Recommendations on how to Alter an Environment Design that Enhances User Ability to Perform the Creative Problem-Solving Process

by

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Abstract

This thesis explores the importance of deliberate environmental design in relation to sustaining quality knowledge work and quality creative work. This thesis will focus on specifically environment design for the Industrial Design student in order to supply specific needs.

This thesis will first explore the behavioral sciences of what is required for a human to achieve and maintain their optimal mindset for producing their best quality of work. This optimal mindset is intimately concerned with understanding how humans achieve effective focus, productivity, and creativity problem solving.

This thesis will provide a literature review, which will consolidate thorough research concerning human factors, ergonomics, neurology, psychology, and the sciences of creativity, behavioral engineering, and workplace design. After this education on the matters necessary to construct environments to support this optimal mindset, this thesis will develop a methodology based on these discoveries.

The end result of this thesis will be a list of guidelines in the form of an outline. This outline of the developed methodology may be used by any Industrial or Environmental Designer as a reference when constructing studio workspaces for either themselves or other designers with the goal of maximizing creative problem-solving performances.

This thesis will conclude by evaluating and redesigning an Industrial Design Student Studio workspace in accordance to this methodology.

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Thank you to both my family as well as the faculty and staff of Auburn University who accommodated me in my studies and believed in me.

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List of Abbreviations

CPSP	Creative Problem-Solving Process

Problem Statement

Industrial Design is a profession that requires the skills of creative problem solving. In order for the industrial designer to reach his or her maximum potential, he or she must also master the art of focus and productivity. Both of these skills require training and are preferably mastered before entering or graduating college and ideally before beginning a career in industrial design. However, educational systems do not always provide the necessary attention, education, or supplementation to developing these skills.

In addition to this cognitive malnourishment, the current social environment which the information age has provided for oncoming generations is a hostile environment for developing the mind to be able to achieve a state of focus. In order for the industrial design student to flourish in a world that provides constant, meticulously engineered distractions and influences that prevent sound states of mind, the educational studio space environment must be carefully engineered and designed to supplement creativity and focus.

This thesis argues that the most sustainable and effective strategy to supplement industrial design students' ability to produce high quality creative work is to design learning environments that supplement the optimal mindset necessary for achieving this standard.

Need for Study

If any designer is to maximize their value to a competitive market, they must depend on their creativity and ability to produce high quality work at an efficient time frame. Without mastering the skills necessary to optimize their performance, industrial design students will always fall short of their potential.

In order to maximize the students' ability to gain the most of their education is to ensure that they are focused and able to engage their creativity. This would allow them to benefit the most from their design education. The most sustainable solution, that serves the most students cycling through a university over the longest time frame, is to design a learning environment in which the students' abilities to focus and be creative are nourished. Environments provide psychological experiences to their occupants by both physical layout and aesthetic elements (i.e. color, materials, etc.). The design of these experiences impacts the users' behavior. Environments can be designed specifically to cater towards specific psychological needs of their users. Through impacting user psychology, environments have the propensity to change user behavior.

By creating a list of recommendations that any designer can apply, more learning environments can be designed and created helps industrial design students achieve an enhanced mindset that allows them to maximize the benefits of their education. This in turn produces better designers for the market.

Therefore, this study focuses on environment design for the industrial design students' studio space. The psychological traits that are engineered to perform at their best ability are the students' ability to focus and their ability to harness their creativity.

Objectives of Study

The objective of this thesis is to create a set of recommendations for a designer to use to design a work environment for the industrial design student. These recommendations provide the necessary criteria for the designer to create an environment that supplements the creative problem-solving process, while also providing proper accommodations for the student to achieve states of focus necessary for reaching deep levels of concentration.

Objectives:

- Conduct research on the following topics
  - the nature of creativity
  - the creative process
  - the nature of focus
  - the impact of distractions on attention
  - environmental elements that enhance creativity and focus
- Create a list of recommendations for designing the industrial design student's workspace based off this research
- Evaluate a design studio in accordance to these recommendations
- Create a design solution for this studio in accordance to the recommendations

Definition of Terms

Creativity: the tendency to generate or recognize ideas, alternatives, or possibilities that may be useful in solving problems, communicating with others, and entertaining ourselves and others

Creative work: work in which the main capital is a manifestation of creative effort, such as artwork

Elements: building blocks for composition such as line, shape, color, texture, size, etc

Environment: the surroundings in which a user operates; consist of a multitude of conditions which may or may not be controlled

Domain: which consists of a set of symbolic rules and procedures

Field: includes all the individuals who act as gatekeepers to the domain. It is their job to decide whether a new idea or product should be included in the domain

Flow: the mental state of operation in which a person performing an activity is fully immersed in a feeling of energized focus, full involvement, and enjoyment in the process of the activity ; “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” (Csikszentmihalyi, 1990, p. 4).

Focus: the state in which the user is able to concentrate their attention on one thing

Knowledge work: work in which the main capital is knowledge; this line of work requires the one to "think for a living”

Methodology: a set of procedures that are developed to assist in leading through the process of design

Macroenvironments: the outward surroundings in which a user operates; the conditions of these surroundings cannot be controlled by any single individual

Microenvironments: the inner surroundings in which a user operates; the conditions of these surroundings can be controlled by the user or a single individual

Studio: a dedicated workspace for design students to learn about the process of design and to perform their creative work

Workspace: the designated area in which a student or employee’s work is to be produced

Assumptions

This thesis makes several commonly known assumptions. Neither proof nor sources are provided for these assumptions due to their general acceptance of belief.

The students are assumed to be males and females between the ages of 18-22 as is standard for most university students. These guidelines are designed under the assumption that none of these students suffer from major disabilities.

It is assumed that all of the necessary technology for industrial design students will be provided by the university and supported by the studio space environment.

Scopes and Limitations

The scope of this thesis is limited to university design programs; however, its application may be applied to other institutions or individuals seeking to optimize their learning atmospheres. While the students' extracurricular activities, behavior, and lifestyle will have impact their ability to focus and maximize their creativity ability, this thesis is limited to only providing proper mental nourishment exclusively to the studio space environment.

Procedures and Methodology

Research

- Study of science of creativity (neurology, physiology, psychology)
- Study nature of focus and attention
- Study of methods and existing office layouts for creatives
- Review case studies of existing studio space
- Establish needs of industrial design students - environmental

Develop recommendations for studio workspace design for industrial design students

Implement design changes on a studio by applying proposed recommendations

- conceptual sketches
- technical drawings
- 3D modeling software
- scale models
- full scale prototype

Anticipated Outcomes

This thesis will conclude with a set of recommendations based on research. University professors or industrial designers may apply these recommendations in the fabrication or adjustments of their own studio workspaces or studios.

The recommendations give direction on adjusting or redesigning the environment both the environment's structural layout and aesthetic components. The structural layout deals with issues such as electrical outlet access, space management, desk arrangements, and so on. The aesthetic components will include elements lighting, color, textures, materials, and so on.

Chapter 2: Literature Review

2.1. Introduction

The current environment in which the industrial design student works today is harmful to human well-being as a whole. This is relevant because human wellbeing impacts a human's ability to be productive, focused, and creative. In his book, *Creativity: Flow and the Psychology of Discovery and Invention*, Csikszentmihalyi (2013), proposes the idea that individuals live and work within a system of macroenvironments and microenvironments, "Here it may be useful to make a distinction between the macroenvironment, the social, cultural, and institutional context in which a person lives, and the microenvironment, the immediate setting in which a person works" (p. 139).

2.1.1. Overview of the Literature Review

This thesis reviews statistical data that supports the hypothesis that the average user (the industrial design student included) lives within a macroenvironment—that is their social, cultural, and institutional environment—that is hostile to human well-being. By definition, the user is unable to control the conditions of the macroenvironment they must reside in (Csikszentmihalyi, 2013). The current macroenvironment of America in the year of 2019 has reached record breaking, epidemic levels nutritional and psychological diseases. The interesting part is that many of these diseases—diabetes, heart disease, metabolic syndrome, Alzheimer's, obesity, anxiety and depression—are preventable and/or can be treated with behavioral changes of the afflicted sometimes even without the help of prescription medication.

These stressors and harms of macroenvironments afflict industrial design students' human well-being as a whole. Specifically, there are components of the macroenvironment that specifically attack the industrial design students' ability to be productive, focus, and harness their creativity. This thesis addresses and defines these components and provides an environment that support and provide strategies that will protect and enable the students' abilities. This thesis also defines human well-being and how it relates to the ability to achieve productivity, focus and adhere to the creative process. This thesis concludes by proposing guidelines to design an educational workspace microenvironment within this macroenvironment that allows the industrial design student to perform at their best.

This thesis acknowledges at neurology and psychology due to the in depth that simple elements of design have the ability to impact a human both cognitively and physically.

2.1.2. The Methods of the Literature Review

This thesis explains what is required of an industrial design student in order for them to fulfill their assignments and accomplish their studies. This includes the type of work the standardize undergraduate programs require of industrial design students. Moreover, this thesis outlines the cognitive processes and subprocesses needed in order for the industrial design student to accomplish their studies. These processes include but are not limited to the creative process, the circular design process, and the psychological design process.

In addition to defining the specific skills exclusively necessary to the profession of industrial design, this thesis outlines the foundational cognitive tools needed for the student to excel within their studies. These skill sets are imperative to the industrial designer, as well as to

all students of any discipline that requires production of valuable work. These skills include the ability to achieve and maintain focus (concentrated attention) for extended periods of time and the ability to produce valuable work at an efficient rate. This thesis will explore the necessary attributes and elements a microenvironment (workspace environment) must provide in order to enable and supplement an industrial design student to perform creative processes and extended periods of focus in order to produce their optimum quality of work.

This thesis dissects the major relevant components of the harmful macroenvironment that directly impact an industrial design student's ability to perform the creative process, focus and accomplish productivity. The justification of this method is to understand what is harmful to the students' cognitive processes in order to intentionally exclude these detrimental factors from the design of the microenvironment.

2.1.3. The Purpose of the Literature Review

This thesis results in the presentation of developed, research-based design recommendations for a designer to use in order to enhance the environment design of existing educational workspaces for industrial design students. Providing researched design recommendations offers a sustainable solution to providing for the needs of both current industrial design students as well as future students. These recommendations strive to design and control these microenvironments to provide the cognitive and creative nurture that is negatively impacted by the students' chaotic macroenvironment. By designing an environment that enhances ease of usability for education, the abilities of the student to focus and apply their creativity will be enhanced and nurtured. This will prepare the student to acknowledge their own

abilities, which will further their development and ensure their success as they graduate and proceed into new microenvironments of the professional world.

In order to design the recommendations for creating such an educational atmosphere, this thesis explores the psychological, physical, and physiological needs required for students to 1) maximize their performance of the creative process, 2) achieve focus, or maintain concentrated attention for an extended period of time, and 3) produce quality work at an efficient rate (be productive).

Finally, this thesis explores and applies behavioral engineering methods toward the design of educational workspaces in order to encourage the student to perform their necessary tasks in their studies of industrial design. This section emphasizes the powerful effect an environment has on changing the behavior of its inhabitants. This information both highlights the dangers of poorly designed or controlled environments, as well as emphasizes the benefits of carefully designed environments for educational pursuits.

2.2. Foundational Cognitive Tools & Processes

This section addresses and explains the importance of the primary foundational cognitive tools and process the industrial design student will rely on in order to be a productive design student: creativity, the creative process, and focus.

2.2.1. Creativity

In order for an environment to enhance a student's creativity, the designer of the environment must understand what exactly creativity is. This section answers the following questions: What is creativity? Is everyone creative? Can you make someone more creative than they already are?

2.3.1.1. What Is Creativity

Creativity has many definitions because throughout history. It has played significant roles across many different realms without necessarily being recognized as creativity until later dates. These definitions change depending on cultures and times. In order to best understand creativity and its behaviors and functions, this thesis begins with exploring the science of creativity from the neurological, anatomical, and physiological perspectives. In 2018, *Time* magazine issued a special edition dedicated to understanding the science of creativity. Included in this collection of scientific journals is author Richard Jerome's interview of Agustin Fuentes, author of *The Creative Spark: How Imagination made Humans Exceptional* and University of Notre Dame anthropologist. Fuentes offers a holistic definition of creativity

> "In a nutshell. . . the essence of creativity is to look at the world around us, see how it is and imagine other possibilities that are not immediately present or based on our immediate personal experience. Creativity is seeing the possibilities and then trying to make those imaginings into material reality" (Jerome, 2018, p. 6).

Fuentes' definition insinuates that creativity is a cognitive tool that creates connections. This definition is supported by the neurological studies conducted by brain-sciences professor John Kouinos from Drexel University.

2.3.1.2. Neurologically

John Kouinos (2018) conducted studies focusing on the cognitive activity of the brain during the creative process. Research was collected using functional magnetic resonance imaging (fMRI) and high-density electroencephalography (EEG). In order to understand what creativity is according to Kouinos's research, it is important to understand the duality of the brain—or as more commonly referred to—the two hemispheres. Kluger (2018) efficiently sums up the commonly accepted belief of the left and right hemispheres of the brain.

> "Popular wisdom in recent years has held that the brain's two hemispheres neatly divide the day's tasks. The left brain, so the thinking goes, is the serious brain—critical, analytical, skeptical, mathematical. It's also where language lives. The right brain, by contrast, is the wild child—artistic, abstract, insightful, intuitive" (p. 12).

Kouinos's (2018) study reveals that an individual's level of creativity is dependent on the physiological structure of the brain.

> "It's not just the activity of the brain that determines a role in creativity it's also its wiring plan..... the brain's white matter tracks— bundles of nerve fibers covered by fatty sheathing that serve as the cabling connecting various brain regions and structures" (Kluger, 2018, p. 14).

This fatty sheathing is called myelin, which is discussed by author Cal Newport who is referenced later in the subject of defining focus. Myelin plays a key role in the ability to recall information. The more myelin coating the brain synapses that access information stored in the brain, the quicker the individual can recall this information. “To be well versed in a subject is to be well-myelinated" (Newport, 2016, p. 36). This is relevant to the study because the individual has the ability to increase the amount of myelin that coats the synapses. This concludes that measures can be taken by the user to enhance their creative ability. “White matter roadways across the brain are nearly the same in everyone. . . But there can be a difference in cables that cross from right to left [hemispheres]” (Kluger, 2018, p. 14). This difference in cables or wiring is the key differentiating factor between creative brains and non-creative brains.

The findings of Kouinos’s experiments reveal that what determines creativity is the amount of white matter in the brain that connects the two hemispheres. The more white matter roadways that interconnect the brain, the more creative the individual is based on creative reasoning scores, which were distributed during the study. “There aren’t many connections that span the hemispheres .....Individuals with more of them also tended to have higher creative reasoning scores,” (Kluger, 2018, p. 14).

Based off of this study, creativity is dependent on an individual’s brain physiology, or in other words, the individuals’ brain structure. This means that individuals cannot increase their capacity to be creative. However, the practice of exercising the existing white matter roadways enhances their existing ability to be creative, much like how going to the gym increases muscle

mass. (i.e. You cannot grow muscles that do not exist; however, you can enhance the performance of the existing muscles that you are born with.)

The science that defines creativity in this study lines up with the internationally best-selling author and distinguished Hungarian-American psychologist Mihaly Csikszentmihalyi's (2013) well-developed theories on creativity, which will be discussed in the next section.

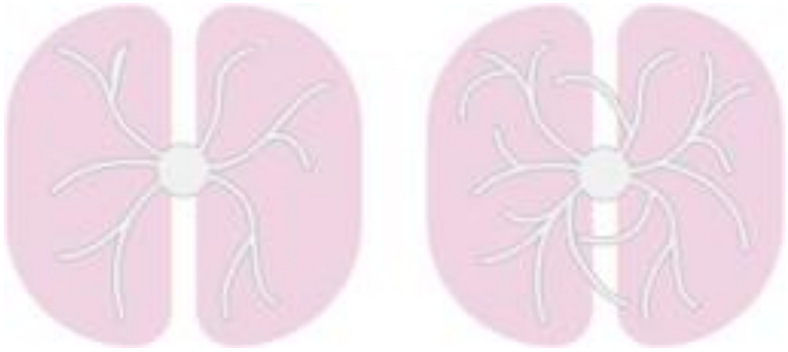


Figure 1. Anatomy of Creative Brains and Less Creative Brains. Adapted from "This is Your Brain on Creativity," by J. Kluger, 2018, *Time Special Edition: Science of Creativity,* page number. Copyright 2018 by Times Books.

2.3.1.3. Cultural Definition of Creativity

Former head of the Department of Psychology at the University of Chicago, Csikszentmihalyi (2013) defines creativity in the context of cultural significance.

> "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," (p. 28).

This definition of creativity demands not only cultural recognition, but the adoption and acceptance of the creative innovation to change the existing culture of the domain. Based on this definition, creativity must be able to build off of existing ideas so as not to create an idea that

cannot fluently be implemented into the existing domain. This definition is significant because it implies that in order for creativity to play a significant cultural role, the individual requires pre-existing ideas and information to elaborate in order to successfully pursue creative endeavors. This means that creativity builds off of other skills and therefore a student can be more creative or less creative than his or her peer. This gives creativity economic value and adds competition to the creative job market.

2.3.1.4. Economic Value (To Id Student)

Economically speaking, creativity is an asset to the industrial designer. Fuentes (2018) states, "Creativity is as much a part of our tool kit as walking on two legs and having a big brain," (Jerome, 2018). Fuentes argues creativity is valuable to any human. In context of the industrial design student, creativity is valuable in a centralized market demanding creative talent. Therefore, the more creative a student is, the more value they present to a market demanding creative professionals.

A student of industrial design seeking to maximize their economic value to a job market should consider creativity as an economic asset. Considering drawing and the ability to create ideation sketches as an illustration, the ability to create ideation sketches is a required skill on a job application. The ability to draw is one of the tools that is used by the student to create ideation sketches. In this sense, creativity is a tool that is used to enhance the ability of the individual to draw connections and innovate. Creativity's matching skillset would be creative problem solving—a critical skill set to the profession of industrial design.

By assuming there is an economical market demand for creativity, logic implies that creativity has value and is therefore a scarce resource. However, Fuentes (2018) argues, “People pigeonhole creativity as belonging to a single, individual or a group of geniuses . . . each and every human has this incredible capacity to imagine and to change things” (Jerome, 2018). Every human has this ability to a certain degree. The requirements of the roles of industrial design student call for creativity in order for success within the field of industrial design. If every human has the capacity to be creative, what should set industrial design students apart is the refinement of the ability to use creativity and apply it to problem solving within the domain of industrial design. If creativity is a tool accessible to everyone, the industrial design student’s most profitable course of action is to master the technique of applying the tool that is creativity.

2.3.1.4. Creative Enhancement

The neurological study of creativity revealed that an individual’s ability to be creative is dependent on their two aspects of physiological brain structure: 1) the wiring plan or layout of the white matter and 2) the fitness of these anatomical structures. Like physical fitness, creative fitness is attained through exercise. Betty Edwards (2012) is a researcher and author who has dedicated her life to the study of cognitive shifting in order to improve creative thinking through implementing cognitive shifting techniques in school curriculums. “As a side benefit, this cognitive shift to a different-from-usual mode of thinks result in a marvelous state of being, a highly focused, singularly attentive, deeply engaging, wordless, timeless, productive, and mentally restorative state” (p. XXVII). Edwards defines cognitive shifting as the developed skill of intentionally switching which hemisphere is dominant when performing a specific task.

Edwards' application and recognition of the functions and physiology of the duality of the brain accurately correspond with Fuentes' and Kouinos's previously discussed studies and research.

> "The dualities and differing characteristics of the two halves of the brain and body, intuitively expressed in our language, have a real bias in the physiology of the human brain, but because the connecting fibers of the corpus callosum [—the largest white matter structure in the brain—] are intact in normal brains and can block passage of information, we are often not fully aware of contradictory responses occurring in the two halves" (Edwards, 2012, p. 36).

Edward's recognizes and applies neurological research into her teaching of usable techniques for students to enhance and exercise their creativity.

Edwards' (2012) distinguishes "modes" that define which side of the brain is dominant in the function of specific tasks. "The L-mode is the "right-handed," left-hemisphere mode. The L is foursquare, upright, sensible, direct, true, hard-edged, unfanciful, forceful. The R-mode is the "left-handed," right-hemisphere mode. The R is curvy, flexible, more playful in its unexpected twists and turns, more complex, diagonal, fanciful. Edwards argues that applying mindfulness and intentional control over which hemisphere is in control of which phase of the creative problem-solving process enhances an individual's ability to perform creative problem-solving techniques. Edwards predominant tool for inducing this shift is by teaching the students to draw. "Drawing induces a focused, alert state of consciousness that can last for hours, bringing significant satisfaction, and, unlike some self-induced altered states, is productive in terms of work output," (p. 60).

2.2.2. Creative Process

If creativity is the tool, creative problem solving is the skill. There is a distinguished method for creative problem solving known as the creative process. The documentation of the history behind this process began as early as the 1950s and has continued in its development. This thesis will refer to the five-step creative process that is supported by Csikszentmihalyi's (2013) research.

	CSIKSZENTMIHALYI (2013)	CROPLEY AND CROPLEY (2012)	MARTENS (2011) WALLAS (1926)	LAWSON-KNELLER (2006)	OSBOURNE-PARNES	JP GULLIFORD
STEP 1	PREPARATION	PREPARATION	PREPARATION	INSIGHT	MESS FINDING	FILTERING
STEP 2	INCUBATION	ACTIVATION	INCUBATION	PREPARATION	DATA FINDING	COGNITION
STEP 3	INSIGHT	GENERATION	ILLUMINATION	ILLUMINATION	PROBLEM FINDING	PRODUCTION
STEP 4	ELABORATION	INSIGHT	VERIFICATION	VERIFICATION	IDEA FINDING	
STEP 5	EVALUATION	VERIFICATION			SOLUTION FINDING	
STEP 6					ACCEPTANCE FINDING	

Figure 2. Comprehensive diagrams of creative processes. Adapted from Idea Sandbox. (2001). https://idea-sandbox.com/cps-methods/#axzz5xR9uL0lu

The steps of the creative problem-solving process evolved over centuries of debate. Today Csikszentmihalyi's (2013) model is the most current and widely accepted model. Edwards (2012) proposes the practice of intentionally aligning L or R-Mode thinking based on a modified version of Csikszentmihalyi's creative process.

In the subject of enhancing creative thinking in students who may have no prior experience with intentional creative thinking, Edwards (2012) proposes applying L mode and R mode cognitive shifting.

"I suggested that the stages may occur because of shifts in right-and left- hemisphere emphasis: -First Insight: R-mode leading -Saturation: L-mode leading -Incubation: R-mode leading -Illumination (The Aha!): R-mode and L-mode celebrate the solution -Verification: L-mode guided by R-mode visualization" (p. 245).

L MODE / R MODE	EDWARDS (2012)				
PROCESS	INSIGHT	SATURATION	INCUBATION	ILLUMINATION	VERIFICATION
R MODE	R mode leading		R mode leading	L mode unity	R mode guides with visualization
L MODE		L mode leading		R mode unity	L mode dominant

Figure 3. Edward's R-Mode and L-Mode CPSP. Reprinted from *Drawing on the Right Side of the Brain* (p. 245), by K. M. Pike, 2008, London: Souvenir Press. Copyright 2012. Reprinted with permission.

Her proposal is based on providing the best suited hemisphere to the specific stages of the process.

"Through studies with animals, split-brain patients, and individuals with intact brains, scientists believe that the control question may be decided mainly in two ways. One is speed: which hemisphere gets to the job quickest? A second way is motivation: which hemisphere cares most or likes the task best? And conversely: which hemisphere cares least and likes the job the least?" (p. 43).

This applies a more efficient and fluent performance of the process from the student's perspective.

Without a clear understanding of the creative process, the nature and operation of creativity has the potential to appear vague and ambiguous. Edwards acknowledges this, "Creativity moves through different phases. Trying to produce a finished version in one move is

usually impossible. Not understanding this can make people think they are not creative at all," (Edwards, 2012).

2.2.3. Creative Environments

The creative process illustrates a much more diverse and complex cognitive landscape for creativity. The neurological research confirms that sensory restriction is ideal for the insight phase. Kouinos's ECG data collected during the insight phase of creativity provides more insight to the inner workings of the brain.

> "'We call it a brain blink,' says Kounios. 'For an instant before you have an insight, you're less aware of your environment.' That, he explains, is also part of the reason so many people do their best thinking in the shower. 'There's sensory restriction–white noise and you can't really see much, says Kounios," (Kluger, 2018, p. 14).

Caywood (2004), in the book *Big Design for Small Space* addresses the collaborative forms of creative work. "As design is a cyclical process, ideas are constantly polished by input from other team members. Isolation of certain team members can hinder this process," (p. 154). In accordance to this argument, it makes sense to deduce that the preparation phase requires the opposite—sensory stimulation supplied by other creatives.

Leonardo DaVinci himself offers more contradictory advice aiming at minimizing distraction. "An artists' studio should be a small space because small rooms discipline the mind and large ones distract it" (Jerome, 2018, p. 52).

With the creative process divided into five different phases, with each seeming to benefit from different environmental conditions, the design for one conducive environment must be done carefully and intentionally. The building evidence suggests that the workspace must consist of both private and public spaces in order to fulfill the needs of the creative process. This theory is confirmed by Antonelli, editor of Workspheres, "[This publication] comes from the concept of the individual workspace as a halo, a private and personal space, that better defines and enables interaction" (Antonelli, 2001, p. 134).

2.2.4. Focus

Focus is the individual's ability to concentrate their attention on one single stimulus or task for an extended amount of time. In order to harness attention, it helps to understand its nature as finite. "… Attention is a limited resource: There is just so much information we can process at any given time" (Csikszentmihalyi, 2013, p. 8). If attention is a limited resource, that means in order for attention to be efficiently applied, it must be managed in a sustainable way.

Newport, author of multiple books studying the science and practice of focus and productivity, has dedicated his career to studying how best to manage attention to produce high quality work. He argues the practice of focused work is both under-appreciated and a valuable skill in a world that emphasizes overuse of digitalized communication tools. A common theme that spans across Newport's books is the idea that the social and cultural environment (the macroenvironment) that most students and workers inhabit, pressures the use of tools that are designed to attack a user's ability to develop extended periods of focus. Without focus, both the creative problem-solving process and efficient productivity is unattainable. Newport proposes a

theory of, “Deep Work: Professional activities performed in a state of distraction-free concentration that push your cognitive capabilities to their limit. These efforts create new value, improve your skill, and are hard to replicate” (Newport, 2016, p. 7). Newport also contrasts the term by defining its much more familiar antonym: Shallow Work. “Shallow Work: Non-cognitively demanding, logistical-style tasks, often performed while distracted. These efforts tend to not create much new value in the world and are easy to replicate” (Newport, 2016, p. 6).

Further studies on the nature of focus revealed the nature of attention and an individual’s ability to focus as being dependent on cognitive closure. “Cognitive closure. . . represents the decision (conscious or unconscious) to end a cognitive/deliberative process” (Leroy, 2009, p. 9-10). Leroy continues to elaborate on the conditions that directly impact cognitive closure. ". . . the need for cognitive closure is heightened under **time pressure** (Heaton & Kruglanski, 1991; Kruglanski & Webster, 1983), **mental fatigue** (Webster, Richter, & Kruglanski, 1996) or **environmental noise** (Kruglanski & Webster, 1991)” (Leroy, 2009, p. 11).

One of the key interests for the purpose of this thesis is that the nature of the decision to end a cognitive process can be either conscious or subconscious. Newport (2016) also highlights the nature of the individual’s subconsciousness as very detrimental to maintaining or breaking focus. “Even though you are not aware at the time, the brain responds to distractions. . .an interruption, even if short, delays the total time required to complete a task by a significant fraction." (Newport, 2016, p. 51).

One clear objective can be extracted from these studies of attention—the subconsciousness must be oriented in a way that supports the industrial design students' resolve to focus their attention on solving the necessary tasks that their roles require. "The issue is then to understand what can aid people in switching tasks, that is, what can help them temporarily close their minds to one task when they must concentrate on another" (Leroy, year, p. 34). The need is even more dire for creative disciplines, now that the creative process is established as comprising as five separate, diverse processes. This role of quieting and directing the subconscious can be accomplished through an environment designed to promote productivity.

2.2.5. Productivity

Productivity is a result of focused attention applied to the creative process which results in the production of high-quality work. Productivity requires adequate resources to perform the task. For instance, industrial design students cannot be productive in their task to draw concepts without being supplemented drawing materials. The students' ability to draw is meaningless without the proper resources necessary to create drawings.

Newport (2016) provides a formula for the production of high-quality work. This formula implements his theory of deep work: "High quality work produced = (Time spent) x (intensity of focus) . . . By maximizing his intensity when he works, he maximizes the results he produces per unit of time spent working" (p. 40).

In order to understand how to create an environment that maximizes productivity, it is necessary to delineate the factors of an environment that are hostile to productivity. The greatest

challenge with this is that technology is a required resource for industrial design students to be productive. The internet is required for research and email is required for communication services. Technology's complex role in the educational environment can be moderated to some degree by good design as Antonelli (2001) argues in her book *Workspheres*, "Good design can act as the mediator between technology and human beings and is always an advocate of the latter" (p. 8).

Further recommendations suggest environments that put the student at ease will encourage high rates of productivity. "Relaxation and physical well-being are universally considered very important for optimum productivity" (Antonelli, 2001, p. 16).

The nature and in-depth study of the creativity process, focus, and productivity may only be briefly taught in correspondence of industrial design student's formal education, if at all. As demonstrated by the research outlined by university curriculums, no classes were offered with specific instruction to master these essential skills.

2.3. Behavior Engineering and Ease of Usability

This thesis strives to influence the behavior of industrial design students. The final output of the design is a list of design recommendations for how to design in an educational learning work environment for industrial design students. This environment will enhance the student's abilities to apply their creative abilities to the creative process, achieve a focused state on their work, and ultimately produce work at an efficient rate (be productive). Therefore, it can be established that the enhanced environment design will influence students' behavior. Therefore, it

is necessary to include research covering theories of persuasive behavioral techniques through technologies.

Dr. B.J. Fogg who established the Persuasive Technologies Lab at Stanford University is one of the leading researchers on modern technologies driving human behavior. In his research and development of the theory of captology, Fogg (2009) developed the Fogg Behavioral model in order to explain how users operate

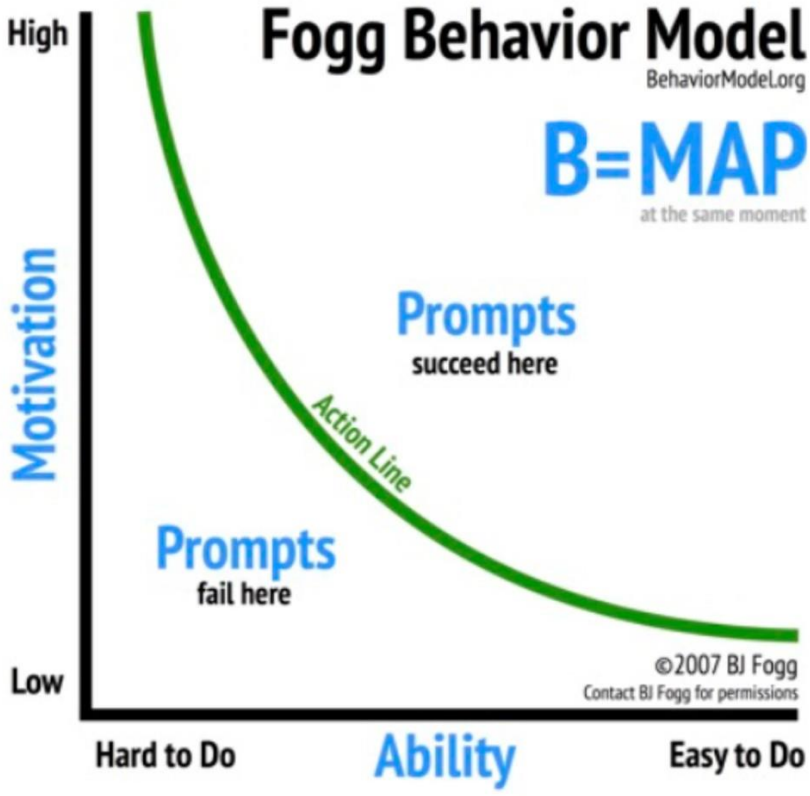


Figure 4. The B.J. Fog Behavior Model, Retrieved November 10, 2019, from https://www.behaviormodel.org/. Copyright 2007 by BJ Fogg. Reprinted with permission.

"The [Fogg Behavioral Model] asserts that when people are persuaded to perform a behavior, then three factors have come together at once: motivation, ability, and trigger" (Fogg, 2009, p. 1).

Put in simpler terms: the easier the task is for the user to accomplish, the less motivation this user requires in order for them to complete the task. Fogg suggests designing for the purpose of altering the user's motivation. "The goal in designing for motivation is, conceptually, to move a user to a higher position in the [Fogg Behavior Model] landscape" (p. 3).

Further characterization of the nature of Fogg's theories on ease of usability focuses on the nature of human motivation:

> ". . .the natural wiring of human adults: We are fundamentally lazy. As a result, products that require people to learn new things routinely fail. Instead, to increase a user's ability, designers of persuasive experiences must make the behavior easier to do. In other words, persuasive design relies heavily on the power of simplicity. A common example is the 1-click shopping at Amazon. Because it's easy to buy things, people buy more. Simplicity changes behaviors" (Fogg, 2009, p. 5).

If the specific target behavior is for the industrial design student to produce high quality creative work, then Fogg's model proposes a service or design that will increase the user's motivation, trigger, and/or ability.

Based on the psychological evidence of the effects environmental elements have directly on human psychology and indirectly on human behavior, an effectively designed environment

must rely on a harmony of these elements. “The design of an environment through a variety of means such as temperature, sounds, layout, lighting, and colors can stimulate perceptual and emotional responses in consumers and affect their behavior” (Kotler, 1973, p. 3233) (Kurt & Osueke, 2014, p. 1). The elements addressed in this thesis therefore include layout, lighting and color.

2.3.1. Application to Creative Ability

Csikszentmihalyi’s (2013) analysis of where creativity is the prevalent corresponds with Fogg’s principles of ease of use. “. . . creativity is more likely in places where new ideas require less effort to be perceived” (p. 9). Furthermore, Csikszentmihalyi even recommends that the secret to enhancing creativity is through environment design. “It is easier to enhance creativity by changing conditions in the environment than by trying to make people think more creatively” (Csikszentmihalyi, 2013, p. 1).

Csikszentmihalyi’s (2013) later published a book called Flow, which analyzes the state of focused productive creative work. He refers to this state as “Flow” state. “This is what we mean by optimal experience ..... Such events do not occur only when the external conditions are favorable .....Optimal experience is thus something that we make happen” (Csikszentmihalyi, 1990, p. 3). Csikszentmihalyi’s (1990) disclaimer establishes that the conditions of the environment will not necessarily guarantee the proper targeted behavior. However, his syntax in “events do not occur **only** when the external conditions are favorable” suggest that favorable external conditions are still helpful, if not necessary.

2.3.2. Application to Focus, Limited Attention, & Productivity

Leroy (2009), draws light to the drain that distractions provide to an individual's attention. "Undivided attention makes people more cognitively vigilant and intellectually alert and is associated with increased cognitive effort (Kahn, 1990; 1992, cited in Leroy, 2009, p. 67). In light of the science of ease of use, divided attention increases the amount of ability that is required of the student to accomplish the target behavior of producing creative work. Therefore, anything that divides, scatters, or breaks a student's concentrated attention or focus decreases their productivity

Focus + Creativity = Productivity.

Leroy's conclusions on the nature of attention are further supported by Fogg's Behavior Model ". . . Compared to people who are motivated to reach cognitive closure, people who are not motivated to reach cognitive closure are more likely to keep thinking about a task even after it has been finished" (Leroy, 2009, p. 70). This further supports the idea that motivation drives focus.

Newport (2016) also acknowledges this with "The principle of least resistance: in a business setting without clear feedback on the impact of various behavior . . . to the bottom line, we will tend towards behaviors that are the easiest in the moment" (Newport, 2016, p. 88). Newport even highlights on the fact that even if the results are harmful, students will gravitate towards which behavior requires less effort. "Humans are naturally biased toward activities that require less energy in the short term, even if it's more harmful in the long term (Newport, 2016, p. 130).

By understanding the psychology and mechanics of what drives student behavior, further implementation of usability techniques can engineer the student's behavior by making the processes as easy to perform as possible within their educational environment. This environment must be created as a microenvironment within the student's current macroenvironment. This macroenvironment will be further defined in the next section.

2.4 Environments

In his New York Times Bestseller, *Leaders Eat Last: Why Some Teams Pull Together and Others Don't,* Simon Sinek (2017) analyzes factors of the work place cultures that promote success within different corporations. "When people have to manage dangers from inside the organization, the organization itself becomes less able to face the dangers from the outside" (Sinek, 2017, p. 16). This statement supports Csikszentmihalyi's (2013) theory of micro- and macro- environments. "Here it may be useful to make a distinction between the macroenvironment, the social, cultural, and institutional context in which a person lives, and the microenvironment, the immediate setting in which a person works" (p. 139). While Sinek's approach and research focuses on social aspects of workplace, his theories still apply to the power an environment has to change people's behavior. "Simply by changing the environment in which people worked, the same people started acting differently toward each other" (Sinek, 2017, p. 13).

2.4.1 The Macroenvironment

According to Csikszentmihalyi's proposal, macroenvironments are the social, cultural, and institutional context in which a person lives. The conditions of macroenvironments are outside of the user's control. Macroenvironments are chaotic and without any method of controlling its conditions, are prone to cause sensory overload, stress, and anxiety. This thesis proposes that workplace cultural norms surrounding technology and networking tools is a harmful element of the macroenvironment. This culture is hostile to the industrial design student's optimal mindset.

Newport (2016) defends this proposal:

> "The idea that network tools are pushing our work from deep to shallow is not new. . . [Along with The Shallows, other works have been produced such as] William Power's Hamlet's BlackBerry, John Freeman's The Tyranny of E-mail, and Alex Soojung-Kin Pang's The Distraction Addiction— all of which agree, more or less, that network tools are distracting us from work that requires unbroken concentration, while simultaneously degrading our capacity to remain focused" (p. 7).

Caywood (2004) also confirms this. "Today, major changes are happening in the workspace, brought about by the rapid evolution of information technology" (p. 131). The overarching problem of this element within the macroenvironment is, expectations for people to manage every notification that is provided by digital networking technologies, conditions the human brain to have a short attention span (Leroy, 2009). This conditioning provided by the macroenvironment, directly impacts an industrial design student's ability to focus on their work.

> "Perhaps predictably, this clash of old neural systems with modern innovations has caused problems. Much in the same way that the "innovation" of highly processed foods in the mid-twentieth century led to a global health crisis, the unintended side effects of digital communication tools—a sort of social fast food—are proving to be similarly worrisome" (Newport, 2019, p. 145).

Further confirmation that this phenomenon directly impacts the upcoming generation of the creative work force is apparent by national standards. "When the American Psychiatric Association published its fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) in 2013, it included, for the first time, behavioral addiction as a diagnosable problem" (Newport, 2019, p. 30).

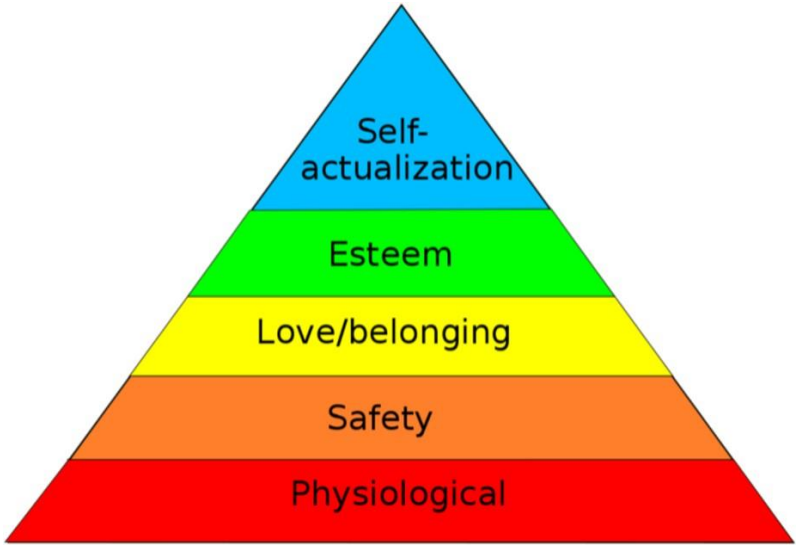


Figure 5. Maslow's Hierarchy of Needs, Retrieved November 10, 2019, from https://en.wikipedia.org/wiki/Maslow%27s_hierarchy_of_needs. Copyright 2014 by Creative Commons. Reprinted with permission.

In terms of Maslow's hierarchy of needs, Antonelli (2001) makes the comment that due to popular cultural trend and belief, workspaces are expected to provide top tier level needs such as self-actualization, rather than just a means to pay for food and shelter. "It is no longer enough that work fulfill low-level needs; it is now supposed to provide a sense of mission and spirituality" (p. 22). This new demand for workspace environment criteria demands that a ". . . new typology of the workplace has to be conceived from scratch and needs to accommodate new human behavior" (Antonelli, 2001, p. 14).

The industrial design student's macroenvironment does not nurture the psychological well-being and foundational cognitive skills needed to perform the role of an industrial designer at an optimal level. In order for enhanced work performance, the industrial design student must rely on a microenvironment to provide the proper nourishment for an enhanced mindset. This enhanced mindset requires components that provide the ability to achieve productivity, and support or enhance a student's motivation to achieve focus and apply the creative process. Fortunately, the chaos of the macroenvironment can be countered by the design and implementation of a microenvironment. "We can, however, gain control over the immediate environment and transform it so that it enhances personal creativity" (Csikszentmihalyi, 2013, p. 140).

2.4.2 The Microenvironment

The microenvironment, unlike its counterpart, the macroenvironment, is within a single individual's capability to establish order and control. Microenvironments can be designed,

created, and altered for the purpose of directly serving the needs of an individual. This can have a profound effect on the individual's state of mind.

> "One's environment affects one's state of mind. The designer works with typical office designs each day— workstations, lobbies, reception areas, conference rooms, etc. But the use of these spaces by the designer on a daily basis in his or her own firm affects the reality of design" (Caywood, 2004, p. 154).

While the macroenvironment of the industrial design student may consist of his or her university, community, or national culture and social regulation, the microenvironment includes smaller, controllable spaces within this world. The educational workspace of the industrial designer is its own microenvironment.

Due to the diversity of needs of a single educational studio for industrial design students, it is not unlikely that some educational workspaces comprise of multiple microenvironments. The needs of these microenvironment or environments, to best serve the educational requirements of industrial design students, must be regulated by environmental elements. Further elaboration on the specifics of these elements will be discussed in the methodology presented in Chapter 3. However, the overarching goals of the elements of the microenvironment must serve to sustain the three needs of Fogg's targeted behavior: ability, motivation, and trigger.

The elements must serve to create a sense of ease for usability to the industrial design student. This can be achieved by designing the elements of the environment to encourage the

user towards a psychological state of a relaxed ease of being. The element of color, like lighting and temperature, has potent psychological as well as physical effects on the human body.

> "The hypothalamus houses the body's biological clock (Wright, 2008). This is so because it governs our body's temperature, our appetite, sexual functions, sleeping, and behavioral patterns, and so on. It has been proved several times that color has a physical effect on humans due to its energy. . ." (Kurt & Osueke, 2014, p. 4).

In accordance with the specifics of the creative process, different colors should be paired accordingly with different phases and goals of the creative process. Further elaboration will be provided in the guidelines illustrated in Chapter 3.

The trait of adjusting an environment to create an ease of use for creative processes, is actually a very distinguished trait among creatives according to Csikszentmihalyi.

> "…what sets 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 that rhythm of their thoughts and habits of action. Within this environment of their own making, they can forget the rest of the world and concentrate on pursing the Muse" (p. 127-128).

This nature personal pattern, while highly individualistic to each creative, evoke trends and patterns among creatives as a whole.

2.4.3 The Impact of Environment

Csikszentmihalyi (2013) offers the idea that environments not only nature creativity, but also attract it. "…creative individuals tend to gravitate toward centers of vital activity, where

their work has the chance of succeeding" (Csikszentmihalyi, 2013). Current research leans toward the theory that careful and meticulous measurements of environmental elements combine to create optimal environments and cultures to supplement creative inspiration or states of deep focus. Csikszentmihalyi also recognizes the tendency to associate beautiful nature scapes with creative inspiration:

> "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" (p. 136).

However, Csikszentmihalyi hypothesizes that the rejuvenating qualities of the atmospheres to relax the mind are the more likely factors of creative inspiration. The psychologist hints that beauty may be inspiring, however difficult to prove as a necessary stimulation of creativity.

> "… the idea is that such a setting will stimulate thought and refresh the mind, and thus bring forth novel and creative ideas. Unfortunately, there is no evidence- and probably there never will be- to prove that a delightful setting induces creativity," (p. 135).

The propensity for environments to affect human psychology is so profound in fact, that mere color has been proven to induce total behavior adjustments. In his New York Time's Bestseller, *Drunk Tank Pink,* Adam Alter (2013) investigates unseeingly factors such as color

that are applied in institutions to control violent prisoners. The title is derived from a catalogued event where violent prisoners were placed in cell that was painted a shade of pink that proved to soothe their hypothalamus into inducing a calmer psychological state. Alter's studies suggest that steady and cyclical use of intentionally designed environments can adjust long-term behaviors. Color is perhaps one of the most powerful tools a designer can use to adjust an environment because of the high ease of application and adaptation. Color also has the ability of serving multiple purposes.

> "Color can perform a multitude of roles and can affect a person's emotions, energy level, and sense of order, or disorder. As well is can set the tone of interior and make it seem formal, or informal, masculine or feminine, coolly aloof or invitingly warm" (Poore, 1994, cited in Kurt & Osueke, 2014, p. 2).

Colors induce entire psychological experiences at no cost to the viewer's energy expenditure. "Colors are psychological experiences .....Color is fundamental to sight, identification, interpretation, perceptions, and senses. Some colors evoke psychological reactions through signals such as warmth, relaxation, danger, energy, purity, and death" (Courtis, 2004, p. 266).

Environments profoundly affect their occupants on a physical and psychological level. However, no matter how well-designed and engineered an environment is to accommodate the needs of an industrial student, the student will always be responsible for his or her own ability to perform their tasks as students and designers.

> "Creativity is not determined by outside factors but by a person's hard resolution to do what must be done. Which place is best depends on the total configuration of a person's characteristics and those of the task he or she is involved in. Someone who is relatively more introverted may wish to perfect his act before stepping before the limelight. A more extroverted person may enjoy competitive pressures from the very beginning of her career. In either case, however, choosing the wrong environment will probably hinder the unfolding of creativity" (Csikszentmihalyi, 2013, p. 133).

However, according to Csikszentmihalyi, environments still play a critical role in excluding the factors that hinder the industrial design student from completing their work.

2.6 Conclusion

In conclusion, the research in this literature review presents and analyzes the research necessary for establishing the need for an educational workspace environment for industrial design students. The purpose of this environment design is to shield the industrial design students from negative elements that impede their ability to maintain concentration in order to apply their creativity to the creative process and produce high quality creative work. Along with protecting students' cognitive state from detrimental distractions, this environment must supplement and enhance students' ability to perform work by providing visual elements that sustain well-being and structural elements that do not impede their ability to perform the tasks necessary to their mastery of industrial design skills and educational requirements.

This research has established the industrial design students' educational needs and requirements by conducting research on accredited and esteemed undergraduate industrial design programs. Moreover, this review has also specified and justified the necessary and foundational cognitive and psychological skills that is required for the student to optimize their success in their educational domain. These skills include creativity/ creative problem-solving process, focus, and productivity. In depth characterization and deconstruction of these skills further explained their specific environmental requirements. This review also evaluated case studies of workspaces as well as research concerning the psychological and physical impact environments have on individuals.

The environment design must serve the student's physical needs, psychological needs, as well as promote optimum application of the creative problem-solving process as well as performance of productive focus work. This research will now be applied in developing a list of recommendations by which any designer, student, teacher, or user can apply to their surrounding university educational studio workspace. These recommendations give guidance for changes in the environment that provide maximum benefits for creativity, focus and productivity to industrial design students using the space.

Chapter 3: Analysis & Recommendations

3.1 Introduction

The purpose of these recommendations is to promote a studio learning environment that enhances a student's ability to follow the creative problem-solving process. The previous chapter discussed the research necessary to understand the creative problem-solving process as well as the psychological properties, needs and subprocesses it requires of the student.

This chapter provides diagrams and charts to be used as supplementary tools to the given recommendations. These tools reference the research discussed in Chapter 2. They also explain the analysis of the relationships between the psychological needs of the design student and the physical requirements of the student's workspace environment.

3.2 The Two Approaches

There are two different approaches that may be used to design an environment to support the creative problem-solving process. The first approach analyzing the existing environment in terms of physical elements of the room. This approach is called the Physical Approach. An example of this approach could be "A room comprises of four walls, a ceiling, and a floor. Since this is a room, it must have these things. What color should those be in order to supplement creativity?"

The second approach analyzes the design of the environment from the perspective of serving the psychological needs of the creative problem-solving process. This approach is called the Psychological Approach. An example of creating the environment from this perspective would be, "Focus requires light, therefore, there should be lights in the room."

On one hand, the priority of the environment is to serve the user's psychological processes and creative possibilities, thus prioritizing the Psychological Approach. On the other hand, these optimal mindsets and thinking ideology will be limited to the physical limitations of the environment, thus prioritizing the Physical Approach. The goal is to maximize the designer's psychological ability to follow the creative process. This goal is to be achieved via an enhanced physical environment. Therefore, it is necessary to begin the redesign process with the Physical Approach and follow with the Psychological Approach to refine design choices.

Recommendations:

1. Use the physical approach to analyze an existing environment or plan a future environment
2. Use the psychological approach to refine the choice the of the physical aspects that create the environment
3. Look for relationships between the physical and psychological elements of the room
4. Determine which factor or factors should be changed that would cause the most impact to the room
5. Try to solve more than one problem with a single change

3.2.1 The Two Perspectives: Environment (Physical) & Human (Psychological)

To understand the Physical and Psychological Approaches, it is crucial to understand their purposes as well as their relationships with each other. Consider Figure 6 which demonstrates a diagram of the relationship between the physical environment and the design student and inhabitant of the room.

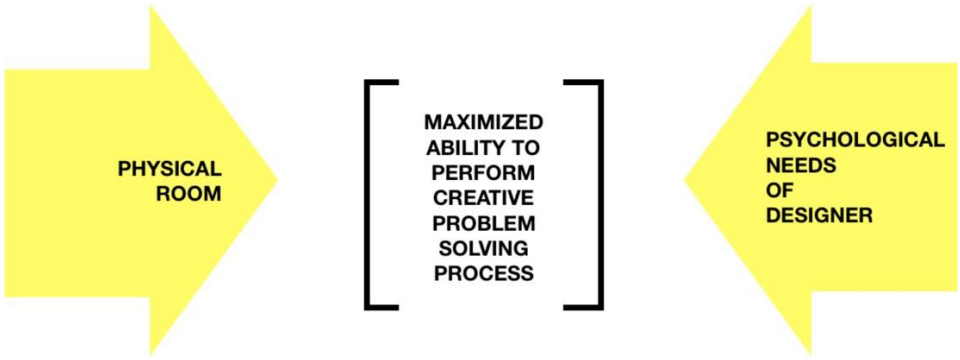


Figure 6. The Two Approaches

The diagram below represents the physical placement and organization of the relationship of the room (both physical and metaphysical) and its occupant, the human (both physical and psychological).

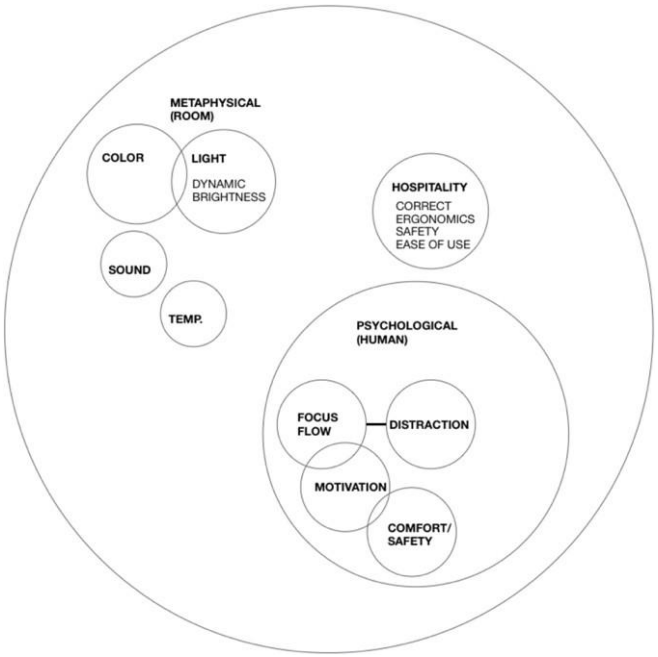


Figure 7. Diagram of the Relationship between Approaches

The psychological human inhabits the physical body of the human. The physical human inhabits the physical room. However, this physical room is perceived by the human psychologically. This means that the human psychologically simplifies the room as it becomes more familiar and identifies the necessary parts of this environment with which to interact. This metaphysical environment exists within the physical environment, yet although this environment is intangible, the human perceives him/herself to exist within it.

3.2.2 The Environment Perspective: Physical Approach & Relationships

The Physical Approach broaches the problem by primarily considering the physical elements of the environment design. This approach views the relationships between the environment and the human in physical terms, as illustrated in Figure 8.

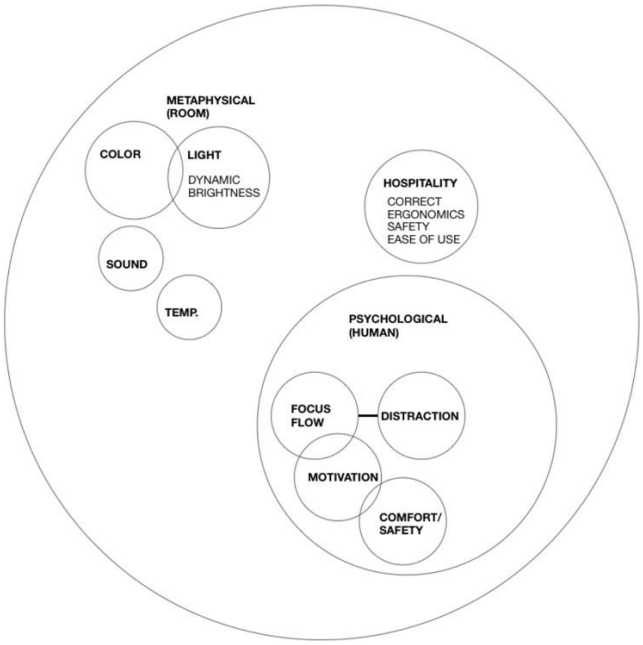


Figure 8. Relationships of Physical Aspects

The diagram in Figure 8 elaborates on the factors that comprise or include the physical room and the physical human. It also provides an overarching view of the dynamics of the human in relation to the environment. This tool allows the designer to process and understand the elements that combine to not only create a complex environment but visualize the human's place and points of interaction within this physical environment.

3.2.3 The Human Perspective: Psychological Approach & Relationships

The Psychological Approach addresses the problem from the primary considerations of the human and their needs. For this thesis, those needs are what the creative problem-solving process requires of the user's psychologic characteristics and skills. This perspective is based from the user's psychology in terms of how it is impacted by the environment's metaphysical characteristics (which are influenced by its physical characteristics)

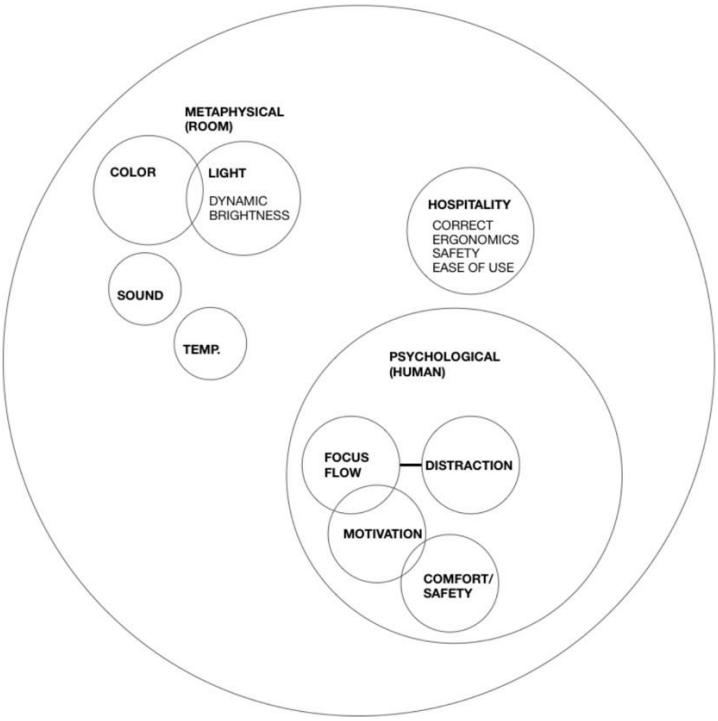


Figure 9. Relationships of Metaphysical and Psychological Aspects

Figure 9 elaborates on the factors that comprise or include the metaphysical room and the psychological human. This diagram is much less literal than the Figure 8. since the subjects being depicted are intangible.

3.2.4. Bringing the Two Approaches Together: Physical & Psychological

The two approaches are tools that provide a way to observe the problem from two different perspectives. They should never be used exclusively of each other because there are cross relationships between the physical human and the psychological environment as well as the metaphysical environment and the physical human. Figure 10 represents the connections between specific aspects of the room and the specific psychological human aspects using color.

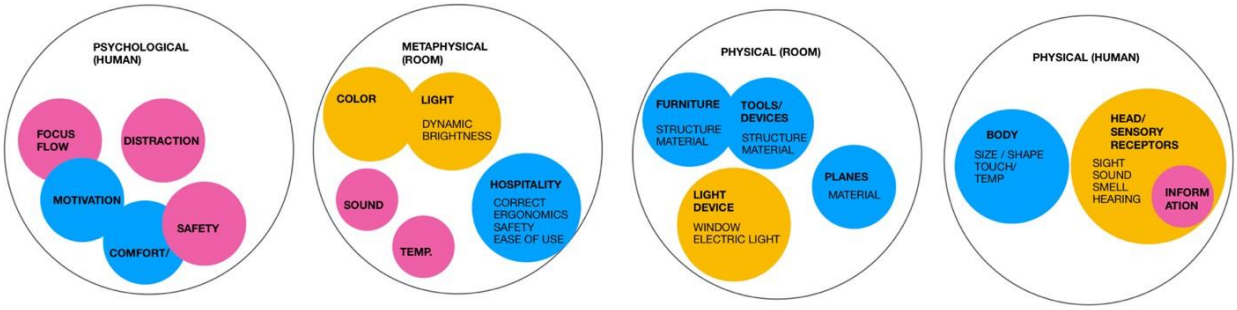


Figure 6. The Two Approaches

Environment design must incorporate balance between four elements: Environment, Mentality, and Relaxation, and Stimulation. It is necessary to understand how these four central elements relate to each other in order to design an environment to enhance user ability to perform the creative problem-solving process. This relationship is illustrated in Figure 11.

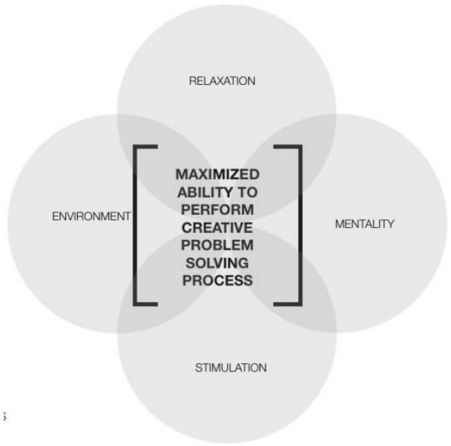


Figure 11. Methods of Maximizing User Ability to Perform the CPSPS

There are two separate opposing dualities 1) Environment and Mentality and 2) Relaxation and Stimulation. Environment and Mentality represent the two opposing perspectives to approach solving the problem (which is how to an environment to maximize user ability to perform the creative problem-solving process). These two opposing forces must be balanced in order to create a mutually symbiotic relationship between the two. These two elements are

managed and sustained via Relaxation and Stimulation. This means the components of each of the Environment and Mentality are controlled to maintaining harmony using balanced the practices of Stimulation and Relaxation.

Figure 11 can be expanded upon by including the elements that contribute to the elements that are associated with the Physical Approach and Psychological Approach. Figure 12 delineates this expansion of the specific components that the Environment and Mentality are comprised of.

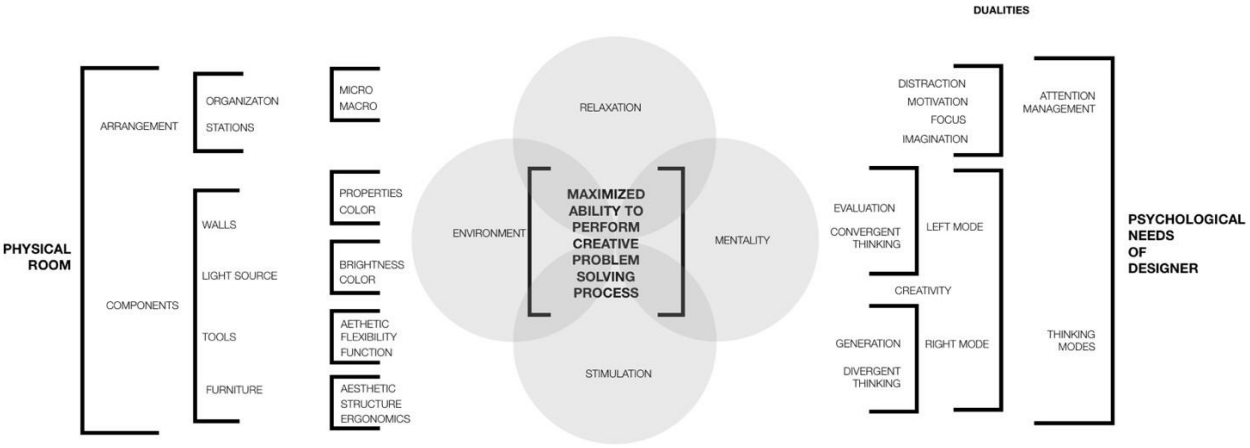


Figure 12. Recommendations for using 2 Approaches

3.3 Psychological Approach for Maximizing CPSP

This section discusses all of the detailed components of the creative problem-solving process from the Psychological Approach. According to the diagram in Figure 12 the Psychological Approach builds the key central element Mentality, which is crucial in creating an enhanced creative problem-solving environment. Topics will comprise of both the necessary psychological processes the user will need to supplement the creative problem-solving process, as well as a quick overview of the creative problem-solving process itself.

3.3.1 The Steps of the Creative Problem-Solving Process

Beginning with an analyzation of the creative problem-solving process establishes a strong foundation of our understanding of its procession and subprocesses. The process itself developed throughout the course of history as both educational and technological advancements improved. With these developments, the number and details of the steps altered. Figure 13 below is a comparative analysis chart which depicts the different steps of the more widely accepted developments and models of creative problem-solving processes.

PROCESS	CSIKSZENTMIHALYI 2013	MARTENS (2011) WALLAS (1926)	LAWSON (2006) KNELLER (???)	OSBOURNE-PARNES	JP GULLIFORD
STEP 1	PREPARATION	PREPARATION	INSIGHT	MESS FINDING	FILTERING
STEP 2	INCUBATION	INCUBATION	PREPARATION	DATA FINDING	COGNITION
STEP 3	INSIGHT	ILLUMINATION	ILLUMINATION	PROBLEM FINDING	PRODUCTION
STEP 4	ELABORATION	VERIFICATION	VERIFICATION	IDEA FINDING	
STEP 5	EVALUATION			SOLUTION FINDING	
STEP 6				ACCEPTANCE FINDING	

Figure 13. Comprehensive diagrams of creative processes. Adapted from Idea Sandbox. (2001). https://idea-sandbox.com/cps-methods/#axzz5xR9uL0lu

Note the similarities of the sequences between each model. This thesis applies the most recent and widely accepted five step creative problem-solving process developed by Csikszentmihalyi in 2013.

PROCESS	CSIKSZENTMIHALYI 2013
STEP 1	PREPARATION
STEP 2	INCUBATION
STEP 3	INSIGHT
STEP 4	ELABORATION
STEP 5	EVALUATION

Figure 14. Csikszentmihalyi's 5 Step CPSP. Adapted from Idea Sandbox. (2001). https://idea-sandbox.com/cps-methods/#axzz5xR9uL0lu

3.3.2 Convergent & Divergent Thinking

Osborne and Parnes (1977) model of the creative problem-solving process addresses convergent and divergent thinking as adjacent phases that are integrated within the actual steps of the process.

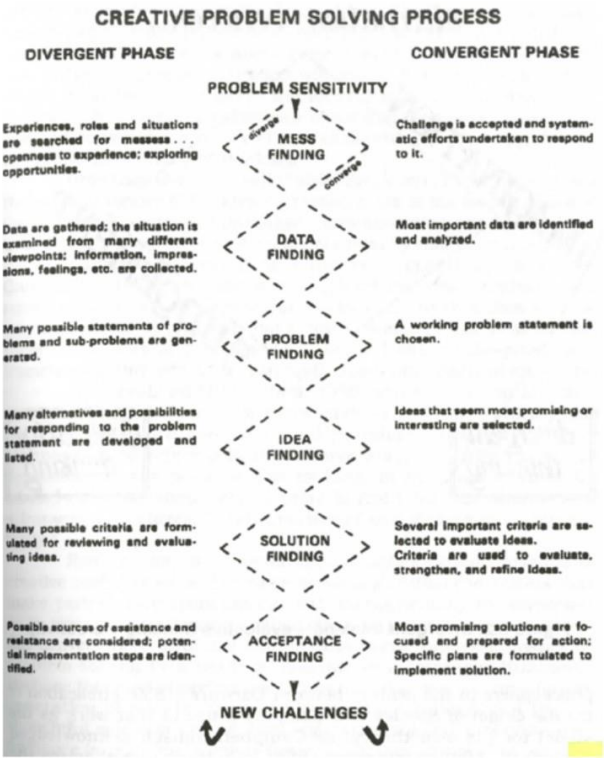


Figure 15. The Osborne-Parnes CPSP. Reprinted from *Critical Creative Processes* (p. 133), by Runco, 2003, Hampton Press. Copyright 2003 by the Association for Memory Research. Reprinted with permission.

Divergent and convergent thinking are opposing directions or modes of thought. Divergent thinking involves expanding, seeing new possibilities, taking risks and produces many unconventional solutions. Convergent thinking involves logical, sequential analyzation, exploring, sorting, identifying, evaluating, closing in on an idea, and ideally produces one single solution.

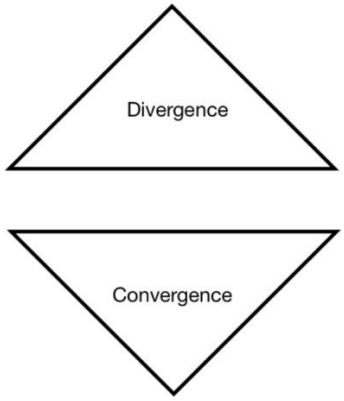


Figure 1. Divergent and Convergent Thinking. Adapted from *Critical Creative Processes* (p. 134), by Runco, 2003, Hampton Press. Copyright 2003 by the Association for Memory Research. Reprinted with permission.

Table 1. *Example of Convergent and Divergent Thinking*

Kind of Thinking	Convergent	Divergent
Typical Processes	Being logical	Being unconventional
	Recognizing the familiar	Seeing the known in a new light
	Combining what "belongs" together	Combining the disparate
	Homing in on the single best answer	Producing multiple answers
	Reapplying set techniques	Shifting perspective
	Preserving the already known	Transforming the known
	Achieving accuracy and correctness	Seeing new possibilities
	Playing it safe	Taking risks
	Sticking to a narrow range of obviously relevant information	Retrieving a broad range of existing knowledge
	Making associations from adjacent fields only	Associating ideas from remote fields
Typical Results for the Individual	Greater familiarity with what already exists	Alternative or multiple solutions
	Better grasp of the facts	Deviation from the usual
	A quick, "correct" answer	A surprising answer
	Development of a high level of skill	New lines of attack or ways of doing things
	Closure on an issue	Exciting or risky possibilities
	A feeling of security and safety	A feeling of uncertainty or excitement

Figure 17. Example of Convergent and Divergent Thinking. Reprinted from "In Praise of Convergent Thinking," by A. M. Cropley, 2006, *Creativity Research* (18), 392. Copyright 2006. Reprinted with permission.

A simplified version of Divergent Thinking and Convergent Thinking is Generating and Exploring. Divergence is needed for idea generation, and convergence is needed to explore these generated ideas and select and refine the most promising solutions.

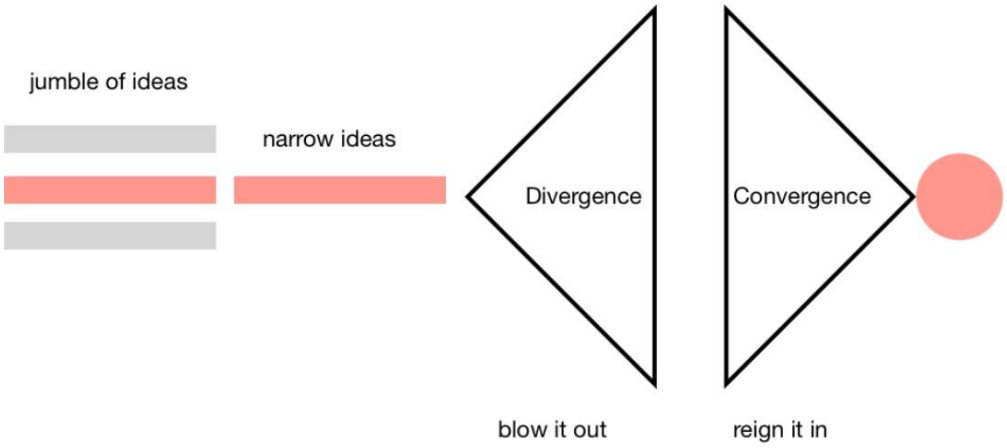


Figure 18. How Convergent and Divergent Thinking work. Adapted from Idea Sandbox. (2001). https://idea-sandbox.com/cps-methods/#axzz5xR9uL0lu

Table 2. *Processes of Divergent and Convergent Thinking in Generating Novelty*

	Generation of Variability		Generation of Orthodoxy	
Phase	**Examples of Processes of Divergent Thinking**	**Result**	**Examples of Processes of Convergent Thinking**	**Result**
Generating	Linking Transforming Reinterpreting Branching out	Engineer sees similarity between steel rods and spaghetti	Recognizing the familiar Reapplying the known Sticking to the rules	Engineer does not see a similarity between steel and spaghetti
Exploring	Shifting contexts Exceeding limits Crossing boundaries Creating surprise	Engineer concludes that steel rods can be replaced with spaghetti: Novelty to be sure—but in this case, a disaster!	Avoiding risk Being certain Staying within limits Seeking simplicity Assessing technical and financial feasibility	Engineer sticks to steel rods to reinforce concrete: No innovation, but building does not fall down!

Figure 19. How Convergent and Divergent Thinking work: example. Reprinted from "In Praise of Convergent Thinking," by A. M. Cropley, 2006, *Creativity Research* (18), 399. Copyright 2006. Reprinted with permission.

Convergent and divergent thinking are crucial to enhancing the potential of the creative process—however in order to enhance the process, convergent and divergent thinking should be integrated at strategic moments within the duration of the creative problem-solving process. According to Osborne and Parnes, both are needed for each step of the creative problem-solving process. However, Cropely's creative problem-solving model prioritizes only one of the two methods of thinking for specific steps in the process.

Table 4. *Creative Processes, Traits, and Motives in the Phases of Production of Novelty*

Phase	Action	Result	Necessary Process
Information	Perceiving	Initial activity	
	Learning	General knowledge	Convergent thinking
	Remembering	Special knowledge	
Preparation	Identifying problem	Focused special knowledge	Convergent Thinking
	Setting goals	Rich supply of cognitive elements	
Incubation	Making associations	Combinations of cognitive elements	Divergent thinking
	Bisociating		
	Building networks		
Illumination	Making a promising new configuration	Novel configuration	Divergent thinking
Verification	Checking relevance and effectiveness of the novel configuration	Appropriate solution displaying relevance and effectiveness	Convergent thinking plus divergent thinking
Communication	Acting on feedback	Effective presentation to others	Convergent thinking plus divergent thinking
	Achieving closure		
Validation	Judging relevance and effectiveness	Product acclaimed by relevant judges	Convergent thinking

Figure 20. Cropley's Creative Process, Relative Traits, and Subprocesses. Reprinted from "In Praise of Convergent Thinking," by A. M. Cropley, 2006, *Creativity Research* (18), 402. Copyright 2006. Reprinted with permission.

For this thesis, the model shown in Figure 20 is the accepted understanding of convergent and divergent thinking in accordance with Csikszentmihalyi's five step creative problem-solving process. This model is also supported by research and ideas concerning cognitive duality that is introduced in the next section.

3.3.3 R & L Mode

R-Mode and L-Mode are characterized by the specific physical hemispheres that are active in the user's brain as they work to solve a problem. Only one mode can be active at a single time. Figure 21 consists of a diagram of the specific characteristics of R- and L-Mode.

L MODE		R MODE	
VERBAL	*using words to name, describe and define*	NON VERBAL	*Using non-verbal cognition to process perceptions*
ANALYTIC	*Figuring things out step by step and part by part*	SYNTHETIC	*putting things together to form wholes*
SYMBOLIC	*Using a symbol to stand for something*	ACTUAL,REAL	*relating to things as they are, at the present moment*
ABSTRACT	*taking out a small bit of information and using it to represent the whole thing*	ANALOGIC	*Seeing likenesses among things, understanding metaphoric relationships*
TEMPORAL	*keeping track of time, sequencing one thing after another*	NONTEMPORAL	*Without a sense of time*
RATIONAL	*drawing conclusions based on reason and facts*	NONRATIONAL	*Not requiring a basis of reason or facts; willingness to suspend judgement*
DIGITAL	*using numbers as in counting*	SPATIAL	*Seeing where things are in relation to other things and how parts fo together to form a whole*
LOGICAL	*drawing conclusions based on logic*	INTUITIVE	*Making leaps of insight, often based on incomplete patterns, hunches, feelings, or visual image*
LINEAR	*thinking in terms of linked, sequential ideas*	HOLISTIC	*seeing whole things all at ocne; perceiving overall patterns and structures, often leading to divergent conclusions*

Figure 21. A Comparison of L-Mode and R-Mode Characteristics

Figure 21. A Comparison of L-Mode and R-Mode Characteristics. Reprinted from *Drawing on the Right Side of the Brain* (p. 30), by K. M. Pike, 2008, London: Souvenir Press. Copyright 2012. Reprinted with permission.

Edwards recommends the technique of actively switching from one mode to the other by presenting the current mode with a task that the brain is incapable of achieving unless it is in the desired mode. It is recommended that this same technique is applied to switch to desired modes through designing at least two zones within the environments, at least one of them suiting L-

mode and one for R-mode. This will allow the student supplementation in switching cognitive modes at their desire. Figure 22 demonstrates the logic of this strategy in accordance with the logic of Edward's technique.

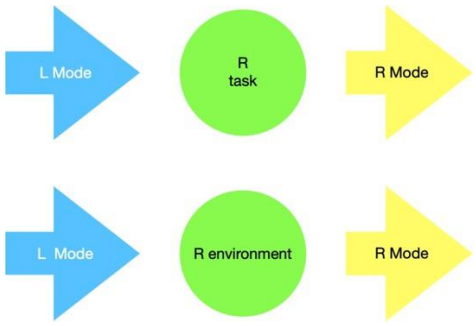


Figure 22. Logic of Using an Environment for Cognitive Shifting. Adapted from *Drawing on the Right Side of the Brain* (p. 44), by K. M. Pike, 2008, London: Souvenir Press. Copyright 2012. Reprinted with permission.

It is necessary to establish when these switches are necessary. Components of R-Mode thinking favor components of divergent thinking. The same is true of L-Mode and convergent thinking. Figure 23 provides a cross-comparison of the parallel nature of divergent and convergent thinking with R- and L- Mode.

L MODE		R MODE	
VERBAL	*using words to name, describe and define*	NON VERBAL	*Using non-verbal cognition to process perceptions*
ANALYTIC	*Figuring things out step by step and part by part*	SYNTHETIC	*putting things together to form wholes*
SYMBOLIC	*Using a symbol to stand for something*	ACTUAL,REAL	*relating to things as they are, at the present moment*
ABSTRACT	*taking out a small bit of information and using it to represent the whole thing*	ANALOGIC	Seeing likenesses among things, understanding metaphoric relationships
TEMPORAL	*keeping track of time, sequencing one thing after another*	NONTEMPORAL	Without a sense of time
RATIONAL	*drawing conclusions based on reason and facts*	NONRATIONAL	*Not requiring a basis of reason or facts; willingness to suspend judgement*
DIGITAL	*using numbers as in counting*	SPATIAL	*Seeing where things are in relation to other things and how parts form together to form a whole*
LOGICAL	*drawing conclusions based on logic*	INTUITIVE	*Making leaps of insight, often based on incomplete patterns, hunches, feelings, or visual image*
LINEAR	*thinking in terms of linked, sequential ideas*	HOLISTIC	*seeing whole things all at once; perceiving overall patterns and structures, often leading to divergent conclusions*

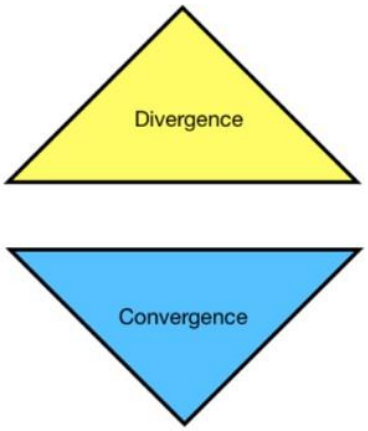


Figure 23. L-Mode and R-Mode with Divergence and Convergence. Adapted from *Drawing on the Right Side of the Brain* (p. 30), by K. M. Pike, 2008, London: Souvenir Press. Copyright 2012. Reprinted with permission.

R-Mode and L-Mode thinking are best used for specific steps of the creative problem-solving process. Edwards developed a method for applying these modes to specific steps in Copley's creative problem-solving process (2014, p. 40).

L MODE / R MODE	EDWARDS (2012)				
PROCESS	INSIGHT	SATURATION	INCUBATION	ILLUMINATION	VERIFICATION
R MODE	R mode leading		R mode leading	L mode unity	R mode guides with visualization
L MODE		L mode leading		R mode unity	L mode dominant

Figure 24. Edward's R-Mode and L-Mode CPSP. Reprinted from *Drawing on the Right Side of the Brain* (p. 245), by K. M. Pike, 2008, London: Souvenir Press. Copyright 2012. Reprinted with permission.

3.3.4. Motivation

The final relevant psychological component to supplement the user's creative problem-solving process ability is motivation. Motivation must be considered in order to promote the desired user behavior within an environment. Factors that determine the success of the desired user behavior (in this case the behavior is performing the creative problem-solving process) are the level of ease of usability and the level of motivation of the user.

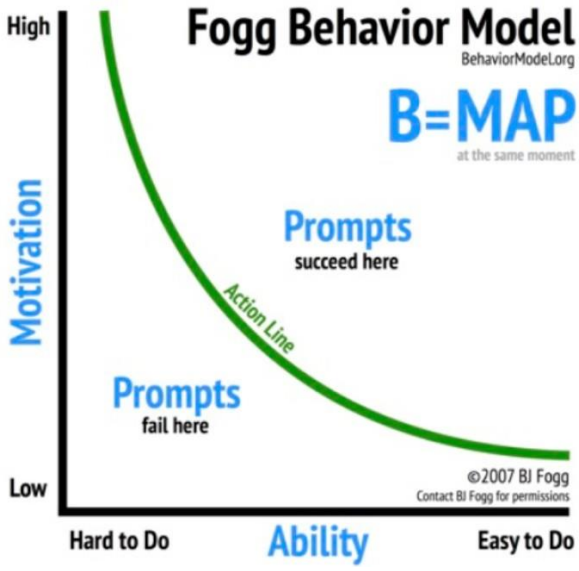


Figure 4. The B.J. Fog Behavior Model, Retrieved November 10, 2019, from https://www.behaviormodel.org/. Copyright 2007 by BJ Fogg. Reprinted with permission.

This behavior model should be considered in the development of the environment from the user's perspective.

3.3.5. Conclusion

This section has addressed the recommended psychological components to consider when designing an environment to enhance a designer's ability to perform the creative problem-solving process. The next section addresses the components to be considered from the physical approach and what is required of the environment.

3.4. Physical Approach for Maximizing CPSP

This section will discuss all of the detailed components of the creative problem-solving process from the Physical Approach. The Physical Approach considers solving the problem of designing an environment to in terms of the environment's physical limitations and existing opportunity. The Physical Approach results in the key central element of Environment, which is crucial in creating an enhanced creative problem-solving environment. Topics will comprise of both the necessary physical elements the user will need to creative the environment to support the creative problem-solving process.

3.4.1. Macro-/Micro- Environments

It is recommended to apply Csikszentmihalyi's theory of Macroenvironments and Microenvironments in order to divide the workspace into more manageable sections. This division also allows the designer to efficiently divide and organize priorities of the spaces. The Microenvironments that exist within the Macroenvironment is the same configuration of team

that is made up of many individuals. The individual students each possess their own microenvironment in which they perform their individual, more private work. The collective microenvironments of each student exist within the macroenvironment, which is the overall workspace environment for the class. This macroenvironment also serves as a communal space for teamwork among the individual students. Figure 26 demonstrates the relationship between a typical Microenvironment and Macroenvironment.

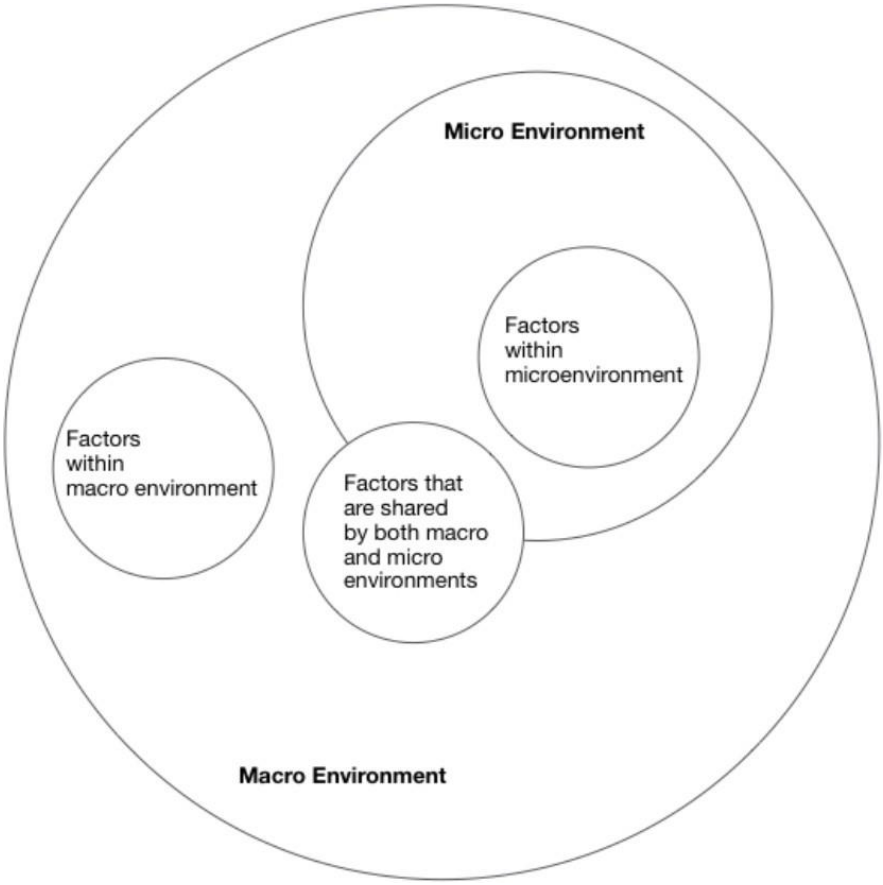


Figure 26. Macro-/Micro- Environment Relationship. Adapted from *Creativity the Psychology of Discovery and Invention* (139), by M. Csikszentmihalyi, 2013, New York: NY, Harper Collins. Copyright 2013. Adapted with permission.

Consider Figure 26 to see this concept applied to the studio space design. The macro-environment comprises of the factors of the studio workspace that serve the collective class as a

group. It also hosts the individual microenvironments. Individuals have limited control over the macroenvironment. The microenvironment exists within the macroenvironment. The microenvironment represents the immediate personal workspace that the individual design student has control over. Figure 27 shows a diagram that delineates the relationships between multiple environments.

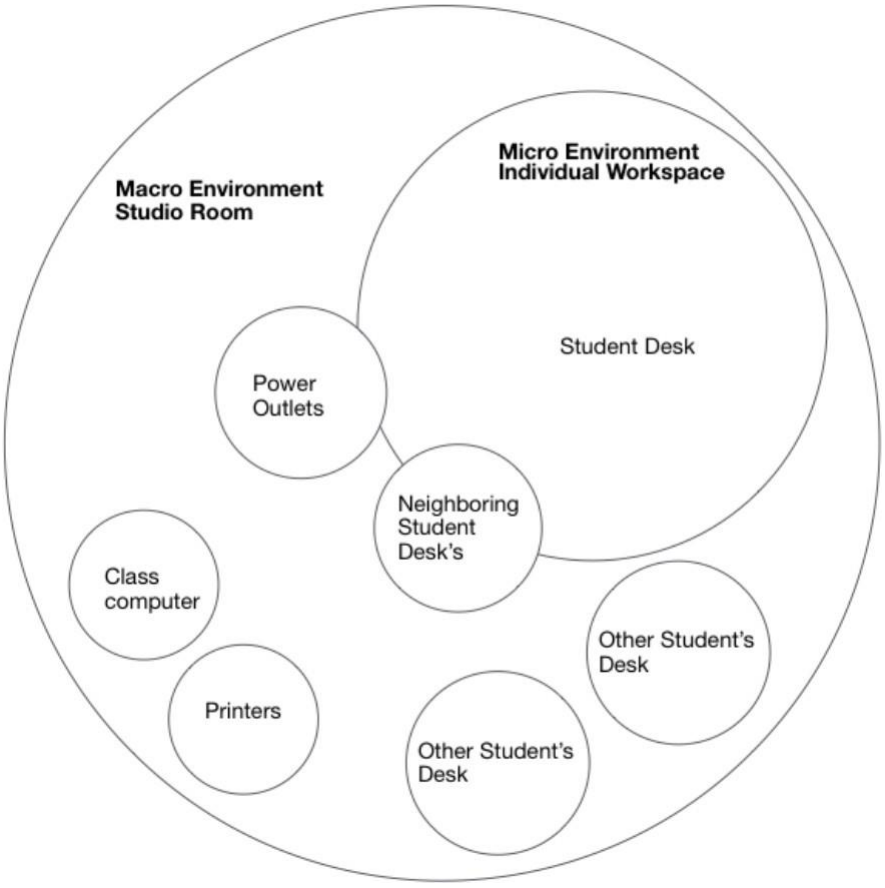


Figure 27. Macro-/Micro- Environment Relationship Applied to Studio Space Design. Adapted from *Creativity the Psychology of Discovery and Invention* (139), by M. Csikszentmihalyi, 2013, New York: NY, Harper Collins. Copyright 2013. Adapted with permission.

Understanding the concept of Microenvironments and Macroenvironments and how they relate to each other is a valuable tool when designing an environment that must serve an individual user as well as a collective group of users. Figure 28 is another representation of the macro- and micro- environments. In this case the black area represents the macroenvironment while the white areas within the black represent microenvironments.

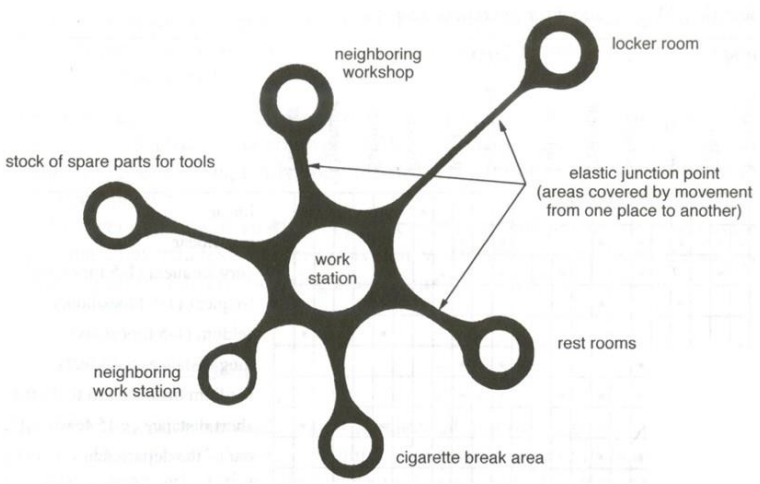


Figure 28. Range of Action and Exploration Around the Workstation. Reprinted from *Critical Creative Processes* (p. 134), by Runco, 2003, Hampton Press. Copyright 2003 by the Association for Memory Research. Reprinted with permission.

In order to create an environment to cater to the user's and users' specific needs to follow the creative problem-solving process, it is useful to understand macroenvironments and microenvironment in the context of creative problem-solving process. Figure 29 offers a chart that explains the optimal primary target users for each environment.

	MACRO ENVIRONMENT	MICRO ENVIRONMENT
PRIORITIES		
Primary Target User	Group	Individual

Figure 29. Target Users for Macro-/Micro- Environ. Adapted from *Creativity the Psychology of Discovery and Invention* (139), by M. Csikszentmihalyi, 2013, New York: NY, Harper Collins. Copyright 2013. Reprinted [or adapted] with permission.

Microenvironments more efficiently serve individuals than groups. Macroenvironments more efficiently serve groups than individuals. Figure 30 demonstrates a chart of recommendations that categorizes the psychological roles by micro- or macroenvironments.

	MACRO ENVIRONMENT	MICRO ENVIRONMENT
PRIORITIES		
Primary Target User	Group	Individual
PSYCHOLOGY		
CON/DIV	Divergent	Convergent
L/R	Right	Left
CPSP	1. Preparation	4. Evaluation
		5. Elaboration
SENSORY STIMULATION	Imagination/ Distraction	Focus

Figure 30. Psychological Roles of Macro- and Micro- Environments. Adapted from *Creativity the Psychology of Discovery and Invention* (139), by M. Csikszentmihalyi, 2013, New York: NY, Harper Collins. Copyright 2013. Reprinted [or adapted] with permission.

The macroenvironment and microenvironment are tasked with providing the definite working environment for steps one, four, and five of the creative problem-solving process. Steps two and three typically occur during periods of relaxation, step three is known to specifically occur sporadically and unpredictably. Because of this these steps may or may not occur within the studio space, therefore this thesis will make any strong or definite recommendations concerning these steps specifically.

Reference the following guidelines when considering the micro-/macro -environment design within the studio:

- Acknowledge the goals of the environment.

  Goals of Macroenvironment: To provide a working environment that 1) hosts individual student's personal workspaces (microenvironments) and 2) provides collaborative working environment for the class as a whole.

  Goals of Microenvironment: To provide the individual student with a personal workspace.

- Encourage personalization of Microenvironments.

Refer to the chart in Figure 31 when assessing an existing studio space from the Psychological Approach.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Does the macroenvironment serve the group?				
Does the macroenvironment support divergent thinking?				
Does the macroenvironment support R - mode?				
Does the macroenvironment stimulate imagination				
Does the macroenvironment provide a working environment that hosts individual student's personal workspaces (microenvironments)?				
Does the macroenvironmentprovide collaborative working environment for the class as a whole?				
Microenvironment:				
Does the microenvironment serve the individual?				
Does the microenvironment support convergent thinking?				
Does the microenvironment support L - mode?				
Does the microenvironment stimulate focus?				
Does the microenvironment encourage personalization by user?				
Does the microenvironment provide the individual student with a personal workspace?				

Figure 31. Reference for Macro-/Micro- Environment Analysis

3.4.2 Analogue & Digital Tools

Tools (also referred to as “artifacts”) enable the student to perform their required tasks within the workspace environment. These tools can be categorized as either analogous (e.g. pencils, paper, whiteboards, etc.). or digital (computers, printers, etc.). “It is strongly recommended to use both computer tools and traditional tools and media equally” (Alhajri, 2016).

The different qualities of both digital and analogous tools create benefits and disadvantages depending on which task the tool is being used for. For instance, digital tools are better served for create the advantage of eliminating time consuming processes such as going to the library for research or writing and sending information by hand. “With the computer it is possible to do easily and quickly those things that it was difficult and time-consuming to do in the past” (Alhajri, 2016).

However, digital tools tend to “dehumanize” the process due to the limitations of the machine. “Although the computer is known for expediency, precision and rendering abilities, it falls short in imitating the quirky and raw qualities of hand-crafted letterforms” (Alhajri, 2016). This quality of work is much better suited for traditional or analogue tools. These tools provide flexibility and a more intimate experience between the user and the information and ideas.

	Analogue Tools	Digital Tools
Benefits	Hands on/ more intimate	Speed / more efficient
	easy to collaborate	hard to collaborate
Disadvantage	Limited by human capability	Limited by machine capability

Figure 32 Pros and Cons of Digital and Analogical Tools. Adapted from *Steal Like an Artist: 10 Things Nobody Told You About Being Creative.* (32), by A. Kleon, 2012, New York: NY, Workman Pub. Co. Copyright 2012. Reprinted adapted with permission.

The qualities of each type of tools possess optimize them for either collaborative work or an individual's work. It has been established that macroenvironments best serve a collaborative group, and Microenvironments best serve individual workers. Therefore, it can be deduced that analogue tools should be prioritized within Macroenvironments since their qualities are better suited for collaborative groups. Meanwhile the nature of digital tools best serves the needs of individual workers and therefore belong within the Microenvironment of the studio space. Figure 33 demonstrates the benefits, disadvantages, and appropriate environments for each type of tool.

	Analogue Tools	Digital Tools
Benefits	Hands on/ more intimate	Speed / more efficient
	easy to collaborate	hard to collaborate
Disadvantage	Limited by human capability	Limited by machine capability
Best fit for	MACRO ENVRIONMENT	MICRO ENVIRONMENT

Figure 33. Digital and Analogical Tools role in Macro-/Micro- Environments. Adapted from *Creativity the Psychology of Discovery and Invention* (139), by M. Csikszentmihalyi, 2013, New York: NY, Harper Collins. Copyright 2013. Reprinted [or adapted] with permission.

It is always recommended to consider how each physical element within the Physical Approach fits into the creative problem-solving process. For instance, since the Preparation phase of the creative problem-solving process must take place in the macroenvironment, it must be assumed that collaboration is necessary, and an intimate exploration of the problem is desired over speedy, privately performed work. This promotes the conclusion that analogue tools are a

better fit for the first step of the creative problem-solving process. Figure 34 demonstrates analogue and digital tools' best application based on this process.

PROCESS	CSIKSZENTMIHALYI 2013	MACRO/MICRO	ANALOGUE/DIGITAL
STEP 1	PREPARATION	MACRO	ANALOGUE
STEP 2	INCUBATION	undefined	undefined
STEP 3	INSIGHT	undefined	ANALOGUE
STEP 4	ELABORATION	MICRO	COMBO
STEP 5	EVALUATION	MACRO	COMBO

Figure 34. *Digital and Analogical Tools role in the CPSP*. Adapted from *Creativity the Psychology of Discovery and Invention* (139), by M. Csikszentmihalyi, 2013, New York: NY, Harper Collins. Copyright 2013. Reprinted [or adapted] with permission.

It is recommended to apply the chart provided in Figure 35 to assessing an existing studio space's organization of analogue and digital tools from the psychological approach.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Are the tools predominantly analogue?				
Do the tools serve the group?				
Do the tools support divergent thinking?				
Do the tools support R - mode?				
Do the tools stimulate imagination				
Do the tools provide a working environment that hosts individual student's personal workspaces (microenvironments)?				
Do the tools provide collaborative working environment for the class as a whole?				
Microenvironment:				
Are the tools predominantly digital?				
Do the tools serve the individual?				
Do the tools support convergent thinking?				
Do the tools support L - mode?				
Do the tools stimulate focus?				
Do the tools encourage personalization by user?				
Do the tools provide the individual student with a personal workspace?				

Figure 35. Reference for Digital and Analogous Tool Analysis

3.4.3. Lighting

This section discusses natural lighting, dynamic lighting, and lighting brightness. Natural lighting is considered the best option; however, its availability is limited by the architecture of

the building. Dynamic Lighting is an alternative to natural lighting and is associated with managing user stress by directly corresponding to hormonal levels of cortisol (stress hormone) and melatonin (sleep hormone) of the user. Lighting brightness and quality is related to encouraging or discouraging convergent, divergent thinking, L-Mode, R-Mode, focus for analytical processes, and creativity.

Lighting has very direct effects on user psychology and is therefore a very critical element in workspace design. Lighting may be provided by either windows or lighting devices. Windows that provide natural lighting are ideal for workspaces. If windows are unavailable, other adjustments can be made to optimize lighting conditions to encourage creativity, productivity, and stress management. Lighting conditions must provide the users with visual ability to accomplish their work.

Natural lighting is accessed by windows or skylights. "According to Lloyd (2001) the best option is natural lighting" (Warner & Myers, 2010, p. 30). This type of lighting is associated with stress reduction, productivity, and creativity. "People with a window, or people with access to daylight within 5 m (15 ft) had higher satisfaction with lighting than people without a window. Having a window in the office appears to assist the coping process in response to stress at work and at home (Kaplan, 2001; Leather et al., 1998)" (Veitch, 2016, p. 214).

> "Using daylighting to achieve the higher daily light exposure indoors would be an energy-efficient solution (when coupled with appropriate electric lighting controls), and in addition would probably be biologically effective because daylight is rich in the

> spectral regions to which the novel photoreceptors are most sensitive (450–470 nm) (C.I.E, 2004)" (Veitch, 2016, p. 211).

If natural lighting is unavailable, dynamic lighting is designed to mimic natural lighting in order to achieve the same effects natural lighting provides. "This lighting pattern is believed to have positive impact on the health and well-being of office occupants and would lead to higher visual performance" (Motamed, 2019, p. 215). This is achieved by adjusting illuminance or brightness to mimic the same levels of illuminance caused by the cycle of natural lighting. This would be managed by installing dimmers and manually adjusting the brightness levels periodically in correspondence to typical human hormone levels of melatonin and cortisol. Human circadian rhythm dictates the patterns of melatonin and cortisol levels. This rhythm responds to light patterns.

> "Two important hormones (e.g. melatonin and cortisol), whose concentrations are believed to have a considerable impact on the performance, alertness and mood of human beings, have been identified. Using the results of human studies conducted in different time of the day or the night with different light intensities would allow establishing an optimal quantitative dynamic lighting pattern. Moreover, the phase-response curve, a chronological diagram depicting the circadian phase shift as a result of exposing the subject to light, could also be taken into consideration to optimize the lighting pattern" (Motamed, 2019, p. 2).

This means that brighter light early in the morning helps the user increase alertness. The bright light lowers melatonin levels while raising cortisol levels.

"..... exposure to brighter light in the early morning advances the circadian phase, in other words it contributes to increase alertness. The phase delay in the early afternoon when circadian criteria are also applied is supposed not to have a significant" (Motamed, 2019, p. 6).

Therefore, the dynamic lighting pattern dictates bright light is needed particularly in the morning in the workspace environment. Bright light is also necessary in the earlier afternoon, but to a lesser degree.

> "What is certain is that a higher illuminance level needs to be provided in the early morning and for a short time after lunch break, when the user is more likely to undergo daytime sleepiness according to the temporal profiles of human sleep propensity" (Lavie and Zvuluni 1992 cited in Motamed, 2019, p. 5).

This pattern benefits the user by reducing biological stress by matching the environment's light patterns to the user's circadian rhythms. "This lighting pattern is believed to have positive impact on the health and well-being of office occupants and would lead to higher visual performance" (Motamed, 2019, p. 7).

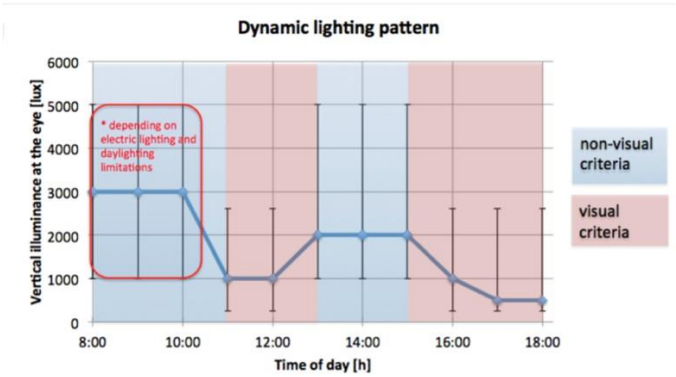


Figure 36. Dynamic Lighting Pattern. Reprinted from *Short-term Memory Loss* (p. 6), by K. M. Pike, 2008, New York, NY: Mackerlin Press. Copyright 2016 by The Authors. Reprinted with permission.

Dynamic lighting pattern supports overall human wellness by controlling the user's stress hormones.

Brightness levels also contribute to human psychological processes directly linked to the creative problem-solving process. Brightness levels of a room have been proven to enhance or diminish a user's ability to think convergently or divergently. "…. bright environment tends to encourage analytical processes, while a darkened environment seems to be conducive to creativity" (Bissantz & Siemon, 2016, p. 10).

The understanding is that dimly lit rooms create environments that are more relaxed and less orthodox. "Overall, the majority of studies confirm that dim rooms appear more relaxing and calming than brightly lit rooms..... dim rather than bright light creates a cozy and relaxing atmosphere, which is typical for a safe and benign environment" (Steidle & Werth, 2013, p. 68). These conditions are prime for encouraging divergent and R-Mode thinking. "By changing the room's atmosphere (freeing vs. confining), the lighting condition can induce a global and

explorative processing style, which in turn improves creative performance" (Steidle & Werth, 2013, p. 68).

The effect is mirrored. Brightly lit rooms have the opposite effect on user psychology: enhancing analytical processes, L-mode and convergent thinking. "[P]articipants in the dim room performed better on the creativity task and worse on the analytical thinking task than participants in the bright and control rooms" (Steidle & Werth, 2013, p.76). Because of this mirror effect, bright and dim rooms can be assigned to specific steps in the creative problem-solving process to enhance user psychological ability.

	BRIGHT	DARK
SUPPORTS	ANALYTICAL PROCESSES	CREATIVITY
IMPAIRS	CREATIVITY	ANALYTICAL PROCESSES

LIGHTING QUALITY	Supports/enhances
Bright	Convergent Thinking
Dim	Divergent Thinking

Figure 37. Lighting and Convergent/Divergent Thinking. Adapted from "Freedom from constraints: Darkness and dim illumination promote creativity.," by Steidle, A. & Werth, L., 2013, *Journal of Environmental Psychology, 35.* 4. Copyright 2013 by the Elsevier. Adapted with permission.

Avoid Fluorescent light bulbs. Fluorescent light bulbs are rampant in educational facilities. However, these bulbs impair user psychological wellbeing. This in turn negatively affects productivity. "Unfortunately, in most schools the typical lighting source is fluorescent lights. Indications are; however, this type of lighting can cause students to become hyperactive and agitated, which diminishes productivity" (Warner & Myers, 2010, p. 30). A simple switch of lightbulbs provides an easy, inexpensive solution.

"It may not be practical to change the entire lighting system in a classroom or lab facility, but a compromise can be found in changing traditional fluorescent lights to full-spectrum

tubes, which can improve visual performance and decrease fatigue" (Mahnke, 1996 cited in Warner & Myers, 2010, p. 30).

For quantifiable recommendations, use 500 lux for horizontal illuminance and a minimum of 250 lux for vertical illuminance.

"A recommended illuminance value based on the existing norms for workplane lighting sufficiency as well as for avoiding discomfort glare is also needed. Regarding the lighting sufficiency, the standard EN 12464-1 recommends a horizontal illuminance of 500 lux on the workplane. The Handbook of Industrial Engineering (Salvendy, 2001) declares that for offices illuminated by overhead luminaires (as in our case) the ratio between vertical and horizontal illuminance must be in the range of 0.3 to 0.5. Thus a minimum vertical illuminance equal to 250 lux (500*0.5) can be assumed. In addition to illuminance, discomfort glare is also taken into account by defining boundaries for simplified Daylight Glare Probability (DGPs) (Wienold & Christoffersen, 2006). This index indicates the probability for the user to experience glare sensations; in order to avoid perceptible discomfort glare, the DGP must be lower than 35%" (Motamed, 2019, p. 215).

Avoid glare. Glare causes visual discomfort and serves as a distraction to the user in a work setting.

"Glare, which is unwanted light that is higher in luminance than the adaptation level, can be a stressor that causes discomfort. This can occur either directly from light sources in the field of view, or by reflection in glossy surfaces" (Veitch, 2016, p. 211). Avoid creating glare by using non-reflective material for horizontal work surfaces.

Avoid flicker. Flicker can be caused by contact problems, faulty wiring connections, worn-out receptacles, or bad filaments. The older the bulb is the likelihood of it flickering increases. “Low-frequency flicker might also constitute a stressful lighting condition because of the neural activity it generates, which may interfere with the individual’s actions (Eysel and Burandt, 1984; Schneider, 1968 cited in Veitch, 2016, p. 212).

Apply the chart provided in Figure 38 to assessing an existing studio space’s lighting quality via the Physical Approach.

QUALITY				
Select type of lighting:	Natural	Flourescent	LED	Other
Select Brightness	Bright	Dim	Adjustable	
ILLUMINANCE				
Horizontal Illuminance:	Good	Bad		
Vertical Illuminance:	Good	Bad		
GLARE				
Vertical Glare:	Good	Bad		
Horizontal Glare:	Good	Bad		
FLICKER				
Do the bulbs flicker?				
Are there any current devices in the studio that specifically alter the quality of lighting?	Yes	No	If yes, specify:	

Figure 38. Reference for Lighting Physical Analysis

Apply the chart provided in Figure 39 to assessing an existing studio space’s lighting quality via the Psychological Approach.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Does the lighting support the use of analogue tools?				
Does the lighting serve the group?				
Does the lighting support divergent thinking?				
Does the lighting support R - mode?				
Does the lighting stimulate imagination				
Does the lighting provide a working environment that hosts individual student's personal workspaces (microenvironments)?				
Does the lighting provide collaborative working environment for the class as a whole?				
Microenvironment:				
Does the lighting support the use of digital tools?				
Does the lighting serve the individual?				
Does the lighting support convergent thinking?				
Does the lighting support L - mode?				
Does the lighting stimulate focus?				
Does the lighting encourage personalization by user?				
Does the lighting provide the individual student with a personal workspace?				

Figure 39. Guide for Lighting Psychological Analysis

3.4.4. Color

Color can be applied to a wide variety of elements within the environment. This section focuses on the specific effects color has on psychological processes that are relevant to user ability to perform the creative problem-solving process.

The effect color has on user psychology depends on the length of the color's wavelength. "Longer wavelength colors (warm colors) are seen as provoking, whereas short wavelength colors (cold colors) calm down." (Kwallek, Woodson, Lewis, & Sales, 1997; Stone & English, 1998 cited in Bissantz & Siemon, 2016, p. 212). Longer wavelength colors should be used as stimulating factors while shorter wavelength colors should be used as calming factors.

In fact, colors have been directly linked to psychological processes that are collinear with convergent and divergent thinking.

> "Findings show that red can also impair performance (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007). Especially when tasks require exactness, red and to a lesser degree also yellow can positively affect performance (Goldstein, 1942). Whereas colors like green and blue impair focusing on a task" (Bissantz & Siemon, 2016, p. 11).

Based on this information, red and yellow to a lesser degree encourage performances requiring exactness, a quality shared with convergent thinking.

> "Elliot and colleagues (2007) proposed that viewing red in an achievement context can undermine performance on challenging tasks that require mental manipulation and flexibility. They posited that red is associated with failure and danger and evokes avoidance motivation in such contexts, which impedes performance attainment" (Elliot & Markus, 2013, p. 102).

Blue and green appear to have the opposite effect. "Some experiments have yielded evidence suggesting that viewing blue or green may be particularly beneficial for creative performance" (Lichtenfeld, 2012; Mehta & Zhu 2009; Kuller, 2009 cited in (Elliot & Markus, 2013, p. 102). The relaxing and refreshing effect of greens and blues suggest that these colors should be associated with divergent thinking processes. "Because green has the power to help people adjust to new environments, skillful designers use lots of plants and other forms of green in hotel lobbies, offices, and restaurants (Aves & Aves, 1994 cited in Kurt & Osueke, 2014, p. 4). "Blue encourages intellectual activity, reason, and logical thought. Blue is the color of the intellect. In the same evidence about raising blood pressure with red, blue is deemed to lower

blood pressure" (Kurt & Osueke, 2014, p. 2). The blues and green colors correspond with the same effect nature has on people.

> "Conceptually, blue and green seem reasonable candidates for consideration, as they both have positive links in the natural realm (e.g., blue sky and water, green foliage and vegetation) and both have been shown to be associated with positive content [blue, e.g., openness, peace]" (Kaya & Epps 2004; Mehta & Zhu 2009 cited in Elliot & Markus, 2013, p. 102).

	RED	YELLOW	BLUE	GREEN
SUPPORTS	CONVERGENT	CONVERGENT	DIVERGENT	DIVERGENT
IMPAIRS	CREATIVITY	CREATIVITY	FOCUS	FOCUS
WAVELENGTH	SHORTEST	SHORT	LONGEST	LONG

Figure 40. Color Reference. Adapted from "Freedom from constraints: Darkness and dim illumination promote creativity.," by Steidle, A. & Werth, L., 2013, *Journal of Environmental Psychology, 35.* page number. Copyright 2013 by the Elsevier. Adapted with permission.

Consider the following guidelines:

- Consider implementing plants in the studio space as small bursts of relaxing green colors to reduce stress and promote productivity. "Studies over the years have shown that introducing plants into an interior workspace increases well-being and makes employees happier. — 15% productivity increase. University of Queensland School of Psychology" (Kinugasa-Tsui, 2016, p. 12).
- Implement reds and yellows for Convergent thinking processes.
- Implement blues and greens for Divergent thinking processes.
- Encourage blues and greens to reduce stress and promote wellbeing.

Apply the chart provided in Figure 41 to assess an existing studio space's color via the Physical Approach.

	Colors	Location
1st most prominent		
2nd most prominent		

Figure 41. Reference for Color Analysis from the Psychological Approach

Apply the chart provided in Figure 42 to assess an existing studio space's color via the Psychological Approach.

Guidelines	Yes	No	If no, why?	List possible solutions
Are the colors supportive of Divergent thinking?				
Are the colors supportive of Convergent thinking				
Do the colors provide distraction?				
Do the colors support relaxation/stress reduction?				
Do the colors provide any other benefit/disadvantage?				

Figure 42. Reference for Color Analysis from the Psychological Approach

3.4.5. Furniture, Artifacts, & Decor

Furniture, artifacts and decor consist of the items that fill a classroom. The furniture is meant to support the user's physical body, the artifacts are meant to assist the user in directly performing their work (whether digitally or analogously), and the decor is meant to supply visual stimulation.

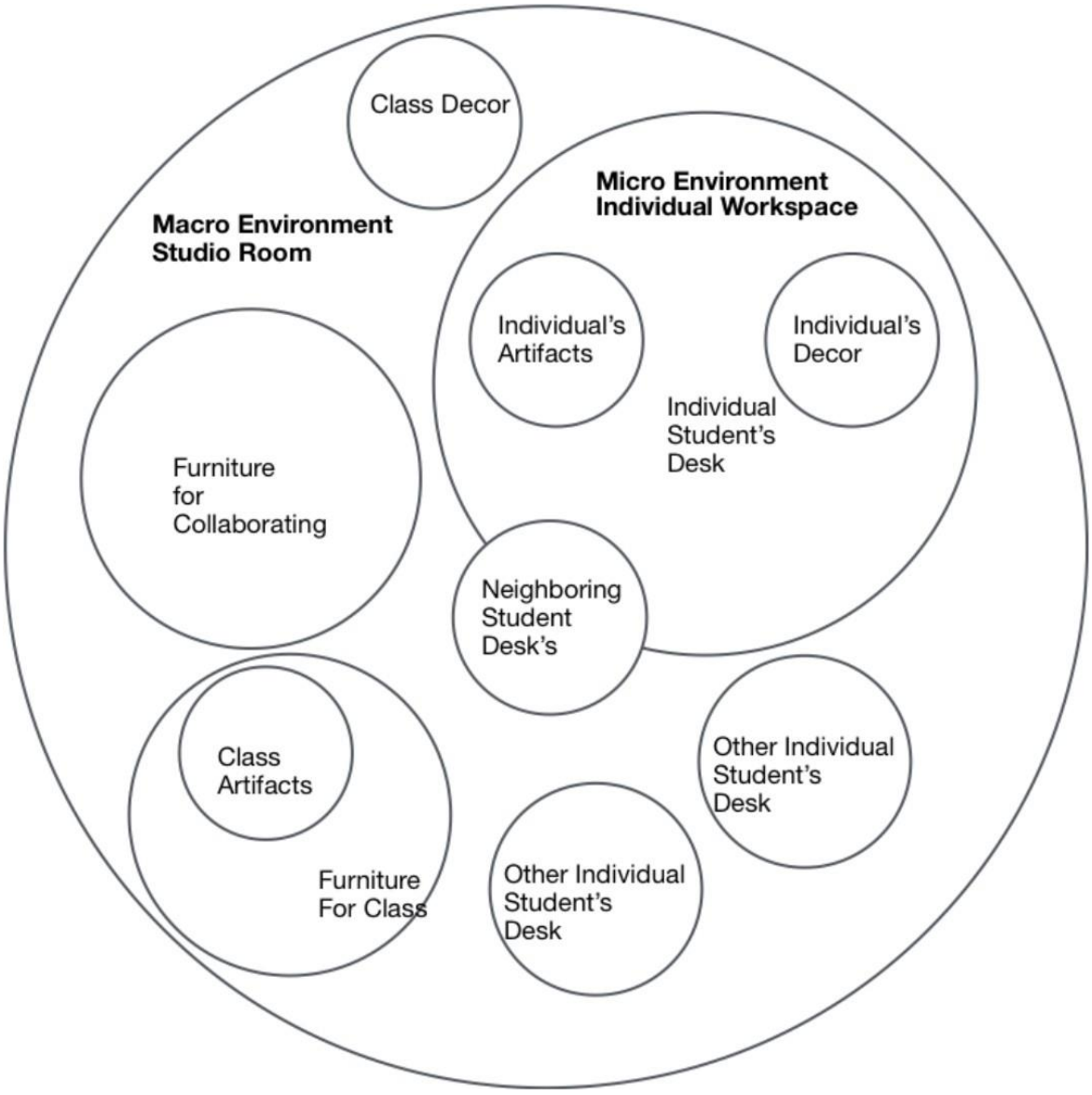


Figure 43. Microenvironments & Furniture, Artifacts, and Decor. Adapted from *Creativity the Psychology of Discovery and Invention* (139), by M. Csikszentmihalyi, 2013, New York: NY, Harper Collins. Copyright 2013. Reprinted [or adapted] with permission.

Furniture exclusive to the macroenvironment provides for the collaborative groups while furniture belonging to the microenvironment provides for an individual. The furniture must meet certain criteria in order to be determined sufficient for the creative, educational setting. “In a classroom that facilitates creativity, furniture design should address several issues. These should

include not only usability and durability, but also psychological appeal (aesthetic issues) as well as comfort, safety, and health (Cornell, 2002)," (Warner & Myers, 2010, p. 31).

Artifacts within the workspace should be assigned the purpose of assisting the users in their cognitive processes by managing information. "The cognitive process of memory, our ability to record, store, and retrieve information, is applied. . . by providing an environment that stores information-rich articles (artifacts)" (Antonelli, 2001, p. 215).

Decor ideally should either provide information vital to the user's work or encourage motivation or stress relief. "[C]ue-rich environments…simply provide a level of cognitive stimulation necessary for [students] to engage their domain-relevant and creativity relevant skills" (Warner & Myers, 2010, p.228). The decor should be used as a means of personalizing the environment to reflect the stage of the concurrent step of the creative process. This means decor should change throughout the process to reflect the most current information. "[U]seful information presented in the nature of objects, artifacts, tables, images, tabletops etc. can facilitate the process at an implicit level" (Kristensen, 2004, p. 95). The visual stimulation allows the user to psychologically enter the realm of their work with minimal effort.

The purpose of all three of these elements (furniture, artifacts, and decor) is to enable the environment to be a tool that increases user ability to perform their creative work. The goal of these tools is to equip the environment with the tools the users need to solve perform their work as efficiently as possible.

> "Design is concerned with building our relationship with these tools 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, 2001, p. 11).

For furniture recommendations, the first priority is to provide sufficient ergonomic dimensions in order to accommodate the user. "Two principles of sound ergonomic thinking are worth remembering: it shouldn't hurt, and it should prevent injury" (Gee, 2006, p. 8). It is important to consider that the furniture in an educational setting will be used by a wide range of students throughout the years. This requires the furniture to be durable and adjustable. "Because of the diversity of human sizes, tables and chairs should be adjustable. Instructors and students should feel encouraged to get up and move around" (Gee, 2006, p. 8). These ergonomics should "consider reach, clearance, and posture" (Pheasant, 1986, p. 64).

A modular system for furniture is also recommended to facilitate easy rearrangement. "Modular design of the system . . . makes rearrangement easy and flexible" (Pile, 1984, p. 54).

The following figures of ergonomic guidelines outlined below are recommended .

		Letter	Specifications: Measurement	Specifications: BIFMA Guideline
Seated Work	Height for Thighs	A	Thigh clearance + Shoe allowance + Popliteal height	At least 26.8"
	Depth for Knees	B	Buttock-knee length – Abdominal extension depth	No less than 17"
	Width for Thighs	Not Shown	Hip breadth, sitting + Movement allowance + Clothing allowance	No less than 19.8"
	Height at Foot Level	C	Lateral malleolus height + Shoe allowance	4.2"
	Depth at Foot Level	D	Buttock-popliteal length + Foot length – Abdominal extension depth	No less than 23.5"
Standing Work	Height at Foot Level	C	Lateral malleolus height + Shoe allowance	4.2"
	Depth at Foot Level	Not Shown	None	6.5"
	Width at Foot Level	Not Shown	Hip breadth, sitting + Movement allowance	19.8"
Support Surfaces for Computer Desks	Sitting Height for Input Devices (Desk)	F	Popliteal height + Elbow rest height, sitting + Shoe allowance – Input device thickness	22.2" – 28.5" (adjustable) 28.5" (non-adjustable)
	Sitting Height for VDTs (Eye Height)	G	Eye height, sitting + Popliteal height + Shoe allowance	Complex interdependencies; allow top of screen at eye level; approximate height: 42.6" – 52.6"
	Standing Height for Input Devices (Desk)	Not Shown	Elbow rest height, standing + Shoe allowance – Input device thickness	36.7" – 45.6"
	Standing Height for VDTs (Eye Height)	Not Shown	Eye height, standing + Shoe allowance	Complex interdependencies; allow top of screen at eye level; approximate height: 56.9" – 69.8"
	Viewing Depth	H	None	No less than 15.7" from VDTs to eyes

Table 9. BIFMA guidelines for desks and worksurfaces. Measurements can be visualized using Figure 10 on page 31. All measurements are in inches.

Figure 44. Desk Top Ergonomic Guidelines. Reprinted from "*Bodyspace: Anthropometry, ergonomics, and the design of work*," by S. Pheasant & C.M. Haslegrave, 2006. Copyright 2006 by Taylor & Francis. Adapted with permission.

Figure 8. Measurements from BIFMA guidelines used for ergonomic chairs. See Table 3 for values. (Allsteel Sum™ task chair pictured)

		Specifications: Measurement	Specifications: BIFMA Guideline
Seat Height	A	Popliteal height + Shoe allowance	15.0" – 19.9"
Seat Depth	B	Buttock-popliteal length– Clearance allowance	No deeper than 16.9" (fixed) 16.9" included (adjustable)
Seat Width	C	Hip breadth, sitting + Clothing allowance	No less than 18"
Backrest Height	D	None	At least 12.2"
Backrest Width	E	Waist breadth	14.2"
Backrest Lumbar	F	None	Most prominent point 5.9" – 9.8" from seat pan, in and out 1
Armrest Height	G	Elbow rest height	6.9" – 10.8" 7.9" – 9.8"
Armrest Length	H	None	None
Distance Between Armrests	I	Hip breadth, sitting + Clothing allowance	18" (fixed) 18" included (adjustable)

Table 3. Specific BIFMA chair design guideline measurements. See Figure 8 for visualization. All measurements are in inches.

Figure 45. Chair Ergonomics Guidelines. Reprinted from "*Bodyspace: Anthropometry, ergonomics, and the design of work*," by S. Pheasant & C.M. Haslegrave, 2006. Copyright 2006 by Taylor & Francis. Adapted with permission.

As for the arrangement, different shapes or arrangements of furniture encourage and enable different audiences. Linear or square shaped desks promote private work by a single individual. Linear configurations that point users to face the same direction is preferred for listening to one speaker. Circular large tables serve a collaborative group more efficiently.

> "The linear space may appear tidy and well-ordered, but it is difficult for a group of people to assemble to discuss preparations or feed new information into the system. This is best done when a circular structure can be realized. Often, meeting rooms or lecture theatres are used in sharing information. But these are usually intended to communicate the ideas from one person to an audience, not the audience sharing information. Thus a centralized or radial shape seems more appropriate, in the sense that communal space can be realized at the centre of the creative space" (Kristenson, 2004, p. 92).

PROCESS	CSIKSZENTMIHALYI 2013	FURNITURE	ARTIFACTS	DECOR
STEP 1	PREPARATION	Linear	Provides ability to record, store, and retrieve information	Cognitive Stimulation or Stress Reduction
STEP 2	INCUBATION	undefined	personalized	Cognitive Stimulation or Stress Reduction
STEP 3	INSIGHT	undefined	undefined	Cognitive Stimulation or Stress Reduction
STEP 4	ELABORATION	Linear/Circular	Provides ability to present, refine	Cognitive Stimulation or Stress Reduction
STEP 5	EVALUATION	Linear/Circular	Provides ability to present, refine	Cognitive Stimulation or Stress Reduction

Figure 46. Furniture, Artifact, and Decor Roles in CPSP. Adapted from "The Physical Context of Creativity," by T. Kristensen, 2004, *13* (2), 91. Copyright 2004 by Blackwell Publishing Ltd. Adapted with permission.

Consider the following guidelines for furniture of the studio space are as follows:

- Implement separate square-shaped furniture in a linear arrangement for private, individual work.
- Implement fewer, larger circular-shaped furniture for collaborative work.

- Use the recommended ergonomics in Figures 44. and 45.
- Modular furniture is best for organization and storage since flexibility is needed in the educational workspace setting.
- Design the furniture in the context of what tools it will hold and function it will serve.
- Consider furniture that is easily moveable to encourage rearrangement of room to suit needs.
- Add features that consider power strips to provide ease of accessibility to every desk.

Consider the following guidelines for artifacts:

- Analogous artifacts are best for collaborative, creative, divergent tasks.
- Digital artifacts are best for focused, private, individual work.

Consider the following guidelines for decor:

- The decor should provide visual stimulation to enhance creativity, motivation, or stress reduction.
- Consider adding plants (real or fake) to the work environment to promote stress reduction or general wellbeing.
- Consider DR. B.J. Fogg's behavioral model. Consider the attention budget figure in choosing sensory stimulations: balance stimulators with suppressors.

Apply the chart provided in Figure 47 to the existing studio space's furniture analysis via the Psychological Approach.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Does the furniture support analogue tools?				
Does the furniture serve the group?				
Does the furniture support divergent thinking?				
Does the furniture support R - mode?				
Does the furniture stimulate imagination				
Does the furniture provide a working environment that hosts individual student's personal workspaces (microenvironments)?				
Does the furniture provide collaborative working environment for the class as a whole?				
Microenvironment:				
Does the furniture support digital tools?				
Does the furniture serve the individual?				
Does the furniture support convergent thinking?				
Does the furniture support L - mode?				
Does the furniture stimulate focus?				
Does the furniture encourage personalization by user?				
Does the furniture provide the individual student with a personal workspace?				

Figure 47. Reference for Furniture Analysis

Apply the chart provided in Figure 48 to the existing studio space's artifact analysis via the Psychological Approach.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Does the artifacts support analogue tools?				
Do the artifacts serve the group?				
Do the artifacts support divergent thinking?				
Do the artifacts support R - mode?				
Do the artifacts stimulate imagination				
Do the artifacts provide a working environment that hosts individual student's personal workspaces (microenvironments)?				
Do the artifacts provide collaborative working environment for the class as a whole?				
Microenvironment:				
Do the artifacts support digital tools?				
Do the artifacts serve the individual?				
Do the artifacts support convergent thinking?				
Do the artifacts support L - mode?				
Do the artifacts stimulate focus?				
Do the artifacts encourage personalization by user?				
Do the artifacts provide the individual student with a personal workspace?				

Figure 48. Reference for Artifact Analysis

Apply the chart provided in Figure 49 to the existing studio space's decor analysis via the Psychological Approach.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Does the decor support analogue tools?				
Does the decor serve the group?				
Does the decor support divergent thinking?				
Does the decor support R - mode?				
Does the decor stimulate imagination				
Does the decor provide a working environment that hosts individual student's personal workspaces (microenvironments)?				
Does the decor provide collaborative working environment for the class as a whole?				
Microenvironment:				
Does the decor support digital tools?				
Does the decor serve the individual?				
Does the decor support convergent thinking?				
Does the decor support L - mode?				
Does the decor stimulate focus?				
Does the decor encourage personalization by user?				
Does the decor provide the individual student with a personal workspace?				

Figure 49. Reference for Artifact Analysis

3.4.6. Open & Closed Space

The workspace environment consists of both open spaces and closed spaces. Open spaces serve collaborative groups performing teamwork and therefore should be exclusive to the macroenvironment. Closed spaces serve individual workers performing private work that requires focused attention and therefore exist within the microenvironment.

Open spaces are large spaces that enable flexibility and freedom. This atmosphere encourages divergent thinking and collaborative teamwork.

> "As a target to shoot for, the ideal classroom should be configured with high ceilings an few walls to help communicate openness, plenty of room for freedom of movement, allowances for flexibility/mobility, and places where students can talk and confer (Lloyd, 2001; Kelly, 2001). Techniques that can be used to make existing space configurations amenable to a creative environment include the use of wall and ceiling colors that convey the sense of openness, and putting machines, benches, and cabinets on wheels so that

they can be moved to reconfigure the room as circumstances require and needs change" (Warner & Myers, 2010, p. 32).

Lighter colors and open space can help to make the space feel larger and airier. "Space can be made to appear bigger by painting it with white or light colors, rearranging the furniture, or by relocating storage units," (Yager, 1989, p. 64). Open spaces are inclusive and enable individuals to engage with each other. "As design is a cyclical process, ideas are constantly polished by input from other team members. Isolation of certain team members can hinder this process" (Douglas, 2004, p. 154).

Open spaces encourage divergent thinking and also R-mode due to how the space is managed.

> "[One] reason why [this setting] may help creativity is that novel stimulation is not evenly distributed. Certain environments have a greater density of interaction and provide more excitement and a greater effectiveness of ideas; therefore, they 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" (Csikszentmihalyi, 2013, p. 129).

The biggest concern with open spaces is they often harbor many distractions. This is the biggest criticism about open office spaces.

> "Big trends in business today actively decrease people's ability to perform deep work, even though the benefits promised by these trends (e.g. increased serendipity, faster

> responses to requests, and more exposure) are inarguably dwarfed by the benefits that flow from a commitment to deep work . . .” (Newport, 2016, p. 53).

However, this quote dismisses open office spaces completely. Due to the nature of creative work, they do provide benefits for collaborative, creative work. Although open workspaces come with distractions, these distractions can be managed.

Distractions more commonly exist within open spaces. Distractions include any sensory stimulation that diverts user attention from processes or information that help the user accomplish their work. Distractions include temperature, traffic, and sound. “While room temperature apparently has little impact on creativity (Fang, Wyon, Clausen, & Fanger, 2004; Kawaguchi, Tanabe, Nishihara, Haneda, & Uchida, 2009; Wyon, Andersen, & Lundqvist, 1979), environmental distraction (ambient noise, foot traffic, and visual exposure level) can undermine perceived support” (Steidle & Werth, 2013, p. 68).

The preferred range for temperature in the workspace setting is around 71.6-degree F. “If the temperature is out of the optimal range [70°F (21,11°C) - 79.9°F (26,61°C)] the temperature has to be adjusted up to the optimal temperature of 71.6°F (22°C)” p 13 (Bissantz & Siemon, 2016). The temperature should remain mild and consistent to avoid stuffiness. Too hot renders the user sleepy, while too cold renders the user uncomfortable and distracted.

> “Compounding the negative effects of a room temperature that is too high would be a sense of stuffiness and confinement. The availability of a reliable flow of fresh air is another example of a sensory variable that is critical to the creative potential of a

classroom. Lloyd (2001) addressed the need for fresh air best by stating, “Nothing happens without oxygen” (p.16),” (Warner & Myers, 2010, p. 32).

The issue of traffic can be eliminated by applying appropriate walkways in-between desks and furniture. “Ergonomic thinking considers the entire environment and how it supports and interacts with the human body. Well-planned pathways, open access to equipment and supplies, and ease of moving furniture are all ergonomic considerations” (Gee, 2006, p. 2).

Distracting sounds can be addressed by implementing sound absorbing materials in the environment, or by providing a background sound system. Sound volume within the room should not exceed 85dB. “If the sound volume is close to or higher than 85dB, the sound and noise level should be adjusted” p 13 (Bissantz & Siemon, 2016). The background sound system is intended to desensitize the users to ambient sounds.

> “The concept and use of background sound masking is based on two general principles: 1. The higher the level of ambient background sound in a space, the less awareness to a given level of intruding sound a listener will have ..... 2. Our hearing is capable of discerning only that intrusive sound which is louder in intensity than the initial ambient background sound” (March & Stahovic 1984, p. 21).

If a background sound system cannot be implemented, students may also be encouraged to use their own headphones. “The detrimental effects of noise are usually associated with tasks that need to be performed continuously for relatively long periods of time without rest breaks,” (Sanders & McCormick, 1987, p. 92).

Closed spaces are intended for the individual student's private workspace in order to focus their attention. Full enclosure is typically a waste of space and resources therefore, I recommend implementing small vertical barriers to mark the borders of the student's desk. "Full enclosure for each person with intermittent needs for full privacy is usually a waste of space and money" (Pile, 1984, p. 10). Half barriers will create a feeling of privacy which will assist in the user's focus. "Loss of privacy has made some aspects of work impossible" (Pile, 1984, p. 13).

Encourage individual students to personalize their workspaces.

> "Not only will you feel better if you define some of your public space as private, or if you display a few meaningful photographs or possessions, you will feel more in control of your space, and having control at the workplace is linked to increased worker satisfaction and less stress" (Sanders & McCormick, 1987, p. 50).

Personalizing workspace gives the user a feeling of control over their territory, which reduces stress and encourages productivity. "Such space is usually personalized, and people design it themselves. The idea of sharing 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. Only flexibility can make this happen" (Kristensen, 2004, p. 92).

Provide adequate storage spaces for the students so they can maintain an orderly desktop. This will create a spacious feeling and keep the desktop flexible and open for use. "Eliminate clutter from your work surfaces for a more spacious feeling" (Yager, 1989 p. 63).

Closed spaces are intended to enhance a user's control over their attention by providing an environment that shields the user's attention from distractions that exist within the Macroenvironment. "… Attention is a limited resource: There is just so much information we can process at any given time," (Csikszentmihalyi, 2013, p.8). The more distracting elements that are unfiltered in the environment, the more stressed the user becomes. "Undivided attention makes people more cognitively vigilant and intellectually alert and is associated with increased cognitive effort (Kahn, 1990; 1992)" (Leroy, 2009, p. 5).

Concentration of attention or focused attention is necessary for convergent thinking and is best performed in closed spaces. This is due to the closed space's characteristic of creating a more private, separate, personal environment within the classroom (or macroenvironment). "Deliberate practice cannot exist alongside distraction, and that it instead requires uninterrupted concentration. As Ericsson emphasizes, "Diffused attention is almost antithetical to the focused attention required by deliberate practice" (Newport, 2016, p. 35-36).

Refer to Figure 50. to understand how spatial organization relates to the creative problem-solving process.

PROCESS	CSIKSZENTMIHALYI 2013	KRISTENSON'S GUIDE
STEP 1	PREPARATION	Communal
STEP 2	INCUBATION	Private (out of studio) or Communal (for info)
STEP 3	INSIGHT	undefined
STEP 4	ELABORATION	Communal/Private
STEP 5	EVALUATION	Communal/Private

Figure 50. Spatial Organization in Relation to CPSP. Adapted from "The Physical Context of Creativity," by T. Kristensen, 2004, *13* (2), 93. Copyright 2004 by Blackwell Publishing Ltd. Adapted with permission.

For the first step (preparation) of the creative problem-solving process, the goal of the spatial arrangement is to "support as much information flow and absorption as possible to each member…" (Kristensen, 2004, p. 90). The preferred space suited for this job would be an open space, due to the need for collaboration.

The second step (incubation) was originally established as taking place away from the studio. However, "staying in the room where all the information from the preparation stage is kept may facilitate such implicit perception as a process of 'priming'" (Kristensen, 2004, p. 90). This initially suggests the open space if not for the criteria of "the cognitive processes [in the incubation stage] seem to be essentially a personal or private affair," (Kristensen, 2004, p. 90).

The fourth and fifth step "must resemble the preparation stage, as the operations are similar" p 90 (Kristensen, 2004). This points us back to the open space. However, the cyclical process of the elaboration and evaluation imply the application of rotation between closed and open spaces. "The preparation and elaboration stages typically require a combination of communal and private space. The incubation and insights stages probably require more private space. For example, useful information presented in the nature of objects, artifacts, tables, images, tabletops etc. can facilitate the process at an implicit level" (Kristensen, 2004, p. 95).

Refer to Figure 51 for the benefits, disadvantages and characteristics of open and closed spaces.

OPEN: communal spaces		CLOSED: private spaces	
PROS	**CONS**	**PROS**	**CONS**
Decor sharing information	many distractions	fewer distractions	less sharing of ideas
communal sharing ideas	harder to focus attention	control over environment	divergent thinking is hard
debriefing of ideas	less individual control over environment	easier to focus	collaborative work is harder
presentation of ideas	convergent thinking is hard	privacy encourages convergent thinking	
area for collective learning	private work is harder		
exposure encourages divergent thinking			

Figure 51. Open and Closed spaces. Adapted from "The Physical Context of Creativity," by T. Kristensen, 2004, *13* (2), page 94. Copyright 2004 by Blackwell Publishing Ltd. Adapted with permission.

Refer to Figure 52 as a reference for how open and closed spaces correlate with convergent and divergent thinking.

	OPEN	CLOSED
SUPPORTS	DIVERGENT THINKING	CONVERGENT THINKING
IMPAIRS	CONVERGENT THINKING	DIVERGENT THINKING

Figure 52. Open/Closed spaces and Convergent/Divergent Thinking. Adapted from "The Physical Context of Creativity," by T. Kristensen, 2004, *13* (2), 94. Copyright 2004 by Blackwell Publishing Ltd. Adapted with permission.

Refer to Figure 53 as a reference for how open and closed spaces correlate to L and R-Mode thinking.

	OPEN	CLOSED
SUPPORTS	R mode	L mode
IMPAIRS	L mode	R mode

Figure 53. Open/Closed spaces and L/R Mode. Adapted from "The Physical Context of Creativity," by T. Kristensen, 2004, *13* (2), 94. Copyright 2004 by Blackwell Publishing Ltd. Adapted with permission.

Refer to Figure 54 as a reference for how open and closed fit into the five-step creative problem-solving process.

	LAYOUT SPACE:	LAYOUT TABLE:	DOMINANT THINKING	DOMINANT MODE
STEPS	PRIVATE/COMMUNAL	PRIVATE/COLLAB	CON-/DIV- ERGENT	R MODE / L MODE
PREPARATION	COMBO	OPEN	DIV/CON	R
INCUBATION	PRIVATE	OPEN	DIVERGENT	L
INSIGHT	PRIVATE	PRIVATE	CONVERGENT SWITCH	R
EVALUATION	COMBO	OPEN	DIV LEAD /CON	R & L UNITY
ELABORATION	COMBO	OPEN	DIV/CON LEAD	R VISUALIZES/ L LEADS

Figure 54. Open/Closed spaces relationship with the CPSP. Adapted from "The Physical Context of Creativity," by T. Kristensen, 2004, *13* (2), 94. Copyright 2004 by Blackwell Publishing Ltd. Adapted with permission.

Consider the following recommendations for managing open and closed spaces within the studio:

- To manage sound distractions in the open space, consider sound panels of sound absorbent material that reduce distracting sounds
- Provide storage for students to avoid clutter.
- Encourage the students to take advantage of vertical space in order to display work and ideas
- "Keep frequently used items in the most convenient places and rarely used items out of the way or out of the [room] in general" (Silber, 2004, p. 237).
- "Don't put things where they fit, put them where they are used; or if they are not used, store them out of the way" (Silber, 2004, p. 112).

Refer to the chart provided in Figure 55 to list the elements within the spaces when assessing an existing studio space from the Physical Approach for open and closed spaces.

Open Spaces	Closed Spaces

Figure 55. Recommendations for Open/Closed Space Physical Analysis

Refer to the chart provided in Figure 56 to analyze the open and closed spaces within the existing studio space from the Psychological Approach.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Is the majority of the macroenvironment space open space?				
Does the space support the use of analogue tools?				
Does the space serve the group?				
Does the space support divergent thinking?				
Does the space support R - mode?				
Does the space stimulate imagination				
Does the space provide a working environment that hosts individual student's personal workspaces (microenvironments)?				
Does the space provide collaborative working environment for the class as a whole?				
Microenvironment:				
Do the microenvironments contain closed spaces				
Does the space support digital tools?				
Does the space serve the individual?				
Does the space support convergent thinking?				
Does the space support L - mode?				
Does the space stimulate focus?				
Does the space encourage personalization by user?				
Does the space provide the individual student with a personal workspace?				

Figure 56. Recommendations for Open/Closed Space Psychological Analysis

3.4.7. Conclusion

This section has addressed the recommended physical components to consider when designing an environment to optimize a designer's ability to perform the creative problem-solving process. The next section concludes this chapter by providing an all-encompassing chart of both psychological and physical components to be used as a reference and recommendation.

3.5 Conclusion

This chapter has classified the specific components of both psychological and physical elements in terms of their roles in the creative problem-solving process. Refer to Figure 55 as a reference to understand each element's role in the workspace environment.

	PSYCHOLOGICAL COMPONENTS			PHYSICAL COMPONENTS			
	DOMINANT THINKING	DOMINANT MODE	TYPE OF WORK	LIGHTING	TOOLS:	LAYOUT SPACE:	LAYOUT TABLE:
STEPS	CONVERGENT/DIVERGENT	R MODE / L MODE	COLLABORATIVE/PRIVATE	DIM/BRIGHT	ANALOUGE/DIGITAL	PRIVATE/COMMUNAL	PRIVATE/COLLAB
PREPARATION	DIV/CON	R	COLLABORATE	BRIGHT	ANALOUGE	COMBO	OPEN
INCUBATION	DIVERGENT	L	PRIVATE	DIM	undefined	PRIVATE	OPEN/CLOSED
INSIGHT	CONVERGENT SWITCH	R	PRIVATE	undefined	undefined	PRIVATE	CLOSED
EVALUATION	DIV LEAD /CON	R & L UNITY	COLLAB/PRIVATE	DIM/BRIGHT	COMBO	COMBO	COMBO
ELABORATION	DIV/CON LEAD	R VISUALIZES/ L LEADS	COLLAB/PRIVATE	DIM/BRIGHT	COMBO	COMBO	COMBO

Figure 57. Psychological & Physical Elements in Relation to the CPSP. Adapted from "The Physical Context of Creativity," by T. Kristensen, 2004, *13* (2), 94. Copyright 2004 by Blackwell Publishing Ltd. Adapted with permission.

The next chapter applies the recommendations illustrated in this chapter in the construction of a desk designed to create the microenvironment for the individual student's microenvironment.

Chapter 4: Application

4.1 Introduction

In this chapter, the recommendations discussed in Chapter 3 are applied to an existing Industrial Design studio using Auburn University's INDD 3110 class as an example. The recommendations will be used to evaluate the studio environment's ability to assist its users in performing the creative problem-solving process. After the room is analyzed and evaluated in accordance to the guidelines explained in the previous chapter, the recommendations will be demonstrated by developing a solution to solve one or more of the studio environment's problems.

4.2. Process for Evaluation

The recommendations discussed in Chapter 3 dictate the process for redesigning an existing design studio:

- Use the Physical Approach to evaluate the elements that create an existing environment
- Use the Psychological Approach to understand the relationships between the existing physical elements and the desired psychological processes
- Look for relationships between the physical and psychological elements of the room
- Determine what factors would cause the most psychological impact to the room through using the most economical physical changes.
- Prioritize solution options based on how many problems they solve or psychological processes they support.

The evaluation of the studio space is begun by starting with the physical approach discussed in Chapter 3. Since the evaluation is of an existing environment comprised of physical aspects, the physical approach will require analyzing physical elements that already exist, which narrows the scope of research. Once we understand the studio from the physical approach, we will change our perspective to the psychological approach in order to reach a design solution that serves both physical and psychological needs of the studio environment.

	PSYCHOLOGICAL COMPONENTS			PHYSICAL COMPONENTS			
	DOMINANT THINKING	DOMINANT MODE	TYPE OF WORK	LIGHTING	TOOLS:	LAYOUT SPACE:	LAYOUT TABLE:
STEPS	CONVERGENT/DIVERGENT	R MODE / L MODE	COLLABORATIVE/PRIVATE	DIM/BRIGHT	ANALOUGE/DIGITAL	PRIVATE/COMMUNAL	PRIVATE/COLLAB
PREPARATION	DIV/CON	R	COLLABORATE	BRIGHT	ANALOUGE	COMBO	OPEN
INCUBATION	DIVERGENT	L	PRIVATE	DIM	undefined	PRIVATE	OPEN/CLOSED
INSIGHT	CONVERGENT SWITCH	R	PRIVATE	undefined	undefined	PRIVATE	CLOSED
EVALUATION	DIV LEAD /CON	R & L UNITY	COLLAB/PRIVATE	DIM/BRIGHT	COMBO	COMBO	COMBO
ELABORATION	DIV/CON LEAD	R VISUALIZES/ L LEADS	COLLAB/PRIVATE	DIM/BRIGHT	COMBO	COMBO	COMBO

Figure 58. Psychological & Physical Elements in Relation to the CPSP. Adapted from "The Physical Context of Creativity," by T. Kristensen, 2004, *13* (2), 94. Copyright 2004 by Blackwell Publishing Ltd. Adapted with permission.

Figure 59 displays photos taken of the studio which will be used as the case study.

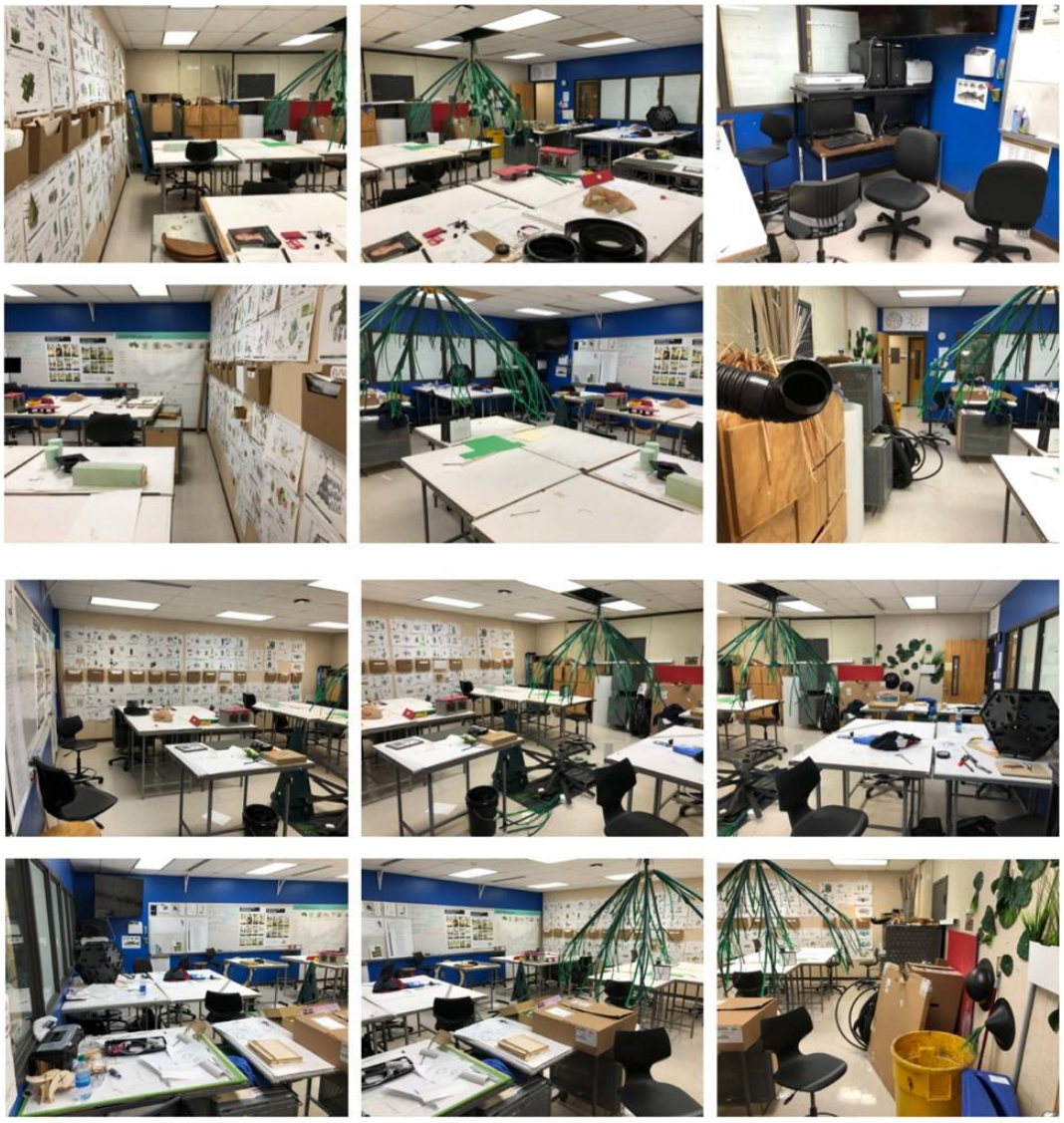


Figure 59. Photos of Studio

It is recommended to create a diagram of the environment in order to simplify the layout in a way that is easier to analyze. Refer to the diagram in Figure 60 as an example.

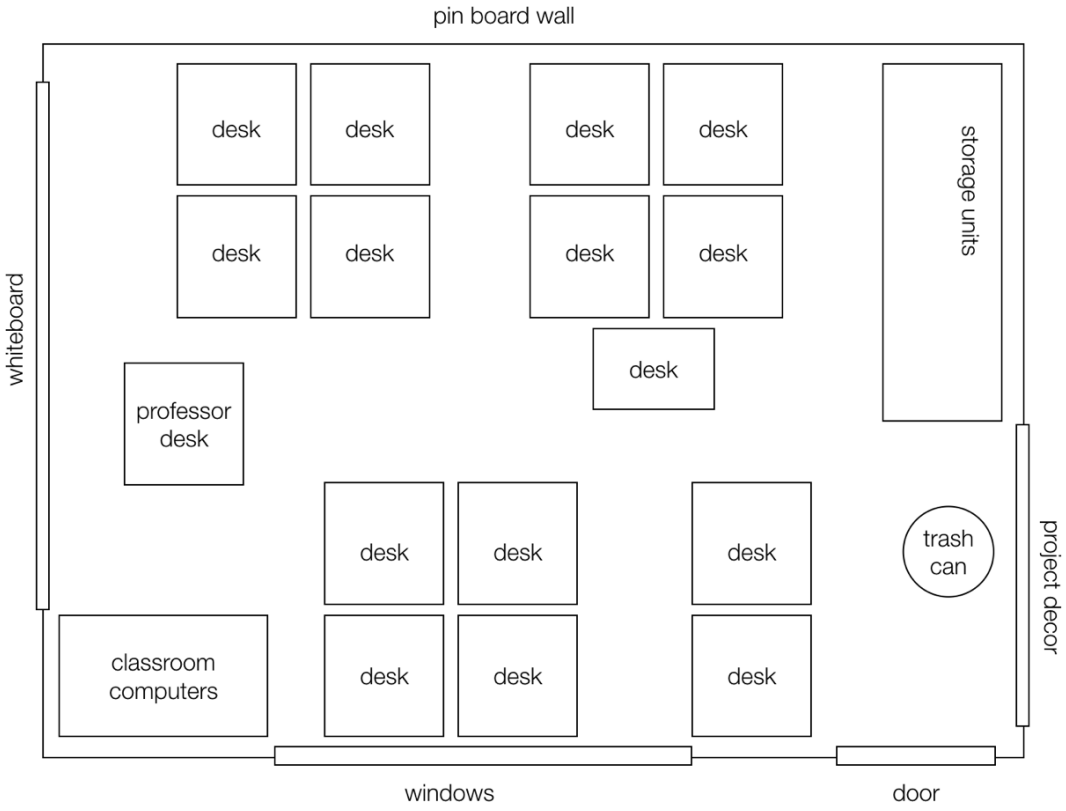
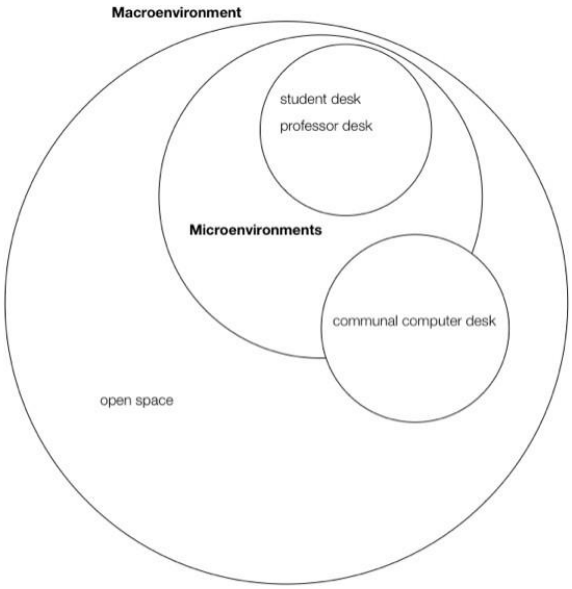


Figure 60. Photos of Studio

4.2.1. Macro-/Micro- Environments

First, it is necessary to identify macro-/micro- environments within the existing studio. These environments are analyzed using the diagrams in Figure 61.



student desks	teacher desk	Computer desk	open space
personal tools	for meetings	2 computers	models
personal work	chairs	scanner	project references
some storage units by desks		tv for presentations	sketches posted up
chairs		2 drawing tablets	project info posters
some extension cords			storage system
			white board
			power outlets
			lighting devices
			windows
			trash cans

Figure 61. Macro-/Micro- Environments of the Sample Studio with Chart Labeling the Features Within these Environments. Adapted from *Creativity the Psychology of Discovery and Invention* (139), by M. Csikszentmihalyi, 2013, New York: NY, Harper Collins. Copyright 2013. Adapted with permission.

There are two microenvironments reserved for individual users and one micro-environment that is open for any individual student to use. This open microenvironment is the computer desk which hosts two computers, drawing tablets, a printer and a scanner. Although this zone technically serves more than one specific individual, it is still is defined as a micro-environment because it is used for individual, private work.

The other two types of microenvironments are the professor's desk and the students' individual desks. These desks are spread throughout the room. The macroenvironment of the studio room also contains artifacts, decor and furniture that are intended for the class to use collaboratively. These items are scattered throughout the room, existing in between the microenvironments. The macroenvironment seems to be very cluttered and disorganized, with unused storage boxes taking up much of the would-be open space.

Chapter 3 established the goals of both the macroenvironment and microenvironment:

- Goals of Macroenvironment: To provide a working environment that 1) hosts individual student's personal workspaces (microenvironments) and 2) provides collaborative working environment for the class as a whole.
- Goals of Microenvironment: To provide the individual student with a personal workspace.

Always consider these goals and compare them with the current balance of the existing macroenvironments and microenvironments in order to understand what needs to change. The studio environment for 3110 meets the basic criteria for these goals.

Using the Psychological Approach, it is apparent that the cluttered state of the macroenvironment inhibits the ability of the students to collaborate. Research presented in Chapter 2 establishes that clutter promotes stress and distraction which impacts user ability to focus. The students' personal desks/workstations are each their own microenvironments that exist within the macroenvironment, and therefore are directly impacted by the state of the macroenvironment. The macro- and microenvironments of the studio are meant primarily for the first, fourth, and fifth stages of the creative problem-solving process (Preparation, Elaboration, and Evaluation).

Figure 62 demonstrates the chart provided for the Psychological Approach of the macro- and micro- environments when applied to the case study.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Does the macroenvironment serve the group?	✓			
Does the macroenvironment support divergent thinking?	✓			
Does the macroenvironment support R - mode?	✓			
Does the macroenvironment stimulate imagination	✓			
Does the macroenvironment provide a working environment that hosts individual student's personal workspaces (microenvironments)?	✓			
Does the macroenvironmentprovide collaborative working environment for the class as a whole?	✓			
Microenvironment:				
Does the microenvironment serve the individual?	✓			
Does the microenvironment support convergent thinking?		✓	not enough privacy, closed space, option for order/organization	add optional blinds to desks
Does the microenvironment support L - mode?		✓	too open/collaborative	adjust space for private work, add storage options/ configurations
Does the microenvironment stimulate focus?		✓	too open/collaborative; no privacy	add optional blinds to desks
Does the microenvironment encourage personalization by user?		✓	no storage, room for personalization	add space dividers so students can pin up decor`
Does the microenvironment provide the individual student with a personal workspace?	✓		yes, however this space is configured for collaboration	add blinds/ space dividers

Figure 62. Macro-/Micro- Environments

Further sections of this chapter explore more factors of the physical elements that explain the quality and dynamics of the microenvironments and macroenvironments in more detail.

4.2.2. Analogue & Digital Tools

According to the guidelines in Chapter 3, analogue tools are better suited for the macroenvironment and digital tools are better suited for the microenvironment. An evaluation of the studio environment reflects this and is demonstrated in Figure 63.

	ANALOGUE	DIGITAL
MACRO	white board	TV
	pin board walls	
	project artifacts	
	storage boxes	
	project decor	
MICRO	personal artifacts	2 computers
		2 tablets
		printer
		scanner
		personal computers

Figure 63. Analogue and Digital Tool Analyzation of Sample Studio

The Psychological Approach informs us that analogue tools are preferred for the macroenvironment, collaborative work, open spaces, divergent, and R mode thinking. The analogue tools of the studio follow these guidelines.

Figure 64 demonstrates the chart provided for the Psychological Approach of the digital and analogue tools applied to the case study.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Are the tools predominantly analogue?	✓			
Do the tools serve the group?	✓			
Do the tools support divergent thinking?	✓			
Do the tools support R - mode?	✓			
Do the tools stimulate imagination	✓			
Do the tools serve a working environment that hosts individual student's personal workspaces (microenvironments)?	✓			
Do the tools provide collaborative working environment for the class as a whole?	✓			
Microenvironment:				
Are the tools predominantly digital?	✓			
Do the tools serve the individual?	✓			
Do the tools support convergent thinking?	✓			
Do the tools support L - mode?	✓			
Do the tools stimulate focus?	✓			
Do the tools encourage personalization by user?	✓			
Do the tools serve the individual student within their personal workspace?	✓			

Figure 64. Completed Guide for Digital/Analogous Tool Analysis

4.2.3. Lighting

The studio is lighted via ceiling bright fluorescent lights. Because there are few glossy materials in the studio, there is little glare. The only glare originates from the white board. The lightbulbs in the studio are 09667 LED11.5WT8/48/840-G7D 4' 11.5W 1,800 120+ 4000K 80+ 210° Frosted Glass 50K. They offer the specifications listed in Figure 65 below.

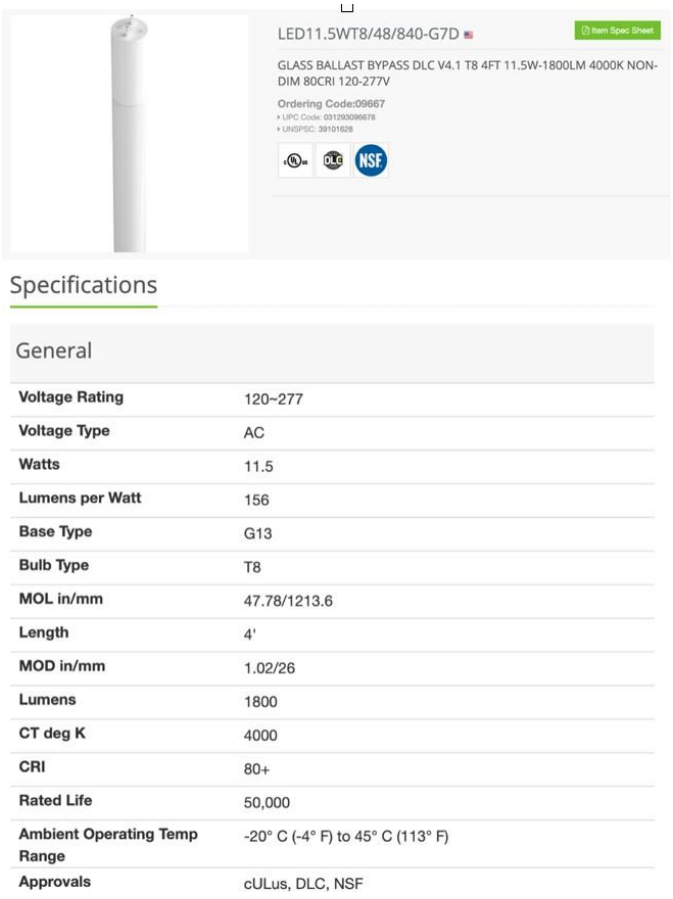


Figure 65. Lighting Specifications of the Sample Studio

The studio has windows that face an indoor hallway. These windows are covered with project decor and no light is provided through them.

The Psychological Approach shows us that fluorescent lights cause visual and hormonal stress and that horizontal glare is more of a concern than vertical glare. Although this bulb is an LED, the quantifiable elements of these lights do not meet the guidelines. They are they provide 1800 lumens verses the recommended 500 lumens, which classifies the studio room as too bright. The lights are not individually controlled and therefore the quality of light cannot be adjusted. Natural light of course would be a better option; however, since the windows in the

studio face an indoor hallway, this is not a possibility. The brightness is not adjustable and therefore only benefits convergent thinking and L-mode analytical thinking processes.

Figure 66 demonstrates the chart provided for the Physical Approach of the lighting applied to the case study.

QUALITY				
Select type of lighting:	Natural	Flourescent	LED	Other
Select Brightness	Bright	Dim	Adjustable	
ILLUMINANCE				
Horizontal Illuminance:	Good	Bad	if bad explain:	
Vertical Illuminance:	Good	Bad	if bad explain:	
GLARE				
Vertical Glare:	No glare	Glare	if so explain:	
Horizontal Glare:	No glare	Glare	if so explain: create by whiteboard	
FLICKER				
Do the bulbs flicker?	Yes	No		
Are there any current devices in the studio that specifically alter the quality of lighting?	Yes	No	If yes, specify:	

Figure 66. Completed Guide for Lighting Physical Analysis

Figure 67 demonstrates the chart provided for the Psychological Approach of the macro- and micro- environments applied to the case study.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Does the lighting support the use of analogue tools?	✓			
Does the lighting serve the group?	✓			
Does the lighting support divergent thinking?		✓	too bright, not adjustable	install dimmers; install light diffusers
Does the lighting support R - mode?		✓	too bright, not adjustable	install dimmers; install light diffusers
Does the lighting stimulate imagination		✓	too bright, not adjustable	install dimmers; install light diffusers
Does the lighting provide a working environment that hosts individual student's personal workspaces (microenvironments)?	✓			
Does the lighting provide collaborative working environment for the class as a whole?	✓			
Microenvironment:				
Does the lighting support the use of digital tools?	✓			
Does the lighting serve the individual?	✓			
Does the lighting support convergent thinking?	✓			
Does the lighting support L - mode?	✓			
Does the lighting stimulate focus?	✓			
Does the lighting encourage personalization by user?		✓	too bright, not adjustable	install dimmers; install light diffusers
Does the lighting serve the individual student within their personal workspace?	✓			

Figure 67. Completed Guide for Lighting Psychological Analysis

4.2.4. Color

There is one wall painted deep blue. The studio project artifacts that are scattered throughout the macroenvironment are mostly green fake plants. This is a fortunate accident because the guidelines in chapter 3 recommended adding real or fake plants to reduce stress. According to the psychological process, the blue color induces divergent thinking and stress relief which is good for user motivation. Coincidentally, the fake foliage scattered through the room technically promotes stress relief as well.

Figure 68 demonstrates the chart provided for the Physical Approach for analyzing color of an environment when applied to the case study.

	Colors	Location
1st most prominent	Blue	Wall of the studio
2nd most prominent	Green	Decor and artifacts

Figure 68. Completed Guide for Physical Analysis of Color

Figure 69 demonstrates the chart provided for the Psychological Approach for analyzing color of an environment when applied to the case study.

Guidelines	Yes	No	If no, why?	List possible solutions
Are the colors supportive of Divergent thinking?	✓			
Are the colors supportive of Convergent thinking		✓		add yellows and reds
Do the colors provide distraction?		✓		add yellows and reds
Do the colors support relaxation/stress reduction?	✓			

Figure 69. Completed Guide for Psychological Analysis of Color

4.2.5. Furniture, Artifacts, & Decor

The studio's organization of its furniture, artifacts and decor are similar to the proposed organization in Chapter 3.

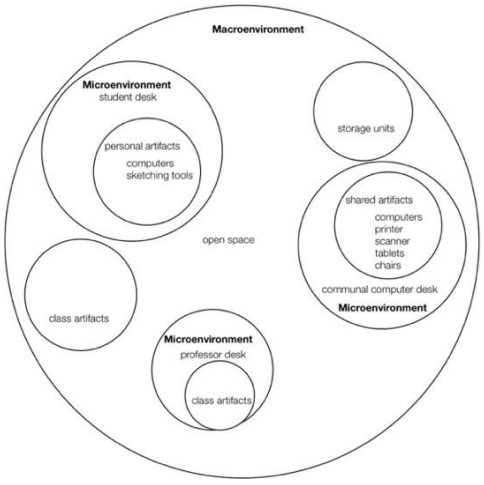


Figure 70. Furniture, Artifact, and Decor Layout of the Sample Studio

Beginning with the furniture, although the ergonomics are correct, the desks are very heavy and do not have casters, and thus are very hard to move. They do not offer any storage for tools or artifacts. They are not collapsible or modular and are therefore very hard to store efficiently. They have square shaped desktops and offer no privacy. Due to their shape and

arrangement, only a very few of them can reach power outlets without implementing extension cords.

The storage units take up an enormous amount of space and are not used by the students. They are big clunky boxes without wheels. Their doors are hard to open. A couple of the students have moved single storage units to sit next to their desk. They are the only students who use them. The storage units are haphazardly piled and class artifacts that are seldom used are placed on top of them and hardly ever touched.

The Psychological Approach tells us that furniture should be flexible in order to support creativity and promote ease of use (and therefore higher user motivation). The linear form of the desks is suited for private work for closed spaces and supports user attention to the front of the room where the professor resides. Because of the lack of panels, the divisions between desks are visually vague and the space feels more open than closed. This discourages the user from personalizing and exercising control over their own creative space. This inhibits divergent thinking, R-mode thinking, and focus during private work due to exposure to distraction. The arrangement of the desk does not provide power to the students' desks so that they can charge their digital devices.

The storage units are a textbook example of B.J. Fogg's Behavior Model. They are difficult to use and the motivation to use them is low despite the need for storage. They are located far from the desks where the user needs to have immediate reach of their tools. They are difficult to open and easily smash fingers if the user isn't careful. They are also buried in the

clutter of visual reference artifacts for the studio. Due to their configuration and arrangement, the student has nowhere to store their tools and valuable studio space is wasted.

The artifacts that are permanently in the room are mostly the project artifacts. These are the fake plants, materials, and building supplies, which are all used as interactive references for the students' projects. They are scattered throughout the room and are easily within everyone's view from their desks. One artifact is hung from the ceiling.

Most students transport their daily artifacts via backpacks. These artifacts include laptops, chargers, cellphones, sketching tools, notebooks, and sketchbooks. Some students leave personal toolboxes containing their class supplies on their desk or on the floor by their desk. When the studio is occupied, the student's personal artifacts are all visible to everyone in the room.

Using the psychological approach, we deduce that the artifacts around the room offer design inspiration which supports the preparation, elaboration, and evaluation phases of the creative problem-solving process. Despite the problems caused by their occupation in the macroenvironment, they offer visual stimulation needed for the creative process, divergent thinking, and creativity.

All of the decor in the room provides information about the current project. There are Gantt charts of the project's schedule, posters depicting research, a pin board wall neatly displaying the students' ideas for the project. Some of the decor is taped to the white board. The

whiteboard is also used to share important general information as needed, such as assignment deadlines.

The psychological approach informs us that the decor exists in the macroenvironment and depicts vital information that every student can view collectively in the room. This supports the creative problem-solving process and especially serves the preparation phase of the process.

Figure 71 demonstrates the chart provided for the Psychological Approach for analyzing the furniture of an environment when applied to the case study.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Does the furniture support analogue tools?	✓			
Does the furniture serve the group?	✓			
Does the furniture support divergent thinking?		✓	not interactive/adjustable/flexible	add casters
Does the furniture support R - mode?		✓	not interactive/adjustable/flexible	switch furniture with adjustable furniture
Does the furniture stimulate imagination		✓	not interactive/adjustable/flexible	offer furniture with flexible configurations
Does the furniture provide a working environment that hosts individual student's personal workspaces (microenvironments)?	✓		no there is no privacy/closed space	
Does the furniture provide collaborative working environment for the class as a whole?	✓			
Microenvironment:				
Does the furniture support digital tools?		✓	no furniture does not enable power	implement furniture with power outlet features
Does the furniture serve the individual?		✓	no there is no privacy/closed space	add blinds to furniture
Does the furniture support convergent thinking?		✓	no there is no privacy/closed space	add blinds to furniture
Does the furniture support L - mode?		✓	no there is no privacy/closed space	add blinds to furniture
Does the furniture stimulate focus?		✓	no there is no privacy/closed space	add blinds to furniture
Does the furniture encourage personalization by user?		✓	no it offers no adjustable/ customizable features	add furniture with better storage options
Does the furniture provide the individual student with a personal workspace?		✓	no there is no privacy/closed space	add blinds to furniture

Figure 71. Completed Guide for Furniture Analysis

Figure 72 demonstrates the chart provided for the Psychological Approach for analyzing the artifacts of an environment when applied to the case study.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Does the artifacts support analogue tools?	✓			
Do the artifacts serve the group?	✓			
Do the artifacts support divergent thinking?	✓			
Do the artifacts support R - mode?	✓			
Do the artifacts stimulate imagination	✓			
Do the artifacts provide a working environment that hosts individual student's personal workspaces (microenvironments)?	✓			
Do the artifacts provide collaborative working environment for the class as a whole?	✓			
Microenvironment:				
Do the artifacts support digital tools?	✓			
Do the artifacts serve the individual?	✓			
Do the artifacts support convergent thinking?	✓			
Do the artifacts support L - mode?	✓			
Do the artifacts stimulate focus?	✓			
Do the artifacts encourage personalization by user?	✓			
Do the artifacts provide the individual student with a personal workspace?	✓			

Figure 72. Completed Guide for Artifact Analysis

Figure 73 demonstrates the chart provided for the Psychological Approach for analyzing the decor of an environment when applied to the case study.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment	✓			
Does the decor support analogue tools?	✓			
Does the decor serve the group?	✓			
Does the decor support divergent thinking?	✓			
Does the decor support R - mode?	✓			
Does the decor stimulate imagination	✓			
Does the decor provide a working environment that hosts individual student's personal workspaces (microenvironments)?	✓			
Does the decor provide collaborative working environment for the class as a whole?	✓			
Microenvironment:				
Does the decor support digital tools?	✓			
Does the decor serve the individual?	✓			
Does the decor support convergent thinking?	✓			
Does the decor support L - mode?	✓			
Does the decor stimulate focus?	✓			
Does the decor encourage personalization by user?	✓			
Does the decor provide the individual student with a personal workspace?	✓			

Figure 73. Completed Guide for Decor Analysis

4.2.6. Open & Closed Space

The only closed space is the computer desk. It is in the corner of the room and tucked behind a student's desk. The rest of the studio is open space which is cluttered with the project artifacts and storage units. Although the individual student desks are each microenvironments,

they do not have any vertical panels or dividers to break up the space. The Psychological process tells us that closed space is important for focus, L-mode processes, convergent thinking and privacy. There is a distinct lack of closed spaces in this studio.

Figure 74 demonstrates the chart provided for the Physical Approach for analyzing the open and closed spaces of an environment when applied to the case study.

Open Spaces	Closed Spaces
Individual desks	Communal Computer Desk
Middle Studio Space	
Alleys between desks	

Figure 74. Completed Guide for Physical Approach for Open/Closed Spaces

Figure 75 demonstrates the chart provided for the Psychological Approach for analyzing the open and closed spaces of an environment when applied to the case study.

Guidelines	Yes	No	If no, why?	List possible solutions
Macroenvironment				
Is the majority of the macroenvironment space open space?	✓			
Does the space support the use of analogue tools?	✓			
Does the space serve the group?	✓			
Does the space support divergent thinking?	✓			
Does the space support R - mode?	✓			
Does the space stimulate imagination	✓			
Does the space provide a working environment that hosts individual student's personal workspaces (microenvironments)?	✓			
Does the space provide collaborative working environment for the class as a whole?	✓			
Microenvironment:				
Do the microenvironments contain closed spaces		✓	no individual closed/private spaces	adjust student desks to accommodate privacy/closed space
Does the space support digital tools?		✓	no power features or storage	adjust student desks to accommodate privacy/closed space
Does the space serve the individual?	✓			
Does the space support convergent thinking?		✓	no privacy/closed space/ storage	adjust student desks to accommodate privacy/closed space
Does the space support L - mode?		✓	no privacy/closed space/ storage	adjust student desks to accommodate privacy/closed space
Does the space stimulate focus?		✓	no privacy/closed space/ storage	adjust student desks to accommodate privacy/closed space
Does the space encourage personalization by user?		✓	no customizable features	adjust student desks to accommodate privacy/closed space
Does the space provide the individual student with a personal workspace?		✓	no privacy/closed space/ storage	adjust student desks to accommodate privacy/closed space

Figure 75. Completed Guide for Psychological Approach for Open/Closed Spaces

4.3. Solution Proposal

The overarching problem of the environment in the studio is the lack of privacy and closed spaces. The furniture is bulky and offers no storage for the students to organize and personalize their artifacts. The current storage furniture is inaccessible and very cluttered, causing visual stress.

All of these problems create a neglect of psychological processes such as L-mode, convergent thinking, privacy, motivation, and focus. These processes need to be supported through the environment in order to maximize the students' potential.

Implementing different desks which provide better storage solutions would dramatically enhance the studio space and the student's ability to perform their creative work. According to the B.J. Fogg model, the easier the desk is for the student to use, the more motivated they are to complete their work. Also, a desk that offered student artifact storage would allow them to maintain a neat and orderly workstation while also negating the need to constantly carry their tools back and forth from class. A desk with a storage option would also eliminate the need for the clunky storage units that waste space and cause stress. The desk will be designed with collapsible panels, privacy and closed space would be an option. The desk will also provide a console that will offer electrical power to students' devices in an orderly, easy to use way. It will also be designed to replace current desktops for easy and economical implantation into the environment.

4.4. Conclusion

The proposed solution of replacing and redesigning the desktops for the case study of the studio follows the guidelines outlined by this thesis. This design solution also enhances the case study studio's environmental influence on the user to apply the creative problem-solving process to the best of their ability.

The goals of the desktop are to provide the opportunity for privacy and the creation of closed space for the design student. The optional piece (hereafter referred to as the "blind") that provides these features also allows and encourages the student to customize their desk in the configuration of their choice. The student is also able to use the blind to pin up personal photos or work to reference as they perform their design tasks. This blind is secured with butterfly screws to ensure safety.

There is also a compartment in the back end of the desk that is used to provide power to the design student in a way that does not create a mess of power cords that move around and clutter desktops and alleyways between desks.

The desktop can be opened easily by the user from a sitting or standing position. When the desk is opened, a storage space is revealed. This storage space allows for flexible configuration which allows the design student to customize their organization options to their liking. The piece that creates the back wall of the storage area has holes that allow the user to organize their chargers and leave their devices within the desk while also charging them.

All of the hinges that allow these movable parts are not visible while looking at the desk. This design decision reinforces neat, organized appearances which reduce visual stress and distraction.

The dimensions of the desktop are designed to allow the desktop to simply replace the current desktops in the case study studio. This simplifies the process of enhancing the desks while also minimizing the amount of labor that would involve replacing the entire desks.

All of the features reflect the science of behavior engineering as discussed previously with B.J. Fogg's Behavior Model. The desk is designed to offer ease of use for the student to perform their work and provide and create the environmental conditions that maximize their ability to apply the creative problem-solving process. According to Fogg's theories, the ease of use provided by the desktop also enhances user motivation to perform their work and the creative problem-solving process.

The following problems of the case study studio were outlined in the previous chapter:

- Poor lighting: There is no natural light through window and the bulbs are too bright without adjustable dimness
- Furniture is not good for flexible/easy reconfiguration— it is heavy, bulky, and does not flatpack
- Unused storage units are configured to be hard to use and waste a large amount of space by creating and encouraging mess and clutter

- Students do not have the ability to neatly organize, customize, configure, or personalize their workspace due to the design of desks and lack of storage space.
- Student artifacts do not have designated spaces and clutter the floors and desktops
- Configuration of the room does not allow most students to conveniently access power for their electronic devices from their desks.
- Few closed spaces exist to support focus, L-mode processes, convergent thinking, and privacy.

The application of this desktop solves the following problems of the studio case study outlined in the previous chapter:

- Provides flexibility by being easy to install and uninstall, adjustable to user choices, and ability to store efficiently
- Reduces visual and physical clutter by providing effective and useable storage space
- Provides the ability to keep a neat and orderly desk by providing storage space to keep tools and artifacts out of sight
- Provides ability for users to customize and personalize their workspace
- Provides the opportunity to create closed space to support focus, L-mode processes, convergent thinking and privacy.

The desktop designed to replace the current desktops provides features that directly address the problems of the studio case study. The implementation of this desktop into the studio case study would enhance user ability to perform the creative problem-solving process as well as

everyday work functions. The figures below depict 3D model renderings of the proposed design solution.

Figure 76. Dimensions of Desktop Redesign

Figure 77. Main Configurations

Figure 78. Desktop and optional Privacy Blind/Pin Board

Figure 79. Easily Accessible Power Strip Compartment

Figure 80. Exploded View

Figure 81. Prototype of Solution in Context

Figure 82. Electrical Cord Storage Feature

Figure 83. Inside Storage Compartment

Figure 84. Before and After New Desk Installation

Chapter 5: Conclusion

5.1. Review

This thesis explored the propensity of environment design to directly impact user ability to perform the creative problem-solving process. This purpose of this thesis was to enhance user ability to perform the creative problem-solving process by means of providing recommendations on how to optimize the user's work environment.

This thesis achieved this by 1) conducting and presenting research on user psychological requirements and skills to perform the creative problem solving process; 2) identifying relationships between these psychological requirements and physical aspects of an environment; 3) developing recommendations for how to enhance workspace environments; 4) applying these recommendations to a case study and developing a design solution to enhance the case study studio space. The solution presented in this thesis addressed a prioritized segment of the problems with the case study environment rather than solving every problem identified with the case study.

5.2. Further Studies

Future studies could explore flexible furniture configurations which catered to the many dualities of the creative problem-solving process. These dualities create seemingly opposing needs of a space, such as both open/closed, private/collaborative work, convergent/divergent thinking, and etc. However, providing for each of these needs in one single space creates problems of efficiency and economically viable solutions. Further studies exploring design

solutions that created flexibility of a single space to serve each duality could maximize the potential of a space to serve all aspects necessary for a designer to perform the creative process.

5.3. Conclusion

The sciences of creativity, psychology, and even neurology have long been misunderstood and looked over as unimportant in industrial design. However, with current research and an ever-increasingly competitive market for creative work, there is hefty economic value in the ability to harness creativity. This thesis argued that creativity is harnessed through the creative problem-solving process and psychological subprocesses of the user. Furthermore, it is the configuration and design of the working environment that either hinders or enhances user ability to perform this creative problem-solving process.

Much like the complex and specific environment conditions required for a grain of sand to transform within the environment of the mouth of an oyster into a valuable pearl, the application of creativity in carefully, deliberately designed and configured environments will produce creative solutions of competitive economic value.

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