Recommendations for Designing Spaces to Support Creativity and Design

by

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Abstract

This thesis explores designing spaces to support creativity and design. It examines supporting the tasks and thinking involved in creative and design processes with the environment. This paper also looks at how individual environmental factors could directly and indirectly influence creativity. Recommendations for designing spaces to support creativity and design were developed through the analysis and synthesis of literature involving creativity, design, psychology, environmental psychology, environmental design, human factors, and workspaces. The recommendations involve designing spaces to support the tasks, processes, and thinking involved within design and creative processes, while also supporting creativity and mood through individual factors in the environment. A studio space was evaluated based on the recommendations. As a demonstration of how to use the recommendations, the studio space was redesigned according to the recommendations and the evaluation. A scale model was developed to demonstrate the design.

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List of Abbreviations

ICL	Interactivity Creativity Landscape
TTCT	Torrance Test of Creative Thinking

Chapter 1: Introduction

1.1 Problem Statement

Creativity and design involves thinking. The environment can have effects on thinking. While creativity can happen anywhere, literature suggests that some environments may be better than others for thinking creatively, particularly in portions of the creative process. The design of the environment can have an effect on one's mood, productivity, attention, and thinking. Different phases of the creative process may call for different elements in the environment, while different activities involved in the design process may call for different support within the environment. In an environment, where designers may spend the majority of their day, it is important that the space be designed as a comfortable area that promotes working and thinking creatively. Understimulation is shown to lower efficiency, while overstimulation can distract and lead to increased stress levels (Kopec 2006). Color and lighting options can have positive and negative physical effects on a designer. Ergonomic furniture that addresses a student's needs and learning process within a studio environment is another area that must be considered. The designer's focus should be on their work, not on their lack of comfort in the environment. Crowding along with a lack of privacy are concerns that lead to higher and more uncomfortable environmental loads as a higher number of students may occupy a space not designed to hold them. Poor environmental design can lead to higher stress levels, hyperactivity, lower efficiency, higher heart rates, or lower efficiency, among other effects (Kopec 2006). Since attention is required for creativity (Csikszentmihalyi, 2013, p. 8), an environment that is set up to minimize

distractions seems important, particularly for flow states, in which people feel more creative as they focus on the task at hand (Csikszentmihalyi 2008). For an environment that designers often work in for extended periods of time, a tolerable, comfortable, and stimulating environment is needed. The environment should provide appropriate stimulation for the creative task at hand; the environment should be conducive to the design activity at hand, allowing designers to focus on the activity and avoid distractions. The space should be designed as an environment where designers want to go to work and create, a place that is ideal for their learning, working, and creative thinking needs, needs that may change throughout the creative and design process. This paper intends to explore how an environment can be designed to benefit the thinking and activities involved in the creative process as it relates to the design process.

1.2 Need for Study

Csikszentmihalyi (2013) suggested different environments might benefit different types of thinking and activities involved in the stages of the creative process, while Haner (2005) suggested that certain elements within the environment may benefit the different stages of the creative process, and Kristensen (2004) suggested that certain spatial arrangements might benefit stages within the creative process. Other researchers have looked at environments that support perceived creativity, looking at a combination of different environmental factors, while some have looked at how individual stimulus affects creative thinking or thinking related to creativity. Csikszentmihalyi (2008) also discussed the state of flow, in which one is completely focused on the task at hand and feels more creative. While not concretely proven, logically, environments designed to help one focus on the task and minimize distractions should designers get into and maintain flow states as they work on their activities involved with the creative and design

process. The design of an environment or environments that focuses on supporting the different stages of the creative process and activities of the design process, and helping designers focus on the task at hand, while providing them with the appropriate stimulation for thinking and tools to work creatively, while also incorporating other elements that make people feel more creative, should be beneficial to creative thinking and working. The recommendations that come from this paper may be beneficial for the design of spaces for both design firms and design education spaces. A better environment that focuses on specific creative needs could provide designers or design students with more comfort, more stimulation and inspiration, more support for their activities, and lead to more productivity, more positive feelings, and more creative thought. Spaces could be designed so that designers or students are more focused and creatively efficient, spaces where designers can get in the zone, spaces where designers want to be, spaces where designers want to work, because the spaces support creative working and thinking.

1.3 Objectives of Study

The objective of this thesis is to develop recommendations for designing spaces that support creativity and design, which could involve focusing on designing for the specific phases of the creative process and for activities within the design process while also incorporating environmental stimuli that increases perceived creativity. The following is a list of objectives this thesis study will involve:

- Research creative process as it pertains to design and the cognitive and physical processes involved
- Research “flow states”

- Research design processes and methodologies and identify common design activities
- Identify and discuss the relationship between the creative process and design processes and the overlap and relationship between the creative process and design activities
- Research how the environment can support the cognitive and physical processes within the creative process as it pertains to design.
- Research case studies that have set up different environments for different creative activities
- Research creative spaces in innovative companies
- Research environments that increase perceived creativity
- Research environmental load and how it affects cognition
- Research furniture, workspace design, and furniture arrangement and how they can affect cognition, behavior, and creativity
- Research how tools can affect creative thinking and acting
- Identify what elements may be beneficial throughout the creative and design process and what elements would change
- Develop recommendations for designing environments that support creative thinking within the creative process and design process.
- Evaluate a higher education industrial design studio learning environment according to the recommendations
- Redesign the evaluated industrial design studio learning environment according to the recommendations

1.4 Assumptions

These assumptions are supported by research in some cases, but may not be entirely proven. This thesis assumes that the research collected and used from books, journals, and the internet is trustworthy. This thesis assumes that the environment and the elements within it can affect one's moods and behaviors and cognition. This thesis also assumes that the environment and the elements within it can aid with creative thinking. This thesis assumes that the environment can help one get into and maintain flow. This thesis assumes that the creative process is related to design processes. This study also assumes that designing the environment for specific stages of the creative process can benefit the thinking involved in the stages. This assumption is also supported and suggested by literature. This thesis assumes that designing the environment for specific design activities should help the participant to hone in on that task and focus their creative energy. It is hard to concretely prove that the environment can enhance creativity, but this idea is heavily suggested throughout literature.

1.5 Scopes and Limits

The scope of this research includes developing recommendations for supporting creativity and design by designing the environment to support stages in the creative process and design activities as well as incorporating elements that increase perceived creativity. This thesis will look at the creative process as it pertains only to the creative discipline of design, primarily industrial design. This thesis will look at the environment's relationship with the creative thinking involved in the stages of the creative process and also with design activities, as well as looking at the specific environmental factors that may increase creative thinking or perceived creativity. The project for this thesis will involve evaluating a higher education industrial design

studio at Auburn University according to the recommendations developed and redesigning the space according to the developed recommendations.

1.6 Definition of Key Terms

Arousal – term describing human brain activity when perceiving stimulus

Arousal Curve – curve that maps arousal or stimulation levels from too low to optimum to too high

Collaborative learning environment – learning environment in which people work and learn together rather than individually

Convergent Thinking – thinking "oriented toward deriving the single best (or correct) answer to a clearly defined question" (Cropley 2006 p. 391)

Creative process – includes phases of creativity including preparation, incubation, insight, evaluation, and elaboration

Crowding – results from too many people in a space, making people uncomfortable; can result in negative psychological effects

Divergent Thinking – thinking that "involves producing multiple or alternative answers from available information" (Cropley 2006 p. 391)

Elaboration – phase of creative process; after evaluation where one continues pursuing, developing, and testing creative ideas, refining them to come to a final solution

Environmental Load – describes level of stimuli within an environment

Environmental Stimuli – variables that make up the environment and influence mood and behaviors (color, light, music, furniture, etc.)

Ergonomics – human factors of a product or environment that affect the comfort and well-being of a person; the study of the human factors of a product or environment that affect the comfort and well-being of a person

Evaluation – phase of creative process; involves the judging of insights to determine whether insights should be further pursued

High load – describes an environment that is more complex or stimulating

Incubation – phase of creative process where an individual reflects and lets ideas connect sometimes unconsciously

Insight – phase of creative process; also referred to as 'illumination;' "presumably occurs when a subconscious connection between ideas fits so well that it sis forced to pop out into awareness, like a cork held underwater breaking out into air after it is released." (Csikszentmihalyi, 2013, p. 104)

Industrial Design – applied art and science of designing objects for manufacturing

Learning environment – all which makes up the space and surroundings in which one learns or one is taught, including tangible and intangible environmental stimuli

Low load – describes an environment that is less complex or stimulating

Overstimulating – describes environmental load levels that are too high; can lead to fatigue, hyperactivity

Preparation –initial phase of creative process; involves "becoming immersed, consciously or not, in asset of problematic issues that are interesting and arouse curiosity" (Csikszentmihalyi, 2013, p. 79)

Stimulus – something that incites a response, physical or mental

Threshold – the point that describes when the level or environmental stimulus becomes too high, overstimulation, or becomes too low, understimulating

Understimulating – describes environmental load levels that are too low; can lead to anxiety and other psychological problems

Visualization – involves making 2D or 3D representations of ideas; can also refer to the representation of an idea itself

Work surface – surface on which one works (desk, table, etc.)

Workspace – area in which one works

1.7 Procedures and Methods

Procedure #1:

- Research creativity, creative process, and flow

Methods:

- Library and internet research
- Draw conclusions

Procedure #2:

- Research design processes and methodologies and identify common design activities

Methods:

- Library and internet research

- Draw conclusions

Procedure #3:

- Identify the relationship between the creative process and the design process and the overlap and relationship between the creative process and design activities

Methods:

- Library and internet research
- Draw logical conclusions

Procedure #4:

- Research how the environment can support the cognitive and physical processes within the creative process as it pertains to design.

Methods:

- Library and internet research
- Draw conclusions

Procedure #5:

- Research case studies that have set up different environments for different creative activities

Methods:

- Library and internet research
- Draw conclusions

Procedure #6:

- Research creative spaces in innovative companies

Methods:

- Library and internet research
- Draw conclusions

Procedure #7:

- Research environments that increase perceived creativity

Methods:

- Library and internet research
- Draw conclusions

Procedure #8:

- Research environmental load and how it affects cognition

Methods

- Library and internet research
- Draw conclusions

Procedure #9:

- Research furniture, workspace design, and furniture arrangement and how it can affect cognition, behavior, and creativity

Methods:

- Library and internet research
- Draw conclusions

Procedure #10

- Research how tools and tool arrangement can affect creative thinking and acting

Methods:

- Library and internet research
- Draw conclusions

Procedure #11:

- Identify what elements may be beneficial through creative and design process and what elements would change

Methods:

- Library and internet research
- Draw conclusions

Procedure #12:

- Develop recommendations for designing spaces that support creativity and design.

Methods:

- Develop recommendations from conclusions drawn from research

Procedure #13:

- Document a higher education industrial design studio learning environment at Auburn University

Methods:

- Observe studio space and take notes
- Photograph studio space

Procedure #14:

- Evaluate a higher education industrial design studio learning environment according to recommendations

Methods:

- Analyze observation and documentation of studio space
- Look for areas of adequacy and improvement according to what should be beneficial to creativity and design in the recommendations

Procedure #15:

- Redesign an industrial design studio learning environment according to the guidelines

Methods:

- Write out ideas for improvement according to the evaluation and guidelines
- Sketch out ideas
- Refine ideas
- Make scale model of redesign

Chapter 2: Literature Review

2.1 Designing the Environment for the Activity

According to literature consideration of the activities taking place in a space is important in the design of an environment. Doorley and Whitthoft (2013) in *Make Space: Setting the Stage for Creative Collaboration* state "consciously or not, we feel and internalize what the space tells us about how to work" (p. 5). It is important that a space is designed to support the particular activity so that the creative individual can focus on what they need to accomplish. Rooms may be reconfigured depending on the needs of the current activity or the amount of the people involved in a given activity. Furniture that is lightweight and on casters makes for an easier time rearranging the room (p. 112). Doorley and Whitthoft point out that the arrangement and selection of the furniture may also make for a faster transition, "Situating students around team tables rather than in seated rows allows these switches to occur quickly, as do rolling partitions" (112).

Karwoski (2006) provided some "Knowledge Base System" considerations on designing interior architectural spaces. The first consideration deals with figuring out what kind of space is needed for the users' activities. The next consideration deals what other expectations, needs, and requirements the space has including: the furniture, fixture, and equipment, convenience, safety, and security, ambient environmental criteria, information displays, durability and maintainability, and space plans (p. 969). All of these considerations deal with what is expected and required to best accommodate the activities of the users within the space. These same types

of questions are applied to workstations within the spaces, as the handbook asks what workstations are needed, what activities will be performed at the workstations and what kind of timeline applies to that, what furnishings, equipment, tools, and materials do the workstations call for, and how should the workstations be arranged if they support separate activities (p. 970). These considerations for the activity of the space help "create the boundaries of the project" (p. 973), while the "Knowledge Base System application…helps develop an encompassing image of what will be a successful project outcome (969)."

This study will explore designing environments for designers in which they are supported in thinking creatively and performing various design activities as they go through the creative process and a design process. According to various literature, environmental elements such as nature, color, light, noise, materials, other inspiration, people, furniture, tools, and space can impact how people feel, think, or interact creatively within an environment. This paper sets out to provide recommendations for designing environments to support creative thinking in the creative process and design thinking activities in a design process while also looking at increasing perceived creativity throughout the processes.

2.2 Defining Creativity

In order to understand what kinds of environments enhance or support creativity, it is important to understand what creativity is and where it takes place. Runco (2007), because of the ambiguity of the term "creativity" suggested that it "be stricken from scholarly literature" (p. 32). Mihaly Csikszentmihalyi (2013) in *Creativity the psychology of discovery and invention* emphasized the question of "where is creativity?" rather than asking what is creativity. He discussed his view of the systematic nature of creativity:

> If by creativity we mean an idea or action that is new and valuable, then we cannot simply accept a person's own account as the criterion for its existence. There is no way to know whether a thought is new except with reference to some standards, and there is no way to tell whether it is valuable until it passes social evaluation. Therefore, creativity does not happen inside people's heads, but in the interaction between a person's thoughts and the sociocultural context. It is a systematic rather than an individual phenomenon. (p. 23)

Martens (2011), citing multiple authors including Csikszentmihalyi, defines creativity as "the ability to produce work that is both new and valuable ", but goes on to say that the "definition reveals that creativity is still very subjective" depending on how loosely or strictly one uses the term new or valuable (p. 65).

Csikszentmihalyi (2013) talked about the system in which creativity takes place that includes the domain, the field, and the individual person:

> Creativity occurs when a person, using the symbols of a given domain such as music, engineering, business, or mathematics, has a new idea or sees a new pattern, and when this novelty is selected by the appropriate field for inclusion into the relevant domain. (p. 28)

Csikszentmihalyi provided his definition for creativity following his logic about where creativity takes place:

> Creativity is any act, idea, or product that changes an existing domain, or that transforms an existing domain into a new one. And the definition of a creative person is: someone whose thoughts or actions change a domain, or establish a new domain. It is important to

> remember, however, that a domain cannot be changed without the explicit or implicit consent of a field responsible for it. (p. 28)

Howard Gardner (2011), author of *Creating Minds An Anatomy of Creativity Seen Through the Lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Gandhi*, shared a similar view of creativity, stating that a creative person must be creative in a domain and must regularly show creativity. He also claimed that creativity is involved in both the solution of problems as well as coming up with new questions and ideas. The most controversial argument that both Csikszentmihalyi and Gardner made was expressed by Gardner in this way:

> But the crucial (if controversial) point here is that nothing is, or is not, creative *in and of itself*. Creativity is inherently a communal or cultural judgment. The most one can say about an entity before it has been evaluated by the community is that it (or he or she) is "potentially creative." And evaluation must be undertaken by a relevant portion of one's community or one's culture: No other arbiters are available. (p. 34)

While Gardner and Csikszentmihalyi shared similar definitions of creativity that involve the creative person being recognized by the field for coming up with something new within a domain, David Kelly, founder of IDEO and Stanford's D. School, and Tom Kelley (2013) expressed a slightly different view of creativity in *Creative Confidence Unleashing the Creative Potential Within Us All*. Kelly and Kelly stated they "think of creativity as using [the] imagination to create something new in the world" (p. 3). However, they did not place the same emphasis on the domain or being recognized by the field as Csikszentmihalyi or Gardner. They claimed that they believe absolutely everyone is creative and that their creativity can be unleashed through their design thinking methodology (p.1; p. 5-6)

Csikszentmihalyi (2013) argued that the term "creative" is used too broadly, as brilliant or personally creative people are mistaken for people that are truly creative. Csikszentmihalyi described personally creative people as "individuals whose perceptions are fresh, whose judgments are insightful, who may make important discoveries that only they know about" (p. 25). Csikszentmihalyi claimed personal creativity is far more subjective than his view of true creativity. He went on to state that people who are brilliant, personally creative, and truly creative are creative in different ways and that true creativity belongs to those who have truly changed a culture such as "Leonardo, Edison, Picasso, or Einstein" (p. 25-26).

While Csikszentmihalyi's definition of true creativity makes sense, it is not very inclusive. Steidle and Werth (2013), defined creativity generally "as the production of novel and useful ideas as well as problem solutions and refers both to the process of idea generation and the idea itself " (p. 67). Webster's dictionary defined creativity as "the ability to make new things or think of new ideas" ("creativity", n.d.). While creativity clearly has a relationship with the domain and the field, requiring the recognition of the field makes creativity apply to a much narrower group of people. For the purposes of this thesis, a more inclusive definition will be used, as this paper primarily deals with supporting creativity for users who may not be on the level of Da Vinci or Einstein. Creativity, within this study, will defined as the ability to make new and valuable things or think of new and valuable ideas within a particular domain. This definition is still subjective and still requires that the outcome is new and valuable, but this definition may include ideas or things that do not completely change or create a domain. Clearly, new things or ideas must be recognized as new, by someone with expertise in a domain, but this definition of creativity does not demand worldwide recognition, does not demand that someone be on the level of Da Vinci or Picasso, and thus, is more inclusive.

2.3 Creative Process And Creative Thinking

In order to understand how to design a creativity-supporting environment, one must understand the creative process and the mental activities involved. According to Csikszentmihalyi (2013), the creative process is often broken down into five steps (p. 79). He noted that in the creative process, there often is overlap between the stages and that stages may be repeated before the final creative outcome is realized (p. 83). The five stages include preparation, incubation, insight, evaluation, and elaboration (p. 79-81). Wallas (1926 as cited in Martens 2011) has an earlier similar model that included stages of preparation, incubation, illumination, and verification (p. 69). Kneller (as cited in Lawson 2006), has a stage of first insight before stages of preparation, illumination, and verification (p. 69). All of these models are extremely similar to each other. The first insight is the initial idea that leads into the rest of the creative process. Illumination and insight are essentially the same, while verification covers evaluation and elaboration in Csikszentmihalyi's model.

The preparation stage involves "becoming immersed, consciously or not, in a set of problematic issues that are interesting and arouse curiosity" (Csikszentmihalyi, 2013, p. 79). According to Csikszentmihalyi, the recognition of problems arising from three main areas: "personal experience, requirements of the domain, and social pressures" (p. 83). Personal experiences are drawn upon most typically in expressive domains such as art and poetry (p. 84). Csikszentmihalyi discussed how one may be inspired by the domain in which they are involved, aspiring for the new state-of-the-art, but he also stated creativity can result from the cross-pollination of domains through the application of ideas within one domain into another one (p. 88). He explained that understanding the domain is vital to creativity: "Of course, a person

cannot be inspired by a domain unless he or she learns its rules…You cannot transform a domain unless you first understand how it works" (p. 88-90). Csikszentmihalyi also discussed how the field influences creative work as ideas may be bounced back and forth between teachers and students, peers, or other creative people (p. 90). The social context of what others are doing may also be very important in the creative process (p. 91). Some problems may be presented to the creative person while others may be discovered if the right question has not yet been asked (p. 95).

While the preparation phase involves the absorption, recognition, and generation of new information, problems, and ideas, Csikszentmihalyi discussed the evidence of the next phase, incubation, where the individual allows ideas to "simmer" in their mind and connect with other ideas:

> After a creative person senses that on the horizon of his or her expertise there is something that does not fit, some problem that might be worth tackling, the process of creativity usually goes underground for a while. The evidence for incubation comes from reports of discoveries in which the creator becomes puzzled by an issue and remembers coming to a sudden insight into the nature of a problem, but does not remember any intermediate conscious mental steps. Because of this empty space in between sensing a problem and intuiting its solution, it has been assumed that an indispensable stage of incubation must take place in an interval of the conscious process (p. 98).

Csikszentmihalyi noted that the creative people he has interviewed all "agree that it is important to let problems simmer below the threshold of consciousness for a time" (p. 98). Csikszentmihalyi explained cognitive accounts of incubation:

> Cognitive accounts of what happens during incubation assume, like the psychoanalytic ones, that some kind of information processing keeps going on in the mind even when we are not aware of it, even when we are asleep…Cognitive theorists believe that ideas, when deprived of conscious direction, follow simple laws of association. They combine more or less randomly, although seemingly irrelevant associations between ideas may occur as a result of a prior connection. (p. 101)

He continued to explain that in the subconscious, "truly irrelevant connections dissolve and disappear from memory, while ones that are robust survive long enough to emerge eventually into consciousness" (p. 101). He discussed how subconscious incubation can break one away from linear thinking, as "intentionality does not work in the subconscious." The freedom from linear thinking allows for "original connections that would be at first rejected by the rational mind [to] have a chance to become established" (p. 102). However, he explains that even though "subconscious thinking may not follow rational lines, it still follows patterns that were established during conscious learning and that the domains involved are still important (p. 102-103).

The next phase of creativity is the insight, referred to as "illumination" by some, the discovery of which is often referred to as an "Aha! Moment." Csikszentmihalyi discussed this moment:

> The insight presumably occurs when a subconscious connection between ideas fits so well that it is forced to pop out into awareness, like a cork held underwater breaking out into air after it is released" (p. 104).

After the insight happens, the idea must be evaluated, leading to the next stage in the creative process. The evaluation stage involves judging the insight to determine whether it warrants

pursuing to take the idea further into the elaboration stage. Csikszentmihalyi explained this transition: “Most lovely insights never go any farther because under the cold light of reason fatal flaws appear. But if everything checks out, the slow and often routine work of elaboration begins (104-105).”

Csikszentmihalyi described the conditions of the last creative phase of elaboration:

> There are four main conditions that are important during this stage of the process. First of all, the person must pay attention to the developing work, to notice when new ideas, new problems, and new insights arise out of the interaction with the medium. Keeping the mind open and flexible is an important aspect of the way creative persons carry on their work. Next, one must pay attention to one’s goals and feelings, to know whether the work is indeed proceeding as intended. The third condition is to keep in touch with domain knowledge, to use the most effective techniques, the fullest information, and the best theories as one proceeds. And finally, especially in the later stages of the process, it is important to listen to colleagues in the field. By interacting with others involved with similar problems, it is possible to correct a line of solution that is going in the wrong direction, to refine and focus one’s ideas, and to find the most convincing mode of presenting them, the one that has the best chance of being accepted. (p. 104-105)

It is important to note that one goes back and forth between the stages in the creative process as they move forward (p.83). Also, it becomes important in designing spaces to consider the creative process to promote certain types of thinking. While the preparation phase may involve a more familiar environment where one is briefed or a problem is communicated between individuals, the incubation stage may benefit from a more relaxing but stimulating space such as nature. The insight can happen at any time and evaluation follows. The elaboration phase

may call for a space that allows for testing and prototyping, but moving back and forth between phases may call for an environment that is conducive to multiple stages of the creative process at once. Environments that are conducive to these stages and designing spaces for these specific stages is discussed in greater detail later in this paper.

Creative thinking involves both convergent and divergent thinking. Csikszentmihalyi recognized that "people who bring about an acceptable novelty in a domain seem to be able to use well two opposite ways of thinking: the convergent and the divergent (p.60)." Arthur Cropley (2006) explained these types of thinking, "convergent thinking is oriented toward deriving the single best (or correct) answer to a clearly defined question," while "divergent thinking, by contrast, involves producing multiple or alternative answers from available information. It requires making unexpected combinations, recognizing links among remote associates, transforming information into unexpected forms, and the like." Cropley stated, "creative thinking seems to involve 2 components: generation of novelty (via divergent thinking) and evaluation of novelty (via convergent thinking) (p. 391)." Cropley proposes a new creative phase model based off of Wallas's (1926 as cited in Cropley 2006) model that adds an information stage preceding preparation and a communication and validation after verification (p. 401). Cropley explains how convergent and divergent thinking are involved in his phase model:

> Striking about the phase model, for present purposes, is that in some phases divergent thinking is needed; in others, however, convergent thinking; yet in others, both are necessary. The crucial idea here is that although both are needed for production of effective novelty, this is not necessarily at the same moment in the process; the creative

person may alternate from one kind of thinking to the other, according to the demands of the process of production of effective novelty. (p. 402)

Csikszentmihalyi (2013) discussed that "most [creativity] workshops try to enhance" divergent thinking and most creativity tests measure divergent thinking. He stated that, "It is probably true that in a system that is conducive to creativity, a person whose thinking is fluent, flexible, and original is more likely to come up with novel ideas (p. 60)," but he went on to say, "divergent thinking is not much use without the ability to tell a good idea from a bad one – and this selectivity involves convergent thinking (p. 60-61)." Clearly, creativity involves both divergent and convergent thinking, and an environment conducive to creativity should support both types of thinking or cater to certain type at a certain phase of the creative process. Kristensen (2004) argued that there are four sub processes that relate to each other and the creative model of Wallas (p. 91-92). These processes include: value creation processes, scaffolding, imagination processes, and materialization processes. Kristensen explained how these sub processes relate to the environment and the creative process, referring to these sub processes as "concepts of spatial embodiment" (p. 94). Value creation involves the goals of the project and determining value. According to Kristensen, "'Scaffolding' means that creative process is designed within a context of space, tools, people and information. This usually takes place at the beginning of the creative processes in order to support the subsequent processes." Kristensen stated that, "the scaffolded environment becomes a part of the creative brain, and an implicit factor that we only question where we detect problems. Problems of sub-optimal environments may be experienced only as symptoms and as emotions can that impair the creative output (p. 92)." Kristensen discussed the role of imaginative processes, "In the creative processes the imaginative is sought, that which did not exist before. Real imagination is concerned with

new insights. In a creative process, imagination may be intense, but with short duration…Imagination is the representation of what does not yet exist. To imagine is to envision or create (p. 93)." Kristensen also explained materialization, "Finally, the materialization process transforms concepts into material objects." Materialization could be accomplished through "sketching and using diagrammatic methods, visual models and tangible objects (p. 93)." Kristensen created a table to explain the working relationship between her "concepts of spatial embodiment and creativity processes:"

	Preparation	Incubation	Insight	Elaboration and evaluation
Value creation	Guiding principle	Guiding principle	Guiding principle	Guiding principle and benchmark
Scaffolding	Physical organization of process	Subject to altering and manipulation	No particular role	No particular role
Imagination	Perceptual rehearsal accumulates information	Perceptual rehearsal accumulates information	The moment of novelty	No particular role
Materialization	Preparation includes tools for materialization	No particular role	A new concept, solution or artefact is material or sensory	The material object or artefact is subject of elaboration and evaluation

Figure 1. Embodied Creative Processes. (Kristensen, 2004, p.94)

Kristensen's suggestions for spaces conducive to her sub processes and the creative process are discussed later in the literature review.

An environment designed to support creativity should consider how to support creative thinking which could be divergent or convergent in nature as well as how to support the individual stages of the creative process: preparation, incubation, insight, evaluation, and elaboration.

2.4 Creativity, Attention, Distraction, and Flow

In the creative process, attention is extremely important. Csikszentmihalyi (2013) talked about how attention is very valuable for creative thinking, "To achieve creativity in an existing domain, there must be surplus of attention available." He went on, "In cultures that are uniform and rigid, it takes a greater investment of attention to achieve new ways of thinking. In other words, creativity is more likely in places where new ideas require less effort to be perceived (p. 8)." Attention and time are very valuable to creative people, as they need time to think about ideas and attention to focus on them. Attention is also limited according to Csikszentmihalyi (2008): "the nervous system has definite limits on how much information it can process at any given time. There are just so many 'events' that can appear in consciousness and be recognized and handled appropriately before they begin to crowd each other out" (p. 28). He went on, "[Attention] cannot notice or hold in focus more information than can be processed simultaneously. Retrieving information from memory storage and bringing it into the focus of awareness, comparing information, evaluating, deciding – all make demands on the mind's limited processing capacity (p. 31)." Csikszentmihalyi explains, "The mark of a person who is in control of consciousness is the ability to focus attention at will, to be oblivious to distractions, to concentrate for as long as it takes to achieve a goal, and not longer" (p. 31). He described, "Attention is like energy in that without it no work can be done, and in doing work it is dissipated" (p. 33).

Controlling and maintaining attention for periods of time is clearly important for creative thinking. Distractions can break the train of thought or not allow thoughts to develop or progress in the first place. Distractions can come from discomfort, excess stimuli, and sporadic stimuli among other things. More specific distractions and their effects are discussed in later sections.

While attention is clearly important for creativity and flow, according to Csikszentmihalyi, "devoting full attention to a problem is not the best recipe for having creative thoughts." For, people "tend to report the highest levels of creativity when walking, driving, or swimming; in other words, when involved in a semiautomatic activity that takes up a certain amount of attention, while leaving some of it free to make connections among ideas below the threshold of conscious intentionality (p. 138)" Csikszentmihalyi went on to explain that this concept also applies to complex stimulating environments, where the sensory interaction affects attention enough but not too much, leaving the mind to wander more freely (p. 138).

While some distractions should be clearly avoided and some extra stimulation may be beneficial to creative thinking, when one is free of distractions and able to entirely focus on one's work, the enjoyable flow state may be achieved. Csikszentmihalyi (2008) defines flow as, "the state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it" (p. 4). Flow is described by Csikszentmihalyi (2013) as having the following qualities:

> There are clear goals every step of the way…There is immediate feedback to one's actions…There is a balance between challenges and skills…Action and awareness are merged…Distractions are excluded from consciousness…There is no worry of failure…Self-consciousness disappears…The sense of time becomes distorted…The activity becomes autoletic. (p. 111-113)

The creative individual can lose oneself to flow in the creative process, experiencing great enjoyment as they execute their creative ideas. "Flow drives individuals to creativity and outstanding achievement" (Csikszentmihalyi, 2008, p. 213). However, distractions can quickly

knock one out of this mental state and derail their creative thinking. Creative people often go to great lengths to avoid this:

> Many of the peculiarities attributed to creative persons are really just ways to protect the focus of concentration so that they may lose themselves in the creative process. Distractions interrupt flow, and it may take hours to recover the peace of mind one needs to get on with the work. The more ambitious the task, the longer it takes to lose oneself in it, and the easier it is to get distracted (Csikszentmihalyi, 2013, p. 120).

For this reason, spaces for certain tasks should be designed in such a way to minimize distraction, whether that distraction is discomfort from poor ergonomics, improper lighting, misplaced tools, noise, or something else. Environments should also be designed in such as a way to promote focusing on the activity.

Csikszentmihalyi (2008) stated, "Enjoyment appears at the boundary between boredom and anxiety, when the challenges are just balanced with the person's capacity to act" (p. 52). While flow is enjoyable, "when a person is able to organize his or her consciousness so as to experience flow as often as possible, the quality of life is inevitably going to improve" (p. 40).

According to Csikszentmihayli, "To experience flow one must set goals for one's actions" (p. 216). However, Csikszentmihalyi claimed, "In some creative activities, where goals are not clearly set in advance, a person must develop a strong personal sense of what he or she intends to do" (p. 55). There are certain activities that may be more conducive to flow, such as "making music, rock climbing, dancing, chess, and so forth," because these activities "were *designed* to make optimal experience easier to achieve. They have rules that require learning of skills, they set up goals, they provide feedback, they make control possible. They facilitate

concentration and involvement by making the activity as distinct as possible from the so-called "paramount reality" of everyday existence" (p. 72).

Csikszentmihalyi discussed how he found that in one study, "people who were more often in flow were especially likely to feel 'strong,''active,''creative,''concentrated,' and 'motivated' (p. 158). However, there can be environmental obstacles to flow, both "natural" and "social in origin" (p. 85).

An environment that is supportive of creativity should help promote concentration and help maintain attention. It should help minimize distractions and support flow as much as possible.

2.5 Design Process and Design Thinking

In designing an environment supportive of both the creative process and design processes, it is important to understand what design processes involve. According to Achten (2008), "In the description of the design process, two perspectives can utilized: that of design theory and of design method. Each has a very distinct view of design processes, but it is fair to claim that there is a very strong interdependency between the two" (p. 16). Design theory "helps to distinguish between what is fundamental to the discipline and what is not; which aspects and concepts matter to design, and which aspects and concepts are incidental." On the other hand, "design methods concern the actual or desired order of the design decisions that are taken in a design process" (p. 17). Achten went on to state a framework is needed when discussing design processes:

> To conclude, if we want to describe design processes, we need a theoretical framework for design. It is basically a descriptive activity with design(ing) as its subject. Based on

theoretical considerations, a design theory may lead to a design method, but this is not necessarily so. Design methods, on the other hand, may be the subject of design theory. Design methods are prescriptive and solution-oriented. A design method always implies

theoretical considerations, a design theory may lead to a design method, but this is not necessarily so. Design methods, on the other hand, may be the subject of design theory. Design methods are prescriptive and solution-oriented. A design method always implies

principles because it identifies important steps and issues in the design process. (p. 18)

Lawson (2006) argued there are three types of views of design processes, views of 'practices,' 'intentions,' and 'aspirations.' The 'practices' view involves asking "what are we actually doing?," while the 'intentions' view involves asking "what are we supposed to do?," and the 'aspirations' view involves asking "what we would like to do?" (p.260).

Bruce Archer (1974) outlined a 'product development' process. This process is split up into six stages and ten steps total. The process starts out with strategic planning, which involves policy formulation, followed by research, which includes preliminary research and feasibility studies. Next is design, which includes design development, prototype development, and training development. Archer discussed that essentially the design phase ends here, but the designer may also be involved in other phases. After the design stage, is development, which includes product development and production planning. Next is the manufacturing and marketing start-up phases, including tooling and market preparation. Last, is the production phase, which includes production and scale (p. 46). While the process Archer provided is fairly straightforward, he stated that processes can "vary from firm to firm, product to product, circumstance to circumstance" (p. 44).

While Archer outlined a fairly linear development process, J. Christopher Jones (1980) proposed an input and output chart of design methods that allows the designer to choose methods based on what information they have and what outputs they want to generate. Jones described his input/output chart:

> It is assumed that the suitability of a method can be judged by comparing its inputs with what the designers already know and its outputs with what they want to find out. Inputs, shown on the left, are the kinds of information that must be available before a method can be used. Outputs, appearing across the top, are the kinds of information that the methods produce. The two scales, input and output, are exactly the same and are placed in order of decreasing generality and increasing certainty. Methods that are useful at the early stages, when nearly everything is uncertain, appear at the top left of the table whereas methods that fit the final stages of design thinking appear at the bottom right. Those that are some distance from the diagonal are strategies, rather than methods, in that they enable designers to jump several stages forward: those that are just above the diagonal are step-by-step methods out of which design strategies may be composed. Some of the methods are repeated below the diagonal to indicate that they can used for back-tracking, i.e. for restating the problem after it has been explored in some detail. (p.79)

While Jones provided a method selection system, "alternative methods and strategies can lead to an acceptable result" (p. 83).

While Archer outlined a product development process and Jones developed a specific input/output methods charts, both of which provide insights into how a designer can go through a design process, neither provide a single, correct, all-inclusive design process. According to Bryan Lawson (2006), "there is no correct view or 'method' of designing, nor one route through

the process" (p. 200). Again, Lawson claimed, "Such data [about design processes] leads us to the inevitable conclusion that there is no one process map of the design process…It is clear that there is a multitude of ways of linking activities together to make a process map. Some might suit particular individuals or organizations for reasons of personality or management or policy" (p. 261). Lawson went on, "Designing is far too complex a phenomenon to be describable by a simple diagram" (p. 289). Achten (2008) discussed how methods may be not applied, strayed away from, or stayed away from entirely in industry (p. 18).

While, clearly there is no one correct design process, and different methods and processes are used and sometimes not used, there are some commonalities of thinking and activities. Jones (1963) stated systematic design involves analysis, synthesis, and evaluation. Analysis involves the "listing of all design requirements and the reduction of these to a complete set of logically related performance specifications." Synthesis involves "finding possible solutions for each individual performance specification and building up complete design from these with least possible compromise." Evaluation involves "evaluating the accuracy with which alternative design fulfil [sic] performance requirements for operation, manufacture and sales *before* the final design is selected" (p. 54). Jones (1980) further discussed analysis, synthesis, and evaluation:

> One of the simplest and most common observations about designing, and one upon which many writers agree, is that it includes the three essential stages of analysis, synthesis, and evaluation. These can be described in simple words as 'breaking the problem into pieces', 'putting the pieces together in a new way' and 'testing to discover the consequences of putting the new arrangement into practice'. (p. 63)

In addition to analysis, synthesis, and evaluation, Jones also discussed how designing involves divergence, transformation, and convergence. He described these stages as " being

merely categories into which the many loose ends of design theory, as it now exists, can be discussed at the inexact, or fanciful, level that our partial knowledge and partial ignorance permit." Divergence "refers to the act of extending the boundary of a design situation so as to have a large enough, and fruitful enough, search space in which to seek a solution" (p. 64). Transformation "is the stage of pattern-making, fun, high-level creativity, flashes of insight, changes of set, inspired guesswork; everything that makes designing a delight" (p. 66). Convergence is "that which, traditionally, is nearly the whole of designing." The convergence stage occurs "after the problem has been defined, the variables have been identified and the objectives have been agreed." The goal of the designer in convergence "becomes that of reducing the secondary uncertainties progressively until only one of many possible alternative designs is left as the final solution to be launched into the world" (p. 68).

Jones discussed how designing involves analysis, synthesis, and evaluation as well as divergence, transformation, and convergence. Other authors discussed the importance of looking at both problems and solutions and interactions between problems and solutions in designing. Nigel Cross (2011) discussed the relationship of design problems and solutions according to interviews with designers:

> Another theme that emerged from Davies's interviews with these leading designers is related to this tricky relationship between the 'problem' (what is required) and its 'solution' (how to satisfy that). Designers recognize that problems and solutions in design are closely interwoven, and that 'the solution' is not always a straightforward answer to 'the problem'. A solution may be something that not only the client, but also the designer 'never dreamed he wanted'. (p. 10)

According to Nigel Cross, “the problem and solution develop together” and “relevant features emerge in tentative solution concepts.” These emerging features have “properties that suggest how the developing solution-concept might be matched to the also developing problem-concept.” Cross stated these “properties are those that are perceived, or recognized, in a partial solution, or a prior solution, that were not consciously included or intended” (p.11).

While Cross stated that “the problem and solution develop together,” Bryan Lawson (2006) made a similar claim that “problem and solution emerge together” in the design process (p. 48). Lawson stated, “Often the problem may not even be fully understood without some acceptable solution to illustrate it” (p. 48). According to Bruce Archer (1974), “In the mind’s eye, problem and solution are seen as a matched couple, the one being the negative or inverse, as it were, or the other.” Archer stated that as a designer progress through the process, “the problem-solution couple gradually becomes clearer and more detailed until both problem and answer are seen to be valid and practicable” (p. 90). Archer explained how looking at the problem and “zooming” in and out can help the designer understand the problem and solution:

> We zoom out to get an overall impression of the problem-solution couple, in whatever state of focus; then we select an interesting detail and zoom in to inspect it more closely. The insights we gain in organizing that detail give us important clues to the nature of other parts of the overall problem-solution when we zoom out again to look at the whole. (p. 90)

According to Achten (2008), because of the limits of memory, “the designer cannot have an overview of the whole problem…Consequently, the design process is sequential in time and iterative.” The designer can use phases to prevent drastic late changes of the design. Achtens stated, “Throughout the design process the designer explores both the solution and the problem.

One might claim that only at the end of the design process is the design problem understood." He went on stating that there is not "one single correct solution" to a design problem and that it is impossible "to determine the degree of correctness;" Therefore, "the designer strives for 'satisficing' rather than perfect solutions" (p. 23).

Clearly, the design process involves exploring the relationship between the problem and solution. Lawson (2006) made a simplified map of the design process, where problem and solution reflect each other, and "the activities of analysis, synthesis and evaluation are involved in this negotiation but the map does not indicate any starting and finishing points or the direction of flow from one activity to another" (p. 48) However, Lawson warned, "this map should not be read too literally since any visually understandable diagram is probably far too much of a simplification of what is clearly a highly complex mental process" (p. 48-49).

2.6 Design Thinking

While there may be no one single design process, the design process at least involves analysis, synthesis, evaluation, divergence, transformation, and convergence, as well as an exploration of both problem and solution. An environment supportive of creativity and design should support the aforementioned processes and thinking. While some of the thinking involved in the design process was discussed in the previous section, several authors discussed further the type of thinking involved in the design process. According to Achten (2008), designing involves knowledge, information processing, and reasoning:

> In order to create (preliminary) design solutions, knowledge and information must be processed. This involves several forms of reasoning. Reasoning by example is major technique used by designers. Whether the previous solution is a precedent, type, or

> analogy, the designer takes some element of the example and, based on the perceived structure of the solution, generates a new solution that is suited to the current design problem. (p. 21)

Achten also stated that the designer can be viewed as an "information processor" trying "to solve wicked problems." According to Achten, "An important design activity is the subdivision and reformulation of the wicked problem into sub-problems in order to make them well-structured. The designer has procedural knowledge of the domain…as well as knowledge of previous solutions" (p. 23).

According to Cross (2011), design thinking involves abductive reasoning, intuitive, and dealing with ambiguity. Cross defined abductive reasoning as:

> a type of reasoning different from the more familiar concepts of inductive and deductive reasoning, but which is the necessary logic of design. It is this particular logic of design that provides the means to shift and transfer thought between the required purpose or function of some activity and appropriate forms for an object to satisfy that purpose. (p. 10)

Cross also explained how designers feel intuition plays a role in the design process, but he went on to say that some intuition can be attributed to experience and "prior learning" (p. 9-10). Cross discussed how designers often deal with ambiguity in the design process as they "will generate early tentative solutions, but also leave many options open for as long as possible; they are prepared to regard solution concepts as temporarily imprecise and often inconclusive" (p. 12).

Bryan Lawson (2006) discussed the importance of understanding users' needs: "Designers must understand something of the nature of these users and their needs whether it is

in terms of the ergonomics of chairs or the semiotics of graphics" (p. 13). According to Lawson, understanding aesthetics is also important (p. 12).

Christopher Jones (1980) discussed taking complicated problems and making them simple in the design process through a restructuring process:

> We can infer that the main principle in dealing with complicated problems is to transform them into simple ones. This recoding, or restructuring, process depends upon the use of a pattern (in this case a drawing or a mental picture of the design) which brings crucial aspects to the fore. Transformation of this pattern, in order to overcome difficulties and to resolve conflicts, depends, in its turn, upon the problem situation to major changes in design and, secondly, freedom and action."

According to Jones, changes in design decisions involve the designer's expression of awareness, understanding, morality, and value (p. 29-30).

Esherick (1963) argued that design solutions get more concrete throughout the design process, as the designer moves from the "concrete world" to the "abstract world" and back to the "concrete world." Esherick argued designers "select, measure, and generalize, guided by [their] goals and objectives" when they analyze, as they "*design* an abstract representation of whatever [they] are analyzing." Esherick went on, "[they] proceed from a world [they] perceive as both concrete and diverse to a world of [their] making, abstract and general." Esherick discussed that some designers can have difficulty getting back to the "concrete world." Esherick argued "The way back, from abstract to concrete, appears then to be a continuous process of design and analysis of the design – the reverse of the first move which was analysis and design of analysis." In the process, "The first specific step should be the design of a *general* solution that is testable – that is *generally* analyzable." After that, the following "steps will become progressively more

concrete, but must have, as the process goes forward, *consistency*." As solutions get more specific and concrete, they should still "be consistent with the general solution with respect to [the] analysis of the problem and with respect to the goal." The process involves "generating diagrams, diagrams of ideas resulting from the analytic process – diagrams that must have an inherent consistency from step to step – diagrams that at the final step are concrete enough that they are built" (p. 80).

In the design process, thinking most likely involves reasoning, information processing, abductive reasoning, intuition, an understanding of users' needs and aesthetic experience, reformulation of problems, and moving from "concrete" to "abstract" to "concrete," as one generates, tests, and analyzes solutions. An environment supportive to creativity and design should support these activities as much as possible.

2.7 Visualization in the Design Process

Visualization plays a key role throughout the design process and aids with thinking. According to Lawson (2006), "designers tend to work in a visual way. Designers almost always draw, often paint and frequently construct models and prototypes…But what is clear is that designers express their ideas and work in a very visual and graphical kind of way" (p. 12). Goldschmidt (2008) explained,

> The question 'why visualise' is almost rhetorical, as we all grew up to believe that 'a picture is worth a thousand words'. The design of physical artefacts are designed consider many elements and those for whom the artefacts are designed consider many elements and their properties, as well as the relationships between them (and in the case of architecture, also between them and their surroundings). Function and form must be

> understood, evaluated and optimized for a successful result. An adequate representation of these complex parameters is not possible without visualization, especially the representation of shapes and forms. (p. 30)

According to Achten (2008), "Limited reasoning and memory capacity is an additional factor that structures design processes. One role of representations such as drawings and models is to form an external memory which can store information about the design by similarity. The designer needs only to glance at the sketch or model to quickly activate the implicitly stored information" (p. 22). Achten went on, "External representations such as drawings and models help to maintain an overview and understand the consequences of design decisions" (p. 23). According to Cross (2011), designers explore problems and solutions with visualizations:

> Another common theme from Davies's interviews is that designers need to use sketches, drawings and models of all kinds as a way of exploring problem and solution together, and of making some progress when faced with the complexity of design…Designing, it seems, is difficult to conduct by purely internal mental processes; the designer needs to interact with an external representation. The activity of sketching, drawing or modeling provides some of the circumstances by which a designer puts him- or herself into the design situation and engages with the exploration of both the problem and its solution. There is a cognitive limit to the amount of complexity than can be handled internally; sketching provides a temporary, external store for tentative ideas, and supports the 'dialogue' that the designer has between the problem and solution. (p. 12)

According to Goldschmidt (2008),

> Whatever the differences in the design process between architecture and industrial design, practitioners in both fields 'think visually' and constantly visualize their thoughts.

> Often visualizing is in fact thinking and not merely recording of thoughts that had already been entertained in the mind. Designers in both fields use all representation and visualization means available to them, from freehand sketching and manual drawing to digital drawings, through physical models and various simulations and movies…In practice, where efficiency is an over-riding value and goal, means are adjusted to ends, and the most effective visuals are used for each purpose, i.e. the most convenient, most economical and most potent modes of visualization are selected at any given time. (p. 41)

While computers can certainly aid in visualization and in the design process, Lawson (2006) discussed the computer's role as merely a tool for the designer:

> Computers so far cannot design in anything like the sense that we use the verb in this book. They may be able to solve well-constrained problems but they cannot design in any of the fields we are discussing here. So if computers appear in the design studio, other than as rather smart drawing boards, their purpose must be to aid design. If this is the case then we must assume that the greatest responsibility and certainly the final say will rest with the human designer. Again logically this tells us that the human designer will necessarily be in a conversational relationship with the computer. In fact the designer is going to have to describe the design state and then interpret some modification of it as suggested by the computer. (p. 282)

Archer (1974) explained visualization can include a variety of modeling:

> The designer uses all sorts of models to capture and manipulate the problem-solution couple which is in his mind's eye. Engineering or architectural drawings are such models. So are sketches, block models, wire models, vector diagrams, force diagrams,

> mathematical formulae and verbal statements. Finally, he builds mock-ups and prototypes. (p. 90)

According to Goldschmidt (2008), there are multiple modes of visualization, one of which is sketching, which there are different types of that can be used for different purposes:

> Sketching is a mode of visualization, alongside other modes. All designers in the survey talk about means of visualization they used in the particular project on which the interview focuses but they generalize to other cases as well. Visualisation, in the evidence provided by the interviews, serves a number of important purposes; first and foremost, as communication in its roles of information and image recording and description, demonstration and sharing, explanation and convincing. Apart from freehand sketches (including annotations), visuals include primarily other manual drawings on paper, digital two- and three-dimensional drawings, and physical models. Digital drawings can be divided into two distinct types: precise measured drawings, and three-dimensional images and renderings. Sometimes animation and movies are also added to the arsenal of visuals. (p. 29)

According to Goldschmidt (2008), "Sketches are the most dominate mode of visualization in design practice. Today they are beginning to be produced digitally as well as manually, but sketches on paper are far from obsolete in the design world" (p. 39). Goldschmidt discussed, as opposed to digital visualization, sketching has advantages throughout the design process, but "especially in its early preliminary phase," where designers can quickly produce freehand sketches anywhere requiring no equipment (p. 31).

Goldschmidt discussed how sketches can be used as communication with team members and clients, both in meetings and in between meetings. Sketches are used to share thought, make

sure everyone is on the same page, and convince clients (p. 30). Additionally, Achten (2008) stated that "external representations" could be used to communicate between parties for legal purposes. "Accurate and precise drawings and documents" are important in these situations (p. 22). According to Lawson (2006), drawings can communicate instructions, as production drawings can communicate for construction purposes and presentation drawings can be used to communicate with clients. Lawson distinguished the 'presentation drawing' and 'production drawing' from the 'design drawing,' which "is done by the designer not to communicate with others but rather as part of the very thinking process itself which we call design" (p. 26).

Lawson (2006) explained there are both advantages and drawbacks with drawing when compared to "the vernacular process:"

> The drawing is in some ways a very limited model of the final end product of design, and yet in a world increasingly dependent on visual communication it seems authoritative. The designer can see from a drawing how the final design will look but, unfortunately, not necessarily how it will work. The drawing offers a reasonably accurate and reliable model of appearance but not necessarily of performance. Even the appearance of designs can be misleadingly presented by design drawings. The drawings which a designer chooses to make whilst designing tend to be highly codified and rarely connect with our experience of the final design. (p. 27)

Goldschmidt discussed the necessity of the physical model as it allows the designer "to get a better feel for the scale, texture, or the mode of operation of an artefact." Goldschmidt noted that "all DI designers used models at least during the development phase of design projects." Goldschmidt stated that digital means may assist model making but that it is not necessary (p. 31). Models, even rough ones, provide insights that drawings cannot. According to Goldschmidt,

"The physical object fulfils needs that no drawing can fulfil: it can be touched and interacted with in ways that are not possible otherwise" (p. 32). Archer went on to say that model definition went from low to high as the design progressed in the design process:

> At the beginning [the designer] needs soft-focus, low definition models which are vague enough to admit of all sorts of unknown variables, yet precise enough to exclude the undesirable. Here, he may use verbal statements, rough sketches and block models. Towards the end he needs sharp-focus, high definition models, and here he may use engineering drawings, schedules and working prototypes. (p. 90)

Goldschmidt broke down designing into three phases or situations involving visualization: "preliminary design," the "development phase," and "discussions with clients and users." Goldschmidt described the visualization occurring during the preliminary design phase:

> At the outset the major means of visualization is sketching. Sketches are made during the search for a solution principle, in most cases following an initial, preconceived idea, by the leading designers(s)…Models are less frequent in the preliminary phase of industrial design. One reason may be that customary three-dimensional drawings are adequate – and more economical – representations at this stage. It may also be the case that rapid prototyping has become the standard mode of modeling, at least for smaller artefacts; making them is reasonably cheap and fast, but preparing the necessary CAD files is time consuming and may also prematurely fix the design properties. Designers may feel that they prefer the freedom of sketches before they commit themselves to CAD files for the purpose of producing a study model. (p. 33)

According to Goldschmidt, no digital drawings are produced in the preliminary phase. Sketches have less of a need to be fancy or impress at this stage. Goldschmidt went on to describe the purpose of sketching at this phase:

> The sketch, at this phase, is a compact 'laboratory' in which designers can experiment with different ideas freely with no cost or any other negative consequences in case of failure. This encourages more experimentation with extreme, unusual and potentially innovative concepts which, due to their novelty, require more testing. (p. 34)

In the development phase, According to Goldschmidt, visualization can play a key role in coordination and communication as this phase "is usually carried out by a larger group of people than the one involved in preliminary design." Goldschmidt went on, "practically all modes of drawing and physical models are used in this phase, each for the purpose it serves best" (p. 34). According to Goldschmidt, "Until not too long ago many large architectural firms employed full-time model makers, and practically every product design firm has at least a small workshop in which models (not rapid prototypes) can be executed. Most such models are fairly rough and their purpose is study and evaluation." Designers may model a similar idea over and over, revising after assessing previous models, "until a satisfactory proposal is achieved." Goldschmidt stated, "This mode of usage resembles sketching and rough preliminary models are sometimes referred to as '3D sketches'." Students also make these types of rough models. Goldschmidt claimed, "Study models continue to play an important role in design development, arguably more so in architecture, especially since all stakeholders, including the client and others who may lack design expertise, can relate to them easily" (p. 36). While models are clearly used in the development stage, Goldschmidt stated, "Sketches and other drawings continue to be essential in the development phase. The state of the design keeps evolving and changes, major or

minor, are subject to frequent discussion and decision sessions." Input and communication play a role in the visualization in this stage:

> Consultants' input needs to be integrated into the design and this requires considerable coordination efforts, and the resolution of problems that keep coming up. Communication therefore builds on detailed representations of latest versions of design drawings, be they measure plans or still free-hand sketches. For communication over distances fax machines and the Internet are used to transmit information, including drawings. (p. 36)

Goldschmidt compared the use of drawings in the preliminary and the development phase:

> By comparison to the preliminary phase, in which sketches mainly express ideas and concepts and may be rather abstract and schematic, in the development phase sketches are more concrete and detailed, and describe the actual designed entity in its many facets. We begin to see digital drawings as well: CAD measured drawings are produced so that all designers and consultants have accurate information as the basis for their interventions. In the case of industrial design, this includes many more 3D drawings than in architecture. Francier, so-called 'presentation drawings' are still rare at this phase, except for interim decision-making meetings for which they are typically prepared. (p. 36)

According to Goldschmidt, visualization also plays a key role in communication with clients:

> Discussions with clients and users take place at all stages of the design process, of course, but are typically built into certain checkpoints in which major decisions are taken. For those occasions designers prepare visuals that are meant to convince the client or users of the merits of the overall proposal, or as regards certain aspects of it. The Delft Interviews show (Table 1) that the means used for that end are mixed: from sketches, which are

> probably used in informal meetings in which certain details may be discussed, through models, to frequent digital drawings (presumable, mostly 3D renderings), and even movies. Often, designers refer to 'presentations' they prepare, which may indicate the use of tools like PowerPoint in order to show visuals, undoubtedly accompanied by oral explanations. (p. 36-37)

According to Goldschmidt, "The more tools we have at our disposal the more there is to choose from, and the wise designer knows that and specifically adjust his choice to the goals the visualization is meant to achieve" (p. 38). Clearly, visualization is an important part of the design process and should be a consideration in the design of an environment supportive of creativity and design. The environment should provide the proper tools and surfaces for visualization tasks, whether that involves more sketching earlier in the process or more modeling and digital work later in the process. The design of the environment should also consider the display of visualization as information can be recalled by looking at former work, freeing up attention for more creative thinking.

2.8 The Design Process: A Simplified Model from Lawson

Lawson formed a simplified model that explained activities of designers (p. 240). The activities of this model are grouped in to categories of 'formulating,' 'moving,' 'representing,' 'evaluating,' and 'reflecting.' 'Formulating' deals with "understanding problems and describing them" (p. 290). This includes ways of understanding, indentifying, and framing problems (p. 292). 'Moving' has to do with "making design propositions" and involves the skills related to "generating ideas about whole or partial solutions" (p. 290). 'Representing' includes the skills that represent ideas including describing with words and visualization through drawings,

computers, or other means. 'Evaluating' involves skills regulating moves "through the use of some kind of evaluation of them, against some set of criteria however precisely or vaguely understood. 'Reflecting' involves "designers actively looking at and thinking about design even when not actually designing" and "a more or less conscious effort" that keeps "the whole design activity on course towards its target" (p. 290). Lawson states that through the activities in these categories, "designers seem able to negotiate their way to a comfortable, or at least satisfactory, understanding both of the problem and the solution and to give their clients and users at least workable and occasionally beautiful and imaginative designs" (p. 290). The groups of activities identified by Lawson as formulating, moving, representing, evaluating, and reflecting should be considered in the design of an environment conducive to creativity and design.

2.9 Creativity and Design Overlapping

Lawson (2006) discussed that creativity in design involves hard work:

> We must, however, not get too carried away with the romantic notion of the creative leap into the unknown. Creative thinkers also characteristically work very hard. True the great geniuses seem to find life fairly easy, but for most of us ideas come only after considerable effort, and may then require much working out…Thus great ideas are unlikely to come to use without effort, simply sitting in the bath, getting buses or dozing in front of the fire is unlikely to be enough. (p. 148)

Lawson (2006) acknowledged that Kneller's five phases of creativity are probably part of designing as well. Kneller's phases included 'first insight,' 'preparation,' 'incubation,' 'illumination,' and 'verification' (p. 148). Lawson also discussed that "creative phases of the

design process are likely to involve alternating periods of intense activity and more relaxed periods when little conscious mental effort is expended" (p. 152).

Lawson discussed how the creative process fits into design:

> So we are beginning to get a picture of the creative process in design. It probably follows the phases of creativity outlined earlier, it involves periods of very intense, fast working rather like juggling, and the relating of many, often incompatible or at least conflicting demands…The idea however is rarely easily found and often comes in a moment of 'illumination' after a long struggle. (p. 154)

According to Haner (2005), "In a simplifying manner, both the process of creativity and the process of innovation are often assumed to be linear in nature, consisting of discernable, distinguishable, and sequential phases" (p. 289). However, the literature surveyed makes clear that both creative and design process can involve going back and forth between stages as one progresses.

Lawson (2006) claimed that designers probably need to used both convergent and divergent thinking in "most equal proportions" (p. 153), as designers "must solve externally imposed problems, satisfy the needs of others and create beautiful objects" (p. 153). Both divergent and convergent thinking are used in the creative process as well to come up with novel ideas and to recognize and pursue the good ideas (Csikszentmihalyi, 2013, p. 60-61).

According to Haner (2005), "Both creativity and innovation processes need to be seen as complex, partly iterative and partly simultaneous efforts" (p. 289). However, literature makes clear that both creative and design processes involve going back and forth between stages as one progresses. Convergent and divergent thinking are also used throughout the processes. According to Haner,

> These attributes, 'convergent' and 'divergent', can be used to describe phases in both, in the creativity process and the innovation process. In the creativity process convergence is seen to be prevailing in the preparation phase as well as in 'elaboration and evaluation'; divergence is considered the main characteristic of the incubation and insight phases. Similarly, in innovation management divergent behavior is seen to prevail at the 'fuzzy-front-end' of innovation in the idea generation phase and convergent behaviour in the phase of concept validation. (p. 289)

Haner claimed that creativity and innovation processes had differences, "but they display common characteristics and patterns that allow for joint reflection (see below). In consequence, it can be argued that successful realization of creativity and innovation processes depends on some not-well-formalized mixture of mastering convergence and divergence, as well as the transition from convergence to divergence and vice versa" (p. 290).

According to the literature, the creative process has a place within a design process. Therefore, supporting the creative process should be an important consideration in designing an environment that supports designing. Thinking in the creative process and design process involves both convergence and divergence. Both of these types of thinking should be supported in an environment conducive to creativity and design.

2.10 Creative Environments

Before determining the best spaces for supporting particular creative and design activities, one must first establish the relationship between the environment and creative thinking. Having access to the domain as well as the field can be beneficial to creative thought (Csikszentmihalyi 2013 p. 128-130). Some environments may be more stimulating, having "a

greater density of interaction and [providing] more excitement and a greater effervescence of ideas; therefore [these environments] prompt the person who is already inclined to break away from conventions to experiment with novelty more readily than if he or she had stayed in a more conservative, more repressive setting" (p. 129).

Csikszentmihalyi discussed how there is no evidence that "a delightful setting induces creativity," because a controlled experiment cannot be performed to recreate the unique creative moments (p. 135). However, he immediately went on to state that individual testimony of creative individuals supports a strong link between the environment and creativity:

> However, accounts by creative individuals strongly suggest that their thought processes are not indifferent to the physical environment. But the relationship is not one of simple causality. A great view does not act like a silver bullet, embedding a new idea in the mind. Rather, what seems to happen is that when persons with prepared minds find themselves in beautiful settings, they are more likely to find new connections among ideas, new perspectives on issues they are dealing with. But it is essential to have a "prepared mind." What this means is that unless one enters the situation with some deeply felt question and the symbolic skills necessary to answer it, nothing much is likely to happen. (p. 135)

While it is impossible to know whether a unique creative thought would happen in a different environment than the one in which it occurred, Csikszentmihalyi continued, "the evidence does suggest that unusual and beautiful surroundings – stimulating, serene, majestic views imbued with natural and historical suggestions – may in fact help us see situations more holistically and from novel viewpoints (p. 137). According to Amabile, (1996, p. 249, cited in Haner 2005, p.

292) ‘Physical environment that are engineered to be cognitively and perceptually stimulating can enhance creativity.’

2.11 Environments for Creative Thinking and Process

Depending on the phase of the creative process or the type of creative thinking involved, a certain environment may be better. Haner (2005) researched creative environments, and argued “that the support of creativity and innovation processes has a spatial dimension” and that “spatial arrangements in work environments – together with appropriate information and communication technologies (ICT) – can support these and other activities through an appropriate design of the socio-spatio-technical ensembles of work spaces” (p. 291). Martens (2011) made a table showing the environments in which creative behaviors were performed according to interviews. The table showed that different behaviors took place in different locations. Many behaviors such as sketching, discussion, and collaboration took place in offices. Analysis could happen at a site, with a client, or in an office. Reports could be written at home. Writing down ideas took place in the office, but with loud music on. Most importantly, creative thinking took place everywhere. According to Martens, “These different behaviors indicate that facilitating creativity will require different spatial settings, not just for different activities and cognitive intensity but also for different personal preferences” (p. 72). According to Martens, “The time spent on creative thinking varied from ‘always in the back of the head’, to part of the travel time home to deliberate and focused for twenty minutes with a blank piece of paper or when meditating. Creative thinking was not always conscious and deliberate. It seemed hard for the interviewees to explain why this behaviour was executed in this way” (p. 73).

According to Martens, “The physical workplace can support the creative process, activities and their changing intensity. It is very important that the physical workplace does not hinder creativity, its processes and activities, for example by too high temperatures or too much noise, or not enough space to host the number of people.” According to Martens, “Facilitating creativity will require different spatial settings, not just for different activities and cognitive intensity but also for different personal preferences” (p. 75). Martens recognized that “the relation between creativity and the physical workplace is complex and that “one has to recognize the specific process and activities involved and especially their cognitive side” (p. 75).

According to Haner (2005), “facilitating creativity and innovation means supporting convergent and divergent behaviors as well as sustaining individual and group activity. This in turn means that spaces for creativity and innovation need to support communication and interaction in times of collocation as well as allowing for privacy in other times” (p. 292). Haner discussed, “A potentially adversial aspect of enhanced communication and interaction is a (perceived) loss of privacy. As visibility can enhance group activity, a loss of privacy can be detrimental to concentration and personal comfort, and therefore to individual creative performance.” According to Haner, “Consequently, work environments supportive to creativity and innovation will have to provide for opportunities for (temporal) privacy, for example, through an appropriate office type mix. This can also be implemented in the context of non-territorial working” (p. 293).

Authors recognized that different stages in the creative process may benefit from different types of environments. Csikszentmihalyi (2008) acknowledged that spaces that benefit incubation and insight may be different than those that benefit preparation and evaluation. For incubation and insight, the stimulus of an environment can provide enough distraction without

going overboard to let the mind flow more freely, put together unusual connections, and come up with original solutions. Csikszentmihalyi stated that, "Devoting full attention to a problem is not the best recipe for having creative thoughts" (138). He discussed the reasoning behind why spaces providing welcome distraction enhance creativity:

> So the reason Martha's Vineyard, the Grand Tetons, or the Big Sur may stimulate creativity is that they present such novel and complex sensory experiences – mainly visual ones, but also birdsong, water sounds, the taste and feel of the air – that one's attention is jolted out of its customary grooves and seduced to follow the novel and attractive patterns. However, the sensory menu does not require a full investment of attention; enough psychic energy is left free to pursue, subconsciously, the problematic content that requires a creative formulation. (p. 138)

Csikszentmihalyi explained, "While novel and beautiful surroundings might catalyze the moment of insight, the other phases of the creative process – such as preparation and evaluation – seem to benefit more from familiar, comfortable settings, even if these are often no better than garrets" (139).

Kristensen (2004) looked into environments that supported the different creative phases of preparation, incubation, insight, elaboration, and evaluation. According to Kristensen, "Physical space is correlated with cognitive space. This is a metaphorical relation, where the physical space gives form to cognition. Our objective is to identify what qualities in the outer space feed into an effective inner creative process" (p. 91). According to Kristensen, for the preparation stage, a primary goal "is to facilitate data and information for the process" The preparation stage could involve indirect or collaborative efforts. Easily organizing, sharing, and retrieving information and ideas is important. Kristensen stated, "The spatial arrangement must

support as much information flow and absorption as possible to each member." According to Kristensen, tools, such as computers, bulletin boards, and other information sharing tools are important. Kristensen went on, "Communal space seems important for teams," while "sometimes a private space is essential for analysis both by individuals and team members" (p. 90).

According to Kristensen, "In the incubation stage, the cognitive processes seem to be essentially a personal or private affair." She discussed that some people perform better alone in this phase while some people prefer to be around others. In either case, according to Kristensen, "Incubation is an implicit cognitive process, but perceptual clues may facilitate process. Staying in the room where all the information for the preparation stage is kept may facilitate such implicit perception as a process of 'priming'" (p. 90).

Kristensen cited Hadamard to explain, "Accounts of insights are often reported as idiosyncratic, and it may not matter much where it takes place" (Hadamard, 1945, cited in Kristensen, 2004, p. 90).

> Kristensen discussed environments for the creative phases of elaboration and evaluation:
>
> We shall compare the results with the goals of the preparation stage where the value creation is at the centre. In this context, thorough analysis and evaluation are necessary in order to see if the desired goals and values are met. Contextually, this stage must resemble the preparation stage, as the operations are similar. While the preparation stage starts with a briefing, the elaboration and evaluation stages end with a debriefing and implementation. While we can assume how space may increase creativity, there are no aspects of this in the theories. (p. 90)

However, within design, visualization, prototyping, and testing are important in elaboration and evaluation and throughout the design process. Therefore, the environment should

support the level of visualization, testing, and prototyping at these later stages. Kristensen even stated, “A simple way of materializing is sketching and using diagrammatic methods, visual models and tangible objects. Therefore, availability of tools for prototyping is important” (p. 93). According to Kristensen, “Memory is sometimes facilitated by the impressions of a particular space. This could be due to different sensory impressions” (p. 93). Furthermore, allowing space for prior visualization to be displayed may also help in these later stages, as visualization can store ideas, freeing up attention for further creative thought. Kristensen discussed, “We make the connection [between workspace and problem space] because the two are natural extensions of each other when we consider embodied and embedded cognition. In particular, when we consider space for design work and research laboratories, this makes sense. Creative people externalize the mental constructs in order to work better with them” (p. 93).

Kristensen concluded her article suggesting the stages of creative process have differences in requirements. She stated, “The preparation and elaboration stages typically require a combination of communal and private space. The incubation and insights stages probably require more private space” (p. 95).

According to the literature, the phases of the creative process could benefit from different supporting elements of creativity within creative spaces. Supporting the different phases of creativity should be important in designing a space or spaces that support creativity and design. The preparation environment could be a more comfortable and familiar space that should support information absorption and sharing. Incubation may benefit from more stimulating, beautiful environments that provide welcome distractions. Incubation could also take place in the same environment as preparation. Insight can happen anywhere but it may be helpful to be in the preparation or incubation space to connect and come up with ideas. Elaboration and evaluation

could have a space similar to that of preparation, but the environment should support the visualization, testing, and analysis of ideas.

2.12 Case Studies on Environments for Creative Thinking and Creative Process

There are a few case studies designed to analyze space intended to support creative thinking and creative process. Kristensen (2004) discussed a case study where a pharmaceutical company commissioned a design studio space part time to support the creative process for their designers. Because the space was only used part time, there were no fixed installations and everything was flexible to allow for other uses. The space was made up of "one big room and several workshops located in a 'clustered' fashion," located in the center of the design studio. The center had "two large tables with drawing facilities and computers." The space used light colors and the floor and walls were "filled with objects and models" (p. 94). According to Kristensen, "competing products and other relevant props were displayed on shelves surrounding the room." She stated that the mainly brainstorming work took place in the preparation phase. During the preparation phase, the space was furnished with tools to support the phase including "bulletin boards, flat tabletops, drawers and filing cabinets for localization of specification, progress reports and sketches." The space also had computers with CAD, and metal and wood shops were close by the space. During the preparation phase, mainly brainstorming work took place.

According to Kristensen, "The incubation phase was not experienced as a real transition." Kristensen stated, "The studio space provided tranquility and this was supported by sufficient space and light colours, availability of many objects, both familiar and strange." Kristensen stated "the view to outside where people would pass, sit for drinks in the sun provided a

continual variation of view." According to Kristensen, "incubation just happened between weeks of intensive collaboration" as part of an incremental process.

According to Kristensen, "Insights were explained to happen in communal sessions, where well-prepared experts presented their revised studies for the others." The wood and metal shops were close by to allow for quickly mocking up and testing ideas for explanation. Previous information such as recordings of meetings, bulletin board and table information was made available.

Kristensen stated, "According to the company and the designers who manage the studio the process is very successful and the collaboration has lasted for several years." Kristensen stated "that the case is only an example of how some companies deliberately use physical space" in their pursuit for creativity (p. 95).

Haner (2005) discussed two case studies that explored environments designed to support creative thinking: the Interactive Creativity Landscape and the Learning Garden. According to Haner, "the Interactive Creativity Landscape (ICL) is an office setting that was particularly designed as a prototype for a work environment supportive to creativity and innovation" (p. 294). The ICL's spatial layout was designed with the creative process phases in mind, as "spatial interpretations for each of" the creative phases were developed "following their respective requirements" (p. 294). These requirements include some of the following insights:

> The preparation phase should support information access and communication using a wide range of channels. The phases of incubation and insight should allow for diversion, playfulness and border crossing. The phase of elaboration and evaluation is supposed to support primarily documentation, visualization, discussion and collaborative work. It has been recognized that while 'preparation' and 'elaboration and evaluation' are dominated

by convergent activities, 'incubation' and 'insight' are consisting of rather divergent activities. (p. 294)

According to Haner (2005), "In response to the specific requirements different zones have been implemented within the ICL: an action zone, an interaction zone and a retreat zone" (Bauer, Haner & Rieck, 2001, cited in Haner 2005). The action zone "supports divergent activity" and "info retrieval and knowledge sharing." It is the "most open part of the ICL" with "a wide variety of info sources and communication channels available." The interaction zone "supports more planned and coordinated interaction" particularly collaborative activities. The zone has smart furniture as well as visualization and interaction devices and "an unusual, i.e. free-formed and orange seating opportunity, termed 'frozen cloud'" (p. 294). The retreat zone is a space separate from the rest. It is a "cocoon-like space that aims at providing privacy to the individual user" and the space lets the user individually adjust elements such as "light, acoustics, and projection" (p. 295). Elements such as "materials, colours, light, and furnishings were chosen to enhance well-being, but not necessarily comfort in the space" (p. 295).

Haner (2005) also discussed the Learning Garden. Haner discussed the origins of the Learning Garden: "A Scandinavian financial institution had decided to improve its internal competence development by introducing a new in-house learning approach. This was to be done by applying new pedagogical methods to increase the degree of learning. Simultaneously it aimed at triggering creativity and support for non-routine work processes" (p. 295). The Learning Garden, similar to the ICL, is an environment that was "structured around processes and towards decision-making, to 'ensure creativity, and stimulate the ability to co-operate."

The Learning Garden is made up "of five different spatial elements: a process arena, an exploration space, a creativity garden, a consensus court and a production studio" (p. 295).

According to Haner, “The process arena is the anchor of the environment and of the processes taking place therein. It resembles a round-shaped meeting room in which issue specification, initial process orientation and team-setting are taking place.” The exploration space “is equipped to provide for communication, information, retrieval, knowledge-sharing and collaborative work in small groups.” The creative garden is designed for “easy-going and fast documentation,” as the space is “meant to provide for flexibility and stimulation.” In this space, “ideas and proposals are to be generated, also through the help of games.” According to Haner, “The consensus court is where decisions are to be made.” The space provides “decision making tools” but has “no regular seating.” The production studio is where “leveraging individual skills the decisions made are refined and documented and further work is organized.”

The Learning Garden uses different colors to differentiate between the spaces and promote certain feelings. The process arena is yellow to promote positive feelings. The exploration space is white, demanding information. The creative garden is “emotionalized by the colour red.” The consensus court is “dark grey which symbolized “neutrality but also formality.” The production studio is an “efficiency-oriented” blue (p. 295).

According to Haner, “Traditional work environments have typically favoured one particular setting (e.g. open-plan offices or cellular offices). By default, such work environments cannot provide support for all phases of creativity and innovation processes, since they typically favour individual or group processes, but hardly ever support both, considering the need for communications and interaction and allowing for privacy. As a consequence it is to be expected that offices offering hybrid infrastructure diversity will become more popular in organizations.” (p. 296). Haner suggested that “spaces for creativity and innovation” could differ in appearance” but “will follow certain principles.” Haner stated, “A thorough comparison of original aims and

actual usage patterns is also needed to understand how well such facilities are adopted by user, with what kind of intentions and with what kind of outcome" (p. 297).

There are examples where environment have been designed to support creative thinking, creative process and innovation. These environments have supported the different types of creative thinking and process in different ways according to the needs of the type of thinking and process. A similar approach could be beneficial in designing an environment supportive of creativity and design processes.

2.13 Personalization and Flow

While supporting creative and design processes is definitely important, a personalized space and an environment supportive of flow could also help users feel and act creatively. Csikszentmihalyi (2008) discussed how throughout history creative people have sought out inspirational environments but also made their own inspirational spaces:

> From time immemorial artists, poets, scholars, and scientist have sought out places of natural beauty expecting to be inspired by the majestic peaks or the thundering sea. But in the last analysis, what set creative individuals apart is that regardless of whether the conditions in which they find themselves are luxurious or miserable, they manage to give their surroundings a personal pattern that echoes the rhythm of their own thoughts and habits of action. Within this environment of their own making, they can forget the rest of the world and concentrate on pursuing the Muse (127 – 128).

Another thing that can help one feel more at home and more creative is the personalization of a space for the individual. Csikszentmihalyi (2008) stated that, "there is much to learn from creative individuals, who generally take great pains to ensure that they can work in easy and

uninterrupted concentration. How this is done varies greatly depending on the person's temperament and style of work. The important thing, however, is to have a special space tailor-made to one's own needs, where one feels comfortable and in control" (p. 140). A space that is designed to reflect the individual "where it is easy to forget the outside world and concentrate completely on the task at hand" helps "preserve and develop individuality, and hence creativity" (143). Creative individuals may incorporate past accomplishments or other inspirational objects into the space as well to remind them what they are capable of and what they are striving for. There are examples of this in leading creative businesses. Groves (2010) displayed how the Vice President of Global Design at Nike filled his office "inspiration and memorabilia" surrounding his passions (p. 144). Designers at Hasbro "create their own caves of inspiration, surrounding themselves with objects and artefacts, images and materials that help them to develop their ideas" (p. 90).

Csikszentmihalyi (2013) explained that, in the end, "Creating a harmonious, meaningful environment in space and time helps you to become personally creative" (p. 146). According to Kristensen (2004), "The idea of sharing a workspace and leaving a clean desk with no personal belongings seems to create a sterile environment that inhibits imagination. What seems to facilitate creativity is personal and idiosyncratic" (p. 93).

Also, according to Martens (2011), "The functionality of the creative workplace is very much about the ability of workers to control the physical environment to meet the required level of solitude, interaction, noise and temperature. Control of the environment can be met by the ability to choose the right place for the task at hand or the ability to alter the environment to suit the task. Somebody's mental ability to exclude the environment is also a form of control over the environment" (p. 75).

According to Martens, "No direct evidence was found on the relationship between flow and physical surroundings. However the role of the physical surroundings could be important by limiting interruptions so employees can get into a state of flow and stay in flow" (p. 69). Martens stated,

> Workplace literature that describes supporting concentration and attention and keeping mental fatigue levels under control provides two strategies: (1) eliminating or mitigating sources of interference (e.g. interruptions), by improving sound proofing for noise reduction, or even improving communication lines from management to reduce uncertainty with employees; and (2) interventions that reduce fatigue: restorative; provide a view that includes natural elements. (p. 69)

Providing areas within an environment may help users feel more creative. Certainly, some personalization should be encouraged and allowing for personalization should be a consideration in the design of spaces. Support for concentration and attention should also be considered, as people feel creative in flow and are able to focus on their creative tasks.

2.14 Creative Spaces in the Business World: Different Types of Creative Spaces

Groves (2010) provided case studies of the environments of some of the most creative businesses in the world. She broke down creative spaces into four groups that support different creative activities including: "*stimulation*, where the mind is inspired or a thought process triggered in some new way; *reflection*, a period of uninterrupted focus; *collaboration*, where ideas are shared and built; and *play*, where experimentation occurs" (p. 12).

Stimulating spaces promote thinking differently by having a variety of stimuli. The space can express a particular attitude, mood, or brand identity through color, graphics, scale,

storytelling, smell, music, furniture, and other factors, engaging "the brain in different ways, which in turn stimulates more creative thought" (p. 12). Many creative companies use these factors to stimulate the creative mind; however, in some cases, an environment without stimulus can cause to the creative individual to think differently. For example, LEGO's innovation room is completely white and without stimulus (p.12).

Figure 2. LEGO innovation room. (Groves, 2010).

Reflective spaces are good for the incubation portion of the creative process. Groves stated, "Periods of intense focus coupled with time to relax and unwind set up the right conditions for a creative brain to problem-solve." Reflective spaces can be private spaces, where the individual can have a more "meditative-like" state. These spaces often incorporate nature, providing stimulus for the individual to distract them enough but not too much so that they can make creative connections between thoughts without being too critical yet (p. 13). Figure 3

shows someone relaxing in an area designed for reflecting. Figure 4 shows an area at Hasbro designed for reflection. The space incorporates natural light and nature.

Figure 3. A Reflection Tub. (Groves, 2010).

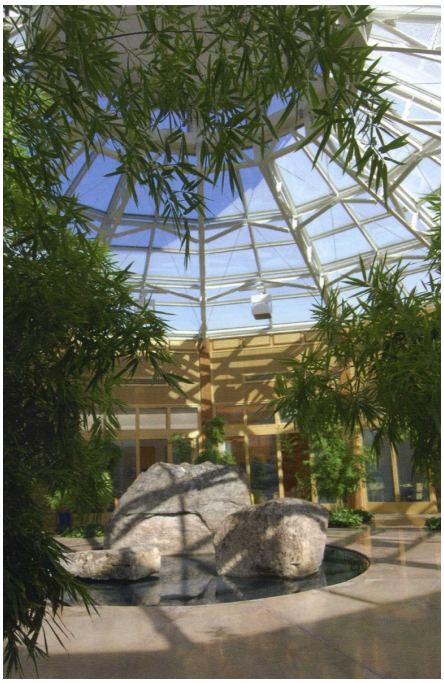

Figure 4. Zen Dome at Hasbro. (Groves, 2010).

Collaborative spaces, according to Groves, “can energize people, put them at ease, make them feel connected with their colleagues and open them up to exploring ideas.” Spaces may be designed to encourage people to stop in particular areas to talk with wider hallways or stairwells. Open spaces can allow for unobstructed communication. Furniture arrangements in groups can give people opportunities to sit down and talk (p. 13). Figure 5 shows people interacting with each other at Innocent Drinks in a space that supports collaboration with appropriate furniture. Figure 6 shows people using a space that supports collaboration with tools, surfaces, and furniture.

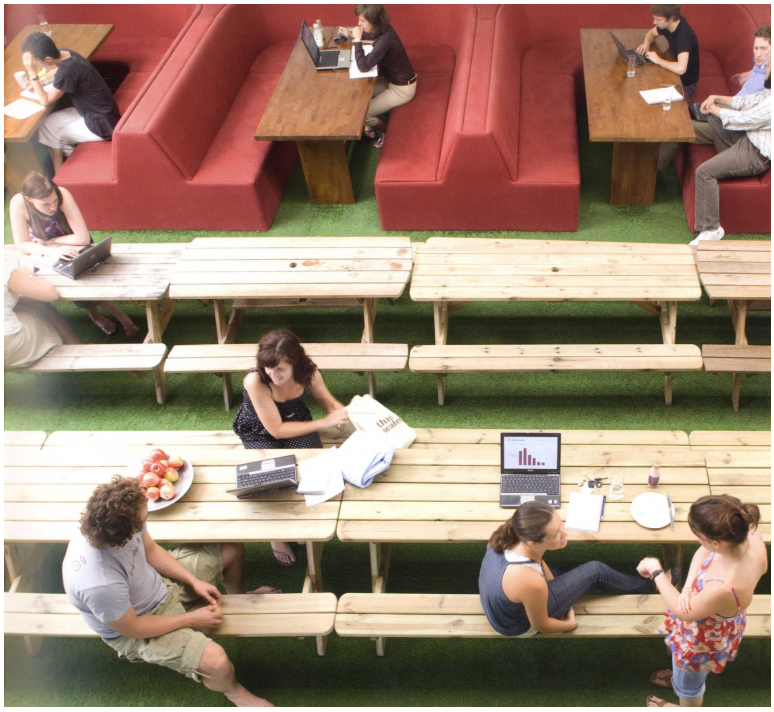

Figure 5. Innocent Collaborative Arrangement. (Groves, 2010).

Figure 6. People using collaborative space. (Groves, 2010).

Spaces designed for play offer a break from work. Groves stated, “Playful spaces elicit a lightness of being that opens up lines of communication between people, helps them to try new things and sometimes is just plain fun.” While play could offer a break, it can also be explorative: When seeking answers to a question, explorative play is the act of doing or making things to test and develop ideas.” Fun environments can also use humor, “lightening the load, lifting spirits and reconnecting people with their inner child” (p. 14). Figure 7 shows an environment designed for play.

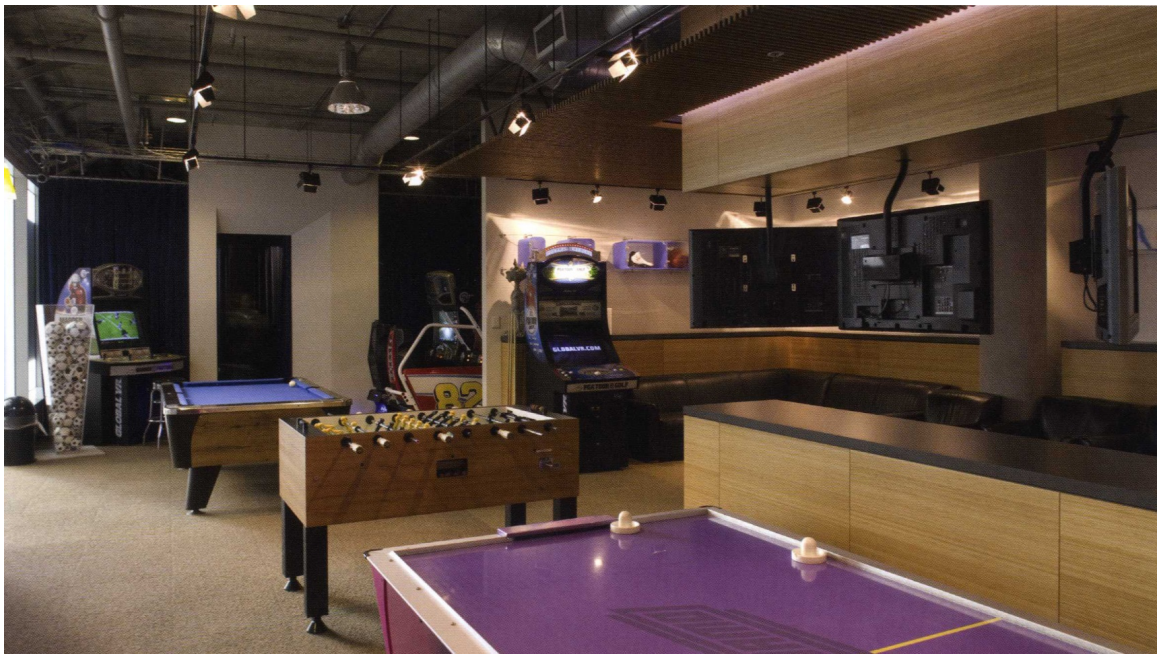

Figure 7. Play space. (Groves, 2010).

Groves' book also showed that spaces can have unique creative identities. Dyson's "headquarters' distinct steel structure…can be viewed as a proud expression of the great tradition of engineering and entrepreneurship from which Dyson originates" (p. 52). Groves also stated, that a "crystalline structure connects existing and new buildings, and communicates an early expression of the Dyson ethos, the company's personality and a sense of what it holds dear" (p. 56). Figure 8 shows Dyson's headquarters.

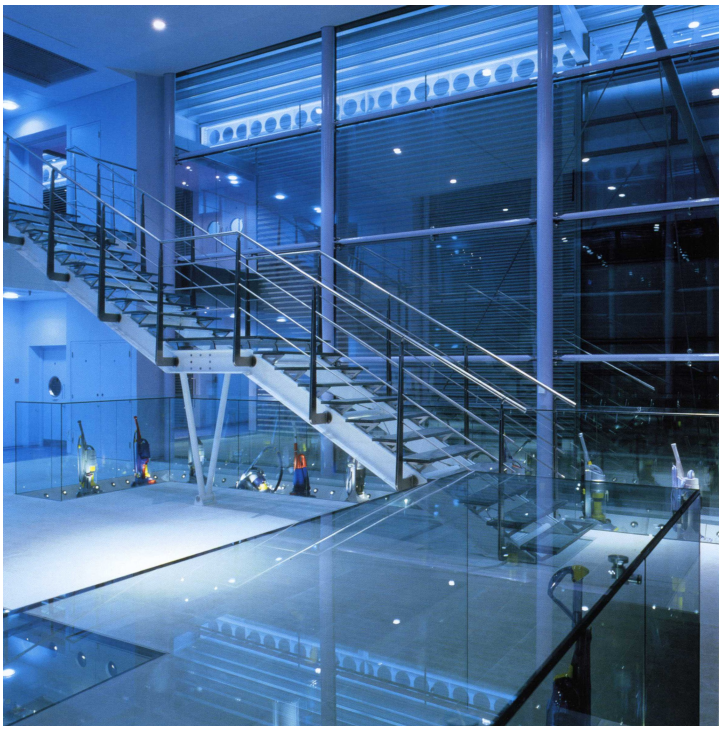

Figure 8. Dyson headquarters. (Groves, 2010).

LEGO's creative identity is expressed through "open space which supports the 'free flow of ideas', lots of bold colour inducing a sense of fun, and the omnipresent LEGO brick" (p. 126). Oakley's headquarters "could be taken for a post-apocalyptic fortress from an alien planet." Groves stated, "Provocative, industrial and iconic, Oakley's headquarters conveys the brand's bold personality and virtues to all who dare to enter" (p. 152). Figure 9 shows the outside of Oakley's headquarters.

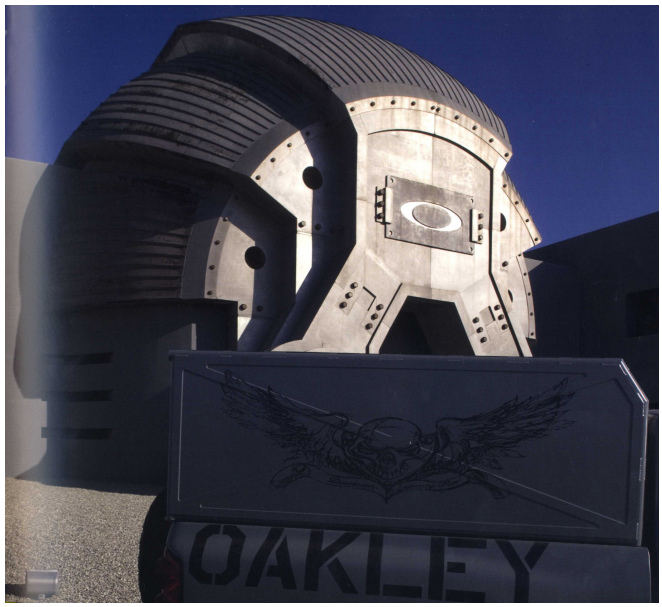

Figure 9. Oakley headquarters. (Groves, 2010).

According to Groves, “Virgin’s brand, visual identity and creative spirit is as evident in its call centres as it is in its Upper Class lounges” (p. 230). Virgin’s spaces make use of colored vinyl graphics with saying that “reinforce a focus on the customer, communicating the Virgin spirit with a sense of fun” (p. 234). Figure 10 shows how Virgin incorporates wall graphics into their spaces.

Figure 10. Virgin wall graphics. (Groves, 2010).

Clearly, some of the most creative businesses in the world are using elements of spaces to give the space unique creative identities. Giving a space a unique creative identity could help designers remained focused on their specific creative goals.

Martens (2011) seemed to agree with some the notions presented by Groves about an environment having a creative identity. Martens argued that the environment "expressing the organization's creative identity" and "stimulating a creative culture" seems important (p. 75).

In designing spaces promoting creativity and design, insights could be taken from creativity supporting environments in the business world that support stimulation, reflection, collaboration, and play.

2.15 Perceived Creativity Studies

Support for creativity could include ambient factors or elements that are said to enhance perceived creativity. Several authors have performed studies on the perceived creativity support of environments. Stokols et al. (2002) performed a "'study [that] examined employees' perceptions of support for creativity at work as a possible mediator of the relationships between objective measures of distracting stimuli and subjective appraisals of social climate, on the one hand, and self-reported levels of job satisfaction and personal stress, on the other." They claimed the results of the study "indicated that both recorded levels of environmental distraction and self-reports of social climate are significantly linked to employees' perceptions of support for creativity at work" (p. 137). They stated, "A more positive social climate was associated with greater perceived support for creativity at work, while "higher levels of environmental distraction at work were associated with less perceived creativity" (p. 138). They also claimed "job satisfaction was significantly predicted by both social climate and levels of environmental

distraction" (p. 144). However, Stokols et al. stated the findings are more "suggestive rather than conclusive" (p. 145). According to Stokols et al., "this study suggested that physical and social features of work environments do influence employees' perceptions and experiences of creativity, and established a basis for future longitudinal studies designed to replicate and extend the cross-sectional relationships reported here" (p. 145).

McCoy and Evans (2002) performed two studies, relating to perceived creativity, one of which involved participants rating photos of environments based on if they though they would feel more creative or less creative in the environment. According to McCoy and Evans, "Analyses identified 5 environmental characteristics that independently predicted greater perceived creativity: (a) complexity of visual detail, (b) view of natural environment, (c) use of natural materials, (d) with fewer cool colors used, and (e) less use of manufactured or composite surface materials" (p. 409).

Their study found that "Environments high in perceived creativity potential most frequently were visually interesting…such environments tended to have extended views; natural materials were liberally present. These spaces had some provision promoting social interaction" (p. 418). McCoy and Evans also discussed environments with low creativity potential as well, "Environments perceived low in creativity potential were consistently windowless, finished in manufactured or composite materials, and with overall cool colors. Although the rooms were sometimes shabby from age and use, they would not necessarily be deemed ugly or to have been designed in artistic bad taste. Rather, the effect, as noted by the raters was "uninviting" and "bland." There was no incentive to spend time in these spaces" (p. 420). McCoy and Evans stated that windows can allow more control over the environment and that "The inability to open or look out the window may contribute to the perception of a nonflexible environment and a loss

of freedom and openness to experience" (p. 420). McCoy and Evans stated, "Evaluated independently, increases in visual detail, wood grain texture, and natural view are perceived to enhance creativity potential. Inversely, increases in cool color temperature and manufactured or composite materials are negatively associated with perceived creativity potential" (p. 417).

According to McCoy and Evans, "Independent ratings of physical characteristics of the settings associated with perceived creative potential included spatial complexity, visual detail, natural views, use of natural material, sociopetal design, cool colors, and use of manufactured or composite material. These significant physical predictors of creativity fit well with several of the original conceptual dimensions of creative enhancing environments." (Pg. 423-424).

The study suggested nature and natural elements "promote creative performance," as they provide visual and tactile stimuli as reminders of the larger natural environment, and perhaps its restorative qualities." According to McCoy and Evans, "high levels of spatial and visual complexity" enhance the creativity potential of places "as the complexity provides stimulation with "visual interest and opportunity for discovery." Additionally, "The personal freedoms of autonomy, openness to experience, and engaging in unconventional thought processes may be fostered in settings in which windows and natural views permit distraction, in which the bounding surfaces are varied and offer a choice of workplaces, and in which multiple functions may be performed" (p. 424). While windows may communicate freedom, static environments that are not "adaptable to task requirements" should be low in creativity potential as they are perceived to not allow "freedom of movement and change." According to McCoy and Evans, "When settings are high in creativity potential, it should be clear where work and social gatherings are permitted. It should be equally clear where both work and social interactions are discouraged" (p. 424).

McCoy and Evans conducted a follow-up study to their photo analysis "to determine if the perceived creativity potential of a setting could actually affect creativity performance. Creative performance tests were given to participants in a highly rated creative potential setting and a lowly rated creative potential setting according to the results from the preceding study. The tests involved participants taking a *Torrance Test of Creative Thinking* as well as making collages in two different environments. According to McCoy and Evans, "Creative potential significantly enhanced creative performance on the collage measure," but "the TTCT was insensitive, however, to the setting variable" (p. 423). McCoy and Evans' second study provided "support for the hypothesis that settings perceived to affect creativity may, in fact, function as perceived" (p. 424). According to McCoy and Evans the collage test clearly supported the hypothesis, while the TTCT results were less conclusive and "may have been less sensitive to the manipulation" (p. 424) of the test.

Ceylan et al. (2008) performed a similar study to McCoy and Evans. They had managers judge the creative potential of office environments and rate elements in photos of office environments as well as self-evaluate physical elements present in the environments. The goal of the study was to test if "offices with different physical settings have different creativity potential" and to see if the "differences in creativity potential can be partially explained by physical characteristics of the office in terms of presence of plants, windows, color, light, materials, spatial arrangements (complexity, furniture), and availability of information sources (books, computer)" (p. 595).

The results showed that "there are significant differences in creativity potential between offices" confirming the "hypothesis that offices with different physical settings have different creativity potential can be confirmed" (p. 595). According to Ceylan et al., the results of this

study also showed that "four physical elements have an effect on creativity potential: complexity, light, plants, and colors" (p. 595). Correlations in the results of the study indicated "that complex and dimly lit offices with few plants and warm colors are associated with low creativity potential. Offices with low complexity, that are brightly lit, have cool colors, and have plants are associated with high creativity" (p. 595). Ceylan et al. conclude that their "hypothesis that differences in creativity potential can be explained by physical characteristics of the office in terms of the presence of plants, windows, colors, light, materials, spatial arrangements (complexity, furniture), and the availability of information sources (books, computer) is confirmed for all physical elements, except for materials and furniture" (p. 595).

Ceylan et al. explained "The managers in our study preferred offices with a low level of complexity because this may facilitate thinking and concentrating for producing novel and useful ideas. They also preferred offices that were brightly lit. The negative correlation between complexity and light may indicate that offices that have a low level of complexity and are brightly lit are associated with freedom and room for thinking" (p. 598). Ceylan et al. stated, "Managers did not prefer offices with mainly warm colors; such environments may be too stimulating. Offices with high creativity potential had more cool colors; cool colors are calming. Plants may help a manager to relax after stress, and result in a positive mood supportive for creativity" (p. 599). Ceylan et al. also stated, "A computer may be associated with availability of information in a private environment, which may be useful in creativity phases where information needs to be gathered. It also gives possibilities for controlled contact with others through e-mail or the Internet; contacts may help to get new ideas" (p. 599). According to Ceylan et al., "the presence of natural materials had no independent effect on creativity potential." (p. 599) Ceylan et al. continued, "We also found no effect of furniture on creativity potential. It may

be that the informants, while evaluating furniture, actually may have judged complexity; they seem to perceive furniture as an aspect of complexity. Our finding of a correlation between furniture and complexity (Table 1) supports this idea" (p. 599)

Ceylan et al. compared their study with that of McCoy and Evans: "Although both studies showed that windows are associated with high creativity potential, the other physical elements that were measured in both studies (complexity, light, color, plants, natural materials and furniture) showed considerable differences" (p. 599). They also stated, "It is possible that there is an optimum level of physical characteristic for nearly all physical characteristics: too little presence of the physical element (complexity, light, color temperature, etc.) nor too much presence is good" (p. 599)

Martens (2008) dealt with perceived creativity in the discussion of "four connected studios" from the group StudioLab. One of these studios, StudioMingle "is a collaborative space with individual workstations to provide researchers a workspace. StudioMingle's goals included being "a protected environment for its users," having 30% occupation of desks "at all times," and promoting "crosspollination" of users through interaction and sharing involving showing work. According to Martens, "The research investigated the perceived contribution of the office space to creativity." The study was narrowed to looking at factors such as "lay-out, furniture, colour, finishing and light." Workers in the space were sent a questionnaire that inquired "about their accommodation needs in relationship to creativity, their satisfaction on these points and the required adjustments."

According to Martens, StudioMingle is an "open plan workspace" that measures 10 x 18 meters. StudioMingle has "18 workstations, a small break-out couch and table and a little kitchen." Martens detailed that "40% of the floor area is covered with furniture," and "visual

contact is possible from 12 of 18 workstations." According to Martens, in StudioMingle, "All workstations are personal but (temporarily) unoccupied work stations can also be used by other researchers." White and grey are the main colors of StudioMingle, as only 30% of the room has color: "mainly in breakout and small personal belongings." The finishing in StudioMingle included a mixture of natural, stone-based, as well as transparent materials, synthetics, metals, and cloth. StudioMingle had a window that provided natural light as well as artificial lighting from Tube Light and desk lamps.

According to Martens "users of StudioMingle think that 'light' and 'lay-out and the way it facilitates contact with colleagues' were most important for the stimulation of their creativity. In the lay-out the openness was especially appreciated as it provided physical space for thought: 'creativity needs a horizon.'" Martens also discussed users' thoughts on color, "The contribution of colour seems relevant to creativity, but can be seen from different perspectives. Almost all of them would like some more warm colours, as it would be nice and could affect their mood. It could be of value for creativity, as the current colours were perceived as boring and not a comfortable atmosphere. Four respondents explicitly mentioned colours to have an effect on the creative potential of the physical work environment." A lack of wall space to present work was a hindrance to creativity. According to Martens, "Users responded ambiguous to noise and the many objects and stuff in the room. Most of the users think that the objects are stimulating; some think the mess hinders their creativity. Some workers thought it was too noisy in StudioMingle, one thought it was to quiet."

User recommendations for making the space more creative included more space to present work, to be "better informed about colleague's work," more color, and fresh air. The space has been changed, with "more colours on the walls and columns have been added to the

room as well as presenting space on whiteboards and panels." The space became quieter as two of the louder workers left. Also, according to Martens, "showcase products have been moved away from the workspace, which reduced the number of interruptions by visitors." No new evaluation was undertaken, but users expressed they were satisfied with the changes [Martens, 2008, Stimulating Creativity with Studiolab section].

According to Martens, the StudioMingle case "illustrates that the office space can be of value for an organizations creativity. Among workers there seems to be general agreement that, a more colourful environment, with some fresh air and space for presenting personal work can contribute to the end-users well-being and creativity." Martens went on to state, "Finally it is apparent that the physical work environment can contribute in different ways to creative organizations." One way is through expressing "creativity to outsiders and its users: by using colourful materials, unusual furniture and presenting physical representations of the organizations work (models, posters, artefacts). An appearance which reflects the identity of its users can also lead to higher satisfaction and a greater sense of belonging." Another way is by stimulating "the mental process of creativity: by providing comfort and well being for individual creativity, and spaces for objects and presentations to be inspired by these artefacts and the work of colleagues." Finally, one more way is through facilitating "creativity, by designing, dedicated spaces which support the number of users, the required noise level (enclosed/open) and stimulate the senses (relaxed or triggered and inspired)" [Martens, 2008, DISCUSSION section].

According to the literature, many elements in a space can affect perceived creativity. Designing to enhance the perceived creativity of an environment through the use of various individual elements such as visual complexity, color, light, nature, materials, sound, displayed objects or information, furniture etc. should also be considered in the design of the best spaces

for creativity and design. These factors and others are individually discussed in later sections in the thesis.

2.16 Comfort, Mood, and Creativity

Before moving into discussion of individual factors, the relationship between comfort, mood, and creativity must be established. According to Dul and Ceylan (2011), "It is interesting to note that may problems and solutions regarding work environments for supporting creativity are very similar to the problems and solutions for work environments for supporting comfort, health and safety." They went on:

> a positive mood may not only mediate or moderate the relationship between work environment and creativity, but also the relationship between work environment and comfort, health and safety. Hence, part of existing ergonomics knowledge on work environments for comfort, health and safety could be readily applied to foster creativity and innovation in organizations, although further studies are needed to explore this. (p. 18)

The link between positive mood and creativity as well as the link between promotion of "comfort, health, and safety" is assumed in the following sections. Surely, both mood and health should be considered in the design of an environment promoting creativity and design.

2.17 Environmental Stimuli

Before individual environmental factors are discussed, the totality of environmental stimulus should be understood. Some literature on learning environments may be applicable to creative design environments because they should support similar things; namely, creative

environments should be stimulating, motivating, and support concentration (Peterson, 2010, p. 180). DAK Kopec (2006), in his book *Environmental Psychology for Design*, gave the following definition for a learning environment:

> A learning environment is a system of complex relationships that exists among the physical structure (size and arrangement of a room), a teacher, and a student. The physical aspects of a learning environment can have a direct influence on learning, behavior, and productivity. The ideal learning environment contains appropriate and comfortable furnishings, provides a variety of tools for learning, facilitates individual learning, and contains design features that are interesting and novel. Also, included in the physical environment are ambient features such as color, noise, lighting, temperature, and odor. These ambient features of an environment tend to influence mood, emotions, behavior, and learning capabilities. (p. 189)

Kopec suggested that learning environments "need to support development by providing a variety of stimuli, accommodating many activities, and furnishing ample opportunities for privacy" (p. 189). For an educational design studio environment or a space intended for design, the space should accommodate the stages of the creative process as well as the design process, as well as providing appropriate stimuli.

In any learning environment, it is important to regulate the levels of stimulation to encourage learning and not distract from it. Kopec explained that any of our senses can overstimulated or understimulated. He stated that the threshold is "the point at which too much or too little stimulation is available. At one end of the threshold spectrum is the absolute minimal intensity of stimulus we can perceive and at the other is the maximum amount of stimulation we

can cope with effectively" (p. 23). Kopec speaks of arousal's effects on learning and productivity in the following way:

> "Optimum arousal is an important factor in successful learning and productivity. While overarousal can lead to cognitive chaos… underarousal can lead to inaction… or even apathy. Simply stated, arousal is a component of the human psych and is dependent on stimulation. Design cannot affect arousal directly, but it can serve to modify stimulation levels that affect arousal" (23).

An environment that provides stimulus within the threshold should be better for learning, creative thinking, and designing, as one is neither overstimulated or understimulated. When discussing the level of stimulation an environment provides, the terms "high load" and "low load" are used. According to Mehrabian (1976) in *Public Spaces and Private Spaces*, "environments that are more varied, complex, novel, large scale, contrasting, dense, surprising, heterogeneous, crowded, asymmetrical, moving, rare, random, or improbable have more load" (p. 12). Mehrabian also claimed that the familiarity of an environment is tied to the environment's load, where an unfamiliar environment results in a higher load because of its unpredictability, while a familiar environment has a lower load because the environment is more predictable (p. 13). Thus, if familiarity and load truly are linked, then as an individual becomes more familiar with an environment, the environmental load should decrease. Spaces with higher environmental load should be better for the incubation process with more stimuli, while lower load may make for more comfortable working. Yet, a certain amount of stimulus and inspiration, whether it is from nature, art, images, etc. is preferable in the studio as long as the space does not become too busy.

Mehrabian discussed how the task at hand had a relationship with load. Mehrabian explored this idea from an educational perspective claiming "when teachers or students are performing high-load tasks, it is better to tone down the environment, keeping the room pleasant but lowering the load" (p. 158). Mehrabian suggested painting spaces in pleasant colors and claimed teachers will only tolerate that higher load environment if the environments are also pleasant (158). Therefore, for an educational design learning environment, it is important to design an environment that considers the environmental load for both the student and the teacher. For other design spaces, the different users of the space should be considered. In terms of a design studio, where creative activities are key, stimulation is definitely wanted. However, the students should not be completely overloaded. It is important to provide them with inspiration, but the environment should not be busy and overwhelming. It should be within the threshold of environmental load.

McCoy and Evans' (2002) study suggested that high visual detail enhances perceived creativity potential (p. 415). Therefore, a higher load environment within the threshold may be best for the creative process.

2.18 Engaging Senses

Engaging other sense besides vision can help improve thinking. According to *The Third Teacher* (Peterson, 2010), Sound, smell, taste, touch, and movement power memory. An environment rich in sensory experiences helps students retain and retrieve what they learn" (p. 177). An environment that engages senses should also be beneficial in creative design environments as it helps people's memory and recall.

Some environments may improve memory recall and attention restoration, both of which would be beneficial in a creative studio environment. Rodemann (1999) referenced a study that found that links exist between the environment and memory recall. The study results showed that images existed in long-term memory, but were less specific than the patterns of the original images. However, as color, movement, sound, and dimension were added to the environment, recall increased (p. 100). Clearly, if engaging senses improves memory and recall, senses should be engaged by a creative environment, as attention would be freed for further creative thought.

2.19 Smell

Augustin (2009) discussed how smell particularly can affect a person. She claimed, "The way that some thing or some place smells is key to our experience of that object or location" (para. 1). Furthermore, smell can have effects on cognition and energy as the scent of jasmine or lemons enhances cognitive performance and "the smell of peppermint is generally physically energizing." She also claimed that "cinnamon-vanilla smells and creativity seem to be linked" (para. 2).

Augustin (2010) also discussed how pleasant smells could benefit the environment or people in several ways. She claimed people are likely to linger in pleasant smelling places. She also stated that pleasant smells generally put people in a positive mood, meaning people are "apt to be more creative and more interested in resolving disagreements genially as opposed to confrontationally." She also claimed that people were more likely to recall positive memories as they smell pleasant scents and that people feel more confident when smelling pleasant scents. She also claimed that "Scented spaces seem larger than unscented spaces" as well as "seem cleaner and brighter than unscented ones."

Clearly, pleasant smells can have a positive effect on people, and it could benefit the users of an environment designed to improve their creative thinking and performance. Smells like lemon and jasmine could enhance cognitive performance, vanilla–cinnamon could enhance creative thinking, and peppermint could energize users of the space. A pleasant smelling environment would also encourage people to stay there longer to accomplish and complete more creative tasks, while also promoting people's moods and therefore creativity.

2.20 Nature

One way in which an environment may improve attention restoration is by incorporating nature into the environment. Kopec (2006) explained that humans are drawn to nature for restoration as nature reduces stress levels and restores attention capacity. One basis for this argument is the theory of attention restoration that claims "restorative experiences occur in settings where we can function primarily in the involuntary mode (i.e., when we can observe or surround ourselves with stimuli that are involuntarily interesting)" (p. 24-25). Reduced stress, attention restoration, and the involuntary interest that allows for connecting ideas is beneficial for creative thinking and design thinking as attention is required for creativity (Csikszentmihalyi 2013) and connecting ideas is an important part of design and the incubation process. It follows that it would be beneficial to bring nature into a creative design environment or allow access to look out to nature.

Perceived creativity studies back up the beneficial qualities of nature in creative environments. McCoy and Evans (2002) noted in their analysis, "As expected, view and natural view correlated strongly with creativity potential" (p. 415). The study results from Ceylan et al. (2008) also suggested that plants are associated with high creativity potential (p. 595). Ceylan et

al. suggested that plants may help people "relax after stress and result in a positive mood supportive of creativity" (p. 599).

Runco (2007) discussed that nature can be inspiring and suggestive. In looking at the natural world, Runco claimed:

> We might find inspiration there, or good analogies or find ideas that can be borrowed or adapted. There are thus several potential benefits to looking to the natural world. Something happening in nature may suggest an analogous solution for a human problem…If you look to nature you might find a solution, or you might something that (by analogy) suggests a solution. Or you might simply find inspiration. (p. 328)

Clearly, it would be beneficial to incorporate nature into an environment that supports creativity and design, as nature reduces stress, restores attention, and can provide interest and inspiration. Nature could be particularly useful as stimulation during the incubation process.

2.21 Color

Nature can reduce stress and improve attention, a key component to creativity, and it can inspire; color also may affect people not only on an emotional but also on a physical level. Emotions, hormones, blood pressure, and respiratory rates are linked to color. Therefore, color can affect one's energy level, mood, and mental clarity (Kopec, 2006, p. 190). Generally, warm colors are considered high-arousal and cool colors are considered low-arousal. However, Kopec (2006) claims that a color's brilliance can change the response to the color. Researchers found that "a significant variance in emotional response happens not because of the color's hue, but rather its level of brightness and saturation." One study even found that lighter green room made people feel less crowded than an identical darker green room (p. 89). Colors may be used as a

dominant factor within a space to stimulate the brain, or they could be used more as an accent piece to give a spark to an otherwise dull space.

Colors can not only be used to reduce the feeling of being crowded and to stimulate the brain, but color can also promote other feelings. Rodemann (1999) discussed that the designer should avoid designing a learning environment that draws connections with a prison, meaning one should avoid plain blocks. Gray (2010) primarily explored how color could influence creativity in his thesis, stating "that color, as an external stimulus, could increase creativity" (p. 53). Gray stated, "The research gathered on emotion in the workplace found a correlation between color and emotion supported by studies from other researchers" (p. 103). However, Gray also claimed, "Although research has been done on the topic and it may be proven that color is subjective to individuals, more research is necessary as to the exact effect of color on emotion and whether a specific emotion can quantitatively be matched to a specific emotion" (p. 104). Using colors that are linked to positive emotions could help keep one in a better state of mind for creativity, free from the distractions of negative thinking.

According to *The Third Teacher* (Peterson 2010), a paint color should support the intended mood of the space (p. 181). In this text, a paint producer discussed how color can enhance or interfere with the function of spaces. The producer claimed that color can effect the atmosphere of a space and the performance of the users. The specifications of the colour whether "bright, attention-getting colors" or "mild, calming colors" depend a good deal on the purpose of the space. The producer stated, "In classrooms students and educators need to feel stimulated and motivated, but not so much that the colors discourage concentration" (p. 180). Stimulation, motivation, and concentration should also be beneficial to design and creative thinking, so tactics used for learning environments may also be useful for other creative design environments. The

producer suggested that the teaching wall of a room be painted a deeper or brighter shade than other walls. The producer claimed that this attracts attention to the particular wall, but gives the eyes a "visual break" when attention is changed to the other walls (p. 180). This technique may be useful in a creative design environment if certain walls are more important than others, particularly in education.

The producer also discussed color for libraries, stating "Walls and shelves lined with books can be energized with the use of colorful wall graphics. Frequently, libraries also contain computers, so remember to select colors that help reduce glare and eyestrain in these areas." Wall graphics could possibly be used in a creative design environment as well, and certainly computer interaction should be considered (p. 180). Virgin uses wall graphics in their spaces to reinforce their creative spirit and inject fun into the space (Groves, 2010, p. 234). The producer in *The Third Teacher* (Peterson 2010) also discussed how color affects the spaces connecting rooms:

> Corridors and stairwells are ideal spaces for bright happy colors to reflect school colors. Mascots and other colorful wall graphics add interest. Strategic use of appropriate colors can help visually shorten long hallways and enlarge small, dark ones. In corridors and stairwells, combinations of colors also can be used effectively to color code sections of the building – depending on use, for example – and can aid navigation and traffic flow in a large or multistory building. (Peterson, 2010, p. 180)

In addition, a designer suggested for classrooms, "Use a subtle chromatic range with many shades, include colors similar to each other, tone upon tone, which can generate vigor and variety, and colors that contrast with one another" (p. 178). This suggestion may also be of use in an environment intended for creativity.

Küller et al. (2006) claimed that "the colour of the workspace stands out as rather important." Küller et al. discussed a study that showed "the index of emotional status was higher throughout the year for those who had the most colourful work environment." They claimed that "it may seem that the brighter the colour, the better it is for those who work there…Still, it is suggested that a moderate increase in the use of good colour design will serve to improve the overall mood of the working staff" (p. 1505). A better mood could be beneficial to creative thinking.

Contradicting suggestions arose from the perceived creativity studies of McCoy and Evans and Ceylan et al. McCoy and Evans claimed in their study, "Cool colors had a significant negative correlation with creativity potential. Environments with a primarily cool color temperature were not perceived to be conducive to creativity" (p. 415). This could have something to do with warm colors being considered high arousal and low colors considered low arousal. However, Ceylan et al. found the opposite, as their study suggested warm colors were associated with low creativity potential (p. 595) while they claimed, "Offices with high creativity potential had more cool colors; cool colors are calming" (p. 599).

In Martens' (2008) study, people felt color would help them be more creative and expressed they wanted more warm color in the environment (User perceptions, para. 2). The Learning Garden, discussed by Haner (2005), is one example in which colors were used in spaces to promote different thinking or moods.

Color has been associated with mood, and a positive mood could help with creative thinking. Color could be used to promote certain feelings, give spaces more personality, and provide more stimulation. People have claimed that colors could help with creative thinking, and there are examples of creative environments that certainly employ the use of color, but it is

inconclusive at this point if there are specific colors that directly enhance creativity. Certainly, color should be considered and used in the design of a creative environment for design.

2.22 Lighting

At the same time colors could change the way someone feels, light can also have an effect on a person. Light affects the cerebral cortex, which deals with thoughts, and the central nervous system, which deals with memory, eyesight, muscle control, and breathing (Kopec, 2006, p. 190). When warm colors and bright lighting are combined, people have increases in brain activity, muscle tension, respiratory rates, heart rates, and blood pressure. The inverse is true when cool colors are combined with dim lighting. White and off-white decrease efficiency by an average of 25% (Kopec, 2006, p. 191). Full-spectrum lighting is linked with decreases in instances of hyperactivity.

In the same way that there is a threshold for environmental load, there is a threshold for the brightness of lighting. Yet, the human eye can adjust to a great deal of light changes, so as long as the lighting conditions are not too close to the threshold, visual performance is not affected (Korwowki p. 874). Flickering light, glare, veiling effects, and insufficient light can cause discomfort (p. 880), and with discomfort comes decreased focus on one's work and creative thoughts. The lighting of a creative design space should allow for individuals to focus and hone in on their creative work without any visual discomfort or distraction.

Spot lighting could be used in a creative space to help designers hone in on a task. Evans (2008) noted in her study that when providing design students with individual lighting, "when the overhead fluorescent lights were off and the incandescent lights were turned on student's voices tended to lower." She also stated, "The room also had a much more attentive feel with the

incandescent lighting than it did with the fluorescent fixtures" (p. 52). Less noise from other students and increased attention should help designers focus on specific tasks.

Also, for computer work, the room does not need to be as lit up, as the screen emits light. Designers at Electronic Arts have a "unique atmosphere of committed, focused creativity, with employees lost for hours on end in their own virtual worlds," blocking themselves in spaces only lit by a computer screen (Groves, 2010, p. 68-69). In *Workspheres* (2001), Small, a multimedia designer discussed the MIT Media Lab in Cambridge, Massachusetts. He discussed that "the space was dark; most of the functional illumination came from the computer screens themselves, creating little pools of activity around the computers" (Antonelli p. 64).

According to *The Third Teacher* (Peterson, 2010), "Natural daylight improves the working environment and has been shown to increase concentration and learning. Daylight can also have an uplifting effect on feelings of well-being and health. It is important for the inhabitant of the building to be aware of the outside environment as it changes throughout the school day" (p. 46). Increases in concentration and well-being should help with supporting creativity.

There have been some studies addressing light and its effect on creativity. Ceylan et al.'s (2008) study indicated that dimly lit environments were associated with low creativity potential, while brightly lit environments associated with high creativity potential (p. 595). However, this could have to do with other factors in the environment or that the test involved rating photographs rather than using the actual space.

Steidle and Werth (2013) performed studies that tested the effect of darkness on creative thinking. Unlike Ceylan et al., they found that darkness was beneficial to creativity as they had users perform certain activities under darker conditions. They stated, "Darkness only increased

creative performance when dim illumination increased the perceived freedom from constraints" (p. 76). The findings generally implied "that illumination can count among the creativity-supportive physical conditions of a workspace" (p. 77).

They also claimed their findings showed "the visual message a luminous environment sends can determine how and when light influences performance and behavior" and stated that their research "extends the knowledge of how visual messages exert their influence." Steidle and Werth's results suggested "that decreasing illuminance levels of direct light increases the perceived freedom to deviate, which in turn promotes explorative processing and creativity. Apparently, darkness triggers a chain of interrelated processes, including a cognitive processing style, which is beneficial to creativity." However, they concluded that "instead of a direct link" to enhancing creating thinking "darkness should be a stimuli triggering attentional tuning. Instead of a direct link…according to our findings, darkness should be a stimuli triggering attentional tuning" (p. 77). Steidle and Werth also stated "that [they] do not assume or conclude that light is detrimental to creativity" (p. 78). Their results indicated "that it is beneficial to adapt lighting conditions according to the task at hand and the stage of the innovation process." They went on to say, "Our results indicate that it is beneficial to adapt lighting conditions according to the task at hand and the stage of the innovation process. Apparently, bright, direct light impedes the generation of new ideas but improves analytical thinking…Hence, it is useful to install and use dimming systems in order to create a fitting luminous environment" (p. 78).

In *The Third Teacher* (Peterson, 2010), a designer suggested that learning environments should have a variety of light sources including incandescent, fluorescent, vapor, and halogen light among others. The designer stated, "Light should be able to create shadows," and argued that both concentrated and diffuse light should be offered as well as different color temperatures

like warm white, rose white, and cool light. The designer claimed that the users "should be able to vary the light intensity and color" (p. 178). While this advice was given for learning environments, this may also apply to creative design environments. Certainly the creation of shadows would be beneficial when analyzing models. The color intensity and temperature adjustment could help with setting mood and honing in focus.

Light clearly can affect a person according to the literature. It seems that a variety of light sources and the ability to adjust lighting is important in an environment that supports creativity. The light could be dimmed to promote freer divergent thinking, or light could be brightened when more analytical thinking is require in the creative or design process. Clearly, one would need enough light for the task being performed and lighting conditions should stay comfortably within the threshold. Spot lighting could possibly be used to help people hone in on tasks. If possible, natural light would be beneficial as it helps with concentration and feelings of well-being, which should allow someone to focus and think. It seems that white and off-white light should be avoided, but otherwise there should be a variety of adjustable lighting that the user can change depending on the desired task to be performed, mood, and type of thinking.

2.23 Noise and Sound

While some elements in a creative environment should be promoted, noise should be avoided. However, sound may help in controlling noise. Martens (2011) stated that interviews expressed that noise was an element that could inhibit creativity (p. 71). Noise, or unwanted sound, is a general stressor. It can make an individual lose focus or have a hard time concentrating (Korwowski, 2006, p. 797). Bursts of noise are particularly distracting (p. 866). According to Korwowski, "A series of studies has shown that speech at low levels can disrupt

memory for items processed visually." This includes disrupting thought for activities like reading or writing (p. 805). It may also include other cognitive and visual tasks that would be abundant in the design profession. Noise as low as 68db can impair performance (p. 805). Controlling noise levels should definitely be considered in a spatial design that is trying to enhance creativity as distractions can break one out of creative trains of thought.

Propst (1968) discussed how different levels of ambient sound affect the office environment. He stated that cubicle offices often have low ambient sound levels, which causes problems such as "speech becom[ing] a high contrast event, difficult to suppress as understandable communication in adjoining areas." He claimed that maintaining a reasonable amount of ambient or masking sound levels would help with speech privacy. He stated that the goal is achieved not through the suppression of sound but its accumulation. According to Propst, "With a masking sound level of 45 to 55 decibels, the office becomes a natural privacy zone structure." Voices have "a zonal projection radius of about 8 to 12 feet." Propst compared this office technique to that used in restaurants that have "zonal privacy because of high ambient sound levels." According to Propst, "This is a usable and understandable state of sound conditioning that an office can utilize" (p. 62). This technique could also be utilized in creative design spaces. With ambient sound, what would be higher contrast distractions would be less noticeable as they would be masked by the ambient sound. It also makes sense that headphones could be used to mask unwanted noise in a similar way that ambient sound does.

The *Third Teacher* (Peterson, 2010) provided strategies for enhancing wanted sound and controlling unwanted sounds in the learning environment. For promoting good hearing in a room, *The Third Teacher* suggested "a quiet background" and "control of reverberation and self-noise." Some strategies for controlling undesirable sound include minimizing noise intrusions

from outdoors, minimizing interference between rooms, and having a quiet ventilation system. *The Third Teacher* provided suggestions for controlling sound dealing with different elements in the rooms. For the ceiling, it is beneficial to have "acoustical ceiling tile with noise reducing co-efficient of .70 or higher." For walls, "surface-mounted fabric-wrapped panels with either a sound-absorbent or sound-diffusive core" would help. For front walls, sound can be reflected to the rear of the classroom with hard wall surfaces. Materials like carpeting on the floor can help absorb sound. Soft furniture can also help absorb sound (p. 42). Some of these techniques could possibly be applied outside of education to control sound.

In a creative environment, noise should be avoided as it can distract, breaking one's train of thought. Ambient sound may be used to mask some of the negative effects of noise. Certain materials could be considered in the design of the environment to enhance wanted sound and control noise.

2.24 Materials

Materials can also play a role in making an environment conducive to creativity. McCoy and Evans (2002) and Ceylan et al. (2008) looked at the relationship between materials and perceived creativity as part of their studies. According to McCoy and Evans (2002), "Manufactured or composite materials had a strong negative correlation with creativity potential whereas natural materials had a positive correlation, implying that enhanced creative performance is perceived in a room in which some identifiable natural material can be found." They continued, stating that "the amount of texture of wood grain was found to be positively associated with creativity potential," and "the presence of glass appeared to enhance ratings of creativity potential" (p. 415). While McCoy and Evans found natural materials as well as glass

were perceived to beneficial to creativity, Ceylan et al. (2008) did not find a significant relationship between creativity and materials in their perceived creativity study (p. 599). However, Ceylan et al. stated earlier in their publication, "The type of materials (manufactured or natural) used in the work environment also may affect mood and creativity. It may be argued that natural materials could affect mood similar to plants" (p. 590).

McCoy and Evans (2002) argued for a mix of both natural and manufactured materials in a creative environment. According to their study, "Though certainly strength and permanence have value in built environments, a tempered mix of permanence with the malleable or manufactured or composite with natural materials appears to be more conducive to creativity. The exclusive use of manufactured or composite materials, by their very nature, also tended to produce environments with little texture or visual complexity" (p. 421)

The Third Teacher (Peterson, 2010) suggested for learning environments creating "a multi-sensory setting with surfaces that are smooth and rough, wet and dry, opaque, bright, translucent, and transparent. Have features that change over time (wood, stone, flowers, fabrics) or remain unchanged (glass, steel)" (p. 178). This advice for having different materials may also be useful in stimulating people in a space meant for creativity and design.

According to the literature, it seems that natural materials in the environment can enhance creative thinking, but an ideal creative environment calls for stimulation through a variety of both natural and manufactured materials.

2.25 Furniture

Furniture also plays a role in the design of an environment conducive to creativity and design. McCoy and Evans (2002) stated,

> Furniture is an integral part of any interior environment. Its presence alone appears to be an indicator of some creativity potential, perhaps due to the viewer looking for comfort, but perhaps more important is its ability to promote social interaction: a sense of cooperation, and even collaboration…The presence of furniture with its sociopetal arrangement may be a cue that the visitor is welcome and could receive social support in that environment. (p. 420)

McCoy and Evans found furniture "to be highly correlated with creativity potential." They went on, "Furniture, rated for its potential to promote social interaction, suggested that a high degree of social potential also implies a high degree of creativity potential" (p. 415).

Chism and Bickford (2002) argued that when designing rooms, furniture, architecture, and technology should be designed to "work seamlessly and harmoniously" (p. 35). Furniture design must consider functionality, comfort, safety, health, usability, and psychological appeal (Chism and Bickford, 2002, p. 35). Clearly, the furniture should perform for its intended use. The furniture should also promote the well being of the user. The furniture should clearly communicate how to use it and what to use it for, and the furniture should motivate the user to continue to use the piece (p. 35).

Chism and Bickford claimed that educational furniture has become more comfortable and flexible as well as more accommodating of information and technology. They stated, "Furniture also now plays a role in making learning environments more fun and dynamic, even more inspirational" (33). Inspirational furniture can be seen in the creative business world.

Figure 11. Bloomberg Inspirational Furniture. (Groves, 2010).

Figure 11 shows an area within Bloomberg's headquarters that has green and white furniture inspired by trees (Groves, 2010, p. 38). Figure 12 shows an image of a conference room at Philips Design where the furniture in the space provides the majority of color in a cool grey room, with a table made from recycled wood, and chairs with various bright colored fabric (p. 171).

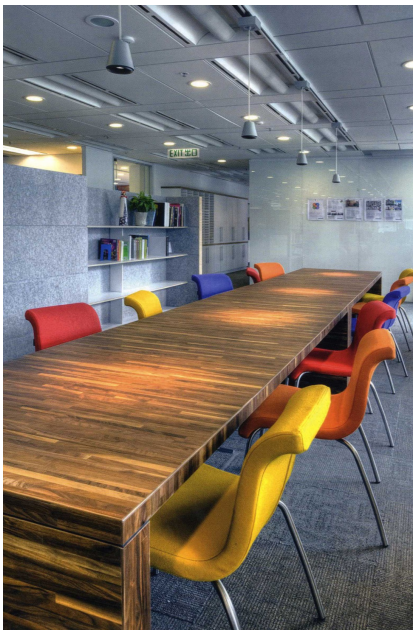

Figure 12. Conference room at Philips. (Groves, 2010).

Furniture can play a role in adding to the overall stimuli in the environment and inspiring designers. While furniture can be an inspiration, it is also beneficial to look at how furniture can be detrimental to an environment, so as to know what to avoid. Kopec (2006) explained the link between sitting for extended periods and physical stress in an educational setting:

> Researchers support this concept that young people who sit for long periods of time accumulate stress to their back muscles, ligaments, and discs and that the incidence of back pain correlates to increased sitting time. Again, students who move around in their seats attempting to find comfort are not paying attention to school work because their physiological needs supersede their cognition demands. (p. 196)

Kopec (2006) also discussed the negative consequences of poor ergonomics:

> The poor ergonomic design of the chairs, coupled with the length of time students are expected to remain seated, can lead to lower back pain, which has become a major health concern in industrialized nations. Musculoskeletal fatigue and pain can cause students to focus more on easing their discomfort than on the subjects they are learning because the human brain is configured to satisfy physiological needs before cognitive needs. (p. 191).

Ergonomic furniture reduces distraction and stress by increasing comfort, thus improving learning. Kopec (2006) gave several guidelines for designing ergonomic educational furniture, saying that the furniture should comfortably allow for students to lean forward to read or work on their desk and allow for students to lean back and listen or watch as they learn. A seat that is tilted forward helps to alleviate back strain by increasing the angle between the trunk and the thigh. Furniture should also be moveable (p. 197).

Chism and Bickford (2002) also gave suggestions for ergonomic furniture:

> Even when we sit, we should still be able to move. Chairs that have flexible backs are preferred because they allow greater occupant movement and positioning. The tension in the back should be adjustable to accommodate the large and small user. Upholstery with adequate foam – usually in excess of one-inch thickness – will reduce pressure points on the back, buttocks, and legs. A waterfall front seat edge is better than a right angle for circulation and comfort. A seat height adjustment range of sixteen to twenty-one inches is available on many chairs. (p. 36)

Adjustability may provide students with varying work heights or furniture they can adjust to fit their needs specifically. If adjustability is included in the design, certainly, the design should communicate how a piece is adjusted. However, just because an environment provides adjustability, it does not necessarily mean the user will take advantage of the adjustability. Chism and Bickford (2002) discussed how adjustability is not fully realized in an educational setting and provided helpful suggestions on getting users to adjust furniture.

> Experience shows that instructors and students take the room as is, rarely moving tables or even adjusting seat height. Making the functions easier, providing training or orientation, and posting suggested room layouts all help people make better use of the environment. (p. 36-37)

According to *The Third Teacher* (Peterson, 2010) flexible and adjustable furniture is beneficial to the user's concentration. This book suggested students should be given "furniture that lets them twist and lean safely." According to *The Third Teacher*, "the movement will increase their ability to concentrate." A study cited in the text showed, "The more adjustable the furniture was, the more frequently students varied their postural behaviors. The results further showed [in 'attention endurance' tests designed to record the students' attentiveness and ability

to concentrate] that giving students increased opportunity to move while seated – rocking, swiveling, and rolling – triggered far-above-average levels of concentration during test taking" (p. 87).

Chism and Bickford (2002) stated that for multiple uses, a height of 28.5 inches is ideal for a working surface. This height allows for the use of computers, reading, writing, drawing, and collaboration (p. 36). Evans (2008) took a survey of various higher education design programs and found that approximately half used standing work height desks of more than thirty inches high, while the others used lower work surfaces (p. 31).

Propst (1968) discussed the "need for separate work units," that allow for performing multiple responsibilities that need different treatment. According to Propst, "The size of the stations can and should vary radically but the important thing to recognize is the necessity to separate substantial tasks into established work locations" (p. 23).

Propst argued for the consideration of complex tasks and "the frequent need for multiple kinds of performance in a single work station." Propst discussed the Action Office II concept, which allowed for "highly varied work stations," permitting "a significant degree of adjustment and selection by the user himself." Propst claimed the user "can shake down [the] facility until it works and [the user] can change it as [their] work restructures," because of the "modularity and system coherence" of the Action Office II (p. 50).

According to Propst, "The traditional office which places a man behind a desk in a single static work situation imposes many limitations for the person conducting intense office activity," and is "most serious fault is that it provides no reasonable options for the physical or the functional task variations of the office" (p. 52).

Propst discussed the arena concept that "emerged from Action Office II research indicating considerable advantage to providing more than one work station and more than one exposure position to the opening of the office." The concept allowed the user to turn freely in a small work arena "to a set of separate work surfaces and at the same time, be free to face or not face an opening." An open "U," created by the placement of "the work stations around the arena edges," faces the entrance. According to Propst, "This open "U" allows mobility and variety in desk tasks and exposure. It also provides more options in conference involvement with others because, again, it gives the user options in how he meets and deals with a visitor" (p. 52).

According to Propst, "The term "work vector" describes particular station positions a user faces in an Action Office II arena arrangement. Located in the arena center he is free to turn and use a suitable work surface, console or conference expression." Propst stated, "A typical Action Office II arrangement would have perhaps three work station components occupying about 240 of the arena" (p. 53).

Designs inspired by Propst's "work vector" oriented Action Office II could be useful in supporting different and separate activities in the design process such as sketching, research, prototype building, and computer work. However, implementing this type of design may be harder in an environment in which space could be limited, such as education.

Another option investigated by Kopec (2006) explored the use of soft furniture in classrooms allowing for a comfortable area for students to work. Students may move between soft and hard furniture, moving around, relaxing, and learning, instead of being pinned in a hard seat all day (p. 196). These techniques may also be employed in an environment outside of education. Groves (2010) showed Innocent Drinks provides designers with quiet "cozy, secluded

nooks" with some soft furniture for designers to get away "from the buzz of the main space" (p. 104).

Furniture definitely plays a role in the design of an environment that supports creativity and design. The furniture should be comfortable and adjustable, to accommodate users and keep their focus on their creative work. The furniture should support the tasks performed in carrying out creative work. Soft and hard furniture may be used in a creative environment. The furniture itself may also be an inspirational part of the environment.

2. 26 Furniture Arrangement

According to Doorley and Whitthoft (2013), "Consciously or not, we feel and internalize what the space tells us about how to work" (p. 5). Kristensen (2004), in her research on environments supporting creativity, discussed how activities should be supported by the floor plan and layout of furniture. According to Kristensen, a circular structure can help groups meet and "discuss preparations or feed new information into the system, while linear spaces make these activities more difficult. Kristensen stated, "Often, meeting rooms or lecture theatres are used in sharing information. But these are usually intended to communicate the ideas form one person to an audience, not the audience sharing information." Kristensen argued that "a centralized or radial shape" would work well because "communal space can be realized at the centre of the creative space." She claimed information, tools, and "earlier successes" could be stored in the middle. According to Kristensen, "In situations where multiple disciplines work together, the need for a central location and information system may be vital." Kristensen argued that "more advanced forms, such as clusters or grids, may improve the space, allowing special attention to be given to the specific requirements of tools, e.g. visual or prototyping" (p. 92).

Impressions of a learning environment may be formed early on. For example, Chism and Bickford (2002) argued that when students enter a classroom, they "form an impression of the environment and experience an associated emotional response" (15). Chism and Bickford argued that a particular space predisposes people to certain behaviors. They gave several examples of this, saying that the way furniture is arranged affects whether people think the environment is for listening or for interacting. They claimed that casters suggest moveable furniture, while desks in rows suggest a lecture setting, and arrangements of tables facing each other suggest a collaborative environment. Table size and shape can also affect how one views how they should use an environment. Smaller sizes may not allow people to collaborate (p. 37).

According to *The Third Teacher* (Peterson, 2010), flexibility is also important, as "a learning space that can be reconfigured on a dime will engage different kinds of learners and teachers" (p. 89). Flexibility should also allow a space to more readily change if needed to support certain activities in the creative and design process.

It seems that the layout of a space can communicate the intended purpose of the space to users. Therefore, a space facilitating creative and design processes should have layouts that support the activities undertaken. Kristensen (2004) argued that a central layout would be beneficial for some activities important to the creative process and design process. Groups of desks would be best if collaboration is intended. In any case, an arrangement that readily allows for change in a creative space seems important to accommodate for different activities in the creative process.

2. 27 Tools

According to Doorley and Witthoft (2013), tools should be kept visible for instruction and inspiration. Doorley and Witthoft stated, "Enhancing access to supplies and tools is absolutely crucial, as people tend to engage with only those items that are near at hand. Showcasing materials and supplies accelerates the potential for those magical moments of creative inspiration" (p. 143).

According to Antonelli (2001), "Design is concerned with building our relationship with [tools such as electronic devices] and with the environments and workstations. It is also bound to ensure that these devices help us to be more creative and efficient by making them easier and more comfortable to use." Antonelli argued that old tools should not be forgotten, claiming, "The future will move in this direction: while technological devices will be scaled down and linked to a network, we will maintain our structural attachment to some traditional tools such as a pen, pencil, eraser, paper, and Post-it notes. This should be the paradigm for design at all levels" (p. 11).

Lawson (2006) claimed that the computer should be considered a tool for the designer that could aid in designing (p. 282). Surely, computer use should be considered in an environment that supports design and creative process.

Glaser (1997) discussed the relationship between electronic tools, space, and mobility:

> The greatest changes in the workplace of our time, however, have their source in the growing presence of new electronic tools. For the fundamental workplace requirement – space itself – these changes, if greatly oversimplified, could be represented by two opposing tendencies.

The first of these tendencies is an increase in electronic equipment that has demanded more space. At the same time, electronic equipment has and is becoming increasingly miniaturized, requiring less space and promising unprecedented mobility. According to Glaser, "The proper response to both trends is a balancing act that requires constant adjustment" (p. 24). Glaser stated, "In many cases, of course, the effect of tools is much less direct. New tools change the way we design; new design changes our workplace; and then a new workplace changes our work" (p. 24).

According to Doorley and Whitthoft (2013), "Providing space to use tools and materials is as important as those objects themselves. Ample work surfaces and opportunities to make and display physical embodiments – whether robots, paper prototypes, or digital experiences – encourage people to create" (p. 143).

The tools used within a space and the activities they are used for should be considered in the design of a creative design environment. Tools should be accessible to support tasks and inspire. Computers and other electronics should be accommodated. There must also be areas and surface to use tools for creative and design tasks.

2. 28 People

The designer must not only consider the stimuli coming directly from the environment but also from people who enter the environment. Michael Brill, president of BOSTI Associates at the time, discussed the need for spaces that accommodate privacy and ones that accommodate interaction when he was interviewed by Sarah Robins in *Workspheres* (2001). Brill claimed that "the ability to do distraction-free work" and having "enough acoustic privacy to concentrate" has a "most powerful effect" on people. He also claimed that "the ability to have easy, informal

interactions with people, which is clearly the primary source of learning and problem-solving" was important, "so that any work environment has to provide for" both privacy and interaction (p. 57).

The literature suggests that collaboration is beneficial to creativity. Groves (2010) specified collaborative spaces one of the types of creative spaces. However, privacy should help individuals concentrate, get into and stay in flow, which would also benefit creativity. Consideration for supporting privacy as well as collaboration depending on the activities is important in the design of an environment that supports creativity and design.

While supporting collaboration and privacy should be considered, crowding should be avoided. Crowding is a major issue that can cause "aggressive behaviors, lower task performances, poor memory, and feelings of anxiousness" (Kopec, 2006, p. 190). Kopec looked at crowding from an educational standpoint and claimed that during competitive times, "crowding [leads] to social and psychological withdrawal." He stated that "both crowding and density have a direct impact on students emotionally and behaviorally. Students who feel crowded will be less likely to develop relationships and may not perform as well in school" (p. 190). In addition, noise from other students or workers could distract, breaking creative individuals out of their flow state or their creative thought process or making it so that type of thinking is never achieved. Besides changing the physical room or building an entirely new building or learning environment, options such as color or workstation design and arrangement could be explored in trying to achieve an environment that is perceived as less crowded. This approach could be highly beneficial for a studio or other learning environment that has a number of people in a small space.

People can enhance or disrupt creative thinking in the design process, through collaboration or interrupting privacy. Both collaboration as well as privacy should be considered in designing creative spaces for design. Crowding should be avoided, and perhaps the design of the space could help people to perceive the space as less crowded. Interaction between people should be supported, but minimizing people from distracting each other should also be supported in creative spaces for design.

2. 29 Display

According to Doorley and Whitthoft (2013), "People get inspired by what's around them" (p. 143). Doorley and Whitthoft went on, "Take cues from toy designers: they engulf themselves with piles of inspirational junk, from simple balls to programmable microcontrollers. These bits and pieces pilfered from the guts of other toys are ready to be crammed into new configurations" (p. 143). Groves (2010) showed how designers at Hasbro surround themselves with toys and other inspirational objects in their workspaces (p. 90-93). Surrounding designers with useful information may also be helpful. Nike makes use of a curved wall to present "global trends and consumer insights" to be easily shared at their Consumer Cultures Center (p. 147).

Propst (1968) discussed the role of display in office culture. According to Propst (1968), at the time, "The suppression of relevant display is one of the most serious deficiencies in our present office culture and one of the factors most assuredly due for correction. This syndrome arises partly from a natural human desire to see our environment neat and controlled in conflict with an equally valid desire to surround ourselves with things meaningful, relevant and stimulating." Propst claimed that offices had at the time "made no effort to reconcile this conflict." Propst continued, "On the other hand, exceptionally able performers have frequently

thrown over this inhibition in favor of highly permissive surroundings, expressing with great pertinence things that count, that identify their very person and serve to motivate."

Propst argued, "Of even greater significance is the importance of sight as a window to mental recall. An office with no relevant visual display deprives the human performer of a spectacular recall tool: the human eye as a receptor for the mind." Propst claimed, "We have tended to overrate memory alone as a recall tool and, as a result, this performance for most people is highly uneven, easily biased and unresponsive to the relative importance of stored information. An eloquent display will always speak, and do so with great efficiency. The only caution is to keep it alive and relevant. Exhausted display is invisible. That offices must now permit display is imperative. It explains our work, defines our individuality and relieves our memory" (p. 21).

Achten (2008) stated that visualization through sketches, models etc. can store information and help designers, who as human beings have limited memory capacity, to quickly recall information (p. 22). Therefore, visualization display should be supported in an environment conducive to design and creativity. Visualization display may be more important in the later stages of the design process. Lawson (2006) stated that understanding the needs of users was important for designers (p. 13). It could also be beneficial to display user research so that designers may also recall that information quickly. The display of information is also important in sharing information with other designers, people, or clients.

The display of information, visualization, and inspiration is important in the design of a creative space for design. Display can help with memory recall, which should free up thinking for further creativity. Personal items or inspirational materials could also be displayed to motivate and inspire users in their creative activities.

2. 30 Smart Technology

Smart technology could also play a role in supporting creativity and design. In *Workspheres* (Antonelli, 2001), six design teams were commissioned by the Museum of Modern Art "to propose realistic solutions that address contemporary issues balancing work and life for the *Workspheres* exhibition" (p. 211). One of these projects, called "personal skies," was by Naoto Fukasawa and IDEO, Tokyo. The project dealt with maintaining personal areas within an organization and involved "the design of a network of collaborators and [considered] human behavior and social relationship." The project consisted of "two tools that can enhance individuality and privacy: a chair that changes color; and a personalized environment." According to *Workspheres*, "The chair and environment are poetic gestures that bring a sense of humor and whimsy to the workplace. The chair adapts to the clothing of the user like a chameleon." The other part of the project also was unique to the user as it projected "the ceiling of choice above one's desk." The user would be able to "use images of the sky in various seasons and weather conditions or a particular location, one's home, or a favorite vacation spot. According to the text, "Like the screen saver on one's computer desktop, the projected image not only delineates the user's space, but also sends a visible personal message to the rest of the office" (p. 217). Control over stimulation in the environment through the use of technology like that in Fukasawa's project could help set the mood in a creative environment, especially if screens could be used to display nature or inspiration not normally found in the environment.

Streitz et al. (2005) explored ambient intelligence and smart technology as part of the environment. The authors discussed that computers would disappear in the environment, as they became more invisible and more incorporated into the environment. They explored the issue of

how people would interact with these new devices in the environment (p. 22). They came up with *Roomware*®, which supported "productivity-oriented" processes through "large interactive walls and tables and multi-user interfaces and software support for brainstorming in electronic meeting rooms." Interactive walls such as *Roomware*® could be beneficial in letting designers display and share information.

Streitz et al. also looked at the use of smart technology for ambient display. The authors "considered that a smart environment based on a calm, ambient technology would best support the informal social encounters and communication processes." They developed the Hello.Wall, which was an ambient display that expressed different patterns in different situations. The patterns could express three different levels of mood and three different levels of presence (p. 23). They also discussed how multimodal stimulation could add to the immersion of gaming. According to Streitz et al., "The modes to stimulate are manifold, ambient light or sound or even creating wind with a simple fan can add to the multi-modal stimulation of the players" (p. 24). While applied to gaming by Streitz et al., similar technology could be used to change the ambient mood in an environment intended to stimulate creative thinking.

Interactive surfaces and smart technology could help display and share information as well as provide ambient mood support. Technology such as this could be particularly beneficial in supporting creative and design processes because an interactive surface could change what it is displaying to support different processes, activities, thinking styles, and moods.

Chapter 3: Recommendations for Designing Spaces to Support Creativity and Design

In supporting creativity and design, the space should support the creative and design process and the thinking and activities involved in these processes; the space should also be stimulating and supportive of positive mood and comfort in supporting creativity.

Supporting creative processes involves support for preparation, incubation, insight, evaluation, and elaboration. Both convergent and divergent thinking should be supported as divergent thinking is used to come up with different ideas and connect ideas, while convergent thinking is used to analyze and evaluate ideas. The environment should promote attention, concentration, and flow. Part of this involves minimizing distraction. The space should also stimulate the user. The space should support positive mood and health as much as possible, as support for these things tends to support creativity as well (Dul & Ceylan, 2011, p. 18).

For design processes, this means support for exploration of both problems and solutions as well as the processes of analysis, synthesis, and evaluation. The exploration of problems could involve research on users or other designs or elements of designing. Display of this research should be supported so that information can be recalled and analyzed more quickly. Supporting visualization and its display is also important in supporting design processes.

3.1 Consider Different Spaces or a Flexible Space to Promote Different Activities in the Creative and Design Process

Because creative and design processes involve different types of thinking, and because activities in the processes can change as the process moves forward or depending on the project, different spaces may best accommodate the changing needs throughout a creative design process. Flexibility can accomplish the same goal. Casters on furniture, adjustable furniture, and adjustable features such as lighting are important in supporting multiple creative design activities.

3. 2 Support Convergent and Divergent Thinking

Both convergent and divergent thinking should be supported in a space conducive to creativity and design, as both types of thinking are used. According to the literature, it appears that different lighting can promote either convergent or divergent thinking. Dimmer lighting, because it should promote more feelings of freedom (Steidle & Werth, 2013, p. 76), may be used for divergent thinking, while brighter lighting, associated with more analytical thinking (p. 78), may be used for convergent thinking. If there is one space that supports creativity and design, which both involve convergent and divergent thinking, providing adjustable lighting seems important. Divergent thinking may also be aided by having more stimuli for welcome distraction. Bringing in nature and other stimuli could help promote divergent thinking. Certain design activities could be geared toward convergent or divergent thinking. In this case, the environment providing access to the necessary tools is important.

3.3 Support Collaboration and Privacy

Since collaboration is supposed to be beneficial to creativity and it is certainly used in businesses, while privacy could help an individual focus on their creative endeavors without distractions, both collaboration and privacy should be supported in the design of creative spaces. This may involve separate spaces entirely, or it could involve an environment that is more flexible to change between supporting collaboration or individual privacy. Groupings of furniture facing each other should help to communicate a collaborative area (Chism & Bickford 2002), while furniture laid out around a central area can help users share tools and information (Kristensen 2004). Communal information sharing tools should be available to in collaborations. Tools like Post-it notes, bulletin boards, and white boards should help users to communicate with each other. It is also possible that computers or other digital devices could aid in communication between designers.

Privacy should be easier to support if private areas are more separated from the activity of collaboration areas. In some spaces, this may not be an option. More spread out and less grouped furniture should communicate less collaborative work. Dividers could be explored in separating individuals. Manipulation of ambient sound between 45 to 55 decibels could help to mask noise from other individuals (Propst, 1968, p. 62) and help an individual focus.

In supporting privacy as well as collaboration, it could be that separate spaces or areas are designed to promote one or the other, or it could be that a space is designed to be flexible in order to switch between the two. Things like casters and adjustable partitions should help in the environment being more flexible.

3. 4 Support Creative Preparation and The Early Stages of the Design Process

According to Csikszentmihalyi (2008), a more comfortable, familiar environment should support preparation (p. 159). Information absorption should be supported by the display of research and inspiration. Information sharing can be supported in a similar way and could involve using tools like Post-it notes, bulletin boards, whiteboards, and electronics. These tools should be available in the environment. Information could be displayed on surfaces intended to be communal for collaboration, or individuals could have their own surfaces or tools to display information to themselves.

Specifically, in the design process, the imagery displayed and shared in this phase could involve information on users' needs, other products, other inspirational imagery, exploration of problems, preliminary solution ideas, brainstorming, and design goals, among other things. The specific imagery displayed can change depending on the project.

The creative process and design process are not quite linear and could involve taking steps forward and then going back and then forward again, and research can continue to be performed throughout the design process to further understand a problem. Also, imagery can help designers recall information quickly, and display of information and inspiration could spur an idea down the road. For these reasons, it could be beneficial to keep information from the preparation phase displayed later.

There could be some initial sketching at this early stage as well as computer work, and these activities should certainly be supported by the space if they are taking place. However, the main goal at this time is to support the display and sharing of information to understand the problem and take in information that will be helpful later in the creative process within the design process.

According to Kristensen (2004), the preparation stage could "require a combination of communal and private space" (p. 95). This could involve following the recommendations for making collaborative and private areas. The amount of collaboration will probably on the project.

While the preparation phase is said to involve more convergent thinking (Haner 2005, p. 294), there may also be some divergent thinking early in a design process with designers generating preliminary ideas. Adjustable lighting should be part of the space to allow for brighter light to promote convergent thinking and dimmer light to promote divergent thinking.

3. 5 Support Incubation for Design

Kristensen (2004) claimed the preparation space could be used as priming for incubation (p. 90). Certainly, one can think and let ideas connect in the same space used for preparation. Since incubation involves more divergent activity (Haner, 2005, p. 294), it should be helpful to have lights that may be dimmed for the preparation phase. An area that one can relax and think could be beneficial to incubation. More private areas could also be helpful, as Kristensen (2004) stated that the thinking processes within incubation "seem to be essentially a personal or private affair" (p. 90). The incubation stage could call for more and different stimulus than the preparation phase. Stimuli such as nature to distract one enough to let designers' thinking flow more freely should also be helpful in this phase.

If the incubation space is in a different location than the preparation phase, the entirety of the design could be devoted to promoting incubation. If the activities occur within the same space, having an adjustable environment should be beneficial in supporting the different type of thinking. Nature could certainly be brought into the space. Adjustable lighting should be

beneficial in promoting incubation. Dimmer lighting could promote divergent thinking. Lighting temperature could be changed to change the ambient feel. Smart technology could be used to provide more ambient stimuli through displaying imagery on screens. Ambient sound could be used to mask distractions from other and could provide welcome stimulus to promote looser thinking.

There could also possibly be a particular area that is dedicated to incubation within a larger space that accommodates multiple creative activities. However, the proximity of this space to other individuals may provide too much distraction.

3. 6 Support Creative Design Insights

A creative insight can happen anywhere according to the literature. Csikszentmihalyi (2008) claimed that the insight could be catalyzed from a more stimulating, beautiful environment like one that would benefit incubation (p. 159). For an insight to happen, one would also need information to reflect upon and connect ideas with. Therefore, while insights can happen anywhere, the recommendations for preparation spaces and incubation spaces could help in bringing the insight to the surface of the designer's conscious mind.

Since the design process and creative process can be iterative, and neither process is exactly linear, insights can continue to happen. An insight could also happen later in the design process through visualization, testing, or analysis. Therefore, recommendations for later stages in the creative and design process could also benefit insights. While an insight can happen anywhere, the recommendations for the other stages of the creative process and design process could also support an insight happening.

3. 7 Support Elaboration and Evaluation and Visualization in the Later Portion of the Design Process

Elaboration and evaluation could benefit from some of the same recommendations for preparation. Within design, visualization is important in exploring and testing ideas and moving forward. Support for visualization is important in these later phases. The display of any prior visualization and research is important as it allows a designer to recall information and move forward in their thinking faster. As visualization increases however, more space may be required to display said visualization. If elaboration, evaluation, and the visualization involved in design are occurring in the same space as previous phases, at this point, it may be useful to display the most relevant and perhaps summarized and finalized information from the research and preparation phase, while doing away with other information, to make more room for supporting the display of visualization. In the same way that the display of imagery has shifted to visualization, work stations and the tools provided may also be more geared towards visualization and testing, rather than information sharing. Although sketching can be used throughout the design process, later in the design process, typically activity may involve more computer work and modeling building. All of these activities should be supported with appropriate furniture and tools.

3. 8 Support Visualization Throughout the Creative and Design Process

The space should continually support the exploration of problems and solutions in the design process. Visualization should be supported in the space, as visualization can help the designer analyze and further develop solutions. This could involve sketching, model building, and digital work, as well as the testing and analysis of prototypes. Appropriate tools should be

accessible for prototyping and testing. Earlier in the process, in terms of visualization more support for sketching may be needed, while later in the process more support for modeling making, digital work, and rapid prototyping will be needed in the space. Making visualization should be supported by providing access to the proper tools for the visualization, whether the visualization is through sketching, model-building, or computer use. Supporting sketching could involve providing pens, markers, straight edges, different papers etc., while supporting model building could involve providing certain materials, cutting tools, and adhesives, among other things. The specific tools could vary according to the specific project or personal preference. Digital work may involve supporting computers and accompanying electronic tools like extra monitors or tablets etc. Certainly, power would need to be accessible for computer work.

Appropriate work surfaces to use visualization tools should also be present. Depending on the size of a model, it may be more appropriate to have a larger work surface than one would need for sketching or computer work. Computer work could have its own dedicated area or it may be that users choose to work off of laptops on more multi-functional surfaces.

The display of visualization after it is made should be supported in creative design spaces, as looking at previous visualization can help designers recall information, freeing attention for further creative thinking.

3. 9 Provide Ample Display Space for Information, Inspiration, Visualization etc.

Inspiration could spark an idea. Looking at information and visualization can help designers recall information quicker, freeing attention for further creative work. Information could also be shared between designers in the design process. Plenty of display space should be provided in a space supportive of creativity and design. This could include items such as pin-up

spaces, surfaces to tape ideas on, and whiteboards. Electronic surfaces could also be used for the display of information, inspiration, and visualization.

3. 10 Support Personalization

According to the literature, it appears that a more personalized space is beneficial to creativity. Areas within a space designed to be personalized could help promote creative thinking. Designers could have areas to display personal items or imagery. They could even adjust and change areas of a space to fit their specific inspirational needs. While not related to the initial design of the environment, personalization could also be encouraged or utilized by people that use the space.

3. 11 Support Flow

Flow should be supported in an environment conducive to design and creativity through the support of attention and concentration. Masking noise with ambient sound should help minimize distractions. Nature is said to restore attention, which could be beneficial to flow. An environment more personal to the user and that reminds him or her of their goals may be beneficial as well. The environment should also support the creative or design task the designer is undertaking as flow involves concentration on the task.

3. 12 Promote Good Mood and Health through Ergonomics and Ambient Elements

Things that are beneficial to mood and health tend to also benefit creativity (Dul & Ceylan, 2011, p. 18). Good ergonomics is important in the environment so designers can focus on their work and not their discomfort. Ambient elements in the environment such as color, light,

furniture, smell, and sound should also be considered to further support good moods. Personalization of the space may also help in supporting mood.

3. 13 Fill the Environment with Adjustable and Flexible Furniture That Could Be Either Soft or Hard

Adjustable furniture can allow for designers to become more comfortable, which could affect their mood. Furniture that allows users to move, whether through swiveling, rocking, or other motions improves attention, which should be beneficial to creative and design thinking (Peterson, 2010, p. 87). Soft and hard furniture could be used in the space to provide variety and communicate different feels for different area.

3. 14 Consider How the Layout of Furniture Communicates and Facilitates the Task

A collaborative environment can be communicated by arranging tables to face each other (Chism & Bickford 2002, p. 37). Kristensen (2004) suggested that a layout around a central hub would help with communal information and tool sharing. If collaboration is wanted, this technique should be useful. For individual work, workstations could be spread out more. Furniture on casters should allow for quick flexibility to change the layout up for different tasks.

3. 15 Provide Appropriate Tools for Creative Tasks in a Space

Often creative and design work is aided by tools. It is important that tools be accessible for use and for inspiration. The tools could change depending on the specific task. Research and information sharing could benefit from tools such as whiteboards, bulletin boards, other types of pin up surfaces, Post-it notes, and computers. Different visualization methods will require

different tools. Sketching may require certain pens, pencils, and markers, as well as papers or sketchbooks. Digital sketching will require other tools. Model making will require different tools depending on the project. Materials will be needed, and other things like measuring tools, cutting tools, cutting mats, adhesives, sandpaper, paint etc. will probably be useful. The computer is a tool as well and can be used for information sharing as well as visualization, documentation, and building presentations. Access to computers seems important in fully supporting creative and design processes. Rapid prototyping equipment and nearby shops should also enable designers to quickly prototype and test creative ideas. The tools needed will change depending on the task, and tasks could also be carried out in different ways, but it is important that the environment accommodates the task at hand by making tools accessible.

3. 16 Provide Appropriate Furniture for Creative Tasks in the Space

While appropriate tools should be provided, so too should appropriate furniture. The furniture in the space should support the creative tasks that are undertaken. This means the designer should have room to sketch when needed, room to make models when needed, a space to use a computer when needed, space to display information when needed, etc. Larger models could require larger surfaces. Certain workstations could even be dedicated to specific tasks if room is available in a space.

3. 17 Provide Stimulation Without Overwhelming

According to the literature, stimulating environments are associated with creativity. Designers should feel stimulated and inspired in the environment, but should not be overwhelmed by it. The totality of elements of color, lighting, furniture, sound, smell, etc. should

stimulate the user. Engaging more senses is also tied to memory, which could help with creative thinking. A variety of lighting is suggested for a creative environment. Lighting should also be adjustable to promote different thinking and moods. Color should certainly be part of the environment. In addition to color, graphics on walls or other surfaces could be used. Furniture could also provide stimulation and be an inspirational part of the environment as well. Smell could promote cognition in different ways. The elements that make up the environment should stimulate and inspire in supporting creativity.

3. 18 Bring Nature Into the Space

Literature supports that nature should help with creative thinking as it provides stimulation, can inspire, and restores attention. Surely, nature should be viewable as much as possible in an environment that supports creative thinking for designing. Windows could allow for viewing the outside world, which may include nature. Nature can also be brought into a space with plants. Perhaps, nature could be hinted at with graphics or objects in the environment that resemble or remind people of nature.

3. 19 Use A Mix of Materials Including Natural Materials

Natural materials and specifically wood grain have been associated with perceived creativity. Natural materials should definitely be used in the design of a creative space. Glass has also been associated with creativity. However, a mix of materials including natural and man-made, aging and permanent may be best for a creative space.

3. 20 Make the Environment Colorful

While it is unclear if there are specific colors that directly enhance creativity, according to literature, color is something that people feel makes them more creative. It also can be a part of the overall stimulus of the environment. A variety of colors should probably be used and different shades and contrasting colors. Color is not limited to only walls: furniture, tools, objects, visualization, and graphics can provide some of the color as well.

3. 21 Provide a Variety of Adjustable Lighting

According to the literature surveyed, it seems that a variety of light sources is important in a stimulating environment. Adjustability of lighting is also important, as dimmer lighting can support divergent thinking and brighter lighting can support convergent thinking. Spot lighting could be useful in helping designers focus on a task. Natural light should certainly be helpful in supporting creativity, as it can increase concentration and can improve "feelings of well-being and health" (Peterson, 2010, p. 46). However, in some interior spaces, bringing in natural light would be very difficult.

3. 22 Control Noise Through Materials and Ambient Sound

Ambient sound between 45 to 55 decibels can mask other noises (Propst, 1968, p. 62), allowing a designer to focus on their creative work with less distractions. If a space has issues with getting too loud, panels wrapped in fabric with cores that are either sound-absorbent or sound-diffusive can help control the noise levels. Carpeting and soft furniture can also help absorb noise (Peterson, 2010, p. 42).

3. 23 Consider Adding Smell

In incorporating smells in the environment, certain smells like jasmine or lemon should be considered as they are associated with enhanced cognitive performance. Peppermint could be considered because it can be physically energizing. Cinnamon-vanilla smells may warrant consideration as they are associated with creativity (Augustin 2009). A pleasant smelling environment also may make people want to stay and work on their creative endeavors longer.

3. 24 Consider Incorporating Smart Technology into the Space for Information Sharing and Ambient Support

Smart surfaces could benefit creative and design processes by providing opportunity for information display and sharing as well as changing ambient visuals and sounds to affect mood and thinking and to inspire. Smart surfaces could be used to display inspirational or competing products, user research, goals, deadlines, and other types of information for the design process. Ambient visuals could involve showing images of nature, inspirational graphics or patterns. Ambient visuals would most likely benefit the incubation stage the most, providing more stimuli for supporting divergent thinking. Injecting sound into the environment could also help in adding stimuli for the incubation process, or in providing ambient sound to mask noise. Smart technology would allow for more flexibility in the environment to support different processes during different stages in the creative and design process.

3. 25 Consider Incorporating Opportunities for Play in Spaces

According to the literature, playfulness and play are associated with creative spaces (Haner, 2005; Groves, 2010). It could be beneficial to incorporate opportunities for play in a creative space. However, one must consider whether playing can disrupt the work of others in a space and whether playing should have a place of its own if this is the case.

3. 26 Consider Giving Spaces Unique Creative Identities

Spaces in the creative business world can often have unique creative identities that inspire workers and remind them of company values (Groves 2010). A space conducive to creativity and design could have a unique identity with elements of the environment coming together to support a certain mood or theme.

3.27 Summary of Recommendations

Figure 13 shows the recommendations and how some of them relate to each other. Recommendations are split up into categories of 'support for different processes,' 'task support,' 'mood support,' 'support for the individual,' and 'considerations.'

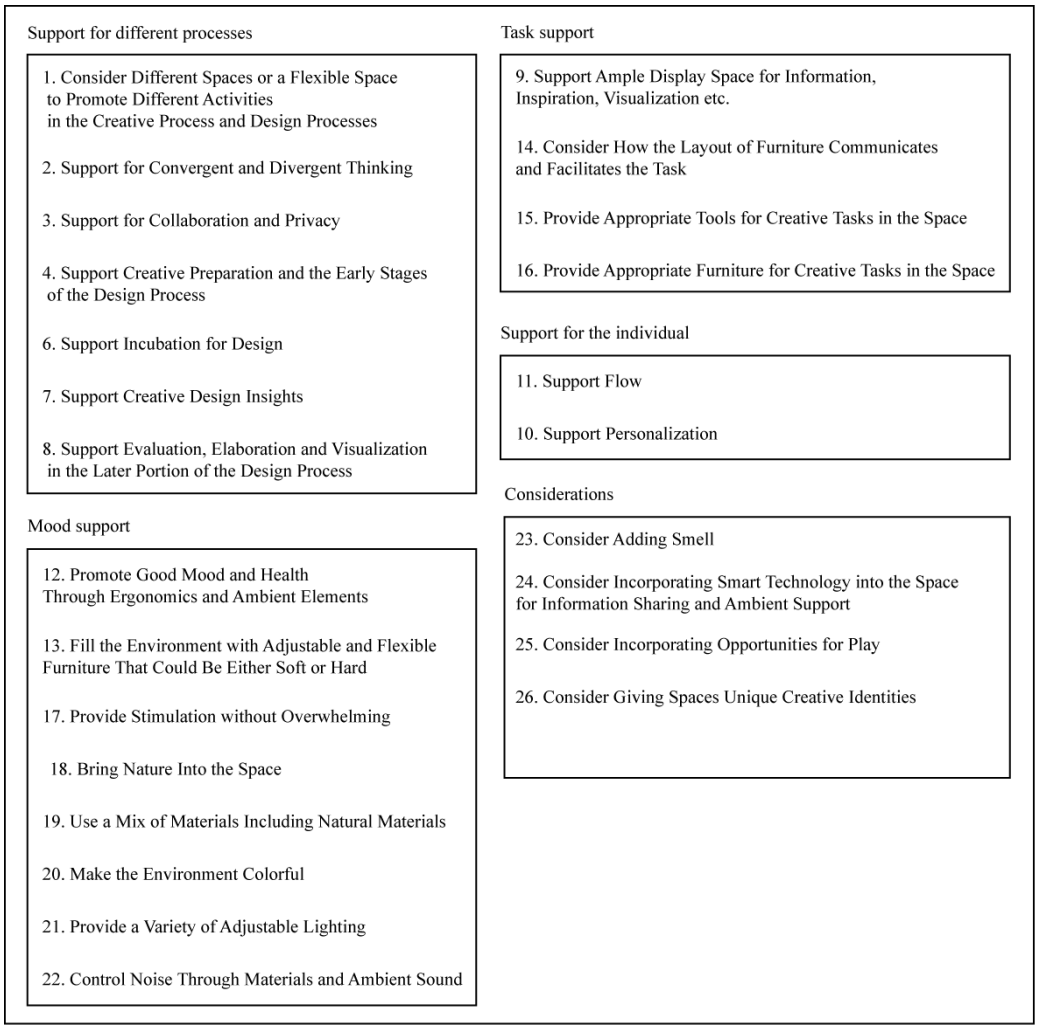

Figure 13. Summary of recommendations.

Chapter Four: Evaluation of an Industrial Design Studio Space Based on Recommendations

A higher education industrial design studio space was evaluated qualitatively according to the recommendations. Some aspects of the studios are adequate while other aspects could be improved. Figures 14 and 15 show the studio space.

Figure 14. Studio space 1.

Figure 15. Studio space 2.

4. 1 Different Spaces of a Flexible Space to Promote Different Activities in the Creative Process and Design Process

The studio is only one area. Research takes place here. Lecturing takes place here. Sketching takes place here. Small-scale model building takes place here. Large-scale model building takes place in the shop close by. Discussion between students and professors take place here. The entire creative process from preparation to elaboration takes place here. Students may perform tasks at home or other locations and bring work in.

The space includes a central area with a cutting mat and a paper cutter. Also in the center is a light table, which is used to display the most recent furniture models. The space includes 15 desks with storage underneath. These desks can be moved around, but they do not have casters, which would make moving far easier. Two walls are covered with pin-up space for displaying sketches, research, inspiration, and other things. Information is also taped to a third red wall with a whiteboard. There is an area dedicated to computer use with three computers on a longer table. Adjustable seats with waterfall front edges and backrests are provided at desks. The computer area has softer seats. Desks are arranged in quads for the most part, except that one of the four groupings of desks only has three. The space has overhead lights that may be turned on or off with no in-between. There is also a projector and a screen in the space used for presentations.

The space does not change that much over the course of the semester. Walls fill up with visualization and models are displayed, filling the space, and the light table and central surface may be moved around some to accommodate for bringing in larger models, but otherwise the space remains the same.

Overall, casters would certainly help in rearranging furniture if needed. Adjustable lighting could help with promoting different thinking and mood. Individual adjustable spot

lighting would also give students more control over their own space. Adjustable partitions or pin-up space could also help improve flexibility. Smart technology could be used for ambient support and information sharing. The central space provides an opportunity for supporting different tasks as the creative and design process moves along.

4. 2 Support for Convergent and Divergent Thinking

The space does not provide any adjustable lighting, which could support divergent thinking through dimmer lighting and convergent thinking through brighter lighting. The space also does not have very much extra inspiration other than previous visualization. A few students have posted up a few inspirational images. For example, one student has pinned up a football player while another has pinned up a beach scene and one more has an image looking out into a sunset. The pictures of the beach scene and sunset are the only representations of nature in the space. Some students have posted pictures of other inspirational furniture pieces. Still outside inspiration is lacking. Unrelated inspirational images may help students make more unrelated connections.

Overall, the environment has a bland feel as three of the four walls are beige and the furniture in the space provides little color. There could be far more color than only the one red wall and scattered personalization and visualization from students. Adding stimuli could help with divergent thinking. Adjustable lighting and smart technology could allow for a change of atmosphere to promote either convergent or divergent thinking. Bringing in nature, outside inspirational images, and increasing the overall stimuli and environmental load may also help increase divergent thinking.

4.3 Support Collaboration and Privacy

Desks are arranged in groupings facing each other, which communicates collaboration. The central area provides some communal tools like the paper cutter and cutting mat as well as a light table that also functions as a visualization display surface. The computer area also is communal. The whiteboard can be used for communal information. Students pin up individual visualization and information on the walls, but some students are closer to their area than others. Interaction between students can be good in an educational studio environment and this space supports that. Perhaps the central area could also support information sharing when needed.

The studio is not always filled up with students and so sometimes privacy may be achieved easier than others. However, adding dividers or spacing out desks more could help promote more privacy. Ambient sound could help mask noise from other students and adjustable spot lighting could help students focus and lower noise levels.

4.4 Support Creative Preparation and the Early Stages of the Design Process

The space provides plenty of pinup space and also has a whiteboard for information sharing and absorption. Computers are also available, which should be good for obtaining and sharing information. In the photographs, there is not too much information displayed besides visualization, so the space may not be used to its full potential for preparation purposes.

Individual surfaces close to students to display information and more of a communal information sharing area could help. The central area seems like it would be a good space for communal information sharing. While there is a large whiteboard on one wall and plenty of pin-up space, perhaps more tools like Post-it notes, bulletin boards, and more whiteboards could

help. Smart surfaces could also help display information during the preparation phase and allow for displaying other visuals at different times.

4.5 Support Incubation for Design

The evaluation of the area as a preparation space can be used to assess the space in terms of using the space as priming for incubation. The space does not support dimmer lighting, which could help promote more divergent thinking. The space doesn't really have a private area where one can go and reflect. The space is rather bland and has little stimuli and no nature other than two posted images. The addition of adjustable lighting and more private areas could help support incubation. More stimuli, especially of nature, could help promote the incubation stage. The addition of softer furniture could also help students relax.

4.6 Support Creative Design Insights

Insights can happen anywhere, including this space. Recommendations of other sections could also be useful in leading to more insights.

4.7 Support Evaluation and Elaboration and Visualization in the Later Portion of the Design Process

The space has plenty of pin-up space, which is good for displaying visualization. Desks seem to give students room to sketch and build scale models. There are some communal cutting tools in the center as well as the light table that is also used a visualization surface. Students can recall information from prior visualization. Students also have storage space under their desks to leave tools and materials. Large-scale models can be built in a near by shop and brought in. It seems

that more information displayed from research and preparation could be useful. More individual display space nearer to each designer may be useful. More communal tools and materials could also be useful. Perhaps, spot lighting could help students focus on their work.

4.8 Support Visualization Throughout the Creative and Design Process

Desks have room for sketching. Students bring in their own sketching tools. Perhaps, there is an opportunity for some kind of organizer. There also could be communal paper in the central area. Students also seem to have space for building scale models. In this particular studio, for the most part students provide their own model making tools and materials. Some studios may function differently. If materials and tools are provided, organization of communal tools and materials seems important. There are available communal computers for digital visualization. Students could also bring in laptops. Power strips are nearby for electronic use at a student's desk. However, these could be better incorporated. There is plenty of wall pin up space and the light table surface for displaying scale models. There could possibly be individual pin-up or display space incorporated into students' workstations. Larger model building can be done in a nearby shop in the building, and rapid prototyping equipment is accessible but not within the studio. Functionally, the space does a pretty good job of supporting visualization and display. One opportunity is for individual display space close to individual students and in their line of sight. Figure 16 shows the desks of some of the students using the space. Figure 17 shows communal computers in the studio. Figure 18 shows how students use power strips for electronic use at their desks.

Figure 16. Student desks.

Figure 17. Communal computers.

Figure 18. Power strip.

4.9 Support Ample Display Space for Information, Inspiration, Visualization etc.

The space has plenty of pin-up space. Information is also taped to the walls and whiteboard. Figure 19 shows how the light table is used as a surface to display models. Perhaps, a surface could be dedicated to the display of models, freeing up the light table. There is also an opportunity for individual display space other than the walls. Smart surfaces could also help display information.

Figure 19. Light table used as a surface for visualization display.

4.10 Support Personalization

Some students have pinned up inspirational images. Some students have brought in organizers to hold things like pens and markers. However, it seems personalization is not fully realized in this space. Perhaps, students could be encouraged to personalize their spaces more by hanging up more uniquely inspirational imagery or display more personal objects. An area incorporated into the individual workstations that allows for personal display could help. Unique desks may help give students more personal work areas. Figure 20 shows how a student has personalized their space with an inspirational image and a unique marker box.

Figure 20. A personalized space.

4.11 Support Flow

Computer speakers could be used to provide ambient sound to help mask noise. No actual nature is present in the space. Nature could be brought in to restore attention. Perhaps, spot lighting could help lower noise levels and help students focus. Personalization could help students by reminding them of their goals.

4.12 Fill the Environment with Adjustable and Flexible Furniture That Could Be Either Soft or Hard

The main seating in the space allows for height adjustment as well as swiveling and moving around. The computer chairs are also adjustable. This seating performs its function well. Perhaps, more soft furniture could be added to the space for relaxation and reflection.

4.13 Promote Good Mood and Health Through Ergonomics and Ambient Elements

The space seems to support ergonomics adequately as the main seating has backrests and waterfall front edges. Computer chairs are padded. Students seem to have enough space for their tasks. Certainly more ergonomic furniture could not hurt. Mood support seems lacking. The space could use more color, adjustable light, inspiration, personalization, perhaps smell and sounds. Figure 21 shows the main seating in the space.

Figure 21. Chairs in the studio.

4.14 Consider How the Layout of Furniture Communicates and Facilitates the Task

Workstations are arranged in three groups of four and one group of three. The groups communicate collaboration. Student interaction could be beneficial in a studio space. There is a central communal table with a cutting mat and a paper cutter, as well as a light table used for model display. There is also a communal computer area with a connected printer. Another disconnected printer takes up space. Seats are on casters that allow for moving, but desks are not.

Casters on desks could allow for quicker rearrangement if wanted, promoting collaboration or privacy as needed.

4.15 Provide Appropriate Tools for Creative Tasks in a Space

The space provides information sharing and display tools like the whiteboard and pin-up walls. Computers are also present. Students bring in their own supplies for sketching and models. For other studios, there could be communal tools and materials. Students have storage underneath their desks. Some of the tool accessibility responsibility seems to fall on the students in bring in their tools. If there were communal tools, the central area or an area easily accessible by all students seems like a good spot to arrange the tools. Figure 22 shows the communal work area with a cutting mat and paper cutter. The work area shown also provides a coffee maker, glue gun, and sharps container among other things.

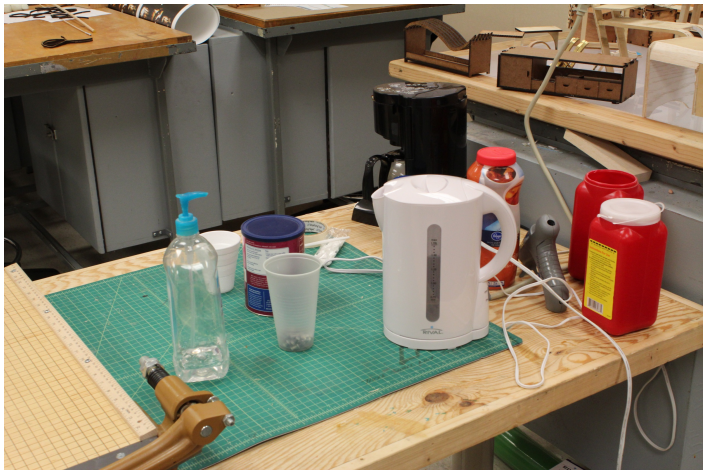

Figure 22. Communal work area

4.16 Appropriate Furniture for Creative Tasks in the Space

The desks provide room to sketch and make scale models. Larger models can be constructed in the shop near by. It does not seem as if there is space to give students multiple working stations for different tasks. The communal cutting table could be higher for standing use. The computer table seems adequate. Pin-up and display space could be incorporated into workstations so that it is closer to students rather than only on the walls. The central area could change throughout the semester to support more research and preparation based tasks in the early portion of the semester.

4.17 Provide Stimulation Without Overwhelming

The environment does not appear to be very stimulating. Figure 23 shows how the one red wall and student visualization provides most of the stimulation. There is opportunity for more personalization, more color, a variety of lighting, inspirational furniture, sounds, smells, and other inspirational elements.

Figure 23. Lack of Stimulation.

4.18 Bring Nature Into the Space

There is no actual nature in the space. There are only a few images of nature. Figure 24 shows how a student has pinned up an image of the outside world. The windows only provide a view of an interior hallway. This is a large missed opportunity for the space to bring indoor plants and objects or images representing nature into the space.

Figure 24. Pinned up nature.

4.19 Use a Mix of Materials Including Natural Materials

The desks have wood tops but they don't have the most interesting or prominent grains. The rest of the space is manufactured materials for the most part. More natural materials and more prominent natural materials could be used. A greater variety between permanent and aging materials could also be used.

4.20 Make the Environment Colorful

There is one red wall. The main seats are black. Computer seats are black and gray. Window and wall linings are gray. The majority of the space goes between beige, off-white, and light wood color. The space appears very bland other than the one red wall and some personal objects, images, and visualization from students. There is an opportunity to add more color on other walls, furniture, surfaces, and objects in the space.

4.21 Provide a Variety of Adjustable Lighting

The space provides one type of non-adjustable lighting. This is a missed opportunity. Incorporating adjustable light, spot lighting, and a variety of lights should help different types of creative thinking and processes.

4.22 Control Noise Through Materials and Ambient Sound

This space is not fitted with noise controlling materials. This may not be too much of an issue unless the studio is consistently too loud. Ambient sound could come from computer speakers. Students using headphones could also help mask noise.

4.23 Consider Adding Smell

Smells in the studio include those of wood and burnt wood. Studios can often smell like certain materials, burnt materials, adhesives, finishes etc. Adding pleasant smells could make people want to stay longer in the space. Peppermint smell could be considered for energizing people. Lemon and jasmine could be considered to enhance cognitive performance. Cinnamon-vanilla could also be considered, as it is associated with creativity. Students could have personal

preferences or associations for certain smells, so it is hard to suggest one specific smell to incorporate into the space.

4.24 Consider Incorporating Smart Technology

Computers are present in the space. There is a projector that can be used for display and presentations. Computer speakers can project sound. The whiteboards can be used for information sharing. Smart surfaces could be considered as an addition and would allow for changing back and forth between supporting information sharing, ambient display, presentations etc.

4.25 Consider Incorporating Opportunities for Play in the Space

Students can be playful themselves and with each other. Computers are available, which could be used for play. There doesn't seem to be too much specific support for play. However, this may not be a bad thing, as play could distract other students from working. A dedicated space for playing elsewhere could be beneficial.

4.26 Consider Giving Spaces Unique Creative Identities

The space does not have a specific creative identity. Giving the space a unique identity or theme could promote certain values and creativity.

4.27 Summary of Evaluation

Figure 25 summarizes the key findings in the evaluation.

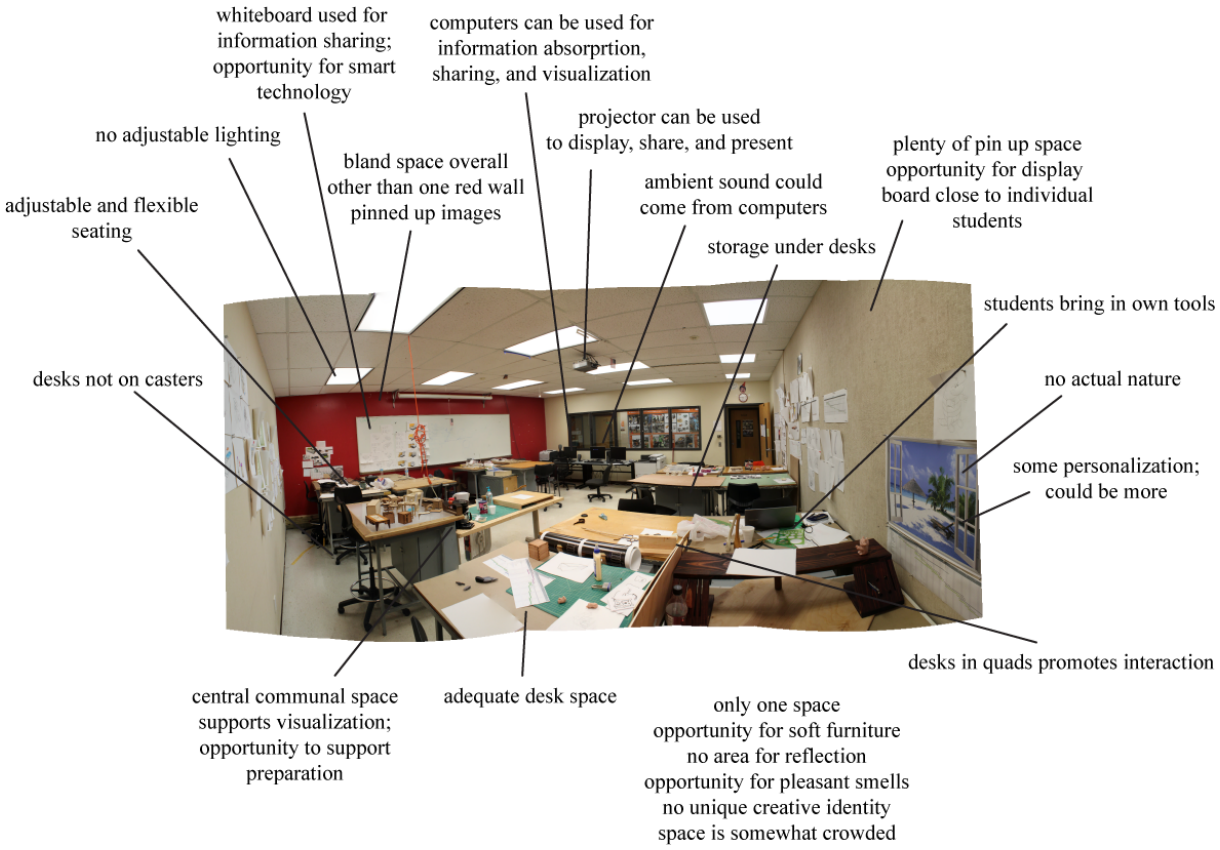

Figure 25. Summary of Evaluation

Chapter Five: Application of Recommendations Through the Redesign of an Existing Studio Space

A redesign was generated for the evaluated studio space according to the recommendations and the opportunities for improvements shown in the evaluation. A scale model of the studio space was built to show the design. The space was redesigned to be more flexible with furniture on casters, adjustable lighting, and a smart surface. Support for the different phases of the creative and design processes was considered in providing tools and surfaces to accomplish tasks. Some elements of the redesign were kept similar to the current studio in situations where the current space addressed recommendations. For example, the redesign features similar desk size and similar seating. However, the colors and materials of the desks and chairs has changed in the redesign. The redesign is far more stimulating through the use of material, color, lighting, etc. One quad of desks was removed in the redesign to prevent crowding. An incubation corner, where students would be able to reflect and relax, with plants and soft furniture was added to the redesign. Figure 26 shows an overhead view of the redesigned space, while figure 27 shows a perspective view of the redesigned studio. The following sections discuss how the different recommendations were used in the redesign of the space and how the space is improved.

Figure 26. Overhead view of redesigned space.

Figure 27. Perspective view of redesigned space.

5.1 Consider Different Spaces or a Flexible Space to Promote Different Activities in the Creative Process and Design Process

The redesign features furniture and chairs with casters, which should allow for more flexibility within the one space, if one wanted to rearrange the desks. The space also incorporates adjustable lighting with adjustable spot lighting for each spotting at their desk, and a lamp in the incubation corner. The space now features a smart surface instead of a whiteboard that will allow for supporting information sharing, presentations, and ambient and inspirational display. The central surfaces in the room can support different tasks throughout the design process, with more support for information display and sharing earlier and more support for visualization making and display later.

5.2 Support for Convergent and Divergent Thinking

The individual adjustable spot lighting at the desks should allow for the overhead to be turned off, allowing for dimmer lighting overall, but still providing light for students to work. Adjustable lighting in the environment should help support divergent lighting with a dimmer-lit space and convergent thinking with a brighter-lit space. The space has increased stimuli through color, materials, nature, and other elements, which should provide for more welcome distraction during divergent thinking. The smart surface in the space could support the display of ambient or inspirational images to help with divergent thinking or could support display of information helpful to convergent thinking.

5.3 Support Collaboration and Privacy

The desks are still arranged in similar groupings. This decision was made, because the desks facing each other promotes interaction between students, which can be helpful. There is also still a central communal area, which can be used by different students, but this space may change to accommodate different functions throughout the process. Individual pin-up space has been incorporated into the workstations of the individual students. This feature could also function as a divider between students. Figure 28 shows the individual pin-up space provided to students.

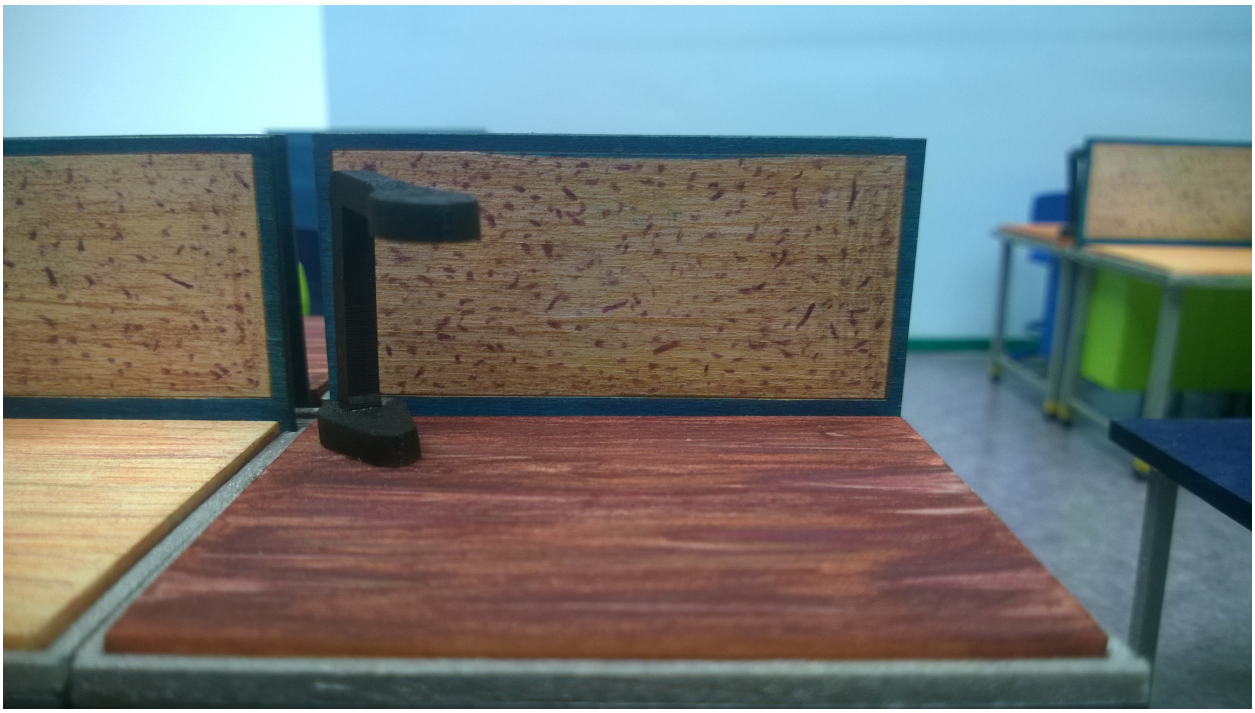

Figure 28. Individual pin-up space.

5.4 Support Creative Preparation and the Early Stages of the Design Process

The redesign still features two walls dominated by pin-up space like the current environment. However, in this early stage, the communal surfaces in the redesign support information display and sharing through a product featuring multiple rotating whiteboards and pin-up surfaces with trays that would hold helpful tools like Post-Its, markers, and pins. The individual pin-up space for each student could also be used to support preparation. The smart surface performs all of the functions of the whiteboard in this phase, but also allows for pulling in and displaying relevant information and imagery and allows for changing to display the most relevant imagery at the time.

5.5 Incubation for Design

The space still functions as a priming environment for incubation with its support for preparation. Improvements to supporting preparation should also support the space as a priming environment. The adjustable lighting provided from the individual student lighting should allow for a dimmer space more conducive to divergent thinking. The overall stimuli within the environment has increased with the use of color, materials, and nature. Ambient sound can be played through computer speakers like the existing space. Ambient sound could also come from the smart surface and provide more stimulation within the space. The smart surface could also be used to display ambient images, images of nature, or other inspirational images in supporting divergent reflection. The redesigned space includes an ‘incubation corner,’ which includes soft furniture, indoor plants, and carpeting. Figure 29 shows the incubation corner in the redesigned studio.

Figure 29. Incubation corner

5.6 Support Creative Design Insights

Insights can happen anywhere including the redesigned space. The improvements from redesigning the space according to other recommendations could help lead designers to more insights.

5.7 Support Evaluation and Elaboration and Visualization in the Later Portion of the Design Process

The space still features pin-up space that mostly covers two of the walls. The desk size is similar in the redesign and should support any tasks currently undertaken. The individual pin-up space at each workstation in the redesign should help students in keeping the relevant imagery

displayed close to them. Figure 30 shows the increased display space. The communal central area in the redesign, shown in figure 31, can change throughout the process to support visualization and visualization display. This is something that is currently supported by the existing space, but in the redesign the central area would be used for different tasks throughout the process.

Figure 30. Increased display space.

Figure 31. Communal area

5.8 Support Visualization Throughout the Creative and Design Process

With the redesign, students still mostly bring in their own tools. Desks still have storage space underneath to provide for tool storage. The communal area in the center in the redesign supports visualization and visualization display when needed. Computers are still available in the redesign, but the computer space is used more efficiently to make room for the incubation corner (Figure 32). There is still plenty of pin-up space on the walls in the redesign. The individual pin-up space increases the amount of pin-up space and allows students to keep certain imagery close.

Figure 32. More efficient use of computer space.

5.9 Support Ample Display Space for Information, Inspiration, Visualization etc.

The redesign still has two walls covered with pin-up space. Other walls can also have paper taped to them like the current space. The individual pin-up space added in the redesign allows for students to pin ideas close by and right in their view, while increasing the total amount of display space. The central area now supports information sharing and display earlier in the process, while supporting visualization and visualization display later in the process. The smart surface in the redesign can be used for all of the information sharing functions that a whiteboard would support while also allowing for displaying other relevant information, inspiration, and visualization.

5.10 Support Personalization

The redesign features desks that have different wood used in their designs. Chairs are also different colors. This could help give students a more unique space. The individual pin-up space that can be incorporated into desks also allows for students to pin-up personal images close by and personalize their space. Students can also be encouraged to personalize their spaces in the same way they could be encouraged in the existing space.

5.11 Support Flow

Nature brought into the redesigned space could help restore attention. Increased personalization could help remind students of their goals. Any extra support for individual tasks in the redesign could help students concentrate on the task. Adjustable lighting in the redesign could help students hone in on their work. Ambient sound could help students ignore auditory distractions. However, achieving and maintaining flow is certainly not guaranteed.

5.12 Promote Good Mood and Health Through Ergonomics and Ambient Elements

The ergonomics in the redesigned space are similar to current space. Desk size has not changed much and should support tasks similarly well. Seating is similar and allows for adjustment and movement. Softer furniture in the incubation corner could help students relax. Stimuli has been increased in the environment with more color, and a variety of materials including natural materials. The stimuli added to the environment could help with the mood of students. The increased support for personalization, if utilized, could also help with supporting mood.

5.13 Fill the Environment with Adjustable and Flexible Furniture That Could Be Either Hard or Soft

The main studio chairs in the redesign are adjustable and flexible like the current chairs, allowing for height adjustment, rolling, and swiveling. Softer furniture is provided in the incubation corner.

5.14 Consider How the Layout of Furniture Communicates and Facilitates the Task

The desks are still arranged in similar groupings facing each other to promote useful interaction between students. One quad of desks was removed from the studio space to reduce crowding, leaving twelve total individual desks for students. There is still a communal work area; however, the area changes to support different processes. The computer area remains; however, the space is used more efficiently as the footprint of the space is reduced by adding a shelf over top of the computers and moving a printer/scanner to the shelf. The rearrangement of the computer area allowed for the addition of the incubation corner, intended to provide a space for students to reflect and relax. The incubation corner features softer furniture and plants.

5.15 Provide Appropriate Tools for Creative Tasks in the Space

The redesign features the plentiful pin-up space of the current space plus the individual pin-up space for students. Tools will be still be mostly brought in by students in the redesign. The redesign still has storage underneath desks. The communal area in the center of the redesign can support communal tool sharing if needed. The computer area still exists, but the space has been used more efficiently.

5.16 Provide Appropriate Furniture for Creative Tasks in the Space

The redesign still features the individual workstations of a similar size and should support tasks in a similar way, but the addition of the individual pin-up space allows for students to pin information and images close by and always in view. The computer area has been used more efficiently as the footprint has been reduced by adding a shelf over the computers, on which printers and scanners can be placed. The central area can support different tasks throughout the design process.

5.17 Provide Stimulation Without Overwhelming

Color has been increased in the redesign. A variety of materials are used in the redesign, including concrete, wood, metal, glass, carpet, plastic, and paint. Nature has been added to the space. Smell is also used in the space. Not all desks are the same as they use different woods. Chairs are also different colors. Visualization and other information and imagery pinned up by users will eventually become part of the overall stimulation. The stimulation has been increased in comparison to the existing space, and the redesigned space should provide a more stimulating environment. It is hard to judge whether it would be best to further increase stimulation or if the space is overstimulating without full implementation and testing.

5.18 Bring Nature into the Space

Indoor plants have been brought into the space in the incubation corner of the redesign. In the same way that pin-up space could be used to display images of nature in the existing space, pin-up space in the redesign could be used to display images of nature. The smart surface could also be used to display images of nature.

5.19 Use a Mix of Materials Including Natural Materials

The redesigned space features a variety of materials, both natural and man-made, aging and permanent. The space includes different woods, chosen for their color and grain and usefulness, in the design of the individual workstations including peroba rosa, American mahogany, and black walnut. The space also features concrete, which should age, glass, painted walls, plastic, carpet, and metal.

5.20 Make the Environment Colorful

The new design is far more colorful than the existing space. Analogous colors were chosen to mostly fill the space. The color palette includes blue-greens, greens, and blues, with a complementary orange-brown. Walls are painted colors, with the teaching wall in the space being the most saturated. Chairs are various blues and greens within the color palette, instead of only black in the existing design. The woods in the desks provide the orange-brown colors complementing the rest of the space. A more colorful environment should help promote perceived creativity according to the literature. This redesign is definitely more colorful. It may not be the absolute best color scheme for enhancing creativity, and some color preferences could be unique to individual users of the space.

5.21 Provide a Variety of Adjustable Lighting

The redesigned space provides adjustable spot lighting for each student, allowing for the overhead lights to be shut off. This allows for a dimmer lit space with localized light for the student. The dimmer lighting could help promote divergent thinking. The individual lighting in

the redesign would be adjustable in brightness as well as color temperature. The smart surface could also be used to provide different colored lights emitted from the display. Figures 33, 34, 35, and 36 show how adjustable lighting can change the space.

Figure 33. Overheads on.

Figure 34. Task lighting.

Figure 35. Cool task lighting.

Figure 36. Warm task lighting

5.22 Control Noise Through Materials and Ambient Sound

Ambient sound can be provided in the redesign through the smart surface and computer speakers. Carpeting in the computer area could help absorb some sound. Headphones may also be provided in the incubation corner to help reflecting students zone out others.

5.23 Consider Adding Smell

Cinnamon-vanilla scent plug-ins could used in the redesigned space to provide for a more pleasant smelling space and one that enhances creativity.

5.24 Incorporating Smart Technology

The redesign features a smart surface that replaces the whiteboard. The smart surface would be able support information sharing as well as display of ambient and inspirational imagery. The smart surface would also be able to emit ambient sound. Figures 37, 38, and 39 show how the smart surface can be used for multiple purposes in the redesigned space.

Figure 37. Smart surface used for information sharing.

Figure 38. Smart surface used for CAD.

Figure 39. Smart surface used for ambient support.

5.25 Consider Incorporating Opportunities for Play in Spaces

No extra opportunities for play have been added in the redesign of the space to minimize play from distracting students trying to work. Of course, students can still find ways to play in the space as they can anywhere. However, what may be most beneficial is having a space nearby dedicated to play that would not distract from those trying to work or reflect.

5.26 Consider Giving Spaces Unique Creative Identities

Giving the space a unique creative identity was not pursued heavily in the redesign of the space, as the projects may change as semesters change and the goals with these projects can change. There are both blue and orange colors in the space, which could hint back at Auburn University's school colors, but the creative identity was not heavily pursued in the redesign.

5.27 Summary of Application and Redesign

Figure 40 summarizes aspects of the redesigned space that support creativity and design.

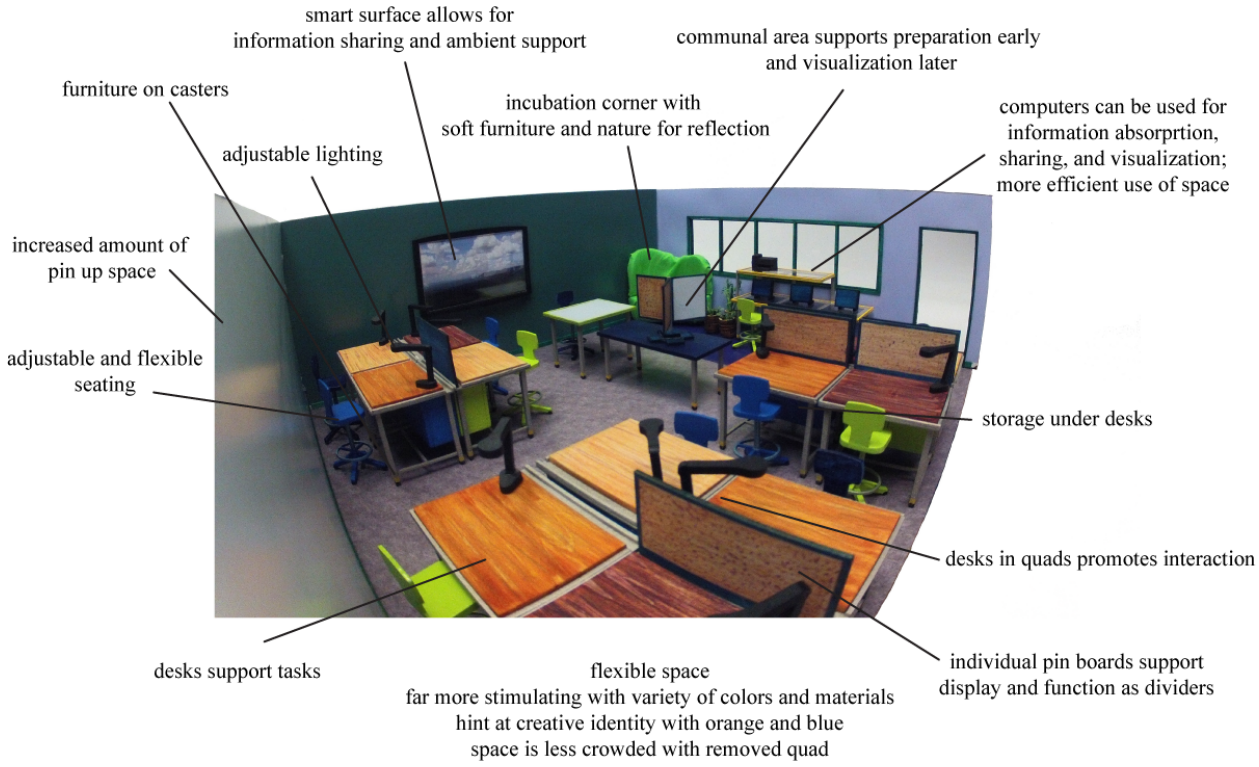

Figure 40. Summary of application and redesign.

Chapter 6: Conclusion

6.1 Summary and Conclusions

This thesis explored how to support the processes and tasks involved in both creativity and design through the design of spaces. Recommendations were generated from the analysis and synthesis of literature involving relevant domains. The recommendations include supporting the cognitive and physical tasks involved in creative and design processes. Different tasks or modes of thinking involved in creativity and design could benefit from different spatial support. Flexibility in a space or having multiple spaces could help support different creative and design activities. Other recommendations deal with elements in the environment that could support mood or make designers feel more creative. A studio space was evaluated according to the generated recommendations. Some aspects of the studio space met recommendations. Other aspects of the studio left room for improvement in supporting creativity and design. The studio space was redesigned according to the recommendations. The redesigned studio, demonstrated with a scale model, provides a more stimulating and flexible space than the evaluated studio. According to the recommendations, the redesigned space should be conducive to the creative phases as they relate to design and also should support thinking and activities undertaken in the design process.

6.2 Limitations

This thesis looked at how to support creativity and design through the design of spaces. The evaluation and the redesign of the higher education industrial design studio space are examples of how to use the recommendations. The recommendations are not intended to be only applicable to educational studio spaces. Recommendations could be applied to spaces outside of education that have different limitations and requirements. The recommendations also deal with only supporting creativity and design. In terms of education, the recommendations would primarily benefit students undertaking creative and design tasks in spaces. Other recommendations specific to the unique activities occurring in educational spaces could be beneficial in designing creative design spaces only intended for education; the same could be said for business spaces.

The scale model of the redesign provided a visual representation of how the recommendations could be applied to an existing space. While the redesign should be supportive of creativity and design according to the generated recommendations, only with full-scale implementation would one be able to definitively judge how users would actually feel, think, and act in the space.

6.3 Future Studies

Future studies could involve generating recommendations unique to business or education for the design of spaces supportive of creativity and design. Full-scale implementation

of recommendations would allow for user testing. Individual recommendations could also be implemented and would allow for user testing.

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