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Creativity and Innovation: A Comparative Analysis of Assessment Measures for the Domains of Technology, Engineering, and Business

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Of Technology, Engineering, and Business

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ABSTRACT

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The purpose of this literature review is to investigate and discuss: (1) the characteristics measured by innovation assessments, and (2) the comparison of characteristics measured by creativity assessments with those of innovation assessments. This will be done by: (1) collecting creativity and innovation assessments, and (2) comparing and contrasting the characteristics measured by each assessment. This study reveals that innovation assessments do not measure the innovation process in its entirety. The findings show that creativity and innovation assessments lack in assessing the entire innovation process, assessing the innovation process on an individual level, and assessing an individual's change or growth in the innovation process. Based on the findings, future research needs to be done to develop an individualized innovation assessment.

Keywords: innovation, creativity, assessment, process

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1 INTRODUCTION

Brigham Young University (BYU) has developed a process of innovation, that is being used to teach technology and engineering students how to be innovative. BYU's innovation process involves idea finding, shaping, defining, refining, and communicating. An assessment is needed to verify that the students learning BYU's innovation process are becoming more innovative. Measuring innovation is a large task, however, Dodgson and Hinze (2000) argue that while "measuring the innovation 'process' in its entirety, a combination of activities that are highly complex, socially embedded, and idiosyncratic, is impracticable… the measurement of the elements that stimulate and shape the process [of innovation] … is considered to be a novel and valuable exercise" (p. 102). According to Dodgson and Hinze's claim, not only is it possible to measure the elements or characteristics of innovation, but it is also a worthwhile endeavor. This research reviews the literature of various creativity and innovation assessments in an effort to identify the common characteristics of innovation processes and models, and compare them with the assessments currently being used to measure innovation. The purpose is to create a knowledge baseline of what should be included in an innovation assessment.

1.1 Problem Defined

The purpose of this literature review is to investigate and discuss: (1) the characteristics measured by innovation assessments, and (2) the comparison of characteristics measured by

creativity assessments with those of innovation assessments. This will be done by: (1) collecting creativity and innovation assessments, and (2) comparing and contrasting the characteristics measured by each assessment.

Many researchers have made the argument that innovation is not the same as creativity (Amabile, Conti, Coon, Lazenby, & Herron, 1996a; Carr & Johansson, 1995; Van de Ven, Polley, Garud, & Venkataraman, 1999). According to these researchers and others, innovation can be defined as structured creativity, focused on producing an innovative product, service, or system (Afuah, 1998; Amabile, Conti, Coon, Lazenby, & Herron, 1996a; COTEC, 1997; Carr & Johansson, 1995; Van De Ven, Angle, & Poole, 1989; Dodgson & Hinze, 2000; OECD, 2005; Osorio, 2009; Smith, 2006; Thompson, 1965). Although related, creativity and innovation are distinct and different (Amabile, Conti, Coon, Lazenby, & Herron, 1996a; Carr & Johansson, 1995). Creativity can be thought of as the starting point for innovation. Consequently, creativity and innovation should be assessed differently.

According to the definitions of creativity and innovation, creativity assessments only test a segment of the innovation process. The issue with this is that creativity assessments are being used to assess innovation, and in so doing, are only actually assessing the preliminary part of innovation: creativity. This is similar to trying to test a student's understanding of math by only administering a multiplication test. While the assessment is valuable to understand the student's grasp of multiplication, it does not provide data on the student's ability to do math, which involves more knowledge (e.g. subtraction, division, and addition). Creativity assessments are useful but only measure one part of the innovation process; an innovation assessment would need to measure the elements or characteristics of the entire innovation process.

There are two domains where an innovation assessment would prove useful. First, an assessment would be useful in academic programs. Innovation and creativity are currently important topics being taught and promoted in universities across the United States. For example at Brigham Young University, their College of Engineering and Technology has the goal of preparing students to understand the process by which innovation can be enhanced to help solve the world's problems ("The Ira A. Fulton College of Engineering and Technology. Our Mission. Brigham Young University," 2011). Consequently, it would prove helpful to both the universities and students themselves to have a measure of each student's innovativeness – to see if their programs are making a difference. The second domain would be early industry experience or setting. Many companies require candidates to take personality, aptitude, and or skill tests to ensure that candidate is the right fit for the position for which they are applying. Because many companies see innovation as an essential characteristic for their company, it makes sense that they would benefit from an innovation assessment they could use with job applicants.

In both of these situations, the person has not proven him or herself to be innovative because his or her ideas have not yet been published or produced. Should an employer have to wait years to learn whether an individual is actually good at innovation? Would professors teach differently if they could measure an increase in their students' innovativeness?

This review aggregates and analyzes current innovation assessments to determine what innovation characteristics are being measured, and then compares those characteristics to creativity assessments – which are more commonly used. To accomplish this, this review seeks to answer the following questions:

1. What is creativity (as defined for technology and engineering and business)?
2. What is innovation (as defined for technology and engineering and business)?
3. What different properties do creativity assessments measure?
4. What different properties do innovation assessments measure?
5. How do creativity and innovation assessments compare?

The analysis of the various creativity and innovation assessments provides data from a literature review of the most frequently cited and used creativity assessments and all of the innovation assessments cited in the domains of technology, engineering, and business. The reasoning for using all innovation assessments in those domains is that there is a much smaller number of innovation assessments compared to creativity assessments.

2 LITERATURE REVIEW

The first part of this literature review involves defining terms. Because this review focuses on creativity and innovation – and because there are numerous definitions of these terms, it is imperative that the definitions used in this review be clear, concise, and representative of the audience for whom this thesis was written: technology, engineering, and business. This study will use these definitions in the second part of the literature review where the most prominent innovation processes and methods used in the fields of technology, engineering, and business are listed and described. The list of the various innovation processes and methods will provide a matrix for comparing the elements of innovation and creativity assessments, and thus provide a tool to easily compare these two complicated and ”fuzzy” terms, whereby providing means to more effectively evaluate the creativity and innovation assessments currently in use.

2.1 Creativity Defined

As early as 1961, researchers had counted between 50 and 60 definitions of creativity in the research literature, leading one researcher to comment “the profusion [of definitions] was enough to give one the impression that creativity is a province for pseudo-intellectuals” (Rhodes, 1961 p. 306). Twenty years later, an extensive literature review concluded, “the literature contains such a variance of definitional statements that the task of defining the concept of creativity is a challenging one” (Welsch, 1980 p. 3). No more agreement exists today than then.

Although the term creativity is used as if general agreement exists on the construct's definition, definitions are more often specific to particular authors than a matter of consensus (Ebert, 1994).

Definitions of creativity can generally be divided into two opposing views. In the first view creativity is defined by culture, meaning a work must be novel or new to that culture to be creative (Stein, 1953). This view limits the application of creativity to products judged as novel and accepted by the society. According to Stein, artists and inventors whose work were simply not accepted would not be considered novel and therefore, not creative.

The second view of creativity says:

> "It is probably only a layman's idea that the creative person is peculiarly gifted with a certain quality that ordinary people do not have. This conception can be dismissed by psychologists, very likely by common consent. The general psychological conviction seems to be that all individuals possess in some degree all abilities, except for the occurrence of pathologies. Creative acts can therefore be expected, no matter how feeble or infrequent, of almost all individuals" (Guilford, 1950 p. 446).

Torrance and Goff (1989) agreed with Guilford, saying, "Some degree of creativity occurs whenever a person solves a problem for which he or she had no previous learned or practical solution" (p.117). An act can be considered creative if it is new to the thinker, and it does not make any difference if society regards the idea as novel (Thurstone, 1952).

There are many definitions of creativity in the fields of technology, engineering, and business. These definitions align with the second view of creativity and rely on psychologists' definitions of creativity (Burroughs, Dahl, Moreau, Chattopadhyay, & Gorn, 2011; Fillis & Rentschler, 2010; Nov & Jones, 2005). Various authors have proposed their own definitions. Table 2-1 lists commonly cited definitions. However, in analyzing the definitions, it appears the common theme of the definitions suggests creativity can simply be defined as follows: creativity is work, products or ideas that are novel and useful.

Table 2-1: Common Creativity Definitions

Creativity Definitions	*Researchers*
Creativity is a product or response that is both novel and appropriate, useful, correct or valuable response to the task at hand.	Amabile, 1996
Creativity may be viewed as the ability to form remote ideational associations to generate original and useful solutions to a given problem.	Atchley, Keeny, & Burgess, 1999
Creativity is the generation of ideas and alternatives.	Carr & Johansson, 1995
Creativity changes an existing domain or transforms an existing domain into a new one.	Csikszentmihalyi, 1997
Creativity is the production of novel and useful ideas or products.	Dewett, 2003
Creativity involves the generation of novel behavior that meets a standard of quality or utility.	Eisenberg, Haskins, & Gambleton, 1999
Creativity is an interaction among aptitude, process, and environment that has novel and useful characteristics, which are defined within a social context.	J. Plucker, Beghetto, & Dow, 2004
Creativity involves the production of novel and useful products.	Mumford, 2003
Creativity is based on work, products or ideas that are novel and useful.	Sternberg & Lubart, 1999
Creativity is the interpersonal and intrapersonal process by means of which original, high quality, and genuinely significant products are developed.	Van Hook & Tegano, 2002

2.2 **Innovation Defined**

Innovation has an equally vague definition as creativity, and some definitions often overlap with creativity. Occasionally, this causes the two terms to become synonymous (Van Gundy, 1987; Sternberg & Lubart, 1999). In response to this issue of synonymy, many researchers have purposefully omitted creativity from their definitions of innovation (Pierce & Delbecq, 1977; Shephard, 1967; Thompson, 1965; Zaltman, Duncan, & Holbeck, 1973). In an attempt to make innovation less vague, this section defines innovation for the domains of technology, engineering, and business. The similarities of the definitions are then discussed.

2.2.1 Technology Domain

Smith (2006) states "innovation is, by definition, novelty. It is the creation of something qualitatively new, via processes of learning and knowledge building. It involves changing competences and capabilities, and producing qualitatively new performance outcomes" (p. 149). That new something that Smith mentions can be qualified with an older definition. Innovation in the technology domain is focused on it being a product related to a new technology (Nord & Tucker, 1987). Afuah (1998) adds to this definition of innovation by claiming it is invention plus commercialization. These definitions suggest that researchers in the technology domain believe that innovation is the process of creating a novel outcome or process that is commercialized. It is assumed that commercializing an outcome or process means the outcome or process is useful. Thus, innovation, in the domain of technology, is a process of creating a novel and useful technological outcome or process.

2.2.2 Engineering Domain

Careful search of literature in the engineering domain revealed that innovation is not clearly defined by most engineering researchers. The word innovation is used in research, but it is left open to personal interpretation. There is one exception.

Carr and Johansson (1995) provided a broad definition of innovation suggesting it is the transformation of ideas (solutions) and alternative ideas (solutions) into useful applications that lead to positive change and improvement. Their definition is focused on an undefined process of innovation. The definition implies that the process of innovation is the transformation of an idea to something useful (product or manufacturing process). It appears the word "useful" is central to Carr and Johansson's idea of innovation and implies that an innovative idea needs to be immediately "useful" to keep up with the speed of change in society (Carr & Johansson, 1995).

2.2.3 Business Domain

Sternberg and Lubart (1999) stated that researchers in the business domain used the term innovation at the organizational level instead of the individual level. Drucker (1985) searched for a way to define innovation in a way that would produce more refined distinctions of what innovation consists. He stated that systematic innovation "consists in the purposeful and organized search for changes usually of an economic or social nature" (Drucker, 1985, p. 35). The social natured changes that Drucker refers to may be considered changes in people interaction. Other researchers hold a similar view but add that innovation "involves creative use as well as original invention" (Kanter, 1983, p. 21). Creative use is to take an existing product and use it in a new way. Original invention means to create a new product that did not previously exist.

More recently in business innovation is defined as "the successful implementation of creative ideas within an organization" (Amabile et al., 1996 p. 1155). The definition from Amabile shows that the business domain is focused on implementation of a product, system, or service, and it's impact. Although that definition of innovation is broad, it has served as a baseline definition from which other researchers in the business domain have evolved it. These researchers suggest that innovation should be considered as the implementation of a new or significantly improved product (good or service), process, method, or organizational method (Baregheh, Rowley, & Sambrook, 2009; COTEC, 1997; Dodgson & Hinze, 2000; OECD, 2005; Van de Ven et al., 1999) for the purpose of advancing, competing, and differentiating an organization in their marketplace (Baregheh et al., 2009; Bessant, Lamming, Noke, & Phillips, 2005; Dyer et al., 2008; Osorio, 2009; Van De Ven et al., 1989; West & Anderson, 1996) .

Based on these definitions, innovation in the business domain is the process of using a number of activities to implement a new or improved product, process, or method used to compete in the marketplace.

2.2.4 Definitions Compared

The three definitions of innovation in the domains of technology, engineering and business show very little distinction. The definitions all imply or include the words novel and useful for describing a product, process, or method that is marketed. Based on the definitions of innovation from the previous sub-sections, innovation is the process of coming up with and implementing a useful, new or improved product, process, or method to compete in the marketplace.

The literature defines innovation as marketing a novel and useful product, system, or service. In contrast, creativity is defined as a novel and useful product, system, or service. The key difference between these definitions is marketing. There are many examples of this commonly found in society and industry. For example, Besemer (1998) uses three chairs in her research. One chair is made of boxes of crackers and canned food. Another is made to look like the front of an automobile. The last is an abstract block with a reclining spot and a place for the feet. Although these chairs were considered creative, they were not marketable. It would probably not be profitable for a business to market the chairs. An innovative chair would be a one that was more marketable. An example might be the pneumatic computer chair. This innovation to the chairs easily allowed a user to adjust the height. These two examples highlight the difference between creativity and innovation. New ideas may be novel and useful, but what separates a creative idea from innovative idea is marketing it.

2.3 Innovation Processes

The definitions of innovation from the previous section all describe innovation as a process. This section describes the most commonly accepted innovation processes, or models, that exist. In addition, this section describes the common elements between the models, and then discusses how these models relate with common innovation elements that can then be analyzed with the innovation assessments.

Models that fit this definition and that are discussed below are: IDEO's, Innovators DNA, Design Thinking-based, Linear Model, Chain-Linked Model, Minnesota Innovation Research Program's model, and BYU's Innovation Model.

2.3.1 IDEO's Design Thinking

Tim Brown, IDEO's CEO, described their innovation process as a "system of spaces" rather than steps that separate related activities (2008 p. 88). IDEO's Design Thinking is made up of three parts: inspiration, ideation, and implementation (See Figure 2-1). Brown explains these three "spaces" as:

> "…'inspiration,' for the circumstances (be they a problem, an opportunity, or both) that motivate the search for solutions; 'ideation,' for the process of generating, developing, and testing ideas that may lead to solutions; and 'implementation,' for the charting of a path to market. Projects will loop back through these spaces – particularly the first two – more than once as ideas are refined and new directions taken" (Brown, 2008a).

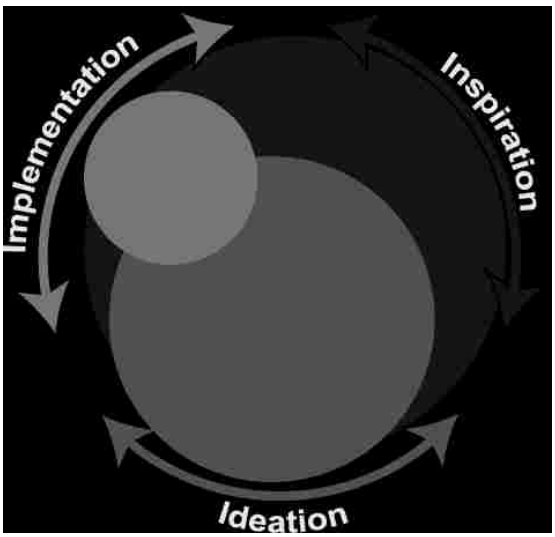

Figure 2-1: IDEO's Design Thinking Model

As shown in Figure 2-1, the three spaces (inspiration, ideation, and implementation) overlap. Another way to define the word inspiration as IDEO uses it is problem finding. This is when problems are found that a possible solution could be made to solve. Inspiration is the largest space because there are many problems or opportunities for businesses. Ideation is when ideas that may solve a problem are generated, developed, and tested. Ideation is shown slightly smaller since this space focused on a few problems and possible solutions. Implementation is getting the final solution, or product, marketed and is shown as the smallest space since the one solution, or product, is followed and implemented. During the entire process, a project will constantly move between the spaces, which is why the figure isn't linear. The three parts of IDEOs Design Thinking match the definition of innovation stated above, which qualifies it to be included in this research.

Another important part of IDEOs process is teams. Teams find ways to overcome barriers, share ideas, make prototypes, ask questions, and support one another (Kelley, 2001). Often, team members adopt temporary roles (i.e., leader, knowledge gatherer, experimenter,

problem-solver, or designer) for a period of time in the innovation process and are matched to projects to challenge them as the team moves through the three spaces.

2.3.2 Innovator's DNA

The Innovators DNA is explained as the skills that can be developed to enhance innovativeness (Dyer, Gregersen, & Christensen, 2009). The five skills identified in the Innovators DNA are: associating, questioning, observing, experimenting, and networking. Associating is the ability to successfully connect seemingly unrelated questions, problems, or ideas from different areas. Questioning is the process of asking questions (e.g., Why? Why not? What if?), imagining opposites (e.g., hold two opposing ideas in one's thoughts), and embracing constraints (e.g., impose constraints on one's thinking like, "What if we were legally prohibited from selling to our current customers?"). Observing is to thoroughly examine common phenomena. Experimenting means to intellectually explore or ponder different subjects, physically tinker or take apart, or experience new surroundings. Networking is to explain ideas to different people by using a network of diverse individuals to gain a different perspective. Although the purpose of the Innovators DNA is not to actually create a new product, system or service as many of the other innovation processes have, rather, the purpose of the Innovators DNA is to develop an innovative individual to become a leader or entrepreneur (Dyer et al., 2009, p. 62).

2.3.3 Design Thinking-based

The "design thinking-based" innovation model is based on the work of several authors and companies. Osorio (2009) explains that this process happens in phases. These phases iterate between analysis (creating alternative ideas) and synthesis (choosing from these alternatives).

Also at the same time, this process iterates between abstract and concrete, which is to go from a concrete problem, to abstract thinking about how to solve it, and back to a concrete solution (See Figure 2-2). He further explains:

> "This process starts with the definition of an innovation challenge from a problem, idea or business opportunity. Then, the model has four phases, each focusing in a different objective for the development process: (i) learning and discovery, (ii) alternative generation, (iii) system-level pre-launch development, (iv) launch and exploitation" (2009 p. 5).

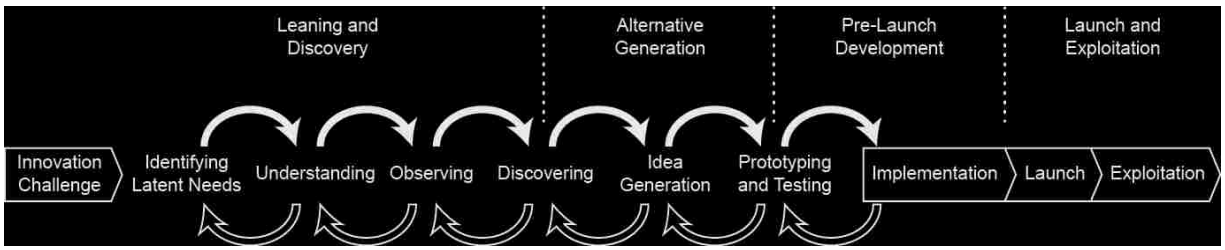

Figure 2-2: Design Thinking-based Innovation Model

Figure 2-2 shows the four phases of the design-thinking based innovation model: (1) learning and discovery, (2) alternative generation, (3) pre-launch development and (4) launch and exploitation. The figure and these phases are further explained below.

First, the learning and discovery phase is when the challenge or problem is identified and understood. The four steps that a team would iterate through are identifying latent needs (e.g. reframe the challenge to understand from different perspectives), understanding (e.g., the breadth and depth of the challenge), observing (e.g., gather information and data), and discovering (e.g., share and compare information with team). The purpose of these four steps is to help understand the non-obvious needs and characteristics of the challenge (Osorio, 2009).

Second, alternative generation phase is when possible solutions go through iterative steps of brainstorming and cycles of prototyping testing. The two steps that a team would do are idea generation (e.g., generate as many ideas as possible to solve the challenge) and prototyping and testing. Prototyping is considered the analysis of concept design and the refinement of ideas through prototyping. Testing is the synthesis of the feedback and data of the prototyping to start a new round of analysis. The goal of these two steps is to achieve a solution that is apt for pre-launch implementation (Osorio, 2009).

Third, prelaunch development focuses on the detailed design of the new product, final rounds of testing, marketing plans (in order to define sales plan) and production plans (in order to evaluate early production output and placement). This is to allow for appropriate market launch and exploitation before getting into the market. To this point, the design-thinking based innovation model involves iterations through all phases. Iteration stops after the third phase.

Fourth, launch and exploitation is focused on generating payback and managing the life cycle of the innovation. This is done by planning and exploiting the launch of the product or process so it can generate sales and maximize monetary return.

The four phases and objectives from the design thinking-based innovation process fit into the definition of innovation. It fits because learning and discovery and alternative generation provide ideas for new or improved products that are useful, and pre-launch development and launch and exploitation take the finalized idea into the market.

2.3.4 Linear Model

In the linear model for the innovation process, one does research, research then leads to development, development to production, and production to marketing (Kline & Rosenberg, 1986). The research step began with basic research and then moves into applied research.

Development begins as the applied research yields results or information. Once development is completed, production begins on the product and then marketing follows. These steps are presented as a one-way street and do not support the role of feedback or a revisit to previous steps to revise or improve (See Figure 2-3). Kline & Rosenberg (1986) criticize this innovation process explaining that "feedback [is] essential to evaluation of performance, to formulation of the next steps forward, and to assessment of competitive position" (p. 286). The source of this model is nebulous because it was never documented, and researchers that have discussed the model rarely acknowledge or cited any original source (B. Godin, 2006).

According to Godin (2006) there are two reasons the linear model survives. First, statistics needed categories for counting resources and allocating money to science and technology. Second, the Organization for Economic Cooperation and Development (OECD) supported this model as social fact with its methodological manuals. However, since the linear model was generally accepted and used for a time by academic organizations and economists, it is included in this review (B. Godin, 2006; Kline & Rosenberg, 1986).

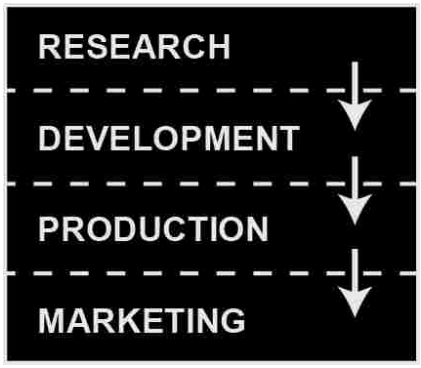

Figure 2-3: Linear Innovation Model

2.3.5 Chain-Linked Model

Kline and Rosenberg's (1986) "Chain-Linked" model of innovation starts with perceived market needs from a potential market then moves through invent/produce analytic design and ideas, detailed design and testing, redesign and produce the idea, and ends at distribute the product and market it. Throughout the process there are different paths for feedback, reviews, knowledge, and research that Figure 2-4 shows (Kline & Rosenberg, 1986). Feedback comes through the iterative visits to the previous step (shown by the circled arrows in the figure) and from the distributing and market step (shown by the arrows heading to the first three steps shown at the bottom of the figure). This process suggests that innovation is not a sequential (linear) process, but rather a process involving many interactions and feedbacks in knowledge creation as shown by the arrows between the research and knowledge areas to the steps in the process (See Figure 2-4). The interactions and points of feedback, according to this process, should involve multiple inputs such as: market needs, user needs, or potential improvements (Kline & Rosenberg, 1986).

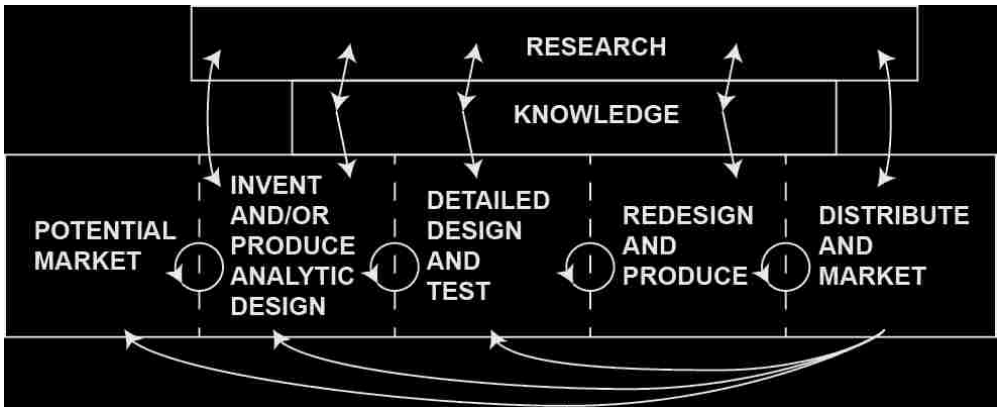

Figure 2-4: Chain-Linked Innovation Model

2.3.6 Minnesota Innovation Research Program's Innovation Process

The Minnesota Innovation Research Program (MIRP) innovation process has three main parts, and its purpose is to map empirically how innovations develop from concept to reality (Van de Ven et al., 1999). It is different than the other processes and methods in that it was created from common patterns that the MIRP found from its multiple longitudinal case histories of 3M, Millipore Corporations, and Qnetics.

First is the initiation period. This part of the process focuses on a gestation period in which events set the stage for innovation. Often this occurs over a number of years. During this time concentrated efforts to initiate innovations are developed and given to resource controllers to get the resources needed to launch innovation development.

Second is the developmental period. During this period, the initial idea diverges into numerous ideas, setbacks and mistakes occur, and the criteria for success and failure often change. People participate in fluid ways as their roles change and investors and top managers are involved. As more people get involved, relationships are developed with other organizations, and interaction with competitors, trade associations, or government agencies creates an infrastructure to support the development of innovations.

Third is the implementation or termination period. This last part of the process is where innovation adoption and implementation occurs by linking the "new" with the "old," or innovations stop when resources run out or executive decisions are made to stop (Van de Ven et al., 1999).

2.3.7 BYU's Innovation Model

The model that BYU uses draws upon many of the principles and processes of those listed above – but is distinct in that it focuses on idea communicating. The final product is identified

and methods to communicate the idea are explored instead of a final product or service being sent to the market since the university's program is not concerned with marketing. BYU's innovation model has five parts: idea finding, idea shaping, idea defining, idea refining, and idea communicating (See Figure 2-5).

As Figure 2-5 shows, each part is then broken down into three tools. Idea finding incorporates observing, experiencing (e.g., situations or events), and inquiring (e.g., asking questions). These tools guide a person to find ideas by being aware of his or her surroundings through being conscious of what he or she is experiencing and questioning situations or events. Idea shaping incorporates organizing (e.g., categorizing ideas by similarities), simplifying (e.g., finding the central part of the idea), and clarifying (e.g., explaining the idea clearly). This takes the ideas from the previous step and shapes them by organizing the ideas in written form. Writing the ideas down helps to clearly define the idea and simplify it. Once the ideas are written down, idea defining then incorporates viewing (e.g., look at the problem differently), associating (e.g., associate ideas with other situations, topics, or objects) and connecting the ideas. Viewing the ideas organized in one way helps a person start associating and connecting the ideas in new ways. Idea refining involves visualizing the ideas to validate them and provide iterations. The last part in the process is idea communicating, which involves showing, demonstrating and describing the idea in various methods (e.g. prototypes, drawings, or role-play).

Figure 2-5 shows two more things. First, that the innovation process involves iterations between the parts. For example, idea shaping through clarification often leads back to idea finding. Also, idea communicating provides feedback for all steps of the innovation process and may start it all over again. Second, it shows that the innovation process takes place in an innovation environment. This environment may provide leadership that encourages innovation, a

fail early-fail often mentality, judgment deferral, intrinsic motivation, prototyping, and collaborative freedom. With this environment, the professors believe that the innovation process will better succeed.

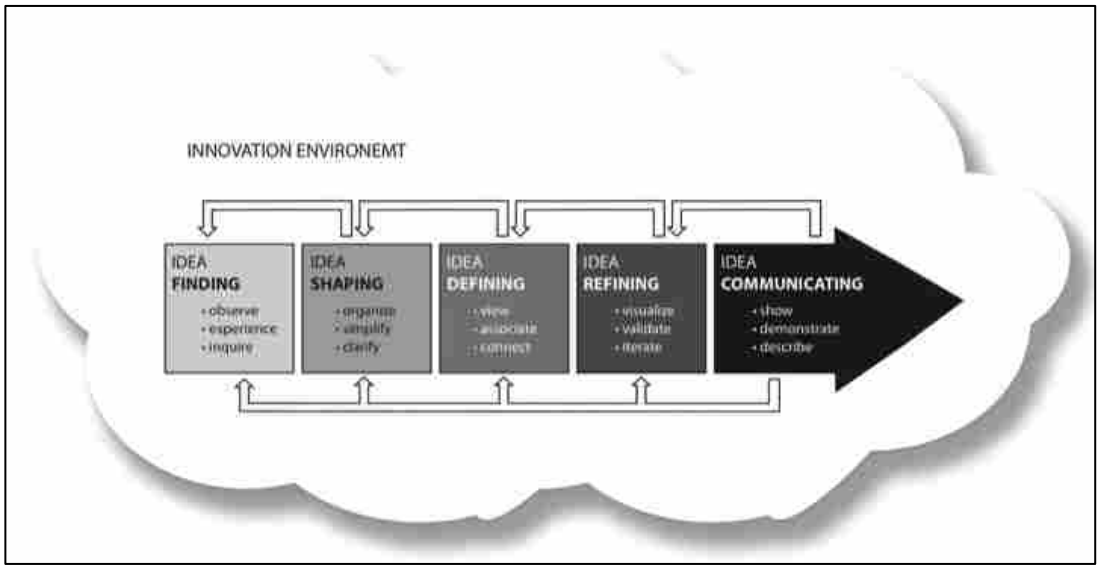

Figure 2-5: BYU's Innovation Model

2.3.8 Common Elements in the Innovation Processes

The common characteristics of the innovation processes were identified to provide a baseline with which to later compare the assessments. To start, the seven innovation processes listed above were analyzed to identify the characteristics of each process. The characteristics of each innovation process were then listed in a matrix to discern which characteristics were common (see Table 2-2).

The common characteristics of the various innovation processes outlined above are: problem finding, idea forming and developing, and implementing. According to the innovation processes, problem finding involves identifying needs, problems, or challenges that lack a

solution. Idea forming and developing is when possible solutions are formed (e.g., divergent thinking techniques) and developed (e.g., convergent thinking techniques) to the need, problem, or challenge. Finally, the implementing part of the innovation process is when the final idea or solution is marketed or communicated.

This literature review considers the problem finding and idea forming and developing parts of the innovation process to be the divergence phase (i.e., going from one possibility to many)(See Figure 2-6). The idea forming and developing category overlaps with the second part of innovation, convergence. Convergence is going from many possibilities to one result. Furthermore, convergence includes the refined further development, and the marketing (implementation), of the new and useful product, system, or service. Figure 2-6 shows that there is a moment when convergence takes one of the ideas discovered and initially formed and developed, and starts its refined development. This transitional period is not fixed, but it does require the idea(s) to move from an idea-forming phase (divergence) to a refined development and implementation phase (convergence).

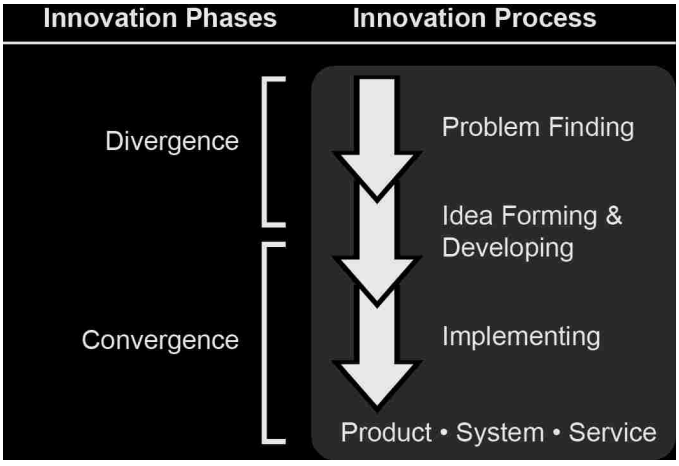

Figure 2-6: Innovation Phases and the Innovation Process

Table 2-2 shows that six out of the seven processes fit all the common characteristics of the innovation process – problem finding, idea forming and developing, and implementing. The one process that does not fit is the Innovator's DNA because it stops short of actually producing a product, system or service. Yet, it is still included in this literature review because the experimenting component of the Innovator's DNA process could produce a product, system or service if it were continued to implementing phase. This process and its relation to creativity and innovation assessments are further discussed in the fourth chapter.

Table 2-2: Comparing Innovation Processes

Innovation Processes	*Components of the Innovation Process*		
	Problem Finding	*Idea Forming & Developing*	*Implementing*
IDEO	Inspiration	Ideation	Implementation
Innovator's DNA	Associating Questioning Observing	Questioning Expiementing Networking	
Design Thinking-based	Defining challenge or problem	Learning & discovery Alternative generation	System level relaunch development Launch & exploitation
Linear Model	Research	Development	Production Marketing
Chain-linked Model	Potential Market	Invent/produce design Detailed design & test Redesign & test	Distribute Market
MIRP	Initiation period	Developmental period	Implementation or termination period
BYU	Idea finding	Idea shaping Idea defining Idea refining	Idea communicating

2.4 **Assessment Defined**

For the purpose of this review, assessment is defined as a process of taking stock of an individual (or a group) by gathering information from a number of sources and attempting to organize and synthesize those data in a meaningful way (Treffinger, Young, Selby, & Shepardson, 2002). In other words, it is the evaluation or estimation of the quality or ability of someone. Assessment then might be undertaken to identify and understand a person's (or a group's or team's) strengths and deficiencies, or for more prescriptive reasons, such as for instructional planning or for placement in a specific position. Researchers agree that assessment is, therefore, a broader and more inclusive term than measurement and is considered vehicle of accountability (Mader, 1995; Treffinger et al., 2002).

Assessments, especially creativity assessments, come in many different forms. Treffinger (2002) states, “Creativity assessment might be regarded as an attempt to recognize or identify creative characteristics or abilities among people or to understand their creative strengths and potentials. Measurement might play a specific role in creativity assessment to the extent that specific tests, inventories, or rating scales provide evidence to help answer such questions” (p. 23) The word assessment is used instead of the word test in order to include the wide range of methods used to evaluate both creativity and innovation.

Even though there exists a wide range of creativity assessments, this literature review focuses on creativity assessments that deal with creative level, not creative style. Creative level and creative style are two independent dimensions (Kirton, 2003). Creative level is associated with intellect, talent, and skill. All people are creative and solve problems, but not in the same manner. That is to say, all people can be deemed to be creative, although not all at the same level or in the same way or style (Kirton, 2003). Creative style is more of a preferred way of thinking,

not ability, and is measured independently. This literature review focuses on creative level assessments that measures change on the creative level scale.

3 METHODS

3.1 Criteria for Inclusion

To answer the research questions, a thorough literature review was conducted using specific terms and limitations to produce refined search results from online, scholarly databases. Following the search, inclusion criteria were used to identify which studies would be included in this literature review. These criteria focused on two main areas: (1) research questions and (2) psychometric properties of the identified assessments.

First, the literature was used in the analysis if the abstract showed proof that the article would answer one of the research questions: (1) What different properties do creativity assessments measure? (2) What different properties do innovation assessments measure? (3) How do creativity and innovation assessments compare? The rationale for focusing on these three questions includes finding assessments that have already been proven valid and reliable and will be relevant for this study.

Second, studies that present psychometric properties of assessments are used in order to collect data on assessments that can then be compared. It is not the purpose of this literature review to prove the validity or reliability of any assessment. Rather, the scope of this literature review is limited to creativity and innovation assessments identified in peer-reviewed literature.

3.2 **Search Procedures**

The search included two parts. First, all relevant, English language articles in the initial search were gathered. Second, articles were chosen that answered the research questions. In the first step, the EBSCO databases and Google Scholar were searched. Using only peer-reviewed journals, searching for exact phrases (see Table 3-1) only in the title field, and searching from the year 1970-2011 refined the Boolean search to provide current, relevant research. The EBSCO search results automatically removed duplicate results in its databases and duplicates between EBSCO and Google Scholar were only counted once as a relevant source. Also, if more than one article referenced the same assessment, the article by the assessment's creator or closest to the assessment's creation date was used. For example, research discussing the consensual assessment technique written by an author other than Amabile was not included, while Amabile's own research was used instead.

Table 3-1: Search Terms

Creativity Terms	*Innovation Terms*
creativity assessment	innovation assessment
creativity test	innovation test
creativity assessment AND properties	innovation assessment AND properties
creativity assessment AND characteristics	innovation assessment AND characteristics
creativity evaluation AND properties	innovation evaluation AND properties
creativity evaluation AND characteristics	innovation evaluation AND characteristics
creativity survey AND properties	innovation survey AND properties
creativity survey AND characteristics	innovation survey AND characteristics
creativity test AND properties	innovation test AND properties
creativity test AND characteristics	innovation test AND characteristics

For every article that fit the inclusion criteria, the search was furthered pursued by using the article's references to provide more sources. Those sources were included if they fit the

inclusion criteria previously mentioned. Often the references led to the original articles that were publications from the creators of certain creativity or innovation assessments.

These results were then grouped into their respective criteria and used to identify characteristics measured in creativity and innovation assessments. The characteristics of each creativity assessment were then used to organize assessments in terms of creativity-related categories (Cropley, 2000; Feldhusen & Goh, 1995; J. A. Plucker & Makel, 2003). These categories are environment (e.g., freedom, organization, or resources), personal/behavioral (e.g., adjective checklist, biographical inventory, motivation, or personal inventory), creative process (e.g., divergent thinking, convergent thinking, or associative thinking) and products (e.g. elaboration, novelty, or detail). Innovation assessments were categorized by the common components outlined in the innovation process or model (See Table 2-2). These categories are environment (e.g., challenge, collaboration, communication, interaction frequency, or leadership), idea forming and developing (e.g., idea evaluation or idea ranking), entire process (e.g., knowledge creation, purchase of information, information updates, sources of information, or cooperation), and product (e.g., environmental effects). The term "press" is may be used to mean the same thing as environment. This literature review uses the word "environment" instead.

All the labeled assessments were then compared to the innovation processes to see how each test aligns with the innovation processes (See Figure 4-1 and Figure 4-2). The characteristics each assessment measures were also compiled into a matrix to compare creativity assessments with innovation assessments.

4 FINDINGS

The results from the review methods are separated into creativity findings, innovation findings, and direct comparison between creativity and innovation assessments. The creativity findings discuss the assessments and the categories derived from the creativity assessments, and then the creativity assessment categories are compared to the innovation process. The creativity assessments are compared with the innovation process in order to clarify how the creativity assessments align with the process. Through the comparison, it will be better understood how creativity assessments might be used to fill gaps in innovation assessments. Similarly, the innovation findings discuss the assessments and resulting categories, which are then compared to the innovation process to identify any possible gaps between the process and assessments. The last section in this chapter provides a direct comparison between creativity and innovation characteristics measured in the different assessments.

4.1 Creativity Findings

In order to find how creativity assessments compared to innovation assessments, the methods in chapter two were followed to identify pertinent creativity assessments. The creativity search using the EBSCO databases and Google Scholar found two hundred thirty-three articles. Of those articles only twenty-one fit the inclusion criteria and were considered relevant. The references of those twenty-one relevant articles were reviewed with the same criteria as the

initial search, and an additional twenty-one sources were found (See Table 4-1). The assessments that were mentioned multiple times were only counted once.

Table 4-1: Creativity Search Results

Creativity Terms	*EBSCO Results*	*Google Results*	*Relevant*	*Additional*
creativity assessment	24	78	11	19
creativity test	42	85	8	2
creativity assessment AND properties	0	0	0	0
creativity assessment AND characteristics	0	0	0	0
creativity evaluation AND properties	0	1	1	0
creativity evaluation AND characteristics	0	1	0	0
creativity survey AND properties	0	0	0	0
creativity survey AND characteristics	0	0	0	0
creativity test AND properties	1	2	1	0
creativity test AND characteristics	0	1	0	0

From the forty-two identified articles, forty unique creativity assessments and their psychometric characteristics were identified (See Table 4-2). The characteristics listed are those that the tests identified.

Table 4-2: List of Creativity Assessments

Category	*Creativity Assessments*	*Characteristics*	
Environment	Business-Creativity Assessment Tool (Cheng, K., Chen, Y. (2009). Developing and Verifying a Business-Creativity Assessment Tool: A Nationwide Study in Taiwan. *Journal of Education for Business,* 85(2).)	Confidence feedback Environment Instructions method	Parental support Personality
	KEYS – Assessing the Climate for Creativity (Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the Work Environment for Creativity. *The Academy of Management Journal*, 39(5), 1154 - 1184.)	Challenging work Creativity Freedom Organizational encouragement Organizational impediments	Productivity Sufficient resources Supervisory encouragement Work group supports Workload

Table 4-2: Continued

Category	*Creativity Assessments*	*Characteristics*	
	Virtual Team Creative Climate (Plucker, J. A., & Makel, M. C. (2003). Assessment of Creativity. In J. C. Kaufman & R. J. Sternberg (Eds.), *The Cambridge Handbook of Creativity* (1st ed., pp. 48-73). Cambridge University Press.)	Acceptance of ideas Challenge Collaboration Dedication/commitment Freedom Goal clarity	Information sharing Management encouragement Personal bond Sufficient resources and time Trust
Personal/ Behavioral	Adaption-Innovation Inventory (Kirton, M. J. (Ed). (1989) Adaptors and innovators: Styles of creativity and problem-solving (pp 56-78) London: Routledge.)	Efficiency Conformity	Originality
	Adjectives Check List (Houtz, J. C., & Krug, D. (1995). Assessment of creativity: Resolving a mid-life crisis. *Educational Psychology Review*, *7*(3), 269-300.)	Conformity Curiosity Fluency Humor Individualism	Intellectual playfulness Risk taking Sensitivity to beauty Tenacity
	Alpha Biographical Inventory (Taylor, C. W, & and Ellison, R. L. (1968) The Alpha Biographical Inventory Greensboro, NC: Prediction Press.)	Breadth of interest Drive towards novelty and diversity Family background	Intellectual & cultural orientation Pervasive & continuing enthusiasm
	Basadur Preference Scale (Basadur, M., & Hausdorf, P. A. (1996) Measuring divergent thinking attitudes related to creative problem solving and innovation management. *Creativity Research Journal*, 9, 21-32.)	Creative individual stereotypes Valuing new ideas	Too busy for new ideas
	Biographical Inventory & Alpha Biographical Inventory (Schaefer, C. E., & Anastasi, A. (1968). A biographical inventory for identifying creativity in adolescent boys. *Journal of Applied Psychology*. 52, 42-48.)	Breadth of interest Drive towards novelty and diversity Family background	Intellectual & cultural orientation Pervasive & continuing enthusiasm
	Creative Activities Checklist (Runco, M. A. (1987) Interrater agreement on a socially valid measure of students' creativity. *Psychological Reports*, 61, 1009-1010.)	Art Crafts Drama	Literature Music Science

Table 4-2: Continued

Category	*Creativity Assessments*	*Characteristics*	
	Creative Behavior Inventory (Kirschenbaum, R. J. (1989). Understanding the creative activity of students Mansfield, CT: Creative Learning Press.)	Consciousness Contact	Interest Fantasy
	Creative Perception Inventory (Houtz, J. C., & Krug, D. (1995). Assessment of creativity: Resolving a mid-life crisis. *Educational Psychology Review*, *7*(3), 269-300.)	Appeal to authority Artistic inclination Awareness of others Imagination Individuality Initiative	Inquisitiveness Intelligence Self-confidence Self-perception of creativity Self-strength Sensitivity
	Creative Personality Scale (Gough, Harrison G. (1979). A creative personality scale for the Adjective Check List. *Journal of Personality and Social Psychology,* 37(8), 1398-1405.)	Affected Capable Cautious Clever Commonplace Confident Conservative Conventional Dissatisfied Egotistical Honest Humorous Individualistic Informal Insightful	Intelligent Interests narrow Interests wide Inventive Mannerly Original Reflective Resourceful Self-confident Sexy Sincere Snobbish Submissive Suspicious Unconventional
	Creative Problem Solving Profile (Gough, Harrison G. (1979). A creative personality scale for the Adjective Check List. *Journal of Personality and Social Psychology*, 37(8), 1398-1405.)	Conceptualizer Generator	Implementor Optimizer
	Creative Styles Questionnaire (Kumar, V. K., Kemmler, D., & Holman, E. R. (1997) The Creativity Styles Questionnaire-Revised. *Creativity Research Journal*, 10, 51-58.)	Believe of unconscious processes Environmental control Final product orientation	Superstition Use of other people Use of senses Use of techniques
	Creativity Checklist (Johnson, D. L. (1979) The Creativity Checklist Wood Dale, IL: Stoelting.)	Constructional skills Flexibility Fluency Independence	Ingenuity Positive self-referencing Preference for complexity Resourcefulness

Table 4-2: Continued

Category	*Creativity Assessment*	*Characteristics*	
	Creatrix Inventory (Byrd, R. E. (1986) Creativity and risk-taking. San Diego, CA Pfeiffer International Publishers.)	Creative thinking	Risk-taking
	Group Inventory for Finding Creative Talent (Rimm, S., & Davis, G. A. (1980) Five years of international research with GIFT. An instrument for the identification of creativity. *Journal of Creative Behavior*, 14, 35-46.)	Curiosity Flexibility Independence	Originality Risk-taking
	How Do You Really Feel About Yourself (Cropley, A. (2000). Defining and measuring creativity: Are creativity tests worth using? *Roeper Review*, *23*(2), 72-79.)	Curiosity Imagination	Preference for complexity Risk-taking
	Iowa Inventiveness Inventory (Colangelo, N., Kerr, B., Huesman, R, Hallowell. N., & Gaeth, J. (1992). The Iowa Inventiveness Inventory Toward a measure of mechanical inventiveness. *Creativity Research Journal*, 5, 157-164.)	Biographical Personality	Vocational
	Life Experience Inventory (Michael. W. B., & Colson, K. R. (1979) The development and validation of a life experience inventory for the identification of creative electrical engineers *Educational and Psychological Measurement*. 39, 463-470.)	Independence training Parental striving	Self-striving or self-improvement Social participation and social experience
	Something About Myself (Houtz, J. C., & Krug, D. (1995). Assessment of creativity: Resolving a mid-life crisis. *Educational Psychology Review*, *7*(3), 269-300.)	Self-perception of creativity	
	What Kind of Person Are You (Houtz, J. C., & Krug, D. (1995). Assessment of creativity: Resolving a mid-life crisis. *Educational Psychology Review*, *7*(3), 269-300.)	Appeal to authority Artistic inclination Awareness of others Imagination Individuality Initiative	Inquisitiveness Intelligence Self-confidence Self-strength Sensitivity

Table 4-2: Continued

Category	*Creativity Assessments*	*Characteristics*	
Creative Process	Creative Reasoning Test (Doolittle, J. H. (1990) Creative Reasoning Test. Pacific Grove, CA. Midwest Publications/Critical Thinking Press.)	Associative thinking Divergent thinking	Inductive thinking
	Flanagan's Ingenuity Test (Houtz, J. C., & Krug, D. (1995). Assessment of creativity: Resolving a mid-life crisis. *Educational Psychology Review*, *7*(3), 269-300.)	Divergent thinking	
	Minnesota Tests of Creative Thinking (Jerome, R. T. (1971). Pennsylvania Assessment of Creative Tendency: Norms-Technical Manual.)	Flexibility Fluency	Originality
	Pennsylvania Assessment of Creative Tendency (Jerome, R. T. (1971). Pennsylvania Assessment of Creative Tendency: Norms-Technical Manual.)	Flexibility Fluency	Originality
	Purdue Creativity Test (Gupta, S. M. (1982). Purdue Creativity Test: Psychometric properties on an Indian sample. Psychological Studies, 27(1), 23-28.)	Flexibility	Fluency
	Structure of the Intellect Abilities Learning Test (Meeker, M. (1985) Structure of Intellect Learning Abilities Test. Los Angeles Western Psychological Services.)	Divergent thinking	
	Test for Creative Thinking (Urban, K. K. (2004). Assessing Creativity: The Test for Creative Thinking – Drawing Production (TCT-DP). *Psychology Science*, 46(3), 387-397.)	Boundary breaking Completion Connections made with a line Continuations Humor and affectivity	New elements Perspective Speed Unconventionality

Table 4-2: Continued

Category	*Creativity Assessments*	*Characteristics*	
	The Creativity Assessment Packet (Cooper, E. (1991). A critique of six measures for assessing creativity. *The Journal of Creative Behavior*, 25(3), 194-204.)	Complexity Curiosity Elaboration Flexibility Fluency	Imagination Originality Overall creativity Risk-taking
	The Guilford Battery (Houtz, J. C., & Krug, D. (1995). Assessment of creativity: Resolving a mid-life crisis. *Educational Psychology Review*, *7*(3), 269-300.)	Fluency	Originality
	The Purdue Inventory (Houtz, J. C., & Krug, D. (1995). Assessment of creativity: Resolving a mid-life crisis. *Educational Psychology Review*, *7*(3), 269-300.)	Asking questions Checking answers Defining the problem Foreseeing consequences Generating hypotheses Guessing causes	Noticing details Selecting the best answer Sensing that a problem exists Using objects in unusual way
	The Remote Associates Test (Houtz, J. C., & Krug, D. (1995). Assessment of creativity: Resolving a mid-life crisis. *Educational Psychology Review*, *7*(3), 269-300.)	Divergent thinking	
	The Stroop Color and Word Test (Golden, C. J. (1975). The Measurement of Creativity by the Stroop Color and Word Test. Journal of Personality Assessment, 39 (5).)	Adaptivity Flexibility Independence from past responses Independence from outside cues	Lack of constriction Persistency Stability Toleration of ambiguity
	Triarchic Abilities Test (Sternberg, R. J. (1997) Intelligence and lifelong learning What's new and how can we use it? *American Psychologist*, 52, 1134-1139.)	Analytical ability Practical Ability	Synthetic ability
	Torrance Tests of Creative Thinking (Torrance, E. P. (1999) Torrance Test of Creative Thinking: Norms and technical manual. Beaconville, IL: Scholastic Testing Services.)	Abstractness Elaboration Flexibility	Fluency Originality Resistance to premature closure

Table 4-2: Continued

Category	*Creativity Assessments*	*Characteristics*	
Product	Consensual Assessment Technique (Plucker, J. A., & Makel, M. C. (2003). Assessment of Creativity. In J. C. Kaufman & R. J. Sternberg (Eds.), *The Cambridge Handbook of Creativity* (1st ed., pp. 48-73). Cambridge University Press.)	Aesthetic appeal Complexity Creativity Detail Effort Expression of meaning Liking Neatness	Novel Organization Planning Representationalism Symmetry Technical goodness Variation Would you display it?
	Creative Product Analysis Matrix (Besemer, S. P., and O'Quin, K. O. (1998). Creative Product Analysis Matrix Model.)	Elegant Logical Organic Originality Surprise	Understandable Useful Valuable Well-crafted
	Creative Product Inventory (Taylor, A. (1975) An emerging view of creative actions. In I. A. Tylor, & J. W. Getzels (Eds.), Perspectives, in creativity (pp 297-325). Chicago: Aldine)	Complexity Condensation Generation Hedonics	Originality Reformulation Relevancy
	Creative Product Semantic Scale (Besemer, S. P., and O'Quin, K. O. (1999). Confirming the Three-Factor Creative Product Analysis Matrix Model in an American Sample. *Creativity Research Journal,* 12(4), 287-296.)	Elegant Logical Organic Originality Surprise	Understandable Useful Valuable Well-crafted

Table 4-2 identifies four categories for creativity assessments: (1) environment, (2) personal/behavioral, (3) process, and (4) product. The four categories are defined below. Two hundred sixty-two characteristics were identified. In light of the many associated defining characteristics only a small sample will be used to help provide clarity of the definition. The selected characteristics being used to define the categories are the common (meaning the characteristic is used in multiple assessments) characteristics between assessments.

First, the Environment category is defined as the surroundings in which creativity occurs. One of the common characteristics of the twenty-six assessment characteristics listed above is freedom. For these assessments, freedom means the autonomy allowed in the day-to-day

conduct of the work. For example, a work environment with high autonomy gives an employee a sense of ownership and control over his own work and ideas, which in turn allows for more creativity and choice. Challenging work is another characteristic measured in the environment category. This characteristic deals with having to work hard on challenging tasks and important projects (Amabile, Conti, Coon, Lazenby, & Herron, 1996b). Organizational encouragement is a culture that encourages creativity and innovation through the fair, constructive judgment of ideas, reward and recognition for creative work, mechanisms for developing new ideas, an active flow of ideas, and a shared vision of what the organization is trying to do. Another common characteristic is sufficient resources. This characteristic measures access to appropriate resources, including funds, materials, facilities, and information. The last common characteristic among the assessments is supervisory encouragement. This is explained as a supervisor, who serves as a good work model, sets goals appropriately, supports the work group, values individual contributions, and shows confidence in the work group. The environment category measures characteristics that influence both the level and frequency of creativity (Amabile, Conti, Coon, Lazenby, & Herron, 1996b). The environment category has three identified creativity assessments (See Table 4-2).

Second, the personal/behavioral category is defined as the personal characteristics or behaviors that are thought to increase the likelihood of creativity or even to be essential for its appearance (Cropley, 2000). The personal/behavioral assessments measure personal beliefs, and are more self-awareness type assessments. One common characteristic of the hundred and twenty-six characteristics listed above is risk-taking. Risk-taking as a personal/behavioral characteristic means the willingness to try new ideas when the outcome is unknown, to make mistakes, or to face social disapproval. Another example is curiosity, and curiosity may be

thought of as a motivational force for creativity. Originality is another of the common characteristics and may be seen as the ability to think or express oneself in an independent or individual manner. Another common characteristic is fluency, which may be seen as the number of ideas that one generates. Another common characteristic is confidence. Confidence may mean that a choice or action is regarded as the best or most effective. The personal/behavioral category measures personality or behavioral traits that a creative individual might possess.

The personal/behavioral category has nineteen identified creativity assessments (See Table 4-2). Eighteen of these assessments measure personality and behavioral characteristics that researchers claim relate to creativity. Based on the assessments' titles, two assessments do not seem to belong in this category - the Adaption-Innovation Inventory and the Iowa Inventiveness Inventory. The reason that these two assessments seem to be out of place with this creativity assessment category is from words in the titles. The words "innovation" and "inventiveness" imply that the innovation process is being followed and a product is being created. However, the search procedures based on creativity assessments identified these two assessments and therefore are included.

Another reason these two assessments are included in creativity's personal/behavioral category is that the characteristics those two assessments measure qualify them to be labeled as a creativity assessment. For example, the Adaption-Innovation Inventory assesses whether an individual is an adaptor (e.g., do things better) or an innovator (e.g., do things differently) (M. Kirton, 1976). To determine which type an individual is, the assessment measures conformity, efficiency, and originality. The Iowa Inventiveness Inventory is an instrument to measure biographical, personality, and vocational variables associated with mechanical inventiveness (Colangelo et al., 1992). These characteristics in both the Adaption-Innovation

Inventory and Iowa Inventiveness Inventory may be found in other creativity assessments in this category.

Third, the creative process category (Table 4-2) is defined as thinking patterns that are a part of creativity. Assessments that fit into this category measure sixty-one thinking characteristics and patterns of an individual. These thinking patterns include divergent (thinking of many ideas), convergent (narrowing ideas), associative (connecting and relating ideas), and inductive (inferring from instances) thinking. One of the common characteristics measured is flexibility, which is the amount of variety in the ideas. The characteristic of elaboration is the amount of detail in the thought. Another characteristic is fluency, and fluency is the amount of different ideas thought up. Originality is another common characteristic that is the ability to produce uncommon or unique responses. The creative process category lists fourteen creativity assessments. Although these same characteristics are found in the personal/behavioral category, the creative process category measure actual abilities and are not self-awareness assessments as found in the personal/behavior category.

Fourth, the product category is defined as physical good that exhibits creativity. The assessments in this category measure forty-one characteristics. The common characteristics include a product's complexity, originality, and usefulness. Complexity is how intricate or developed the product is. Originality considers newness in materials, processes, concepts, and methods of making the product. Usefulness is how beneficial the product is. However, none of the characteristics measured apply to the individual who created the product. The product category's four creativity assessments (See Table 4-2) are concerned with a product only.

4.2 Creativity Assessment Categories and the Innovation Process

The four creativity assessments categories (environment, personal/behavioral, process, and product) are all focused on the individual or product. They all align with how creativity was earlier defined; creativity is work, products or ideas that are novel and new in a certain domain or environment. None of the assessments claim to assess any type of innovation process to transform an idea to product nor were they designed to be used to assess innovation. Comparing the creativity assessment categories to the innovation process shows how they relate (See Figure 4-1). The figure shows the innovation process linearly to more clearly show the relationship between it and the creativity assessment categories.

The creativity assessments in the environment category do not directly relate to any part of the innovation process. Instead, these assessments focus on the environment, or surroundings, in which the innovation process would occur. Indirectly, the characteristics measured by these assessments influence the innovation process by being in place before the innovation process begins, which is why it is placed higher up in the graphic.

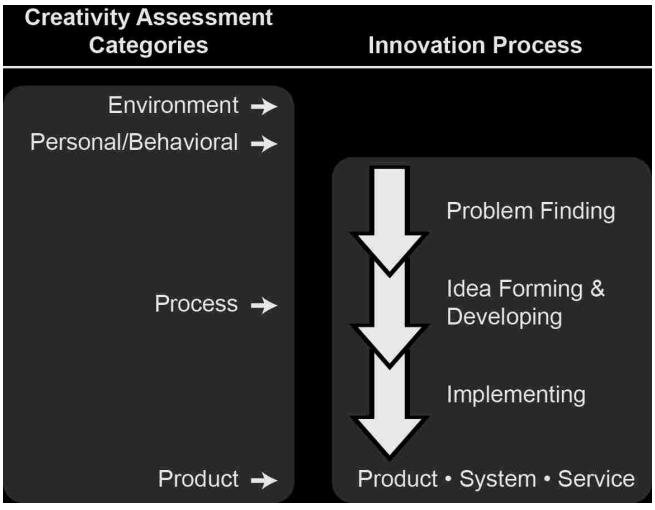

Figure 4-1: Relationship Between Creativity Assessment Categories and the Innovation Process

Likewise, the creativity assessments in the personal/behavioral category do not directly relate to any part of the innovation process. The characteristics measured in this category are self-perceptions and these are usually in place before a person engages in the innovation process. Whether these perceptions would change during or after the innovation process is beyond the scope of this literature review.

Creativity assessments in the process category do relate with the innovation process. The characteristics in this category relate to different thinking processes, and those thinking processes (e.g., divergent, associative, and inductive) deal directly with idea forming and developing's generating, refining, and testing ideas, which are both a part of the divergent phase. However, not one individual test in the process category covers the entire idea forming and developing phase of innovation. Each test focuses on individual parts of that phase.

The creativity assessments in the product category also relate with the end part of the innovation process. The creativity characteristics measured mainly focus on the end product, system, or service, and do not measure the rest of the implementing phase. The implementing phase involves all the steps from building the product to placing it in the market. So, this category aligns with part of the divergence phase in regards to the innovation process. The one partial exception is the characteristic measured called "novelty." Novelty, in the Creative Product Semantic Scale (CPSS), assesses the methods and processes of making the product. Suggesting, that the CPSS's novelty criteria focuses on the process of implementation not marketing the product.

4.3 **Innovation Findings**

Using the same databases and methods as the creativity search, the innovation search revealed ninety-three articles, and only nine met the inclusion criteria. The references of the nine

relevant articles were reviewed with the same criteria as the initial search, and only one additional source was found (See Table 4-3). Ten innovation assessments and their psychometric properties were identified from the ten identified articles (See Table 4-4).

Table 4-3: Innovation Search Results

Innovation Terms	*EBSCO Results*	*Google Results*	*Relevant*	*Additional*
innovation assessment	8	36	7	1
innovation test	23	11	1	0
innovation assessment AND properties	0	0	0	0
innovation assessment AND characteristics	0	5	0	0
innovation evaluation AND properties	0	0	0	0
innovation evaluation AND characteristics	0	4	0	0
innovation survey AND properties	0	0	0	0
innovation survey AND characteristics	0	3	1	0
innovation test AND properties	0	0	0	0
innovation test AND characteristics	0	3	0	0

Table 4-4: List of Innovation Assessments

Category	*Innovation Assessments*	*Characteristics*	
Environment	Innovation Mini-Audit (Suydam, R. L. (2004). Implementation of an Organizational Innovation Assessment Survey.)	Basic values Challenge Collaboration Communication Completion Contemplation	Creativity Customer focus Innovation values Leadership People
	Organization Assessment Instrument (Van de Ven, A. H., & Ferry, D. L. (1980). Measuring and assessing organizations. New York: Wiley)	Design Functions	Structures

Table 4-4: Continued

Category	*Innovation Assessments*	*Characteristics*	
	Siegel Scale of Support of Innovation (Siegel, Saul M. (1978). Measuring the perceived support for innovation in organizations. *Journal of Applied Psychology,* 63(5), 553-562.)	Consistency Continuous development Leadership	Norms for diversity Ownership
	Team Climate Inventory (Anderson, N. R., & West, M. A. (1998). Measuring climate for work group innovation: development and validation of the team climate inventory. *Journal of Organizational Behavior*, *19*(3), 235-258.)	Interaction frequency Participative safety Support for innovation	Task orientation Vision
Idea Forming & Developing	Product-Service Systems Idea Assessment (Fornasiero, R., & Sorlini, M. (2010). Developing an assessment tool for innovation of product and service systems. *International Journal of Internet Manufacturing and Services*, *2*(2), 166-185.)	Idea evaluation	Idea ranking
Entire Process	Community Innovation Survey (OECD. (2005). The Measurement of Scientific and Technical Activities: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data (Oslo Manual). Paris, France.)	Barriers Effects of innovation Expenditure on different activity Manufacturing process Product	Protection methods for innovation Public support for innovation Sources of information and cooperation

Table 4-4: Continued

Category	*Innovation Assessments*	*Characteristics*	
	Community Innovation Survey with Aesthetic Indicators (Alcaide-Marzal, J., & Tortajada-Esparza, E. (2007). Innovation assessment in traditional industries. A proposal of aesthetic innovation indicators. *Scientometrics*, *72*(1), 33-57.)	Design expenditures Design protection Equipment acquisition and maintenance Number of designers on staff Number of firms cooperating in design activities	Number of innovative firms Product renewal rate Protection of design Purchase of information and information updates Sources of design
	Innovation Scoreboard (Radosevic, S., & Mickiewicz, T. (2003). Innovation capabilities in seven candidate countries: an assessment. Louvain-la-Neuve, Belgium.)	Human resources Innovation finance, output, and markets	Knowledge creation Transmission and application of knowledge
Product	Technology Impact Assessment (de Jesus-Hitzschky, K. R. E. (2007). Impace assessment system for technological innovation: INOVA-TEC system. *Journal of Technology Management & Innovation*, 2(2), 67-82.)	Economical impact Environmental impact Institutional and capacity development Introduction of (new) technology and unexpected events	Introduction of (new) technology and unexpected events Social impact
	Wageningen Innovation Assessment Tool (Tepic, M.. Facing the global challenge to raise the innovation power of agrifood companies; Creativing an innovation assessment tool.)	Economic advantage of product Market competitiveness Market need, growth, and size Newness to the firm Product customization	Product superiority and uniqueness Project company resource capability Technological resource capability

Table 4-4 shows four categories of innovation assessments: (1) environment, (2) idea forming and developing, (3) entire process, and (4) product. These categories are derived from the innovation assessments and reflect the innovation process (problem finding, idea forming and developing, and implementing) discussed in chapter 2. For the purpose of this literature review, each category has been defined below. In light of the sixty-two defining characteristics only a small sample will be used to help provide clarity of the definition. The selected characteristics being used to define the categories are the common (meaning the characteristic is used in multiple assessments) characteristics between assessments.

First, the environment category is defined as the surroundings where the innovation process occurs. Innovation assessments that fit the environment category measure twenty-four characteristics that are conducive to the innovation process. While none of the innovation processes explain that environment is a factor of the process, the findings suggest that environment is an important characteristic to be measured. For example, the common characteristic of leadership measures support for the development of new ideas and the support of individual members' personal development. Another example is ownership. Ownership or collaboration is defined as existing when group members feel they originate or develop the ideas, processes, and procedures with which they work as groups (Siegel, 1978). Another common characteristic is vision, and vision is defined as having a shared goal or outcome. These and the others characteristics identified in the four assessments would foster an environment that is more conducive to the innovation process (See Table 4-4).

Second, the idea forming and developing category is defined as generating and developing ideas. The idea forming and developing category consisted of one assessment and measured two characteristics. The Product-System Service Idea Assessment (PSS-idea) measures two

characteristics – idea evaluation and idea ranking. An evaluation of an idea must be made in order to develop an idea, and idea ranking is a process of testing ideas to rank which idea is the best solution for the problem. This assessment is designed to help managers of small businesses make decisions whether a certain innovative idea should be pursued or not (Fornasiero & Sorlini, 2010). The PSS-idea fits this category because Brown (2008) explained that idea forming and developing is generating, developing, and testing ideas. It assesses "the phases coming after idea generation, but before prototyping and engineering a product" (Fornasiero & Sorlini, 2010).

Third, the entire process category covers the entire innovation process and measures twenty-two characteristics. One of the common characteristics measured is knowledge creation, which is defined as business expenditures in research and development, patent applications, or public research and development funding. Another characteristic measured is human resources. This is how many employees are recent college or university graduates, how many employees are currently in education or training, or the working age. Expenditure is another common characteristic and is defined as money spent on different kinds of innovation activity. These activities may be considered to be purchasing new equipment, knowledge (e.g., patents), companies, investments, or upgrading equipment or processes. Protection is another common characteristic and is defined as the right or title to a product usually through patents. All the characteristics in this category are a result of three innovation assessments.

Two of the assessments, the Community Innovation Survey with Aesthetic Indicators, and the Innovation Scoreboard, are based off of the third assessment, the Community Innovation Survey (CIS) (Alcaide-Marzal & Tortajada-Esparza, 2007; Radosevic & Mickiewicz, 2003). The CIS is a survey that the Organization for Economic Cooperation and Development (OECD) develops and sends out to businesses in European countries.

Originally, the main indicators used over ten years ago to measure innovation in the CIS were research and development (R&D) expenditure and numbers of personnel involved with R&D (Alcaide-Marzal & Tortajada-Esparza, 2007). Another traditional indicator for innovation was the number of patents obtained by properties (Abraham, 2001; Godin, 2002). These three indicators were considered to be inputs to innovation and were used to measure innovation as seen in the earlier versions of the CIS. The more recent versions of the CIS assess characteristics such as expenditure on different activity, knowledge creation, purchase of information and information updates, sources of information and cooperation, and transmission and application of knowledge. These characteristics show a move away from the CIS's original focus on R&D and patents and instead focus on a broader view of inputs and outputs of innovation. However, this shift in focus does not assess the idea forming and developing phase of innovation or an individual's innovativeness in any way.

The two other assessments in the entire process category are based on the CIS. The Community Innovation Survey With Aesthetic Indicators builds on the CIS by adding indicators to assess the design process of a product and the actual design of a product. This survey is for companies with products in fashion and customer preference since aesthetics are the basis of their marketability (Alcaide-Marzal & Tortajada-Esparza, 2007). This assessment is based on a company's innovativeness and disregards an individual's ability to innovate. The Innovation Scoreboard gives countries an innovative score based on the results from the CIS. While it is called an innovation assessment, it is more of a scorecard of a country's innovativeness – as the name suggests. Researchers interpret data from the CIS and give a country a score on different parts of the innovation process (Radosevic & Mickiewicz, 2003). That score represents the country and does not relate to individuals.

Fourth, the product category is the effect of innovative products on the environment. The product category of innovation assessments identifies two assessments and measures fourteen characteristics. The assessments are the Technology Impact Assessment and Wageningen Innovation Assessment Tool. Both assessments focus on how an innovative product affects the environment. The Technology Impact Assessment assesses how the product impacts the environment and different systems. The Wageningen Innovation Assessment Tool was designed for the agri-food industry and assesses how innovative products affect agri-food production. The two assessments do not measure an individual's innovativeness or ability to follow the innovation process, which limits these two assessments' usefulness in this literature review. The characteristics identified in the two assessments do not relate to one another and so lack any commonality between them.

4.4 **Innovation Assessment Categories and the Innovation Process**

The innovation assessment categories relate to how innovation was earlier defined in the different domains: the process of implementing a useful, new or improved product, process, or method to compete in the marketplace. Not all of the assessments claimed to assess the entire innovation process. A few of the innovation assessments are more focused on a portion of the process. The relationship between the innovation assessment categories and the innovation process are shown (See Figure 4-2).

From the four innovation assessment categories (environment; idea forming & developing; entire process; product), only the entire process category attempts to assess the entire innovation process as the bracket in Figure 4-2 shows. The assessments contained therein have characteristics that are involved in most parts of the innovation process. This would seem to suggest that the CIS, Community Innovation Survey with Aesthetic Indicators and the

Innovation Scoreboard are best suited to assess the innovation process. However, these assessments fall short in assessing the innovation process in two ways.

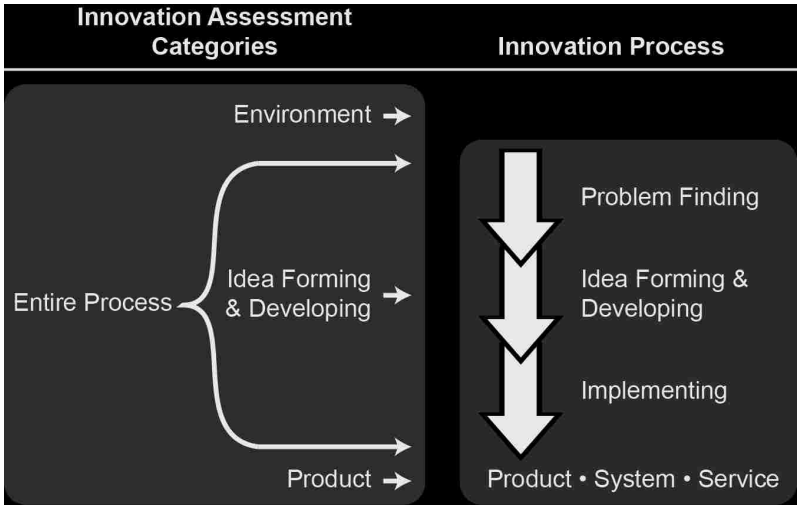

Figure 4-2: Relationship Between Innovation Assessment Categories and the Innovation Process

First, the assessments in the entire process category are focused on a business or country and do not scale down to the individual level. In essence, the assessments are surveys that businesses fill out about monetary input and processes. An individual is not considered in these surveys. Second, the characteristics identified in the process category show that the problem finding and idea forming and developing parts of the innovation process, which are also considered the divergent portion of the innovation process, are not entirely covered. The common characteristic of knowledge creation does not relate with the divergent phase because it is measuring how much money is put into research and development or acquiring patents - not divergence.

However, the entire process category slightly succeeds in one way. The convergence phase is implied in the entire process category. The characteristics measured include manufacturing

process and product. These imply that the business is converging on the one solution to be made into the final product, process or method, which covers the convergence phase.

The other three categories contain assessments that are focused on at least one aspect of the innovation process. Limited in such a way, these assessments cannot be used as standalone measures of the innovation process. Neither can they be used to assess an individual since they are designed with businesses in mind.

The environment category has four assessments that do not directly relate to any part of the innovation process. Instead, these assessments focus on the environment, or surroundings, in which the innovation process would occur. An environment that values collaboration and communication and has leadership that promotes an innovative process would add to the likelihood that innovation occurs. However, that does not suggest that the innovation process *will* happen if those characteristics are present in the environment. Other steps from the innovation process need to be present for innovation to take place. Also, these assessments do not assess an individual's ability to be innovative, which renders it useless for assessing a potential employee's innovativeness or progress in a student's ability to be innovative.

The last two innovation assessment categories (idea forming and developing and product) also fall short. The idea forming and developing category has one assessment, the PSS-idea. While the PSS-idea fits in this category and does this by focusing on part of the innovation process, it does not assess an individual's innovativeness. Therefore, this assessment cannot be considered a valued resource for measuring the innovation process as a whole. Also, the PSS-idea does not engage in the divergence phase of innovation because it only evaluates and ranks ideas. These two characteristics are considered the beginning part of the convergence phase,

which is the assessments purpose, which is to provide feedback whether the idea should be pursued through implementation (Fornasiero & Sorlini, 2010).

The product category has two assessments, the Technology Impact Assessment and Wageningen Innovation Assessment Tool. Neither of these two assessments are designed to assess people. These assessments assess the environmental impact of technology invented specifically to aid in the agri-food process, consequently, the Technology Impact Assessment and Wageningen Innovation Assessment Tool can also be discounted for measuring the innovation process as a whole.

4.5 **Creativity and Innovation Assessments**

Now that the categories for creativity assessments have been compared to the innovation process and the innovation assessments have been compared to the innovation process, the two will be compared to each other. Analyzing creativity and innovation categories shows alignment between the creativity's environment category with innovation's environment category and creativity's process category with innovation's idea forming and developing category (See Table 4-5).

Table 4-5: Creativity and Innovation Assessment Categories

Creativity Category	*Innovation Category*
Environment	Environment
Personal/Behavioral	
Process	Idea Forming & Developing
	Entire Process
Product	Product

In the following tables, the characteristics in each category are listed in alphabetical order to highlight how the assessments relate. No relation is implied between characteristics that are next to each other. The duplicate and similar characteristics have been listed once to avoid confusion.

There are creativity and innovation assessments that assess factors in the environment or surroundings that influence creativity or innovation. (See Table 4-6). Approximately one third of the characteristics are similar between the assessment types. While the wording might be slightly different in the categories, similar characteristics between the two categories are: challenge, collaboration, creativity, interaction, people, support, and structure. Based on the characteristics measured, it appears that the creativity assessments that assess environment could be used interchangeably with the innovation assessments.

Table 4-6: Characteristics from the Environment Categories

Creativity Characteristics	*Innovation Characteristics*
Acceptance of ideas	Basic values
Challenging work	Challenge
Collaboration	Collaboration
Confidence feedback	Communication
Creativity	Completion
Dedication/commitment	Consistency
Environment	Contemplation
Freedom	Continuous development
Goal clarity	Creativity
Information sharing	Customer focus
Instructions method	Design
Management encouragement	Functions
Organizational encouragement	Innovation values
Organizational impediments	Interaction frequency
Parental support	Leadership
Personal bond	Norms for diversity
Personality	Ownership
Productivity	Participative safety
Sufficient resources and time	People
Supervisory encouragement	Structures
Trust	Support for innovation
Work group supports	Task orientation
Workload pressure	Vision

The product categories for creativity and innovation align in name and in their relation to the innovation process. However, the characteristics that are actually measured are quite different between the two categories (See Table 4-7). The single characteristic that is similar between the two categories is originality (uniqueness). The rest of the characteristics are focused differently. This results from the different purposes of the assessments.

Both product categories would seem to relate as they both assess products. However, they do not. The difference is best explained from the definitions of the categories. The creativity assessments are measuring how creative the products are or how a product exhibits creativity. The innovation assessments are measuring the effect of innovative products on the environment. They do not actually assess how innovative a product is. The two innovation assessments in the product category are focused on what effect the product has, while the four creativity assessments are focused on the product itself. Consequently, these two categories and their assessments do not relate.

Table 4-7: Characteristics from the Product Categories

Creativity Characteristics	*Innovation Characteristics*
Aesthetic appeal	Economical impact
Complexity	Environmental impact
Condensation	Institutional and capacity development
Creativity	
Detail	Introduction of (new) technology and unexpected events
Effort	
Elaboration & synthesis	
Elegant	Market need, growth, size, and competitiveness
Expression of meaning	
Generation	Newness to the firm

Table 4-7: Continued

Creativity Characteristics	*Innovation Characteristics*
Hedonics	Product superiority and uniqueness
Liking	Social impact
Logical	Technological resource
Neatness	
Novelty	
Organic	
Organization	
Originality	
PlanningReformulation	
Relevancy	
Representationalism	
Resolution	
Surprise	
Symmetry	
Technical goodness	
Understandable	
Useful	
Valuable	
Variation	
Well-crafted	

Creativity assessments that fit into the creativity process category seem to relate to the assessment in innovation's idea forming and developing category (See Table 4-8). Both sets of assessments measure ideas that result from thinking. The thinking processes involved with creativity are also used in the idea forming and developing step in innovation. However, by examining the characteristics between the creativity and innovation assessments the difference shown is what part of idea forming and developing is being assessed. The creativity assessments measure the entire idea forming and developing process while the innovation assessment measures the ideas after they are formed.

Table 4-8: Characteristics from the Process Categories

Creativity Characteristics	*Innovation Characteristics*
Abstractness	Idea evaluation
Adaptivity	Idea ranking
Analytical ability	
Asking questions	
Associative thinking	
Boundary breaking	
Broadening	
Capturing	
Challenging	
Checking answers	
Completion	
Complexity	
Connections made with a line	
Continuations	
Convergent thinking	
Curiosity	
Defining the problem	
Divergent thinking	
Elaboration	
Flexibility Fluency	
Foreseeing consequences	
Generating hypotheses	
Guessing causes	
Humor and affectivity	
Imagination	
Independence from past responses	
Independence from outside cues	
Inductive thinking	
Lack of constriction	
New elements	
Noticing details	
Originality	
Overall creativity	
Persistency	
Perspective	
Practical Ability	
Resistance to premature	
closureRisk taking	
Selecting the best answer	
Sensing that a problem exists	
Speed	
Stability	
Surrounding	
Synthetic ability	
Toleration of ambiguity	
Unconventionality	

The creativity characteristics measured show the range of idea forming and developing, which is the process of generating, developing, and testing ideas that may lead to solutions (Brown, 2008). A few example characteristics showing the range are divergent thinking, fluency, elaboration, asking questions, convergent thinking, and foreseeing consequences. Divergent thinking and fluency are an example of generating ideas. Elaboration and asking questions are an example of developing ideas, and convergent thinking and foreseeing consequences are part of testing ideas.

The two innovation characteristics measured fit into the last part of idea forming and developing – testing ideas. Those characteristics are idea evaluation and idea ranking. The assessment with these two characteristics does not claim to measure the process of idea forming and developing. It does what it was designed to do – evaluate ideas and rank them.

The creativity assessments and innovation assessments in the idea forming and developing category do not compare very well. They are designed for different purposes. The creativity assessments align better with one part of the innovation process than the innovation assessment does.

The creativity personal/behavioral category does not correlate with any innovation category. The assessments in this category are self-conducted surveys or inventories and assess whether an individual thinks he or she is creative or not (See Table 4-9). As previously discussed, two assessments in this category do not seem to fit in the category. However, the Adaption-Innovation Inventory and the Iowa Inventiveness Inventory are included in this category because the creativity search procedures identified them. Also, the characteristics measured (originality, conformity, efficiency, biographical, personality, and vocational) fit with a personal or behavioral inventory and warrant their inclusion. As Figure 4-1 shows, the

personal/behavioral category would seem to relate to the innovation process discussed in chapter 2. These characteristics increase the possibility of an individual's success with the innovation process and should exist in an individual before the innovation process begins.

An innovation category that does not apply to the creativity side is the entire process category. This is the only category in both creativity and innovation that has assessments directly claiming to measure the innovation process. However, as discussed earlier, these assessments are designed for businesses, not for an individual, and do not adequately cover the idea forming and developing phase of innovation. The characteristics measured from these three assessments show the inadequacy on idea forming and developing and how they focus on businesses (See Table 4-10). The monetary characteristics (equipment acquisition, expenditure on difference activity, protection of design, and purchase of information and information updates) are of no use to measure how well an individual follows the innovation process. Those characteristics are focused on the convergence phase of innovation as a business is beginning or completing the manufacturing process.

Table 4-9: Characteristics from the Personal/Behavioral Category

Creativity Characteristics	
Introversion-extraversion	Self-perception of creativity
Intuitive-sensing	Self-strength
Inventive	Self-striving or self-improvement
Literature	Sensitivity
Mannerly	Sexy
Music	Sincere
Optimizer	Snobbish
Originality	Social participation and social experience
Parental striving	Submissive
Perceiving-judging	Suspicious
Personality	Tenacity
Pervasive & continuing enthusiasm	Thinking-feeling
Positive self-referencing	Too busy for new ideas
Preference for complexity	Unconventional
Reflective	Use of other people
Resourcefulness	Use of senses
Risk taking	Use of techniques
Science	Valuing new ideas
Self-confidence	Vocational

For example, the monetary characteristics (equipment acquisition, expenditure on different activity, protection of design, and purchase of information and information updates) are of no use to measure how well an individual follows the innovation process. Those characteristics are focused on the convergence phase of innovation as a business is beginning or completing the manufacturing process.

Table 4-10: Characteristics from the Entire Process Category

Innovation Characteristics	
Barriers	Number of innovative firms
Design expenditures	Product
Design protection	Product renewal rate
Effects of innovation	Protection methods for innovation
Equipment acquisition and maintenance	Protection of design
Expenditure on different activity	Public support for innovation
Human resources	Purchase of information and information updates
Innovation finance, output, and markets	Sources of design
Knowledge creation	Sources of information and cooperation
Number of designers on staff	Transmission and application of knowledge
Number of firms cooperating in design activities	

5 CONCLUSION

As innovation becomes more important for businesses, the importance also increases to understand how people become more innovative (Dyer et al., 2009). For example, BYU's technology and engineering students are required to take a course on innovation. However, there is not an assessment being used to measure the students' ability to be innovative. An assessment is needed to verify that people, like BYU students, are becoming more innovative.

This research reviewed the literature of various creativity and innovation assessments and identified the common parts of the innovation process, which are problem finding, idea forming and developing, and implementing. Problem finding and idea forming and developing also are considered part of the divergence phase of innovation, while idea forming and developing is also considered to be part of the convergence phase with implementation. The overlap with idea forming and developing between the two phases of innovation occurs during development. Once development stops refining ideas and starts converging to one, it leaves the divergence phase and enters convergence phase of the innovation process.

The innovation process was compared with the creativity assessment categories in order to clarify how the creativity assessments aligned with the innovation process. Similarly, the innovation findings discussed the assessments and resulting categories, which were then compared to the innovation process to identify any possible gaps between the innovation process and assessments. Through the comparisons, gaps were identified in innovation assessments and

how they measure the innovation process. The creativity characteristics were compared with those of innovation to create a knowledge baseline of what may be included in an innovation assessment to fill the identified gaps.

According to the research, creativity was defined as work, products or ideas that are novel and new in a certain domain or environment. Each creativity assessment analyzed focused on distinctly different aspects of creativity. For example, the Consensual Assessment Technique (CAT) measures product creativity, whereas the Torrance Tests of Creative Thinking measures creative ideas, while the Adjectives Check List assessment measures an individual's creativity. All three types of creativity assessments are valid and pertinent to measuring creativity. However, there remains a need to create a more comprehensive and all-inclusive measure. Similar findings were discovered when analyzing innovation assessments.

The definition of innovation varies little depending on the domains defining it. In Technology, innovation is defined as a process of creating a novel and useful technological outcome or process. In the engineering domain, innovation is defined as the transformation of ideas and alternatives into useful applications that lead to change and improvement. While the business domain defines innovation as the process of using a number of activities to implement a new or improved product, process, or marketing method used to compete in the marketplace. However, the definitions suggest the same thing. Innovation is the process of coming up with and implementing a useful, new or improved product, process, or method to compete in the marketplace.

This study reveals that innovation assessments do not measure the innovation process in its entirety - according to the definition listed above. A discussion of this follows below.

To see if such an innovation assessment existed, current creativity assessments and innovation assessments were analyzed to determine what characteristics are being measured. The two sets of characteristics were then compared to each other and to the innovation process. The findings reveal that creativity and innovation assessments lack in: (1) assessing the entire innovation process, (2) assessing the innovation process on an individual level, and (3) assessing an individual's change or growth in the innovation process.

First, none of the assessments assess the entire innovation process. Innovation assessments focus on convergence. Convergence was defined as going from many possibilities to one result. This literature review concludes that business' motivation in measuring innovation is checks and balances. Checks are the review methods of a process or act in which the result of the review may then stop the process or act or provide an alternative. Businesses want to know that their monetary input into research and development, acquiring patents, or purchasing new equipment or technology is going to yield a product, process, or method that will sell. If the monetary input does not yield the requisite result, the business will stop and make adjustments. Because the focus of innovation is on production (the value of new product, system, or service), the current innovation assessments in use focus only on the convergent phase of innovation. In contrast, creativity assessments focus on the divergence phase (See Figure 5-1).

The figure shows how the innovation phases of divergence and convergence line up with the innovation process, and then all the assessments identified are aligned to the innovation process based on what part of the process they measure. Also on the side, two groups of assessments are shown that don't line up with the innovation process, which are the same categories discussed earlier – environment and personal/behavioral.

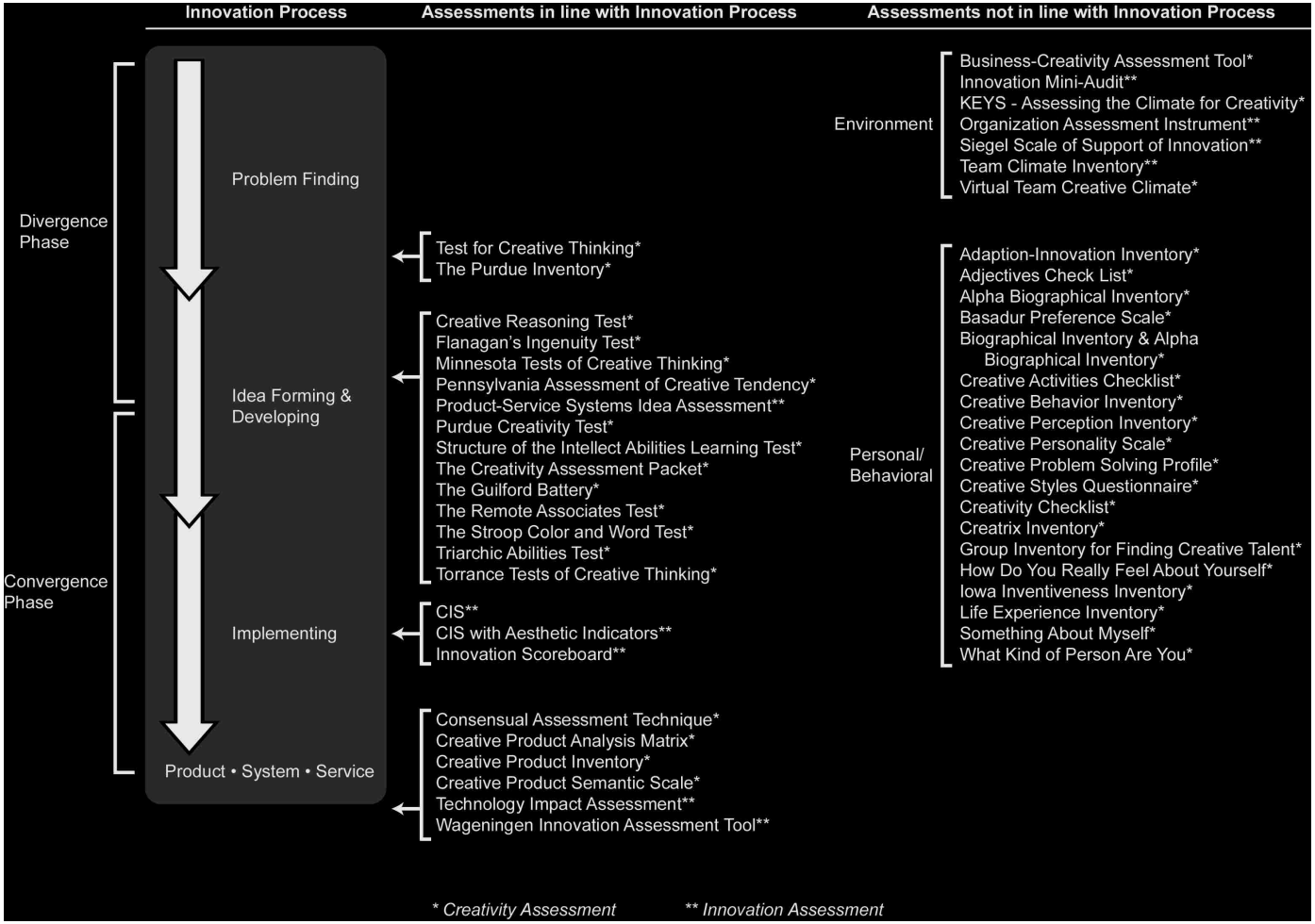

Table 5-1: Assessments Aligned with the Innovation Process and Innovation Phases

The findings and table show that the divergence phase is the first part of the innovation process and the convergence phase the second part. That is to say that innovation is made up of divergence and convergence.

Innovation is the process of coming up with and implementing a useful, new or improved product, process, or method to compete in the marketplace. Therefore, it needs to measure both convergent and divergent phases of innovation.

All of the innovation assessments found in this literature review measure different parts of the process or environment in which the innovation process occurs. An innovation assessment that claims to measure how innovative a business or person is should be able to measure the entire innovation process (i.e., problem finding, idea forming and developing, and implementing) by focusing on both the divergence and convergence phases. Currently, a test of this type does not exist.

Second, innovation assessments are not developed for assessing individuals. None of the assessments this literature review found assessed innovation on an individual level. All the innovation assessments were business oriented. In contrast there were several creativity assessments found that measure an individuals' level of creativity – however, these assessments were creativity centric, lacking a holistic innovation perspective and focused on the divergence phase of innovation.

There are various opportunities where an assessment measuring an individual's level of innovativeness would prove helpful. Two of the opportunities were discussed early in the paper. The first concerned how a professor has taught the innovation process by measuring how innovative a student is. The second involved assessing potential employees' innovativeness before making a decision on whom to hire. These two scenarios would benefit greatly from an

individualized innovation assessment because it would prove helpful to both universities and students to see if their programs are making a difference. Also because many companies see innovation as an essential characteristic for their company, it makes sense that they may benefit from using an innovation assessment as one predictor of job applicants' innovativeness. Although an individualized innovation assessment would prove helpful as an initial screening, it does not guarantee innovativeness. There are other essential qualities that need to also be present to help promote innovation (i.e., culture, environment, coworkers).

Third, the assessments do not measure an individual's change or growth in the innovation process. With regards to there being no innovation assessment designed for an individual, it follows that there is no method to measure an individual's growth in the innovation process. The creativity assessments are often used in a pre- and post-test setting to measure an individual's growth in creativity. Likewise, an innovation assessment should exist that can be used in a pre- and post-test setting.

Based on the findings, future research needs to be done to develop an individualized innovation assessment. Creativity assessments are centered on the divergence phase of innovation. Innovation assessments are focused on the convergence phase of innovation. There's a potential to fill the gaps in innovation assessments by combining different characteristics from different assessments in both divergent and convergent phases. For example, the problem finding part of innovation might take elements from creative personality or behavioral inventories to assess personality characteristics that are related to problem finding, which is the beginning part of the divergence phase. The idea forming and developing part of innovation may incorporate characteristics from creative process assessments, creative product assessments, and innovation idea forming and developing assessments to measure generating, testing, and refining ideas. This

would take characteristics that fit into the divergence phase and the convergence phase. The implementing part may use marketing and implementing characteristics from the CIS that are modified to an individual's level instead of business, which would finish up the convergence phase.

Creating an innovation assessment using characteristics from the problem finding, idea developing and forming and implementing parts of the innovation process would enable an individual or company to assess the entire innovation process (both divergent and convergent phases), the innovation process on an individual level, and an individual's change or growth in the innovation process. This type of assessment is needed because creativity and innovation are different and should be assessed distinctively.

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