RESTRUCTURING EDUCATION TO FUEL CREATIVITY AND INNOVATION

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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THE CREATIVITY CRISIS THREATENS THE FUTURE OF INNOVATION

On December 17, 1903, in the coastal town of Kill Devil Hills, North Carolina, five locals witnessed the first successful sustained flight of a heavier-than-air machine. Orville and Wilbur Wright had discovered the fundamental principles of human flight and successfully tested one of the most influential technologies of the 20th Century. Before the development of a comprehensive theory of aerodynamics, the Wright brothers designed the first functional airplane based on empirical tests conducted in a self-made wind tunnel. Propelled by curiosity and through their ingenuity and creativity, they were able to make the technological leap without the backing of scientific theory. The Wright brothers themselves credited their lifelong curiosity to the environment in which they grew up. Without encouragement, Orville believed, "our curiosity might have been nipped long before it could have borne fruit" (Crouch, 2018, p. 1).

The Difference Between Engineers and Scientists

The Wright brothers would be classified as engineers, not scientists. Though the fields certainly overlap, Kenneth R. Lutchen, the Dean of Engineering at Boston University, distinguishes science -- as the art of discovery -- from engineering -- as the art of innovation (Lutchen, 2010). Engineers employ scientific discoveries through innovation to solve real-world problems. Scientific discovery alone may add little value without an engineer's ability to apply it within a societal context. "While it is true that engineering without science could be haphazard; without engineering, scientific discovery would be a merely an academic pursuit" (Lutchen, 2010, pg. 2). By translating scientific discovery into innovation, engineers couple their scientific background with their ingenuity to produce new solutions. Therefore, the differentiating factor between scientists and engineers is creation. Where scientists discover truth about the created

world, engineers create new technologies to subdue the created world and, hopefully, improve human life and society.

As global problems such as climate change, food insecurity, and healthcare become increasingly threatening, it is necessary that engineers are able to provide solutions through technological innovation. Mere scientific discovery cannot solve these problems, so engineers will be called upon to employ their creative skills to produce effective solutions. Among other soft skills or personal attributes, creativity is seen a necessary skill for the future, according to a survey of technologists, scholars, practitioners, strategic thinkers and education leaders (Rainie and Anderson, 2019). Especially as artificial intelligence and robotics stand to replace millions of workers over the coming decade, human creativity will remain one of the most valuable skills, one that technology cannot replace. Unfortunately, this critical piece of the engineering mental framework is declining in America.

The Failure of the American Education System to Foster Creativity

Kyung Hee Kim (2011, 2017), a researcher at the College of William and Mary, conducted a study of six normative samples of the Torrance Tests of Creative Thinking from 1974 to 2017. Data from over 270,000 kindergarten through 12th grade students and adults indicated that creativity has significantly decreased since 1990 while IQ scores have risen. Kim believes the "Creativity Crisis," as she has dubbed it, is the result of incentives and sanctions linked to standardized test scores which have provoked schools to focus on rote memorization and test-taking skills instead of fostering curiosity and creativity. The most alarming aspect of the study is that the greatest decrease in creativity is among the youngest age group, 5- to 6-year-olds.

Not only are children starting out with less creativity, but the education system stifles what creativity they begin with. Creative potential has been shown to decrease as we age. In a study conducted by George Land (1992), 1,600 children were given the same creativity test at ages 5, 10 and 15. Astoundingly, 98% of 5-year-olds achieved the Genius Level, the highest level possible, compared to 30% of 10-year-olds and 12% of 15-year-olds. Among 280,000 adults who took this test, only 2% achieved "Genius Level." Land blames our education system for stifling creativity at a young age. While some of this decline can be attributed to human nature, Land finds fault with an education system that forces children to constantly judge, criticize and refine their ideas. This is at odds with creative thinking, which thrives in environments that accept unconventional ideas by deferring judgment (T. & D. Kelley, 2014).

Indeed, engineering schools, the very schools that are meant to produce creative innovators, have been shown to reduce creativity from the time students enter the program to the time they graduate (Sola et. al., 2017). This is not surprising to me as my personal experience at the University of Virginia School of Engineering and Applied Science has provided few opportunities to exercise creativity. In my final year at the University of Virginia, the Capstone has been the first mandatory experience that incorporates engineering design and creative thinking. The Capstone challenge is to design and build a device that exploits human energy. This open-ended challenge allows engineering students to employ their creativity and technical skills to produce a novel solution. The Capstone team is designing and building a light source powered by gravity. This experience provides many opportunities to solve technical and abstract problems, demanding creative thinking. However, it may have come too late. While engineering programs teach in-depth technical skills, they lack sufficient opportunities to promote, much less

maintain, the creativity that first-year college students bring to the table with ease. When creativity is so fundamental to innovation, how is this acceptable?

Reversing the Creativity Crisis

Teaching environments must adapt to encourage and preserve the creativity of students. Our education system is expected to produce the engineers who will tackle the global environmental, health, and security problems that will certainly continue to worsen in the future. It is all the more important, therefore, that the decline in creativity be reversed. However, this is a highly complex problem rooted in our societal values and perpetuated through every level of education. Furthermore, the risk of the Creativity Crisis is likely underappreciated. Risk evaluation is highly dependent on the magnitude of the potential danger (Martin & Schinzinger, 2010). On a small scale, one person not living up to his or her creative potential is insignificant; however, extrapolating this to society at large poses a major threat as we face increasingly complex problems of the future.

The purpose of this paper is to suggest effective steps that can be taken now to combat the decline in creativity by preserving and encouraging creative mindsets in children throughout their development. The problem will be analyzed using the framework of Social Constructionism, which proports that people form beliefs about reality based on interactions with others (Berger & Luckmann, 1967). The American education system fails to instill in students a belief in their creative potential. This problem and solution will be viewed as originating from students' interactions with their educators, including teachers, parents, and role models. How can these interactions encourage creative development in education?

THE NATURE OF CREATIVITY

At its core, creativity is an abstract concept that cannot be readily confined by a theory or definition. The flexible nature of creativity necessitates a flexibility of definition. However, specifying key components of creativity will help to identify resources which promote creativity. The Investment Theory of Creativity (Sternberg, 2006) will be used to define a loose definition of creativity and determine roadblocks that must be overcome. Then, key resources will be specified which promote creative development.

The Investment Theory of Creativity

Creativity is not simply an ability to produce new ideas; it is also an ability to evaluate ideas to determine if they are worth pursuing. Simply creating ideas provides little value because innovation necessitates not only new ideas but better ideas. The Investment Theory of Creativity states that creative thinkers are able to create ideas and assess their future value (Sternberg, 2006). Investments are made under the belief that the future value of something is greater than the current perceived value. Therefore, creative thinkers are investors because they pursue new and better ideas though they might be currently out of favor. Truly innovative ideas are often so unconventional that the general public fails to see the future value because they do not fit into the current technological framework. Therefore, creative thinkers are likely to face resistance or rejection because their ideas do not fit into the society's status quo. According to the Investment Theory of Creativity, creative ideas are inherently undervalued by society in general, so creative thinkers must be willing to face resistance. If such defiance towards the status quo is not supported or encouraged to the right degree, many naturally creative thinkers may become dissuaded from expressing their creativity in order to follow the path of least resistance. It is no

wonder then that standardized education systems inhibit creative development as they evaluate students on their ability to meet common standards instead of their originality of thought.

The Required Resources of Creativity

Since traditional education systems are likely to hamper creative development, conscientious efforts need to be made to provide students with the necessary resources to express and develop their creativity. In an article published in the Creativity Research Journal, Robert Sternberg (2006) identifies six resources which promote creative development according to the Investment Theory of Creativity: intellectual skills, knowledge, legislative styles of thinking, personality, motivation, and supportive environments.

Intellectual skills such as synthetic and analytical skills are the foundation for good thinking in general and creative thinking. The first step to producing a creative solution is to synthesize the problem at hand to its core problems. After synthesizing the problem, creative thinkers are able to view the problem in unconventional way and produce new solutions. Once possible solutions have been identified, creative thinkers must analyze them to determine which are worth pursuing and eventually persuade others of the value of their ideas (Sternberg, 2006). A second resource, knowledge or expertise in a field, is necessary for creative thinkers to be able to advance a field because one cannot advance a field unless he or she knows where the field is and which ideas have already been attempted (Sternberg, 2006). However, expertise can lead thinkers to become entrenched in conventional ways of problem solving (Frensch & Sternberg, 1989). The third resource for creativity, a legislative style of thinking, combats the pitfalls of expertise. When people use a legislative style of thinking they decide to think on their own as opposed to following prior methods. This leads to intentionally thinking through decisions in novel ways. (Sternberg, 2006) All three of these resources are required for creative thinking

because each build upon the previous skill; knowledge prevents good thinkers from producing useless or old ideas, and legislative thinking leads experts to approach problems in novel ways.

The previously mentioned resources for creativity have to do with one's intellectual ability to be creative. However, according to the Investment Theory of Creativity it is not enough intellectual skills are not enough to be creative since there is inherent resistance to creativity. The remaining resources that Sternberg (2006) identifies apply to one's ability to overcome or remove obstacles in the way of creative thinking. Personality plays a role in creative development because it can determine one's willingness to take risks and tolerate ambiguity, two important traits when advancing new ideas. Self-efficacy is another necessary personality trait as creative thinkers will often be alone when proving the value of their ideas. Personal motivation is another resource that is necessary to overcome the obstacles of creativity. There must be a personal interest in the work or personal reward for success to propel someone through the resistance to creative ideas. Finally, environments which are supportive and rewarding of creative ideas are essential resources to remove obstacles in the initial stages of creative development. Supportive environments give space for creative thinkers to explore and develop their ideas before taking them to more hostile environments which are quick to challenge. (Sternberg, 2006)

CURRENT STATE OF CREATIVE DEVELOPMENT

The essential resources for creativity should be engrained in education systems and workplaces in order to ensure creative development and practice throughout life. However, the current model of creative development lacks organization and tends to rely on factors outside of the schooling system.

The Current Model of Creative Development

The current state of creative development in America is unstructured at best. Common Core standards in America stress the development of basic skills such as literacy and mathematical competency, knowledge in social studies and science, and analytical and critical-thinking skills (Common Core, 2020). These skills provide the first two necessary resources for the creative development, namely intellectual skills and knowledge. However, a program such as Common Core will likely dissuade legislative thinking, as this style of thinking is by its nature unconventional and non-conforming. Additionally, education standards cannot be expected to ensure development of personalities, personal motivations, or environments that are conducive to creativity. Rather, it is the responsibility of educators to allow for these traits to arise and grow naturally by removing potential obstacles.

Figure 1 depicts an ideal model in which a student has creative opportunities throughout his or her education. However, this ideal case is still disorganized and relies on the decisions and abilities of the student's parents to provide these opportunities. It is unclear which stakeholders in this system are supposed to provide the necessary resources for creativity. Parents may nurture the personality traits necessary (elaborated below), but if the motivation for creativity is not present until engineering school or creative industries, the student's creative potential may not be

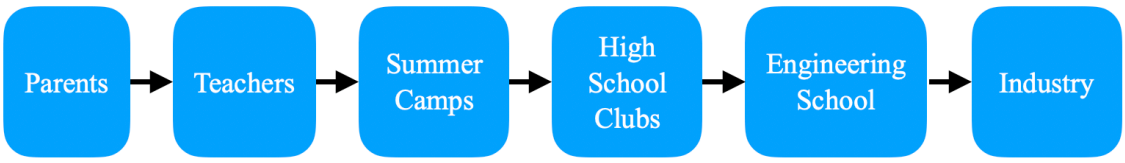

Figure 1. The Ideal Current Model of Creative Development: Assuming the ideal case, where students have access to the following opportunities to explore their creative potential, students may develop a sense of creativity. However, the current system is disorganized and relies heavily on the decisions and abilities of students' parents to provide these opportunities. (Hofer, 2020a)

realized early enough. Furthermore, several of these opportunities are optional, for example summer camps and high school clubs, and may require extra effort and cost to pursue, leaving disadvantaged students with no option at all. An improved model of creative development is needed to organize the process and widen creative opportunities to more students.

Nurturing Creativity Among Children

Children do not need to be taught how to be creative (Land, 1992). In fact, there is a certain essence of creativity which is childlike. Creative thinkers of all ages tend to be more spontaneous and joyful, qualities that are both childlike and conducive to exploring new ideas without judgement or fear of failure (Barron, 1995). The innocence of childhood, the ability for children to see things for the first time without preconceived notions, predisposes them to be creative (Runco 1996). When viewing creative ability among children and adults, Runco (1996) defines creativity as "manifested in the intentions and motivation to transform the objective world into original interpretations, coupled with the ability to decide when this is useful and when it is not" (p. 4). By this definition, both children in their naivete and engineers with expert knowledge can be creative so long as they know when and how to view the world in a new light. For the child, this might look like a makeshift fort, and for the engineer, a skyscraper able to withstand earthquakes. The engineer's creation may be more valuable, but that does not diminish the creativity of the makeshift fort. It is obvious that most children building a fort rely on their creativity by transforming the objective world into original interpretations. If truly creative, the engineer would have done the same to create new solutions to the problems that earthquakes pose to skyscrapers. The challenge is educating the creative children building forts in a such a way that, when they are designing skyscrapers, they are able to apply both their expert knowledge and their childlike creative abilities. The Creativity Crisis shows that the opposite is

happening: people's highest creative potential is at young ages and creative potential only decreases as they age (Urban, 2009; Kim 2011). The current problem is not that creativity is not being taught, but rather, children are not being provided with all the necessary resources to maintain their innate creative potential. Therefore, special measures should be made to preserve and nurture creativity starting young and to equip students to withstand all levels of education with a sense of their creative potential.

EFFECTIVE MEANS OF CREATIVE DEVELOPMENT

Promoting a Growth Mindset

If students are not convinced of their creative potential at a young age, they will lose their intention and motivation to transform the objective world into original interpretations, per Runco's (1995) definition of creativity (Crammond, et al, 2005). In early education, when children's thinking styles and perceptions of the world are forming (McClure et al., 2017), it is paramount to teach students that they can change the world they live in and that it is good for them to change their world. In other words, children should be taught that their creativity can be efficacious and good. If not, children may develop a fixed mindset, whereby they perceive the world and themselves to exist in a predefined state that cannot be changed and any effort to exercise their creativity is futile. A growth mindset is, therefore, key to a creative mindset.

A growth mindset focuses on a thing's ability to change and improve, as opposed to a fixed mindset which tends to assume that the state of something is predefined (Dweck, 2006). A person with a growth mindset is inclined to approach challenging problems as opportunities to learn and improve, whereas a person with a fixed mindset tends to view challenging problems as opportunities with a high risk of failure. According to the Investment Theory of Creativity,

creative thinkers will encounter resistance as they explore unconventional and undervalued ideas. A growth mindset allows children to face these obstacles and seeming failures as opportunities to learn and improve their creative skills. Driven by a deep belief in the potential for things to be improved, they can overcome society's inherent resistance to change. However, a growth mindset cannot simply be taught in an ordinary lesson since it is a fundamental perception of the world that must be internalized through experience. Dweck (2006) shows that the type of praise that a child receives after performing a task can help the child adopt a growth mindset. When children receive praise for their effort as opposed to their ability, they begin to view their efforts as causing the results, making them more willing to try harder tasks and view failure as an opportunity to improve their skills. Praise for genuine effort has been shown to have long term impacts on the children's motivational framework (Gunderson, et al. 2013). If students are motivated by their ability to improve their creative skills rather than their performance, they will be more willing to take risks to exercise their creativity in the classroom and beyond.

The Importance of Parents in Creative Development

Parents are the most influential members of childhood development because they determine whether or not children receive the resources they need. For example, the instructions and feedback that children receive from adults affect how they express their creativity. The Center for Childhood Creativity identified key components of creativity, showing that "creativity is strongly influenced by environmental factors such as explicit instructions, positive process-oriented feedback from important adults (e.g., teachers and parents), and active involvement in novel experiences" (Hadani, 2015, p. 2). Furthermore, direct participation from parents in learning has the potential to develop the key resources to creativity. Through shared participation, parents are able to accompany children in activities which they would not be able

to manage on their own. These types of interactions have the potential to improve cognition, create playful learning environments, and aid in social and emotional development (Shared Discoveries, 2015). Parents have a unique role in the creative development of their children.

Proposed New Model of Creative Development

Incorporating guided experiential learning into education faces several obstacles. Teachers cannot be expected to provide students with the individualized experiences because they are expected to teach dozens of students at a time. The current education system struggles to teach the most basic literary and math skills (DeSilver, 2017), so expecting even more would be unreasonable. Shifting this burden to the parents would be more reasonable to expect since parents are more likely to have the time to dedicate to shared experiences. Furthermore, parent-child interactions have a profound effect on the child's cognitive, social and emotional development (Hadani, 2013). While parents may be able to provide the cognitive and personality traits that are necessary for creativity, they may be unable to inspire their children if their

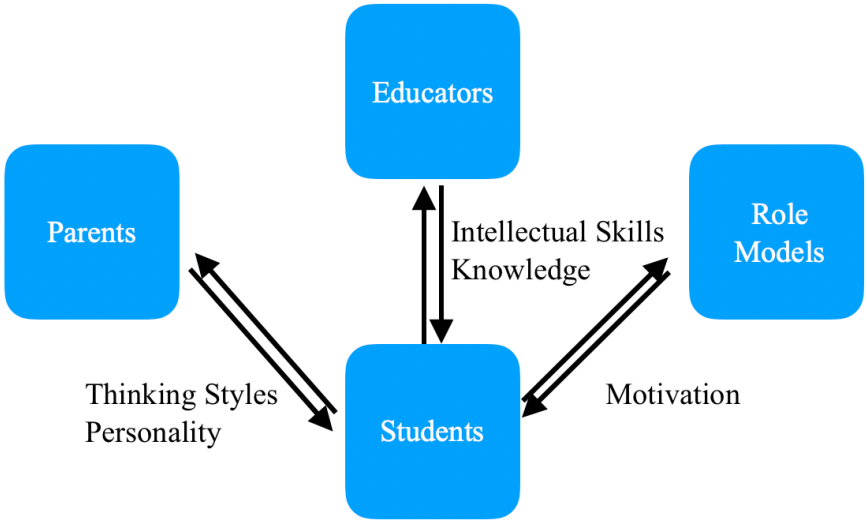

Figure 2. Social Constructionism Applied to Creative Learning: Parents, educators and role models are key to providing the necessary resources to promote creativity in students. Viewing creative education from the perspective of Social Constructionism indicates how each actor should influence the development of creativity in students. (Hofer, 2020b)

interests do not align. Role models in the field of the child's interest could fill this gap and provide the motivation for creative development. Figure 2 depicts how each type of mentor is able to provide distinct resources for creativity.

Another obstacle to improving creative development is the standardization of education. Education standards are beneficial for incentivizing the development of intellectual skills and knowledge. However, standardization does not incentivize the development of creative skills, which are by nature contrary to standardization. This proposed new model for creative development does not expect schools to provide all the resources for creative development, only those resources which they are incentivized to provide, intellectual skills and knowledge. Parents are then free to focus on guided experiential learning, which helps develop the proper thinking styles and personalities necessary for creativity. (Concrete examples of experiences and activities which parents can share with their children are beyond the scope of this paper; however, the Center for Childhood Creativity's 2013 publication entitled *Shared Discoveries: Positive Parent-Child Relationships and Child Development* provides many research-backed examples.) Role models, such as engineers, artists, and writers, can inspire students by sharing how they employ their creative skills in their professions. Therefore, this proposed new model for creative development organizes and separates the responsibilities of providing the necessary resources for creativity to overcome the standardized education system, which is only incentivized to provide some of the resources for creativity.

Conclusion: A New Structure for Creative Development

The Creativity Crisis threatens future innovation in America for generations if our education system continues to reduce the creative potential of students. Creativity needs to be encouraged; it will not survive on its own in our education system which tends to favor

conventional ways thinking. Currently the resources for creativity are potentially present in childhood development, but creative development is unstructured, with various actors with unspecified roles. It is important to focus on creative development starting young because children are naturally creative and simply need to be given the necessary resources to develop their creativity. Mentors (parents, teachers, and role models), therefore, play a special role in reversing the creativity crisis by laying the foundation for creativity in providing the necessary resources for creativity for children at young ages.

By dividing the burden of providing the creative resources among parents, teachers and role models, children can be encouraged to exercise and develop their creative potential through a systematic approach. The education system can become more efficient and effective in providing the key resources of intellectual skills and knowledge. Parents will be able to focus their attention on their child's cognitive and personality traits. Finally, role models can be relied upon to provide the motivation necessary to inspire the next generation of creative thinkers. This structure of creative development ensures that children receive the resources they need to preserve their innate creative potential throughout their education. Promoting creative development in early education will ultimately stem the tide of the Creativity Crisis and prepare the next generation of innovators and engineers to create a better future.

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