technology	*.001	*.009	*.002

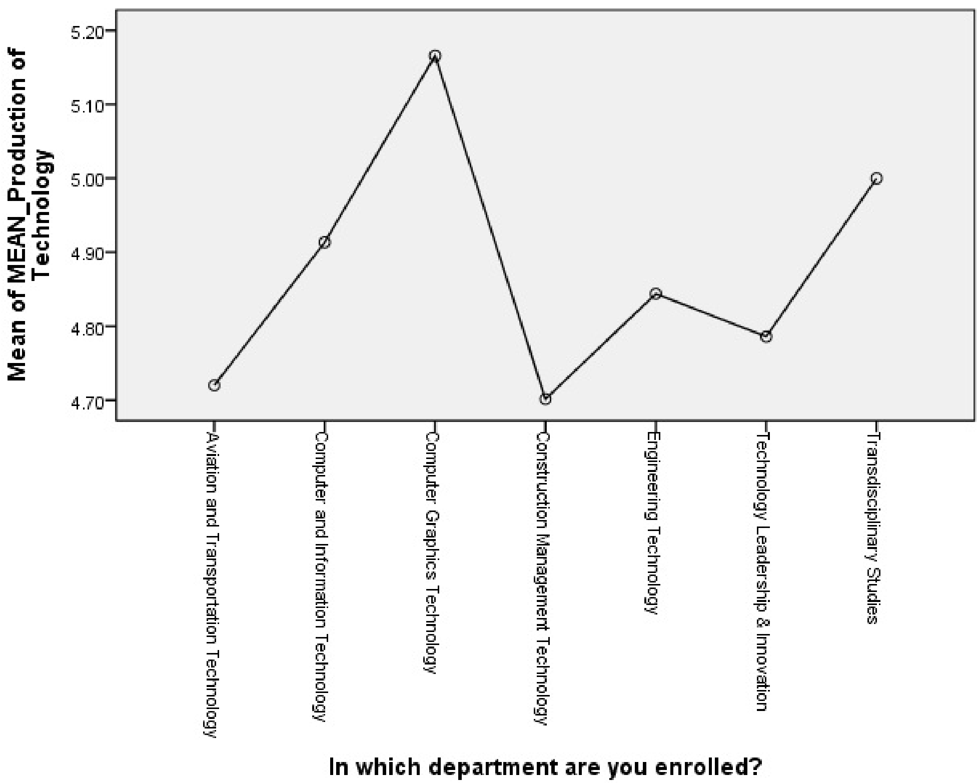

Figure 4.30. Differences among Departments for Production of Technology

4.3 Summary

Chapter Four delineated the analyses and results of the qualitative and quantitative inquiries of the study. For the qualitative inquiry, eight historical cases of technology were analyzed based on the method of grounded theory, and as a result, the mechanism of technology development was drawn and understood as a concatenation of the interactions between technical progress and social demand. For the quantitative inquiry, a total of 387 responses of the survey was analyzed. Four of initial scale items were eliminated to obtain a reasonable reliability and three major factors were found with factor analysis. The IV, understanding of technology, appeared to be positively correlated with the DV, will to control technology, at the 5 percent level of statistical significance. The correlations between those new variables elicited in factor analysis were also found to be significant at the 5 percent level and positive. The control variables of academic affiliation and department were found to have significant effects on the results.

CHAPTER 5. DISCUSSION

The goals of this study were to determine ways to reconcile technology with public interest and to understand the relationship between what we know about technology and how we feel about technology. To achieve the goals, related literatures were reviewed; the mechanism of technology development was built with empirical data; human perception of technology was tested with a survey. Findings of the study are hopefully to be used to establish a platform and path that could lead the public to the essence of technology and also technology to welfare of the public. This chapter looks through the findings, limitations, and research implications of the study.

5.1 Findings

As a core characteristic of technology, the duality of technology that implied technological inherencies of technical reason and social meanings was the principle assumption of the study. As illustrated in Figure 3.1, under the concept of duality, technology incorporates system of engineers and lifeworld of users, which are subjugated to each other by the phenomena of delegation and concretization. Neutrality of technology becomes a myth with the presence of social meanings embodied in technology. Given the huge impact of technology on human societies, the absence of neutrality is, in turn, attributed to the necessity for policy. The concepts of duality of technology were found to constitute technological phenomena in the forms of technical progress, economic values, and social inclinations. Likewise, delegations of social values to technology were witnessed in transitions of existing technology to new ones. Technologies were also concretized in response to the social demand.

Analyses of eight empirical cases of technology development based on the method of grounded theory provided core categories of technical progress, economic values, and social inclinations that maintained proven theoretical relevance. Technical progress presided a phenomenon of any case and it constantly appeared throughout a phenomenon. Technology acted as a cause, an aggravator, a mitigator, or a solution of a phenomenon as progress was made. The importance of economic values was observed to increase as a case was closer to the present era. For numerous cases, economic values motivated technical progress and a technology itself was likely to involve elements of economic enhancement. Also, many of the intervening conditions to a new technology were attributed to economic values and, sometimes, technology was directed to the way in which economic values of certain groups could be secured or maximized. Social inclinations were seen as infrastructure or environment in which technologies and economic values germinated. They were not involved directly with achieving technical progress or realizing economic values. Rather, they were certain kinds of social inclination that could be interpreted as other social values or demands than economic values.

The mechanism of technology development described with the core categories and concepts corroborated by the sample cases could be drawn based on the paradigm model of technology as shown in Figure 4.1. The mechanism turned out to be a concatenation of the interactions between technical progress and social demand of either economic values or social inclinations. Earlier in the study, technology was defined as a distinctive discipline of human intellect that accompanies procedures and systems to fulfill practical needs of humans. Based on the results of the study, the procedures and systems could be described with the mechanism of technology development and interpreted as the interactions between technical reason and social meanings.

Apparently, repetitions of the mechanism were expected to constitute technological paradigms. Technology that is pertinent to public interest, in this context, will be possible if a social inclination toward public interest can be built and applied to the mechanism. The state can shape a social inclination of the kind and intervene in the mechanism of technology development. As seen in the case of personal computers, such an intervention could be accelerated by the potency of the collective actions of citizens. If successful, technology will incorporate the social value of public interest and the paradigm of technology will embrace it.

Survey responses indicated that the common misconception of technology that people come up with high-tech material objects when they are asked about technology was not inferred from the respondents of the Purdue Polytechnic Institute (College of

Technology). However, the biggest misconception of technology was found in the concept of technological knowledge, which especially was distinguished from scientific knowledge; technology was perceived to have a distinctive kind of knowledge and to be practical, but still to be a part of science pursuing the knowledge of nature. Even though the respondents were all students of technology, they were having a hard time in positioning the domain of technology. Technology still seemed to be a mere part of science with more emphasis on practical purpose in everyday life, which was concurred with the term "applied science". Respondents agreed on the idea of value-ladeness of technology and, thus, necessity for human control over technology. However, they appeared to have relatively passive attitudes toward technology. The conflict between the necessity for control and the paucity of faith in the ability to control technology by themselves must attribute respondents' dependency toward someone else such as experts or politicians. Given that the respondents were students of technology including those in graduate courses, the implication is quite critical.

The correlation between understanding of technology and will to control technology was statistically significant but weak as shown in Figures 4.25–4.26 . The hypothesis, those who have higher levels of understanding of technology would more likely to have higher levels of will to control technology, was supported by the data, but only limited amount of the variation in the dependent variable was accounted for by the independent variable. All the correlations between new variables that had been extracted in the process of factor analysis - that is, the application of technology, production of technology, and implications of technology - appeared to be statistically significant but also to be weak as illustrated in Figure 4.28. The control variables of academic affiliation and department were found to have some significant effects on the results.

5.2 Research Implications

While theoretical sensitivity is emphasized, as Charmaz warns, the method of grounded theory with constructivist view may harm objectivity by being more intuitive and impressionistic [91, 95]. By staying within the concepts of critical theory of technology, the results of the study may also fall in the instant joy of lower-level theorizing without completing the full job [91, 96]. However, the study tried to be as faithful as possible to the objectivity and rigor of the grounded theory. Constant comparisons through coding and the paradigm model analysis were done with consistency and hasty theorizing was alerted. Limitations of the secondary data are inextricable. Direct interviews and participated observation of the field of technology should enrich the study of the mechanism of technology development and further effort to verify the mechanism introduced in this study must be meaningful.

Pawson and Tilley emphasized the presence of context to constitute regularity with mechanism [89]. With the mechanism through which technology develops found in this study, social context always should be in consideration. By doing so, a regularity with efficacy can be found to lead the mechanism to the real life-world. To establish a policy of technology that can induce a desirable social change, the mechanism should be evaluated with the context that incorporates multiple variables of the society; the mechanism *per se* cannot provide an adequate explanation.

Conceptual distinctions among four modes of technology reification were too ambiguous to be distinguished empirically and perceived by the respondents. Those theoretical distinctions as well as the distinction between the independent variable and the dependent variable were highly conceptual and, thus, somewhat contrived. And the respondents' perception of the conceptual frame in the ways that they were more familiar with has critical implications for further study.

A small number of scale items had negative effects on both reliability and validity. For further studies to account for more of technology in empirical ways, additional number of items that can successfully operationalize related concepts and average out responding errors should be developed. For the misconception of technological knowledge as seen in Figures 4.9–4.13, for example, further investigation with multiple scale items would be required to decide whether the respondents implied subordination of technology to science or just deep relationship between the two by agreeing with the item statement.

As announced in the beginning, the ultimate destination of this study was democratization of technology, which is about incorporating technology into public interest by empowering citizen participation in constructing technology. Further studies will be continued to reach the destination.

APPENDIX A. MECHANICAL CLOCKS (CASE 1)

Edited from [115]:

The Europeans of the Middle Ages were a pious people, and they considered it a matter of great importance that the prayers described in the Catholic Breviary be said at the correct times. For this reason, all of the many churches and monasteries of that age included a bell tower, and the monks were required to ring these bells at the prescribed hours of the day and night as a signal to the faithful when it was time to say their prayers. But the sandglasses and water clocks that the monks used during the early Middle Ages were notoriously unreliable and inaccurate. In fact, the societies of Greeks, Romans, Indians, and Chinese had used sundials, water clocks, sandglasses, candles, and incense clocks to measure time since ancient times, but each of these methods had serious limitations.

Sundials were accurate only at the specific latitude for which they were designed, and they were completely useless without the sun. Water clocks depended for their accuracy on the action of water dropping slowly through a small hole drilled into the bottom of a container. But since water drips more slowly when a container is nearly empty than it does when the container is full, the water clock was seldom accurate. The sandglasses was hardly better. Designed to measure only twenty minutes or less, since a glass large enough to measure as much as a single hour tended to be large, heavy, and dangerously fragile. Worse still, in order to measure more than one unit of time, the sandglasses had to be turned upside down every time the sand ran out. Incense clocks provided surprisingly accurate way of measuring the passage of time, and were widely used throughout Asia for centuries. But the incense clock had the unique disadvantage of consuming itself in the process of telling time.

Thus, sometime between 1200 and 1300 AD, in response to the Church's desire for more accurate clocks, the craftsmen of medieval Europe began to build mechanical clocks out of metal. These revolutionary mechanical clocks were driven by the force of weights, hanging from chains, that turned the gears of the clockworks. The speed of the turning gears was regulated by a mechanism called an escapement that alternately locked and released each tooth on a special gear. The action of the escapement is responsible for the characteristic ticking sound made by all mechanical clocks.

The escapement made it possible for these new mechanical clocks to tell with unprecedented accuracy, and they represented a huge advance in durability and accuracy over all the other timekeeping technologies. But none of the first mechanical clocks had either hands or faces. Instead, they told time by the ringing of bells. (In fact, the English word "clock" comes from the German word *Gloke*, meaning "bell.") And the clock face that is familiar to us with an hour hand and a minute hand rotating inside a circular dial bearing twelve numbers - did not come into general use until 1700, more than four hundred years after the first mechanical clocks were installed in the towers of Europe's churches and monasteries.

Moreover, none of the early clocks had pendulums. Instead, the escapement on the medieval clock was regulated by a rotating arm, called a foliot, that swung back and forth on a shaft called a verge. The speed of the clock was regulated by moving the weights that hung from the two arms of the foliot. It was not unusual for these early clocks to gain or lose several minutes each day. But the people of the Middle Ages told time only by the hour, and they did not bother with anything as precise as minute. The basic design of the medieval clock did not become obsolete until the invention of the pendulum and the more accurate "anchor" and "deadbeat" escapements in the seventeenth century. Upon Galileo's concept, Christiaan Huygens built the first pendulum clock in 1657. The pendulum clock turned out to be ten times more accurate than its predecessor, and with this greater accuracy, the minute hand finally came into common use.

By far the most important consequence of the European obsession with time was that the construction of accurate clocks required machines that were capable of making precisely crafted mechanical components. In order to run at a constant speed, mechanical clocks required wheels, shafts, and cylinders that were perfectly round and straight. The teeth on their gears had to be evenly spaced, and each tooth had to be exactly the same size and shape. The springs that powered the clocks of later times had to be made in a precisely uniform thickness, with a precisely uniform temper. And all of the tiny screw that held the clock parts together had to be made to fit precisely into the threaded holes for which they were intended.

For this reason, driven both by the clockmakers' need for precision machinery and the public's increasing demand for mechanical clocks, the European craftsmen began to invent the special devices called "machine tools" - which are machines designed to make parts for other machines. As the precision machining continued to advance, new specialists arose. While they were learning how to make clocks, the clockmakers also learned how to make instruments such as sextants and compasses for navigation, astrolabes and theodolites for surveying, and precision scales for weighing. Lens grinders created precision lenses and built telescopes, microscopes, and eyeglasses. All of these instruments and many more stimulated the great advances in science that took place as the Middle Ages came to a close and Europe embraced the new philosophies of scientific inquiry that blossomed into the Renaissance.

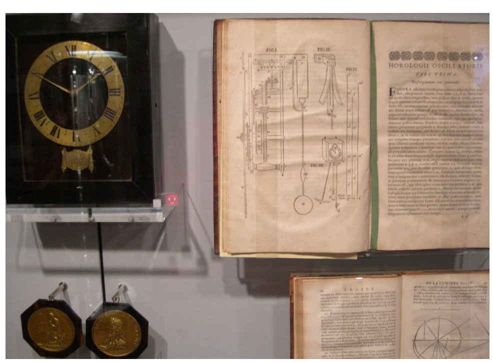

Figure A.1. Huygens' Pendulum Clock (www.google.com)

APPENDIX B. EARLY BICYCLES (CASE 2)

Edited from [76]:

The hobby horse or "pedestrian accelerator," popularized in England in 1818-19 (and slightly earlier, in Germany, as Draisine), was the first commercially-produced vehicle which enabled a man to balance on two wheels and "ride." The bicycles were initially heavy machines with cast-iron frames and wood-spoked wheels rimmed with a metal band. These earliest machines were the product of an advanced carriage- and blacksmith-shop technology, but were soon mass-produced using more sophisticated processes.

The reports and discussion within the periodicals and newspapers of the time demonstrate that sport was a crucial factor in this early evolution of the bicycle. Racing brought together the latest designs and technological developments in a conspicuous and competitive testing ground, and demonstrated clearly the weaknesses of old ideas and the strengths of new approaches. The velocipede was introduced into a context of athleticism and was at first very much an acrobatic activity, concerned with the skill of balance, taking place mostly indoors. And soon, it was proved to be useful also for traveling a longer distance.

The many journalistic accounts of the earliest bicycle competitions in Britain contain frequent expressions of surprise, emphasizing the novelty and sensation of the new sport. The fact that the machine could be balanced and ridden was sufficiently astonishing. The new "two-wheeled velocipede" was promoted and reported in a variety of different competitive and entertainment contexts and promoters of events appear to have experimented to see what would entertain and make money.

There was clearly a strong "show business" element at work. In the marketplace, velocipede competitions quickly took their place among the diverse forms of popular, commercial entertainment. Events were also staged by more "respectable" amateur social gatherings and velocipede clubs. Bicycle racing was clearly "modern," a sport created by a progressive, industrial, technological society. Especially in the larger cities, competitive events also gave promoters and manufacturers an opportunity to mount exhibitions of machines as an additional attraction and source of income, an indication that the sport was, from its very beginnings, used as an advertising vehicle for the bicycle industry. Even in an unusual rural location, racing was linked with ab exhibition of the very latest developments.

A technological and athletic logic mediated the relationship between riders and makers, and also made it likely that riders would become makers and vice versa. An ordinary customer might ride a velocipede occasionally, tolerating deficiencies. But serious riders were more demanding; they were acutely aware of discomfort, inefficiency, comfort and ease. Speed and comfort depended then, as now, on overall design and quality manufacture, rigidity, light weight, and maximum mechanical efficiency, as well as the skill of the rider and the kind of surface ridden upon.

Speed was greatly affected by "gear," defined as the size of the pedaled front wheel of the bicycle, and thus the distance covered with each pedal rotation. Attempts were made to "gear up" this wheel mechanically, but the easiest way to cover more ground with each rotation of the pedals was to enlarge the drive-wheel, resulting in a slight "edge" for a taller rider, with longer legs, over his shorter rival; this could, however, be nullified through better, quicker, pedaling technique. By about 1875, the high-wheel bicycle had thus emerged and would dominate bicycle design for the next ten years, continuing the strong athletic and acrobatic tendencies inherent in the early velocipede displays.

Throughout the 1870s and into the first half of the 1880s, the high-wheel, or "ordinary" bicycle, was the kind of bicycle upon which athletic prowess was demonstrated - both speed over short distances and endurance over long - and those riders proud of their skill on this machine were often initially scornful of the chain-driven "safety" bicycle when it was first introduced in 1884-85. Eventually, the technological innovation of chain-driven bicycle had replaced the old high-wheel bicycles.

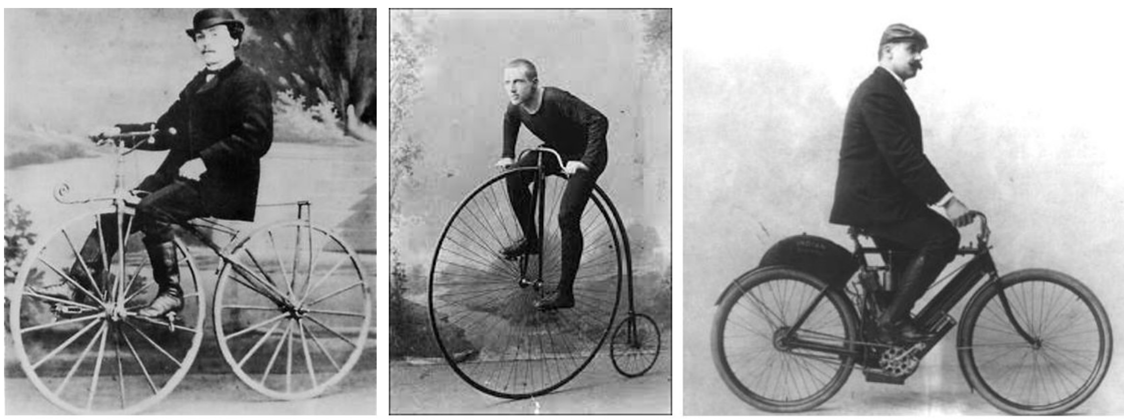

Figure B.1. Early Bicycles (www.google.com)

APPENDIX C. MOTION PICTURES (CASE 3)

Edited from [116]:

Edison came to the idea of motion pictures by making an analogy with the phonograph. As he explained in an 1888 patent caveat, his motion picture machine or kinetoscope was to do “for the Eye what the phonograph does for the Ear, which is recording and reproduction of thing in motion”. Edison drew on this phonograph analogy in two ways. First, he used it to design his first kinetoscope as a machine that replaced the sound groove of the phonograph cylinder with a spiral of tiny photographs. Hoping to record and reproduce both sound and motion, Edison initially placed both the photographic and acoustic cylinders on the single shaft of a machine similar to his phonograph. To view the moving images, Edison had the user peer through a microscope objective. This notion of a single viewer was similar to that employed by the existing phonograph, to which one listened through a set of individual eartubes. Consequently, the first commercial kinetoscope was a peephole machine in which viewers watched the images through a small aperture.

Second, the phonograph analogy informed Edison’s marketing strategy for the kinetoscope. As with many new technologies, it proved easier to adopt this new invention to a preexisting marketing strategy than to pioneer a new scheme. Because phonographs were being sold for use in penny arcades, Edison permitted several phonograph businessmen to establish similar kinetoscope parlors. Again, Edison established a “state’s rights” distribution network in which agents purchased the rights to sell kinetoscopes in a territory, and these agents in turn sold machines to individual arcade owners. Under this strategy, kinetoscopes were manufactured in the Edison Phonograph Works, and Edison turned a profit by selling them outright to arcade owners.

In the early 1890s, the public flocked to the kinetoscope arcades and marveled at seeing short films of boxers and vaudeville acts. These early films were shot at Edison’s laboratory at West Orange under the supervision of Dickson and other staff members. Edison himself took little interest in these films as he saw little long-term potential in the kinetoscope. Located in penny arcades alongside slot machines, phonographs, muscle-testing apparatuses, and fortune-telling machines, the kinetoscope seemed to Edison to be a frivolity. As a result, Edison decided to file only a few patent applications for the kinetoscope in the United States and none in foreign countries.

Although the public flocked to see the first kinetoscopes, they soon grew bored. In response, several kinetoscope exhibitors pressured Edison to introduce a projecting machine and recapture the public’s attention. In 1896, Edison relented and permitted his company to produce a projector based on a patent purchased from Thomas Armat. During the remainder of the decade, the Edison Manufacturing Company sold over 800 projectors to small businessmen who exhibited films in vaudeville halls and makeshift theaters. The Edison laboratory continued to make films on topics such as the beheading of Mary, Queen of Scots and the Battle of San Juan Hill in the Spanish-American War. Significantly, Edison’s associates do not seem to have worried as much about the artistic content of these films as they did about reducing production costs.

Between 1903 and 1907 the American motion picture industry experienced several profound changes. All across the country, small businessmen began opening storefront theaters or nickelodeons where workers and immigrants could see a film for a nickel. Yet at the same time, American movie makers did not enjoy prosperity because the audiences in new nickelodeons preferred films made by British and French producers. In response, American filmmakers struggled to improve the media and as a result developed story films such as *The Great Train Robbery*. These two innovations - the nickelodeon and the story film - permitted entrepreneurs to market movies to a new broad audience, the urban working class. To do so, however, these entrepreneurs had to be sensitive to this audience's tastes and preferences.

In 1905, to permit the production of films to keep up with demand, the Edison organization constructed a large studio in the Bronx in New York. By 1909, Edison had nine directors working at this studio and on location. But most important in the minds of Edison and his associates was that, after several years of litigation, they won a series of favorable court decisions upholding the validity of Edison's patents on the kinetoscope. These legal victories were secured by Edison's attorney, Frank Dyer, who subsequently took over supervision of the motion picture business, first as Edison's chief counsel and then as president of Thomas A. Edison, Inc.

From the outset, Dyer saw the patent victory as an opportunity for limiting the cut-throat competition in the motion picture industry. The success of the nickelodeons had stimulated the creation of thousands of theaters and about a dozen production companies, all competing to produce and exhibit the most exciting films. To bring order out of chaos, the Edison organization tried to use its patents to force all motion picture producers and exhibitors to take out licenses for their equipment. Dyer and other Edison managers insisted that it was not possible to construct either a motion picture camera or projector without infringing on Edison's patents. In 1908, Dyer helped create the Motion Picture Patents Company (MPPC), through which the leading production companies pooled their patents and exerted some control over the industry by requiring all producers and exhibitors to have licenses. Through a set of interlocking agreements, the MPPC controlled the supply of raw film, licensed the major film production companies and manufacturers of projection equipment, restricted the import of European films, coordinated film exchanges, and collected royalties from thousands of theaters.

For the next few years, the MPPC figured prominently in the motion picture industry. At its height, MPPC's subsidiary, the General Film Company, controlled distribution of films to one half of the theaters in the United States. From 1911 to 1915, the Edison organization received one half of the MPPC's royalty and license fees or $1.9 million before expenses. Under these controlled market conditions, the Edison motion picture division enjoyed annual sales of over one million dollars.

Having established a framework of vertical integration, Dyer and the Edison managers turned to shaping the content of their films. Their effort reflected a middle-class bias; they viewed the movies as a product to be consumed by themselves or their social betters. They produced films that emphasized middle-class values and mores. Rather than cater to the urban working class, they became concerned that the middle class was not patronizing nickelodeons. Along with middle-class values, they were also influenced by Edison's producer values and, unlike other film producers of that time, refused to develop a star system to cultivate celebrities to attract moviegoers. The Edison managers were much more accustomed to producing capital goods such as storage batteries and supervising relatively taciturn workers; They may have found many of the mundane tasks related to motion pictures peculiar and even distasteful.

The Edison organization's two-pronged strategy of vertical integration and the infusion of middle-class values into movies eventually faltered. As the MPPC and the General Film Company sought to control more theaters, they angered the owners of independent theaters and film exchanges and attracted the attention of the Justice Department. Antitrust proceedings were begun in 1912, and the government formally ordered the dissolution of the MPPC in 1917. In the marketplace, Edison films also failed. Whereas prior to 1910 movies had been patronized largely by the urban working class, in the teens movies began to appeal to a mass audience of both the working and middle classes, immigrant and native-born Americans, country folk and city dwellers, men and women. Unfortunately for TAE Inc., movies without stars and emphasizing middle-class mores appealed to only a limited segment of this audience.

While the audience, other film makers and theater owners together constructed movies as a form of passive entertainment creating a new consumer culture that stressed celebrity, pleasure, and leisure, Edison decided that the industry needed new hardware. Recalling his original dream of having talking images, Edison worked on a kinetophone that combined a projector with special loudspeaking phonograph placed behind the screen. Edison also introduced a smaller projector for use in churches, schools, and homes, which he called the home projecting kinetoscope. Along with these new machines, he proposed a new direction in programming: educational films. But all of those efforts failed to compensate for the loss of the mass audience for entertaining movies. Eventually, the failure along with the dissolution of the MPPC, spelled the end of the Edison movie division. In 1916 the division stopped manufacturing projectors, and in 1918, after several poor years, Edison ordered the Bronx studio closed.

Figure C.1. Kinetoscope and Nickelodeon (www.google.com)

APPENDIX D. MASS PRODUCTION (CASE 4)

Edited from [117, 118]:

Since the 1920s the term *mass production* has become so deeply ingrained in our vocabulary that we seldom question its origin. Manufacturing in the United States developed along such distinct lines in the first half of the nineteenth century that English observers in the 1850s referred to an “American system” of manufactures. This American system grew and changed in character so much that by the 1920s the United States possessed the most prolific production technology the world has ever known. This was “mass production”. Mass production differed in kind as well as in scale from the techniques referred to in the antebellum period as the American system of manufactures.

In terms of production, it is only with the rise of the Ford Motor Company and its Model T that there clearly appears an approach to manufacture capable of handling an output of multicomponent consumer durables ranging into the millions each year. Moreover, the rise of Ford marks an entirely new epoch in the manufacture of consumer durables in America. The Ford enterprise may well have been more responsible for the rise of “mass production”, particularly for the attachment of the noun *mass* to the expression, than we have realized. Ford sought to manufacture the lowest priced automobile and to use continuing price reductions to produce ever greater demand. Ford designed the Model T to be a “car for the masses”. Ford recognized “the masses” as a legitimate and seemingly unlimited market for the most sophisticated consumer durable product of the early twentieth century. At that time, progressive utility managers advocated the economies of large-scale production machines and power plants, low prices to encourage mass consumption, the cultivation of a widespread market, and continuous flow of production to reduce costs. Some historians see that Ford absorbed some of the electric-utility style of production when he was an engineer at the Edison company in Detroit. Peter Drucker long ago maintained that the Ford’s work demonstrated for the first time that maximum profit could be achieved by maximizing production while minimizing cost. Ford was able to initiate this new “economic revolution” because of advances in production technology, especially the assembly line.

Before their adoption of the revolutionary assembly line in 1913, Ford’s production engineers had synthesized the two different approaches to production that had prevailed in the bicycle era. First, Ford adopted the techniques of armory practice. All of the company’s earliest employees recalled how ardently Henry Ford had supported efforts to improve precision in machining. Ford hired mechanics who knew what was required to achieve interchangeability, and certainly by 1913, most of the problems of interchangeable parts manufacture had been solved at Ford. Second, Ford adopted sheet steel punch and press work. Initially he contracted for stamping work with the John R. Keim Company in Buffalo, New York, which had been a major supplier of bicycle components. Soon after opening his new Highland Park factory in Detroit, however, Ford purchased the Keim plant and promptly moved its presses and other machines to the new factory. More and more Model T components were stamped out of sheet steel rather than being fabricated with traditional machining methods. Together, armory practice and sheet steel work equipped Ford with the capability to turn out virtually unlimited numbers of components. It remained for the assembly line to eliminate the remaining bottleneck - how to put these parts together.

On April 1, 1913, workers in the Ford flywheel magneto assembling department stood for the first time beside a long, waist-high row of flywheels that rested on smooth, sliding surfaces on a pipe frame. The assembly line came swiftly and with great force. Within eighteen months of the first experiments, assembly lines were used in almost all subassemblies and in the most symbolic mass production operation of all, the final chassis assembly. Ford engineers witnessed productivity gains ranging from 50 percent to as much as ten times the output of static assembly methods. There can be little doubt that Ford engineers received their inspiration for the moving assembly line from outside the metalworking industries. Henry Ford himself claimed that the idea derived from the "disassembly lines" of meatpackers in Chicago and Cincinnati. William Klann, a Ford deputy who was deeply involved in the innovation, agreed but noted that an equally important source of inspiration was flour milling technology as practiced in Minnesota. Klan summarized this technology in the expression "flow production".

While providing a clear solution to the problems of assembly, the Ford assembly line brought with it serious labor problems. Ford's highly mechanized and subdivided manufacturing operations already imposed severe demands on labor. The workers had been instructed by the foreman to place one particular part in the assembly or perhaps start a few nuts or even just tighten them and then push the flywheel down the row to the next worker. Having pushed it down eighteen or thirty-six inches, the workers repeated the same process, over and over. Even more than previous manufacturing technologies, the assembly line implied that men, too, could be mechanized. Consequently, during 1913 the Ford company saw its annual labor turnover soar to 380 percent and even higher. Henry Ford moved swiftly to stem this inherently inefficient turnover rate. On January 5, 1914, he instituted what became known as the five-dollar day. Although some historians have argued that this wage system more than doubled the wages of "acceptable" workers, most recently the five-dollar day has been interpreted as a plan whereby Ford shared excess profits with employees who were judged to be fit to handle such profits. In any case, the five-dollar day effectively doubled the earnings of Ford workers and provided a tremendous incentive for workers to stay "on the line". With highly mechanized production, moving line assembly, high wages, low prices on products, "Fordism" was born.

During the years between the birth of "Fordism" and the wide spread appearance of the term *mass production*, the Ford Motor Company expanded its annual output of Model Ts from three hundred thousand in 1914 to more than two million in 1923. A complete Model T emerged from the factory every forty seconds of the working day. Five trains of forty cars each left the factory daily, loaded with finished automobiles. In an era when most prices were rising, those of the Model T dropped significantly - about 60 percent in current dollars. Throughout the Model T's life, Henry Ford opened his factories to technical journalists to write articles, series of articles, and books on the secrets of production at Ford Motor Company. The Ford Motor Company educated the American technical community in the ways of mass production. Soon after the appearance of the first articles on the Ford assembly lines, other automobile companies began putting their cars together "on the line". Ford's five-dollar day forced automakers in the Detroit vicinity to increase their wage scales. Because Ford had secured more than 50 percent of the American automobile market by 1921, his actions had a notable impact on American industry.

Ford's work and its emulation by other manufacturers led to the establishment of what could be called the ethos of mass production in America. The creation of this ethos marks a significant moment in the development of mass production and consumption in America. However, changes in consumers' tastes and gains in their disposable incomes made the Model T obsolete. Automobile consumption in the late 1920s called for a new kind of mass production, a system that could accommodate frequent change and was no longer wedded to the idea of maximum production at minimum cost. General Motors proved to be in tune with changes in American consumption with its explicit policy of "a car for every purpose and every purse", its unwritten policy of annual change, and its encouragement of "trading up" to a more expensive car. Ford production technology had become so highly specialized that the changeover to a new model, the A, brought unimagined problems for the company. Ford learned painfully and at great cost that the times called for a new era, that of "flexible mass production".

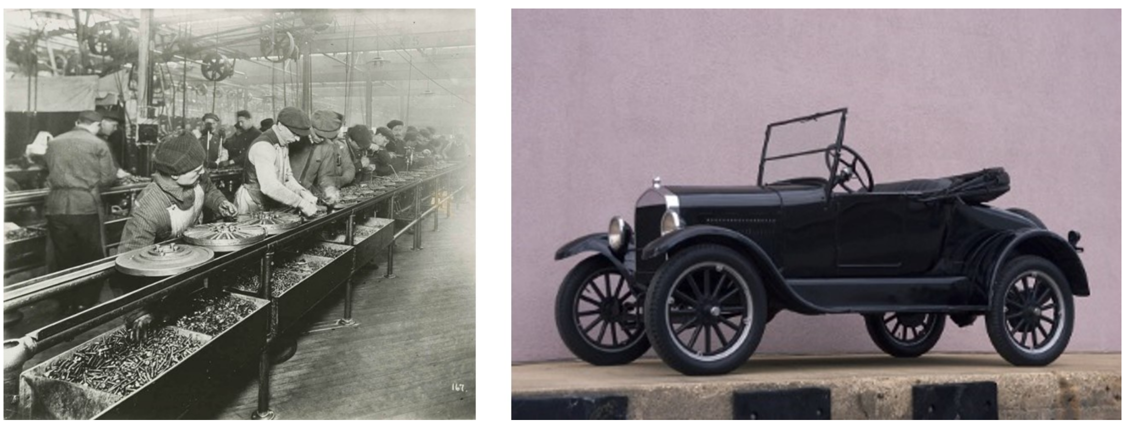

Figure D.1. The First Magneto Assembly Line (left) and Model T Ford (Smithsonian Institution, Henry Ford Museum)

APPENDIX E. FLUORESCENT LAMPS (CASE 5)

Edited from [119]:

On April 21, 1938, the fluorescent lamp was released commercially by the Mazda companies, General Electric, and Westinghouse. The new lighting device could provide brighter and deeper colors of a wider variety than was previously possible with incandescent lamps. Because of their ability to produce “light in hitherto unobtainable pastel tints as well as pure colors,” they were expected materially to affect many phases of lighting practice. Moreover, although their installation costs were higher, they were thirty to forty times more efficient than incandescent lamps for color lighting.

In these early days of fluorescent lighting, the lamp was a “fluorescent *tint* lighting lamp.” Obviously, tint lighting was an important objective for the lighting engineers who were designing the first large-scale applications for these fluorescent lamps. But within half a year of the introduction of the fluorescent tint lighting lamp, another artifact emerged: the high-efficiency daylight fluorescent lamp. A flood of advertising over the signatures of the major lamp companies streamed out, containing such statements as, “three to two hundred times as much light for the same wattage,” “amazing efficiency,” “most economical,” and “indoor daylight at last.” On the other side, the utilities started to fear that the high efficiency of the fluorescent lamp might reduce their electricity sales. With a comparison, to the utility, fluorescence was only half as important as incandescence; to the lamp suppliers it was six times as important, to the contractor 20 percent more important.

Thus a controversy developed - the “load issue.” It took the form of a competition between the two fluorescent lamp artifacts. The utilities, having been alerted by their discovery of the high-efficiency daylight fluorescent lamp, tried to keep the other artifact, the fluorescent tint lighting lamp, in the forefront. They argues that claims about high efficiency were true, but only when fully qualified. And this, they claimed, was not done. Long and detailed arguments were given to point out that the high-efficiency daylight fluorescent lamp really did not exist, but that it was mistaken for the fluorescent tint lighting lamp, which indeed was a valuable new lighting tool, but only for limited purposes. The Mazda companies did not agree with the conclusion that the load on the electricity networks would fall, thus decreasing the utilities’ profits. And so they continued to push, albeit carefully, the high-efficiency fluorescent lamp.

However, the Mazda companies had their own problems with the high-efficiency daylight fluorescent lamp: at the moment of its commercial release, there was no known relation between life and efficiency in fluorescent lamps; in fact, the life of the lamp was not known. They knew that it was something more than 1,500 hours when the lamps were given their original rating, but they did not know whether it could work out to be 15,000 hours or much more. The controversy was fierce, probably because the relevant social groups of Mazda companies and utilities both felt that their common control of the lighting market, as exerted in the incandescent era, was at risk. This threat became especially acute when a third relevant social group entered the arena - the independents, notably the Hygrade Sylvania Corporation.

The aggressive sales policy employed by Hygrade Sylvania created as much of a problem for the utilities as it did for the Mazda companies. The utilities sensed a realignment of forces taking place among the lamp manufacturers and feared that it might lead to methods and activities disorganizing the whole lighting market together with the competitive situation. Hygrade Sylvania was claimed to capture a sizable portion of the market and clearly was advancing the high-efficiency daylight fluorescent lamp, although downplaying the economic risk for the utilities.

Consequently, Hygrade Sylvania's activities resulted in pouring oil on the fire. Various ways of closing this load controversy between the Mazda companies and the utilities were tried. Among them, a new fluorescent lamp, the high-intensity daylight fluorescent lamp, was designed. Retrospectively, one can argue that the third fluorescent lamp was designed - not on the drawing board or at the laboratory bench but at the conference table between the Mazda companies and the utilities. The appearance of the high-intensity daylight fluorescent lamp not only solved the load controversy but also saved the cooperation between the two important relevant social groups. The Mazda companies decided that the utilities' promotion of the high-intensity lamp could be profitable to them as well and General Electric developed a new line of fluorescent lamps of higher wattages. Now it is not difficult to guess why the public was not informed about the cancellation of the high-efficiency lamp and the effort to sell the high-intensity lamp instead.

Figure E.1. An Early Fluorescent Lamp (Smithsonian Institution)

APPENDIX F. THE TELETEL (MINITEL) OF FRANCE (CASE 6)

Edited from [120, 121]:

In the mid 1960s, particularly after the American Congress denied a permit to export a large IBM mainframe computer to the French Government, French political commentators started to voice concerns that France was falling behind the United States in information technology. Some predicted this would soon be an intolerable situation of technological and cultural dependence. Similar concerns continued through the 1970s and influenced a central piece of the industrial policy of the country.

In 1974, the French telecommunication system was very weak. Less than 7 million telephone lines served a population of 47 million. This was one of the lower penetration rates in the industrialized world and equivalent to that of Czechoslovakia. Customers waited four years to get a new line, and most rural areas were still equipped with manual switches. In this context, then president Giscard d'Estaing made the reform of the telecommunication infrastructure a top priority and launched a program under the banner "Le téléphone pour tous."

The government push toward standardization and export of equipment was partially responsible for lowering subscription charges, resulting in more than doubling the number of telephone lines between 1974 and 1979. By the late 1980s, the penetration rate was at 95 percent, one of the higher among the industrialized nations. The magnitude of the investment required to create the telephone network raised questions of how to maintain its expansion and how to recuperate the modernization costs. In early 1978, with the telephone penetration rate growing very quickly, the government realized that telephone traffic alone would not be enough to pay back the investment in the telephone network and the public packet-switched network. They needed new services to increase traffic and approved the videotex and electronic telephone directory. Three years after the successful launch of the telephone penetration campaign, "La grande aventure du Télétel" had begun.

With seven million new telephone lines added between 1974 and 1979, a telephone directory was obsolete before it was printed (and it was printed twice a year). Also, the cost of printing the directory had gone up so rapidly that it lost FF120 million. Furthermore, the cost of printing the directory alone was expected to double in five years, and the quantity of paper was expect to quintuple. Directory assistance was hopelessly overloaded. The number of operators needed in 1985 was forecasted to be 9,000. Given those expenses of printing the directory and operating, the French government planned to distribute terminals free of charge to subscribers.

After the success of initial distribution confined to limited area, the voluntary and free distribution of minitel terminals began: There were only 120,000 minitels in France by the end of 1983, but over 3 million by December 1987, and more than 6 million by December 1992. Videotex services went from 2,000 in January of 1986 to 12,000 at the end of 1989 to more than 20,000 by December 1992. As of 1993, Télétel has over 6 million subscribers and 20,000 services, and handles close to 2 billion calls and 110 million hours of connection time a year.

Through its 20,000 services the Télétel system offers information about entertainment events, train schedules, television and radio programs, jobs and classified ads, interactive games, banking services, grocery and home shopping, comparative pricing, and many other consumer services. Whether it is to be in greater touch with the client, to increase efficiency in distribution, to gain market share, Télétel has become an important component of the business strategy of companies operating in France. After the success of Télétel, automated transactions systems have sprung up throughout the country.

From a social point of view, Télétel has had an impact in a wide variety of ways. For example, the anonymity that the chat services provide has encouraged the sick (e.g. cancer, AIDS) and the troubled (e.g. drug addicts, divorced, abused) to discuss their more intimate problems with others. Télétel has been used as a decentralized, grass-roots vehicle for the discussion of a variety of social issues. Also, it is well known that one of its biggest hits was the so-called “Minitel Rose,” the world’s first electronic adult chatrooms, where people using pseudonyms patiently exchanged direct and crude messages about sex. Télétel or the French minitel, France’s one-time pride and joy born in the glory of French technology with the Concorde and TGV, was shut down on June 30, 2012, some 30 years after its launch.

Figure F.1. Télétel (French Minitel) in 1979 (www.google.com)

APPENDIX G. PERSONAL COMPUTERS (CASE 7)

Edited from [122]:

The introduction and diffusion of personal calculators had several profound effects on the direction of computing technology in the 1970s. The first was that the calculator created a market where chip suppliers could count on a long production run, and thereby gain economies of scale and a low price. As chip density, and therefore capabilities, increased, chip manufacturers faced a variation of the problem that Henry Ford faced with his Model T: only long production runs of the same product led to low prices, but markets did not stay static long enough. That was especially true of integrated circuits, which by nature became ever more specialized in their function as the levels of integration increased. The calculators offered the first consumer market for logic chips that allowed one to amortize the high costs of setting up production lines for complex integrated circuits. The dramatic drop in prices of calculators between 1971 and 1976 showed just how potent this force was.

The second impact was just as important. Pocket calculators, especially those that were programmable, unleashed the force of personal creativity and energy of masses of individuals. This force had been observed among the 'hacker' culture at MIT and Stanford. Such individual activities - only to increase as the prices of calculators dropped - were the first indication that personal computing could be truly a mass phenomenon. The calculators were to be easy enough to use. But customers soon wanted to do more, and finding little help from the supplier, they turned to one another. This supporting infrastructure was critical to the success of personal computing, and in the following decade it would become an industry all its own.

Calculators showed what advanced integrated circuits could do, but they did not open up a direct avenue to personal, interactive computing. Even though each year saw the introduction of new chips that performed more and more sophisticated calculations, those chips were too specialized, too geared toward mathematics, to form a basis for a general-purpose computer. What was needed was a set of integrated circuits - or even a single integrated circuit - that incorporated the basic architecture of a general-purpose computer. Such a chip, called a 'microprocessor', did appear.

In 1964 Gordon Moore, then of Fairchild and soon a cofounder of Intel, noted that from the time of its invention in 1958, the number of circuits that one could place on a single integrated circuit was doubling every year. By the late 1960s Transistor-Transistor Logic (TTL) was well-established, but a new type of semiconductor called 'metal-oxide semiconductor' (MOS), was emerging as a way to place many more logic elements on a single chip. The chip density permitted by MOS brought the concept of a computer-on-a-chip into focus among engineers at Intel, Texas Instruments, and other semiconductor firms. As obvious as it appears in hindsight that the 8080 [Intel microprocessor] would lead to the personal computer, Intel engineers and management did not foresee that path. The steps from the 8080 to the PC were not obvious, just as the Intel 8080 itself was not an inevitable product of improvements in chip density.

As low-cost microprocessors were appearing in small systems, developments in larger systems were pushing down from the 'top'. The most important of these was the ascendancy of interactive, easy to learn software. If personal, it needed two kinds of software. The first was a way to write applications programs. The second was a standard so that these programs could be stored on floppy disks and used on more than one machine. By the mid-1970s those two requirements were also being met. In 1964, the BASIC programming language was invented at Dartmouth College for its pioneering time sharing system. It was an interactive and easy to learn language, which we shall see as a key element in the spread of personal computing a few years later (although we shall also see that significant modifications were also required). In 1966, after enjoying a surge of revenues from installations of its mainframes, IBM also released 'DOS' (Disk Operating System), which was successful.

At this point, around 1974, one can observe the two technological trajectories crossing each other: more and more interactive, conversational systems from minicomputer and mainframe companies, more and more powerful chips, especially microprocessors, from semiconductor companies. Left to the companies pushing these trajectories, they would not have converged. Here is where the electronics hobbyists, cousins of the pocket calculator aficionados, come in. The hobby was evolving rapidly from analog to digital applications, but it was healthy. This group supplied the key component needed to make the transition from the microprocessor to the personal computer; an infrastructure of support that neither the microcomputer companies nor the chip makers could provide.

1974 was the *annus mirabilis* of personal computing. It began with the introduction of the HP-65 programmable calculator in January. That summer Intel announced its 8080 processor chip. In late December, a prototype of the 'Altair' minicomputer, which is a genuine personal computer, went public for less than $400. The invention of Altair had two parts. First was the Altair itself: a capable, inexpensive computer designed around the Intel 8080 microprocessor. Although hobbyists first seized on the product, the Altair was designed and marketed as a serious computer to do the same kinds of things that a minicomputer could do. And nearly every person who bought one recognized that. The second, just as important, was a culture that made place for a personal computer. Selling a computer for less than $400 meant that the extensive support and infrastructure that mini and mainframe companies supplied had to come from elsewhere. For personal computer owners, it came from users' groups (following tradition set by the HP calculators), informal newsletters, commercial magazines, local clubs, conventions - even retail stores. All of these sprang up along with the Altair; many of them lived long after the last Altair computer itself was sold.

By 1977 the pieces were all in place for personal computing to come of age. The Altair's design shortcomings were corrected. Microsoft BASIC allowed programmers to write interesting, and for the first time, serious software for PCs. The ethic of charging money for this software gave an incentive to such programmers. Many computers were being offered with BASIC and five-and-a-quarter-inch floppy disk drives. Machines came with serial and parallel ports, and relatively-standard connections for printers, keyboard, and video monitors were becoming common. Finally, there was a strong and healthy industry of publications, software companies, and support groups to bring novice on board. Three computers introduced that year completed the transition. The retail giant Radio Shack began offering its 'TRS-80' Model 1 in its stores, at prices starting at $400. It was a complete system, including a keyboard and monitor, with cassettes used for storage. The Commodore PET, designed and sold by a company that had made calculators, also came complete with monitor, keyboard, and cassette player built in to a single box. The third machine introduced in 1977 was the Apple II, created by Steve Jobs and Steve Wozniak in a Silicon Valley garage. The Apple II used a different microprocessor than the Altair, but in other ways it was the Altair's spiritual descendant. It came with a version of BASIC written by Microsoft. It had a bus, which allowed Apple and other companies to expand the computer's capabilities and keep it viable into the 1980s.

Figure G.1. Altair and Apple II (Smithsonian Institution)

APPENDIX H. ON-LINE MUSIC (CASE 8)

Edited from [123]:

Since its invention, sound recording technology has continually changed and evolved. The drive to improve sound quality (even though it is difficult for everyone to agree what good quality is) has been a constant factor in this evolution, usually leading to small innovations that were slowly incorporated into studio practices, record manufacturing techniques, or consumer technologies. There have also been inventions that were more revolutionary in nature. The phonograph itself was a revolutionary invention, transforming the scientific field of sound recording into the commercial field of sound recording and sound reproducing. Magnetic and optical recorders were other revolutionary changes, their success requiring significant transformations in the ways recordings were made and used.

Viewing the history of recording in this way makes it necessary to argue that the compact disc and other forms of digital recording were not themselves revolutionary in nature. That statement runs counter to most of the marketing "hype" that has accompanied the CD since its introduction in the early 1980s. It is true that at the time of its introduction and even twenty years later, it represented the highest of high fidelity. Unlike the LP, it did not require operating-room cleanliness to handle and store without degrading its sound. Unlike the cassette tape that preceded it, the CD never stretched, broke, or got "eaten" by its player. The CD's small size and durability made it a good medium for portable listening. Its strongest improvement over the LP was in the area of what audio engineers call dynamic range, which is the difference between the loudest sound and the softest sound that it is possible to record. The lower limit, which is probably the most important of the two, equals the background noise level; on an LP, the background noise is the unavoidable byproduct of the stylus dragging along the surface of the vinyl, added to the hiss of the master tape, which is transferred to the disc during mastering. The CD, especially when coupled with the new generation of digital studio recorders, offered a dynamic range that was considerably better than that of an LP.

But did those improvements in fidelity constitute a revolution? People tended to use the CD and its partner, the CD-R, in the same ways that they used the LP and the cassette for the recording and playback of music. From an anthropological or sociological point of view, there was little to distinguish the new digital technology in terms of its role in society. In the last years of the twentieth century, however, the CD and digital recording technology converged and became part of a development that was truly revolutionary: on-line music.

The controversial technologies for storing and sharing music over computer networks began as a search for ways to "compress" digital audio and video data. Pulse code modulation or PCM from the early 1980s, the standard way of converting analog audio and video signals into digital form, works well for an audio CD, where disc space is not at a premium and masses of data can be transfered within integrated circuits, but it presented problems when engineers began looking for ways to send high quality digital audio over telephone lines or over the airwaves. In 1987, the German nonprofit research consortium Fraunhofer Gesselschaft, through its laboratories at the University of

Erlangen, began working on a project to compress audio data so that the broadcast would require less bandwidth, which was important because of the scarcity of available frequencies and the limitations of existing bandwidth allocations. Those researchers developed an improved mathematical method that could reduce the bandwidth of a digital audio data stream by a factor of twelve with only a minimal loss of sound quality. It did so by analyzing the audio data and using sophisticated algorithms to remove redundant or irrelevant parts of the signal.

Fraunhofer received a patent for the compression algorithm in 1989, but by this time there was growing interest in technologies such as digital telephones, cellular digital telephones, videophones, and videodiscs. Knowing that it could be applied to audio and video, and hoping that manufacturers would adopt the new standard for any or all of these new technologies, they submitted it to a committee called the Moving Pictures Experts Group (MPEG), which was jointly sponsored by two international standards-setting bodies, the International Standards Organization (ISO) and the International Electrotechnical Commission (IEC). By 1992, the group published its first set of compression standards, which it called MPEG-1.

In the meantime, the use of the personal computer and the Internet was exploding. The distribution of digital music on the Internet started about a year after the publication of the MPEG standard. In November 1993, one of the earliest on-line music sources appeared in the form of the Internet Underground Music Archive. In 1994, a seminal Internet discussion group began, called the MPEG-3 Audio Consortium, which itself used the Internet to link people who were interested in the new medium. As the number of enthusiasts grew, privately sponsored archives of songs began to appear as file transfer protocol (FTP) sites, accessible through pre-World Wide Web search engines and file-transfer software packages. Such FTP archives were gradually transformed following the introduction of the World Wide Web in 1993, and became full-fledged web sites as the Web grew more popular in 1994 and 1995. In 1997, the first commercial music download site appeared, MP3.com.

Meanwhile, users needed ways to play these downloaded digital files. “Wave” files could be played by Apple Computer’s Quicktime, or a number of other players. Fraunhofer researchers released a software-based MP3 player for the Microsoft Windows operating system, called Winplay, in 1995, but it was not as successful as AMP Playback Engine of Advanced Multimedia Products. Even more popular was Winamp, a shareware program similar to AMP that was distributed free over the Internet. As the use of the Internet to access MP3 files grew, manufacturers began to introduce players that could accept the digital files from a personal computer, store them in memory, and play them back at the user’s convenience. The first of these, the MPman, was succeeded by the more popular Rio player by Diamond Multimedia. Diamond was subsequently sued by the Recording Industry Association of America. In response to these threats, CoodNoise, MP3.com, MusicMatch, Xing Technology, and Diamond Multimedia announced the formation of the MP3 Association, a group aimed at protecting the interests of companies associated with MP3 technology, in late 1998.

Now, it is clear that another period of accelerated technological change is underway. These changes do not necessarily affect the nature of what people hear, nor are they making much of an impact on how or where they hear it. Studios are still producing the kinds of music they produced before, and people are still listening in their homes, in cars, and in public. But the use of digital recording, personal computers, and the Internet is already changing the patterns of the consumption of music. It is evident, particularly in the behavior of young people, that owning records and amassing collections are no longer as important to consumers as acquiring the music itself, represented by ephemeral and largely intangible digital files. Even more profound are the emerging changes in the recording industry, which is only gradually loosening its grip on the notion that its ultimate purpose is to manufacture something, rather than to distribute and promote music. The recording industry is making the transition from the manufacturing to the service sector of the economy, and in future years it will rely less on sales of physical media than on sales of songs.

Figure H.1. Portable CD Player and MP3 Player (www.google.com)

APPENDIX I. SURVEY QUESTIONNAIRE

IRB Protocol Number 1612018539

RESEARCH PARTICIPANT INFORMATION SHEET

The Relationship between Understanding of Technology and Human Will toward Technology

Eric T. Matson, Ph.D.
Chanwoon Park, M.S.
Purdue University
Department of Computer and Information Technology

Purpose of Research

You have been invited to participate in a research study designed to assess the effect of understanding of the discipline of technology on the will (or attitude) toward technology. By conducting this study, we hope to learn how our colleagues at Purdue Polytechnic Institute think about technology.

Specific Procedures

If you agree to participate in the study, you will complete an eligibility filtering; followed by 16 measurement items with Likert scale. For the last part, there are questions asking your demographic background; however, you will NOT have to disclose any personally identifying information (e.g. name, student identification number).

Duration of Participation

It will take you about **5 minutes** to complete the survey.

Risks

There is no foreseeable risk beyond those encountered in your normal day-to-day activities.

Benefits

Although this study will not benefit you directly, the resulting research should benefit the college and society indirectly by furthering our understanding of the relationship between how much you know about technology and how you feel about technology. The findings may lead to inform interventions and services that could potentially enhance the education system of our college.

Compensation

After you have completed the survey, you will have the opportunity to submit your email address to enter a drawing for a **$50 Amazon** gift certificate. Your email address will not be connected to your responses and will be destroyed once the drawing is finished. The winner will be randomly selected and will receive an email. The odds of winning are dependent on the number of submission.

Confidentiality

Your responses and participation are completely anonymous and confidential. Only authorized personnel will have the access to the data. All data obtained during the survey will be destroyed once data collection is complete. All data will be coded and stored in a computerized file protected by a password. The research records may be reviewed by departments at Purdue University responsible for regulatory and research oversight.

Voluntary Nature of Participation

Your participation is strictly voluntary. You may refuse to participate or discontinue at any time without penalty. You may also decline to answer any question that makes you feel uncomfortable.

Contact Information

If you have any questions about the project, you may contact Dr. Eric Matson at ematson@purdue.edu or Chanwoon Park at park700@purdue.edu. If you have concerns about the treatment of research participants, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN. 47907-2114. The phone number for the Board is (765) 494-5942 and the email address is irb@purdue.edu.

Documentation of Informed Consent

I have had the opportunity to read this information and have the research study explained. I am now prepared to participate in the survey described above.

Are you agree to participate?

○ Yes, let me begin.

>>

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Have you already completed this survey?

- Yes (Please stop answering)
- No (Please proceed)

>>

Are you an undergraduate or graduate student of Purdue Polytechnic Institute (College of Technology)?

- Yes (Please proceed)
- No (Please stop answering)

>>

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To the following statements, please choose the answer that corresponds with your level of agreement.

	Disagree very much	Disagree moderately	Disagree slightly	Agree slightly	Agree moderately	Agree very much
A1. Technology is present ONLY in the forms of physical object.	○	○	○	○	○	○
A2. Every technological object has its own purpose(s) of human need.	○	○	○	○	○	○
A3. In ancient times, technology did NOT exist.	○	○	○	○	○	○
A4. There is a distinctive kind of technological knowledge.	○	○	○	○	○	○
A5. Technology is a part of science.	○	○	○	○	○	○
A6. The knowledge of technology is the knowledge of nature.	○	○	○	○	○	○

	Disagree very much	Disagree moderately	Disagree slightly	Agree slightly	Agree moderately	Agree very much
A7. Technology is more about everyday life than scholarly research.	○	○	○	○	○	○
A8. The term “scientist” refers to a person who is good at technology	○	○	○	○	○	○
A9. Human activities of designing is a part of technology.	○	○	○	○	○	○
A10. Technology develops upon human engagement.	○	○	○	○	○	○

	Disagree very much	Disagree moderately	Disagree slightly	Agree slightly	Agree moderately	Agree very much
A11. Human will is a part of technology.	○	○	○	○	○	○
A12. Technology determines how people live.	○	○	○	○	○	○

	Disagree very much	Disagree moderately	Disagree slightly	Agree slightly	Agree moderately	Agree very much
A13. Technology is subject to be controlled by humans.	○	○	○	○	○	○
A14. The results of the use of technology can be harmful to human beings.	○	○	○	○	○	○
A15. Technology is value-free, thus, neutral.	○	○	○	○	○	○
A16. I can decide whether to accept or deny a technology on my own.	○	○	○	○	○	○

>>

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Into which of the following ranges does your age fall?

- 19 or younger
- 20-24
- 25-29
- 30-39
- 40 or older

Please indicate your gender.

- Man
- Woman

Which of the following best describes your current academic affiliation?

- Freshman
- Sophomore
- Junior
- Senior
- Master's student
- Ph.D. Student

In which department are you enrolled? (If you are enrolled in more than one, please choose the department that you consider your primary affiliation.)

- Aviation and Transportation Technology
- Computer and Information Technology
- Computer Graphics Technology
- Construction Management Technology
- Division of Military Science and Technology

- ◯ Engineering Technology
- ◯ Technology Leadership & Innovation
- ◯ Transdisciplinary Studies

>>

APPENDIX J. IRB APPROVAL

PURDUE
UNIVERSITY

HUMAN RESEARCH PROTECTION PROGRAM
INSTITUTIONAL REVIEW BOARDS

To:	ERIC MATSON KNOY
From:	JEANNIE DICLEMENTI, Chair Social Science IRB
Date:	02/14/2017
Committee Action:	**Determined Exempt, Category (2)**
IRB Action Date:	02/13/2017
IRB Protocol #:	1612018539
Study Title:	The Relationship Between Understanding of Technology and Human Will to Technology

The Institutional Review Board (IRB) has reviewed the above-referenced study application and has determined that it meets the criteria for exemption under 45 CFR 46.101(b).

Before making changes to the study procedures, please submit an Amendment to ensure that the regulatory status of the study has not changed. Changes in key research personnel should also be submitted to the IRB.

Please retain a copy of this letter for your regulatory records. We appreciate your commitment towards ensuring the ethical conduct of human subject research and wish you well with this study.

Ernest C. Young Hall, 10th Floor - 155 S. Grant St. - West Lafayette, IN 47907-2114 - (765) 494-5942 - Fax: (765) 494-9911

APPENDIX K. SURVEY PARTICIPATION REQUEST

2017. 2. 26. Survey Participation Request - Chanwoon Park

Survey Participation Request

Chanwoon Park

Sun 2/26/2017 7:49 PM

To: Chanwoon Park <park700@purdue.edu>;

Dear colleagues at Purdue Polytechnic Institute (College of Technology),

Professor Eric T. Matson and I am conducting a survey to assess **the effect of understanding of the discipline of technology on the will (or attitude) toward technology.**
We expect to learn how our colleagues at the college think about technology.
The survey will NOT take you more than 5 minutes, and upon completion, you will have the chance to win a $50 Amazon gift card by submitting your email address.
Your responses are completely anonymous and confidential, and your participation is strictly voluntary.

To participate, please go to: https://purdue.qualtrics.com/SE/?SID=SV_8D2IHhk6oNOIzyt
More information about the survey is available as well.

I appreciate your help!!

Chanwoon Park
Ph.D. Candidate
CIT / College of Technology
PURDUE UNIVERSITY

https://outlook.office.com/owa/?viewmodel=ReadMessageItem&ItemID=AAMkADFkMzdiOWYyLWMxYTItNGI2NC1hMWM4LWUyYmM5Y2QyYThjYwBGAA.. 1/1

APPENDIX L. THE PARADIGM MODEL ANALYSES

Table L.1. *The Paradigm Model Analysis on (Case 1) Mechanical Clocks*

(A) CAUSAL CONDITIONS:
- Flaws and inaccuracy of existing clocks.
 (sundials, water clocks, sandglasses, incense clocks)
- Religious piety and importance of timely prayer.

↓

(B) PHENOMENON:
- Introduction of mechanical clocks to society.

↓

(C) CONTEXT:
- Increased accuracy.
- Increased market demand for mechanical clocks.

↓

(D) INTERVENING CONDITIONS:
- Even more increased accuracy with the invention of pendulum clocks.
- Limits of handcraft manufacturing system.

↓

(E) ACTION/INTERACTION:
- Development of the precision machinery using machine tools.

↓

(F) CONSEQUENCES:
- Stimulating the inventions of various scientific instruments that led to the Renaissance.

Table L.2. *The Paradigm Model Analysis on (Case 2) Early Bicycles*

(A) CAUSAL CONDITIONS:
- (Market demand for a new means of transportation)
- Advancements in carriage- and blacksmith-shop technology.

↓

(B) PHENOMENON:
- Introduction of bicycles to society.

↓

(C) CONTEXT:
- Increased popularity of bicycles.
- Attempts to commercialize bicycles.

↓

(D) INTERVENING CONDITIONS:
- Increasing demand for new sport events.
- Social sensation of bicycle racing.

↓

(E) ACTION/INTERACTION:
- Development of the racing bicycles with high wheels emphasizing speed.
- Creating a new industry of bicycle racing.

↓

(F) CONSEQUENCES:
- Value conflicts in bicycle design: balance vs. speed.
- New demand for technological solution:
  invention of the chain-driven bicycle.

Table L.3. *The Paradigm Model Analysis on (Case 3) Motion Pictures*

(A) CAUSAL CONDITIONS:
- Technical and social success of the phonographs.
- Invention and commercialization of the kinetoscopes.

↓

(B) PHENOMENON:
- Introduction of motion pictures to society.

↓

(C) CONTEXT:
- Popularity of motion pictures: diffusion of theaters and nickelodeons.
- Expansion of the film industry.

↓

(D) INTERVENING CONDITIONS:
- Increasing competition among producers.
- Diversification of population segments.
- Transition from producer to consumer culture.

↓

(E) ACTION/INTERACTION:
- Dominating the market with patents (MPPC).
- Confining to middle-class values and mores.
- Rejecting the star system of film industry.
- Attempts to recover with new hardwares.

↓

(F) CONSEQUENCES:
- Edison's Failure: shutting down the production.

Table L.4. *The Paradigm Model Analysis on (Case 4) Mass Production*

(A) CAUSAL CONDITIONS:
- Development of technologies of interchangeable parts manufacture and sheet steel punch and press work in the bicycle industry.
- Development of "flow production" technology in other industries.

↓

(B) PHENOMENON:
- Introduction of mass production to society.

↓

(C) CONTEXT:
- Increased productivity with reduced cost: maximum profit by maximizing production while minimizing cost.

↓

(D) INTERVENING CONDITIONS:
- (i) Soaring labor turnover rate due to demanding and dehumanized characteristics of the system.
- (ii) Changes in automobile consumption: changes in consumers' tastes and affordability.

↓

(E) ACTION/INTERACTION:
- (i) Institution of the five-dollar day: sharing excess profits with employees.
- (ii) Agile response to consumers' demand.

↓

(F) CONSEQUENCES:
- (i) Diffusion of mass production system.
- (ii) Transition to "flexible mass production".

Table L.5. *The Paradigm Model Analysis on (Case 5) Fluorescent Lamps*

(A) CAUSAL CONDITIONS:
- Commercialization of the fluorescent lamp by the Mazda companies.
- Technical progress after the first fluorescent "tint lighting" lamp.

↓

(B) PHENOMENON:
- Introduction of the "high-efficiency daylight" fluorescent lamp.

↓

(C) CONTEXT:
- Increased efficiency in electricity consumption: much brighter for the same wattage, thus economical.
- Expected profit increase of the lamp suppliers and contractor at the expense of reduced electricity sales for the utility companies.

↓

(D) INTERVENING CONDITIONS:
- The utilities trying to keep the fluorescent tint lighting lamp in the forefront of the market.
- Appearance of a common threat to both the Mazda companies and the utilities: Hygrade Sylvania selling the high-efficiency daylight fluorescent lamp.

↓

(E) ACTION/INTERACTION:
- Cooperation of the Mazda companies and the utilities against Hygrade Sylvania in order to protect their market share.

↓

(F) CONSEQUENCES:
- Designing and releasing a new product: the "high-intensity daylight" fluorescent lamp of higher wattages.

Table L.6. *The Paradigm Model Analysis on (Case 6) The Télétel (Minitel) of France*

(A) CAUSAL CONDITIONS:
- The backwardness of French information technology in the mid 1960s.
- Political and social consensus for the reform of related infrastructure.

↓

(B) PHENOMENON:
- Reform of the national telecommunication infrastructure: "Le téléphone pour tous".

↓

(C) CONTEXT:
- Increased maintenance cost.
- Demand for new services utilizing the infrastructure.

↓

(D) INTERVENING CONDITIONS:
- High telephone penetration rate.
- Demand for an efficient and capable telephone directory system.

↓

(E) ACTION/INTERACTION:
- Introduction of the Télétel system with the videotex and electronic telephone directory services.

↓

(F) CONSEQUENCES:
- Creating various markets and services with advertisement, interactive games, banking services, grocery and home shopping, etc.
- Creating a unique telecommunication system and culture of France.

Table L.7. *The Paradigm Model Analysis on (Case 7) Personal Computers*

(A) CAUSAL CONDITIONS:
- Diffusion of personal calculators:
  creating a market for chip suppliers and unleashing the force of personal creativity and energy of masses of individuals.
- Limited capacity of personal calculators.
- Invention of a new integrated circuit for a general-purpose computer: microprocessor.

↓

(B) PHENOMENON:
- Introduction of personal computers to society.

↓

(C) CONTEXT:
- Releasing capable and inexpensive personal computers at affordable price: creating a new market of PC.
- Diffusion of interactive and conversational computing activities of individuals.

↓

(D) INTERVENING CONDITIONS:
- Demand for an interactive and easy-to-learn software.
- Demand for non-commercial supporting infrastructure to keep low price.

↓

(E) ACTION/INTERACTION:
- Invention and diffusion of compatible software such as BASIC and DOS.
- Activities of the user groups helping each other and boosting personal computing.

↓

(F) CONSEQUENCES:
- Transition of the computer industry from mainframe to personal computers.

Table L.8. *The Paradigm Model Analysis on (Case 8) On-line Music*

(A) CAUSAL CONDITIONS:
- Diffusion of digital recording technology with the CD.
- Demand for storing and sharing music over telephone lines or airwaves.

↓

(B) PHENOMENON:
- Introduction of MPEG standard:
  a new technology of compressing digital audio data.

↓

(C) CONTEXT:
- Sharing high quality digital audio over computer networks.
- Utilizing the Internet as a new medium of storing and sharing music.

↓

(D) INTERVENING CONDITIONS:
- Explosion of the use of the personal computers and the Internet.
- Demand for new sources of on-line music.
- Demand for new software and devices for on-line music.

↓

(E) ACTION/INTERACTION:
- Appearance of the Internet music archives, compatible devices and software.
- Commercialization of on-line music.

↓

(F) CONSEQUENCES:
- Forming a new culture of music consumption.
- Transition of the music industry from manufacturing to service.

APPENDIX M. CATEGORIES, PROPERTIES, AND DIMENSIONS BY CASE

Table M.1. *Categories, Properties, and Dimensions by Case (1-4)*

Case	Category	Property	Dimension
Mechanical Clock	Time Keeping	Accuracy	Low - High
	Machine Making	Precision	Low - High
		Productivity	Low - High
		Market Demand	Low - High
	Application	Utility	Low - High
Early Bicycles	Riding	Easiness	Easy - Hard
		Speed	Slow - Fast
	Sporting	Popularity	Low - High
	Marketing	Profitability	Low - High
		Market size	Small - Big
Motion Pictures	Playing Movies	Amusement	Little - Much
		Availability	Low - High
	Filming Contents	Popularity	Low - High
		Diversity	Low - High
	Marketing	Market Size	Small - Big
		Competition	Weak - Strong
		Profitability	Low - High
Mass Production	Machine Making	Precision	Low - High
		Standardization	Low - High
		Productivity	Low - High
		Production Cost	Low - High
		Market Demand	Low - High
	Marketing	Affordability	Low - High
		Profitability	Low - High
	Management	Labor Efficiency	Low - High

Table M.2. *Categories, Properties, and Dimensions by Case (5-8)*

Case	Category	Property	Dimension
Fluorescent Lamps	Product Quality	Brightness	Low - High
		Efficiency	Low - High
		Energy Consumption	Low - High
	Marketing	Profitability	Low - High
		Competition	Weak - Strong
		Market Share	Small - Big
		Solidarity	Weak - Strong
Télétel (Minitel) of French	Telecommunications Network	Penetration	Low - High
		Utility	Low - High
		Efficiency	Low - High
	Maintenance Service	Cost	Low - High
		Utility	Low - High
Personal Computers	Computing	Capacity	Small - Large
		Programmability	Low - High
		Portability	Low - High
		Easiness	Easy - Complicated
		Product Cost	Low - High
	Marketing	Profitability	Low - High
		Affordability	Low - High
		Market Size	Small - Big
	Community Resource	Availability	Low - High
On-line Music	Audio Compressing	File Size	Small - Large
		Transmission Rate	Low - High
		Availability	Low - High
	On-line Network	Internet Penetration	Low - High
		User Size	Small - Big
	Marketing	Marketability	Bad - Good
		Market Size	Small - Big
		Profitability	Low - High
		Contents (Songs)	Few - Vast

APPENDIX N. ITEM ANALYSIS WITH ALL SCALE ITEMS

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Reverse of A1	61.33	27.338	.070	.099	.228
A2. Every technological object has its own purpose(s) of human need.	61.56	26.517	.149	.152	.197
Reverse of A3	60.71	27.483	.130	.178	.209
A4. There is a distinctive kind of technological knowledge.	62.13	27.407	.090	.141	.221
Reverse of A5	64.27	30.818	-.170	.194	.303
Reverse of A6	63.14	29.918	-.109	.208	.294
A7. Technology is more about everyday life than scholarly research.	62.18	28.010	.005	.106	.256
Reverse of A8	61.76	28.521	.004	.164	.252
A9. Human activities of designing is a part of technology.	61.40	25.400	.364	.314	.134
A10. Technology develops upon human engagement.	61.22	25.467	.348	.353	.138
A11. Human will is a part of technology.	61.80	27.673	.044	.178	.238
Reverse of A12	63.89	31.526	-.225	.166	.336
A13. Technology is subject to be controlled by humans.	61.55	26.669	.170	.191	.192
A14. The results of the use of technology can be harmful to human beings.	61.67	26.285	.147	.124	.196
Reverse of A15	61.77	27.436	.065	.103	.230
A16. I can decide whether to accept or deny a technology on my own.	61.98	25.813	.141	.095	.195

Figure N.1. Item Analysis with All Scale Items

APPENDIX O. CORRELATION MATRIX

Correlation Matrix[a]

Statistics	Variables	Reverse of A1	A2. Every technological object has its own purpose (s) of human need.	Reverse of A3	A4. There is a distinctive kind of technological knowledge.	A7. Technology is more about everyday life than scholarly research.	A9. Human activities of designing is a part of technology.	A10. Technology develops upon human engagement.	A11. Human will is a part of technology.	A13. Technology is subject to be controlled by humans.	A14. The results of the use of technology can be harmful to human beings.	Reverse of A15	A16. I can decide whether to accept or deny a technology on my own.
Correlation	Reverse of A1	1.000	-.040	.154	-.016	.012	.173	.126	.108	-.033	.017	.020	-.084
	A2. Every technological object has its own purpose(s) of human need.	-.040	1.000	.139	.267	.103	.236	.182	.052	.159	.010	-.052	.105
	Reverse of A3	.154	.139	1.000	-.031	-.030	.180	.227	.196	.020	.178	.058	.053
	A4. There is a distinctive kind of technological knowledge.	-.016	.267	-.031	1.000	.113	.156	.164	-.030	.125	.050	-.094	.141
	A7. Technology is more about everyday life than scholarly research.	.012	.103	-.030	.113	1.000	.103	.114	.019	.050	-.023	-.133	.111
	A9. Human activities of designing is a part of technology.	.173	.236	.180	.156	.103	1.000	.487	.231	.186	.102	.105	.166
	A10. Technology develops upon human engagement.	.126	.182	.227	.164	.114	.487	1.000	.268	.281	.168	.086	.080
	A11. Human will is a part of technology.	.108	.052	.196	-.030	.019	.231	.268	1.000	-.007	.038	.081	.007
	A13. Technology is subject to be controlled by humans.	-.033	.159	.020	.125	.050	.186	.281	-.007	1.000	.192	.018	.149
	A14. The results of the use of technology can be harmful to human beings.	.017	.010	.178	.050	-.023	.102	.168	.038	.192	1.000	.114	.063
	Reverse of A15	.020	-.052	.058	-.094	-.133	.105	.086	.081	.018	.114	1.000	.001
	A16. I can decide whether to accept or deny a technology on my own.	-.084	.105	.053	.141	.111	.166	.080	.007	.149	.063	.001	1.000

Figure O.1. Correlation Matrix-1

Correlation Matrix[a]

Statistics	Variables	Reverse of A1	A2. Every technological object has its own purpose (s) of human need.	Reverse of A3	A4. There is a distinctive kind of technological knowledge.	A7. Technology is more about everyday life than scholarly research.	A9. Human activities of designing is a part of technology.	A10. Technology develops upon human engagement.	A11. Human will is a part of technology.	A13. Technology is subject to be controlled by humans.	A14. The results of the use of technology can be harmful to human beings.	Reverse of A15	A16. I can decide whether to accept or deny a technology on my own.
Sig. (1-tailed)	Reverse of A1		.215	.001	.379	.407	.000	.007	.017	.257	.371	.344	.049
	A2. Every technological object has its own purpose(s) of human need.	.215		.003	.000	.022	.000	.000	.153	.001	.421	.152	.019
	Reverse of A3	.001	.003		.273	.279	.000	.000	.000	.345	.000	.129	.151
	A4. There is a distinctive kind of technological knowledge.	.379	.000	.273		.013	.001	.001	.280	.007	.162	.032	.003
	A7. Technology is more about everyday life than scholarly research.	.407	.022	.279	.013		.022	.012	.354	.162	.327	.004	.014
	A9. Human activities of designing is a part of technology.	.000	.000	.000	.001	.022		.000	.000	.000	.023	.020	.001
	A10. Technology develops upon human engagement.	.007	.000	.000	.001	.012	.000		.000	.000	.000	.046	.057
	A11. Human will is a part of technology.	.017	.153	.000	.280	.354	.000	.000		.443	.227	.056	.449
	A13. Technology is subject to be controlled by humans.	.257	.001	.345	.007	.162	.000	.000	.443		.000	.363	.002
	A14. The results of the use of technology can be harmful to human beings.	.371	.421	.000	.162	.327	.023	.000	.227	.000		.012	.109
	Reverse of A15	.344	.152	.129	.032	.004	.020	.046	.056	.363	.012		.495
	A16. I can decide whether to accept or deny a technology on my own.	.049	.019	.151	.003	.014	.001	.057	.449	.002	.109	.495	

a. Determinant = .352

Figure O.2. Correlation Matrix-2

APPENDIX P. COMPONENT ANALYSIS AND SCREE PLOT

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.293	19.109	19.109	2.293	19.109	19.109	1.846	15.380	15.380
2	1.488	12.400	31.509	1.488	12.400	31.509	1.842	15.354	30.734
3	1.188	9.899	41.408	1.188	9.899	41.408	1.281	10.674	41.408
4	.960	8.002	49.410						
5	.953	7.939	57.350						
6	.931	7.761	65.110						
7	.865	7.207	72.317						
8	.808	6.734	79.051						
9	.775	6.457	85.507						
10	.657	5.471	90.978						
11	.621	5.174	96.152						
12	.462	3.848	100.000						

Extraction Method: Principal Component Analysis.

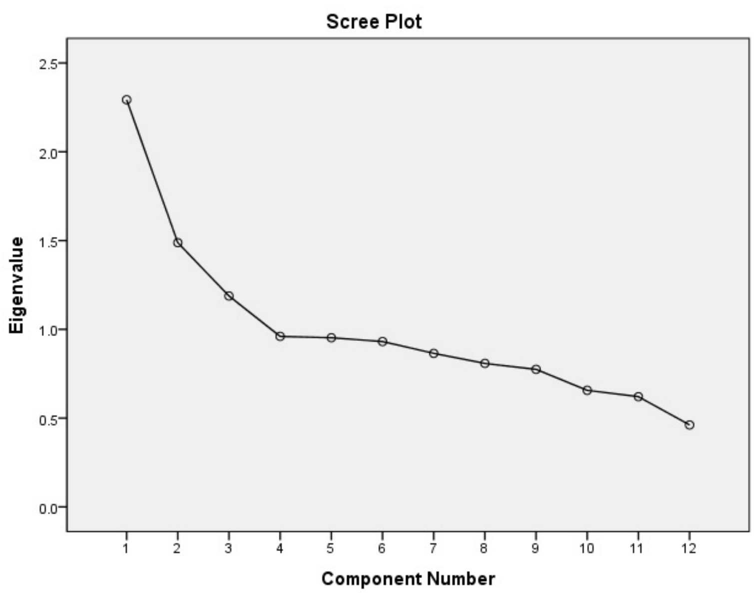

Figure P.1. Component Analysis and Scree Plot

APPENDIX Q. TESTS OF NORMALITY

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
IV Mean	.081	387	.000	.968	387	.000
DV Mean	.074	387	.000	.990	387	.009
MEAN_Application of Technology	.083	387	.000	.981	387	.000
MEAN_Production of Technology	.107	387	.000	.935	387	.000
MEAN_Implications of Technology	.101	387	.000	.978	387	.000

a. Lilliefors Significance Correction

Figure Q.1. Tests of Normality

APPENDIX R. NORMAL Q-Q PLOTS

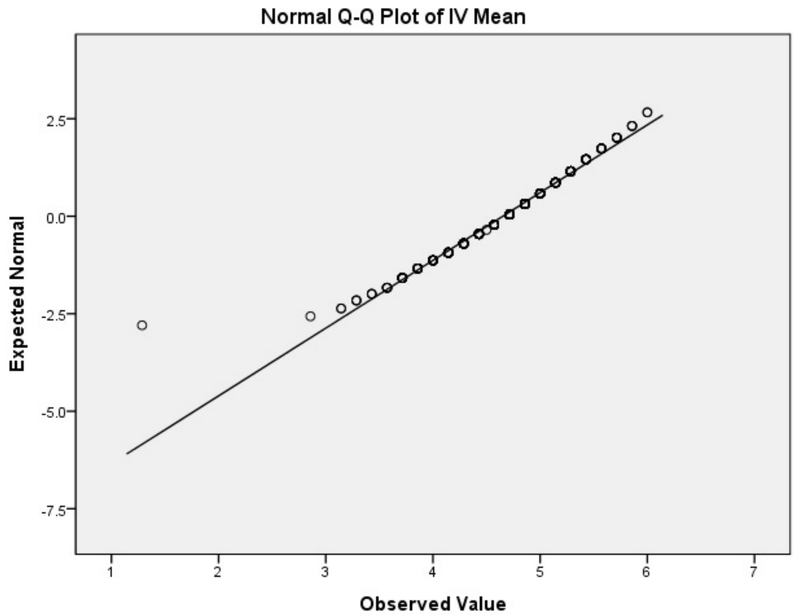

Figure R.1. Normal Q-Q Plot of IV

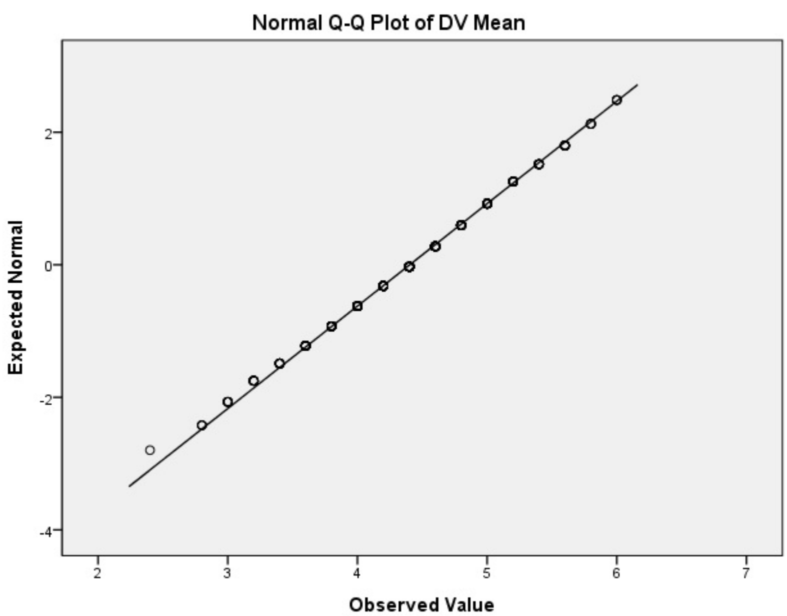

Figure R.2. Normal Q-Q Plot of DV

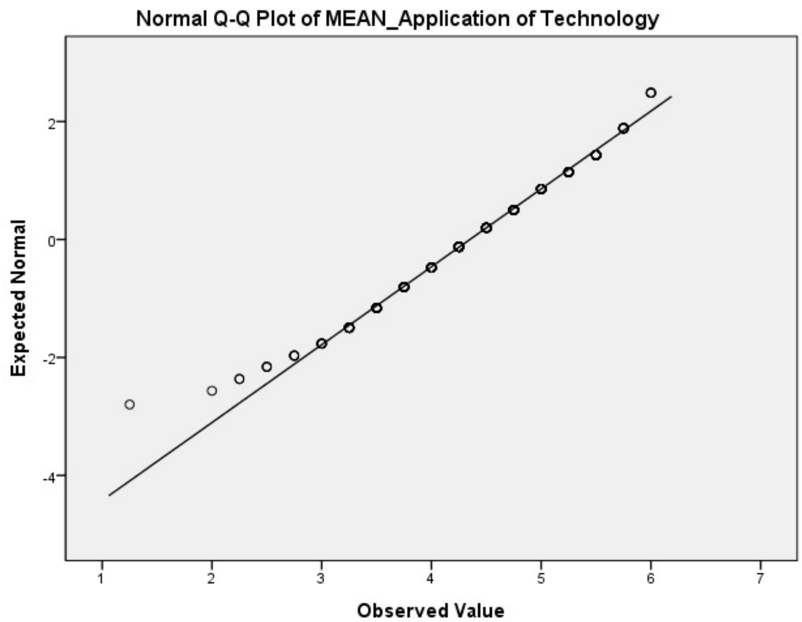

Figure R.3. Normal Q-Q Plot of Application of Technology

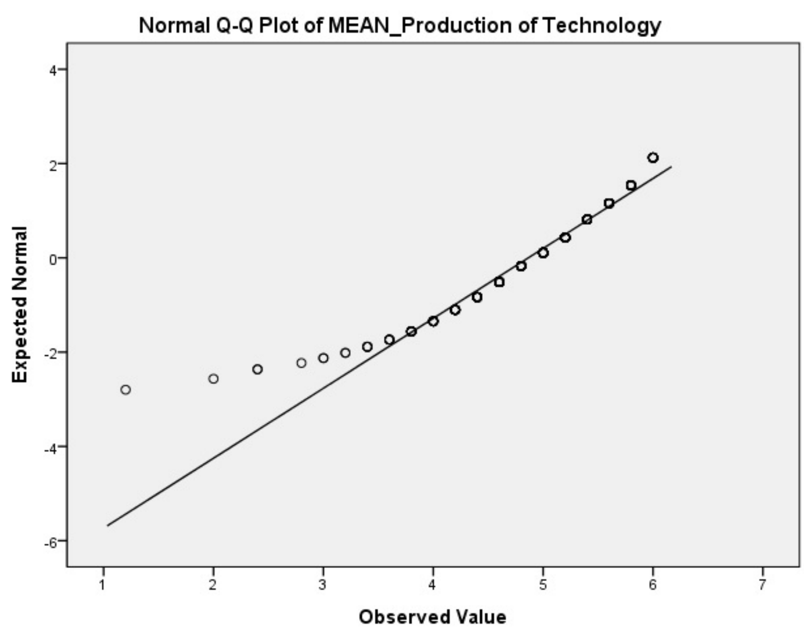

Figure R.4. Normal Q-Q Plot of Production of Technology

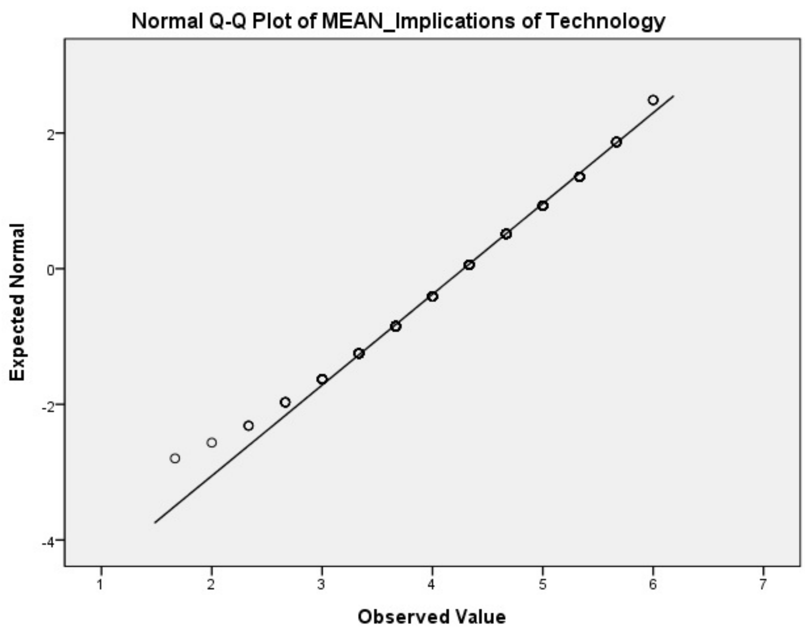

Figure R.5. Normal Q-Q Plot of Implications of Technology

APPENDIX S. TESTS OF HOMOGENEITY OF VARIANCES

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
IV Mean	.599	4	382	.664
DV Mean	1.162	4	382	.327
MEAN_Application of Technology	1.421	4	382	.226
MEAN_Production of Technology	.539	4	382	.707
MEAN_Implications of Technology	1.099	4	382	.357

Figure S.1. Test of Homogeneity of Variances: Age

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
IV Mean	.016	1	385	.898
DV Mean	3.201	1	385	.074
MEAN_Application of Technology	.318	1	385	.573
MEAN_Production of Technology	.000	1	385	.988
MEAN_Implications of Technology	4.451	1	385	.036

Figure S.2. Test of Homogeneity of Variances: Gender

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
IV Mean	1.394	5	381	.225
DV Mean	.939	5	381	.456
MEAN_Application of Technology	2.537	5	381	.028
MEAN_Production of Technology	2.438	5	381	.034
MEAN_Implications of Technology	.394	5	381	.853

Figure S.3. Test of Homogeneity of Variances: Academic Affiliation

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
IV Mean	1.229	6	380	.290
DV Mean	1.757	6	380	.107
MEAN_Application of Technology	1.675	6	380	.126
MEAN_Production of Technology	.567	6	380	.757
MEAN_Implications of Technology	.726	6	380	.629

Figure S.4. Test of Homogeneity of Variances: Department

APPENDIX T. KRUSKAL-WALLIS TEST: DIFFERENCES ACROSS CV

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of IV Mean is the same across categories of Into which of the following ranges does your age fall?.	Independent-Samples Kruskal-Wallis Test	.861	Retain the null hypothesis.
2	The distribution of DV Mean is the same across categories of Into which of the following ranges does your age fall?.	Independent-Samples Kruskal-Wallis Test	.583	Retain the null hypothesis.
3	The distribution of MEAN_Application of Technology is the same across categories of Into which of the following ranges does your age fall?.	Independent-Samples Kruskal-Wallis Test	.499	Retain the null hypothesis.
4	The distribution of MEAN_Production of Technology is the same across categories of Into which of the following ranges does your age fall?.	Independent-Samples Kruskal-Wallis Test	.401	Retain the null hypothesis.
5	The distribution of MEAN_Implications of Technology is the same across categories of Into which of the following ranges does your age fall?.	Independent-Samples Kruskal-Wallis Test	.715	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure T.1. Kruskal-Wallis Test: Age

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of IV Mean is the same across categories of Please indicate your gender..	Independent-Samples Mann-Whitney U Test	.990	Retain the null hypothesis.
2	The distribution of DV Mean is the same across categories of Please indicate your gender..	Independent-Samples Mann-Whitney U Test	.726	Retain the null hypothesis.
3	The distribution of MEAN_Application of Technology is the same across categories of Please indicate your gender..	Independent-Samples Mann-Whitney U Test	.433	Retain the null hypothesis.
4	The distribution of MEAN_Production of Technology is the same across categories of Please indicate your gender..	Independent-Samples Mann-Whitney U Test	.837	Retain the null hypothesis.
5	The distribution of MEAN_Implications of Technology is the same across categories of Please indicate your gender..	Independent-Samples Mann-Whitney U Test	.877	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure T.2. Kruskal-Wallis Test: Gender

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of IV Mean is the same across categories of Which of the following best describes your current academic affiliation?.	Independent-Samples Kruskal-Wallis Test	.018	Reject the null hypothesis.
2	The distribution of DV Mean is the same across categories of Which of the following best describes your current academic affiliation?.	Independent-Samples Kruskal-Wallis Test	.576	Retain the null hypothesis.
3	The distribution of MEAN_Application of Technology is the same across categories of Which of the following best describes your current academic affiliation?.	Independent-Samples Kruskal-Wallis Test	.119	Retain the null hypothesis.
4	The distribution of MEAN_Production of Technology is the same across categories of Which of the following best describes your current academic affiliation?.	Independent-Samples Kruskal-Wallis Test	.009	Reject the null hypothesis.
5	The distribution of MEAN_Implications of Technology is the same across categories of Which of the following best describes your current academic affiliation?.	Independent-Samples Kruskal-Wallis Test	.181	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure T.3. Kruskal-Wallis Test: Academic Affiliation

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of IV Mean is the same across categories of In which department are you enrolled? .	Independent-Samples Kruskal-Wallis Test	.054	Retain the null hypothesis.
2	The distribution of DV Mean is the same across categories of In which department are you enrolled? .	Independent-Samples Kruskal-Wallis Test	.079	Retain the null hypothesis.
3	The distribution of MEAN_Application of Technology is the same across categories of In which department are you enrolled? .	Independent-Samples Kruskal-Wallis Test	.258	Retain the null hypothesis.
4	The distribution of MEAN_Production of Technology is the same across categories of In which department are you enrolled? .	Independent-Samples Kruskal-Wallis Test	.006	Reject the null hypothesis.
5	The distribution of MEAN_Implications of Technology is the same across categories of In which department are you enrolled? .	Independent-Samples Kruskal-Wallis Test	.728	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure T.4. Kruskal-Wallis Test: Department

APPENDIX U. CORRELATIONS BETWEEN NEW VARIABLES

		MEAN_Application of Technology	MEAN_Production of Technology	MEAN_Implications of Technology
MEAN_Application of Technology	Pearson Correlation	1	.170**	.140**
	Sig. (2-tailed)		.001	.006
	N	387	387	387
MEAN_Production of Technology	Pearson Correlation	.170**	1	.193**
	Sig. (2-tailed)	.001		.000
	N	387	387	387
MEAN_Implications of Technology	Pearson Correlation	.140**	.193**	1
	Sig. (2-tailed)	.006	.000	
	N	387	387	387

**. Correlation is significant at the 0.01 level (2-tailed).

Figure U.1. Correlations between New Variables

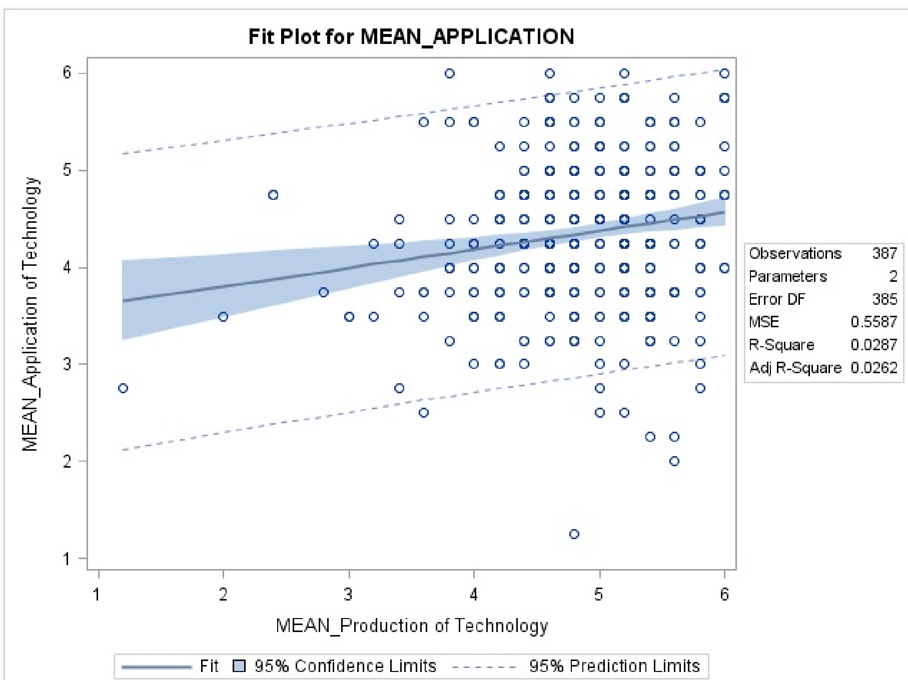

Figure U.2. Fit Plot for Application-Production

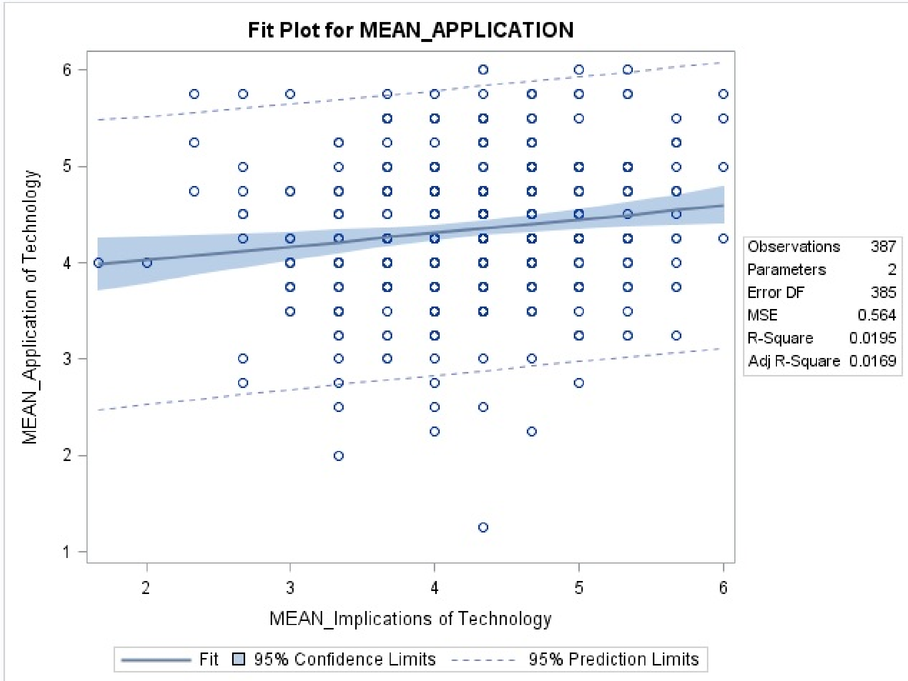

Figure U.3. Fit Plot for Application-Implications

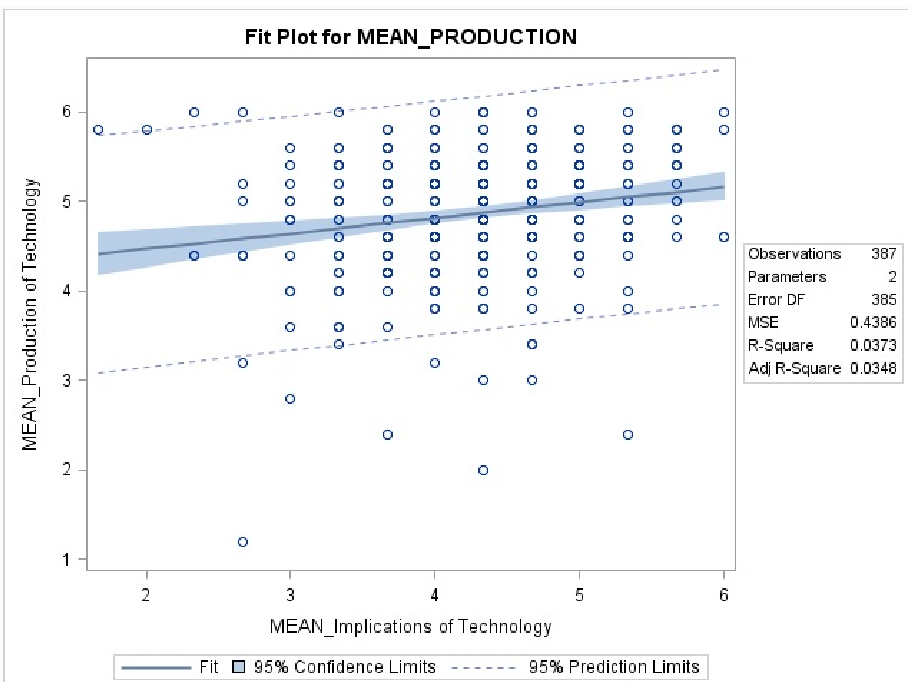

Figure U.4. Fit Plot for Production-Implications

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