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Creativity in Science, Engineering, and the Arts: A Study of Undergraduate Students' Perceptions

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Creativity in Science, Engineering, and the Arts: A Study of
Undergraduate Students' Perceptions

by

Dildora F. Beaulieu

A dissertation submitted in partial fulfillment of the
requirements for the degree of

Doctor of Education
in
Educational Leadership: Postsecondary Education

Dissertation Committee:
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Portland State University
2021

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Abstract

Creativity is widely recognized as being invaluable for human development and a crucial 21st century talent. Preparing students for an uncertain and complex world requires that higher education promote students' imagination, originality, curiosity, and flexibility and build their capacity to take risks to try new approaches to problem-posing and problem-solving. However, little is known about how undergraduates enrolled in different disciplines view creativity. This quantitative study at a university in the northwestern United States assessed how undergraduate students in different academic disciplines responded to an instrument on creativity measurement developed by Dlouhy (2012). The study asked: How do undergraduates in science, engineering, and the arts compare in their *perceptions of creativity*, their *creativity self-perception*, and their views about the role of *creativity in education*? Through principal component analysis, I found that the three perceptual components of creativity were highly correlated; therefore, I conducted my analysis with a single response variable of *overall creativity*, representing summed perception across the three components. Through multiple linear regression, I found that academic discipline was a significant predictor of perceptions of creativity, with students in the arts scoring 6.6% higher than students in engineering and 6.4% higher than those in science-related programs. Science and engineering students scored nearly equally in their perceptions of creativity, with science students scoring only 0.2% higher than engineering students. Given the importance of creativity in all fields, I recommend that future researchers explore the potential for interventions in post-

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secondary science and engineering courses to increase students' perceptions of
creativity.

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Chapter 1: Introduction

There is a global crisis in creativity, and creativity and innovation have become worldwide areas of concern (Bloom & Dole, 2018). In response to this concern, a special issue of *Global Education Review* (volume 5, issue 1) gathered a number of previously published articles that examined different aspects of this crisis. For example, Kim (2011, as cited in Bloom & Dole, 2018) reported that over the past several decades, a decline in creativity in the United States has been observed, based on the scores of the E. Paul Torrance Test of Creativity, which continue on a downward trend. The implications of this decline were foreshadowed more than a decade ago by the business community in the *Harvard Business Review* article, America's Looming Creativity Crisis (Florida, 2004 as cited in Bloom & Dole, 2018). Zhao (2012, as cited in Bloom & Dole, 2018), which reviewed the literature of neuroscience research on creativity and reported that important research findings on the decline in creativity have had little impact on educational practice. In their introduction to the collection, Bloom and Dole (2018, p. 1) concluded that "While there are differing views of what creativity is and why it is important, the authors in this issue tend to agree that creativity needs to be an intentional goal in education."

Preparing students for an uncertain and complex world requires that higher education promote students' imagination, originality, curiosity, flexibility, and build their capacity to take risks to try new approaches to problem-posing and problem-solving. Creativity makes students imaginative, original, curious, and willing to try new things, and because of its positive impact on society, the topic of creativity has drawn much

attention (Zhou et al., 2013). Specifically, in higher education, there has been an increasing focus on the explicit and implicit teaching of creative skills (Egan et al., 2017; McWilliam et al., 2008) both in the United States and abroad (Crosling et al., 2015). It is critical for students to develop creative and innovative thinking skills that will support them as they venture out into the world after obtaining their degrees (Mulholland, 2016). The process of learning creativity also improves students' skills in problem solving and innovation (Cropley & Cropley, 2010), as well as prepare them for post-education careers and endeavors. However, higher education is faced with a challenge: teaching, learning, and fostering creativity to prepare and help students thrive in the workforce and society. Innovation and diversification of ideas need to be supported and nurtured across all disciplinary domains in higher education.

There have been many calls for universities to incorporate creativity into curricula to help students develop skills in divergent thinking, problem solving, innovation, and collaborative learning, but there is very little research into how students themselves perceive creativity and its role in their higher education. Research is needed to better understand students' perceptions about creativity and how those perceptions differ for students from different disciplines. Therefore, this research study investigated the extent to which students in different fields perceive creativity as important. Three central areas were addressed: (1) perception of creativity—the general beliefs that respondents have about creativity as a human trait; (2) creativity self-perception—the role that respondents believe creativity plays in their personal lives; and (3) creativity in education—the role that respondents feel creativity plays in education.

Background and Significance of the Problem

Despite many calls for development of creativity curricula, and for the teaching of creativity even in courses for which creativity is not an explicit learning objective, universities still struggle to effectively foster students' creativity. Also, universities have difficulties creating environments that promote creativity, in part because both teachers and students are accustomed to a lecture–exam style of teaching and learning (McWilliam et al., 2008; Sandri, 2013), in part because teachers do not feel supported to teach creativity within their schools and in part because teachers were themselves students within a university system that did not teach them skills in creativity, leading to educators with limited views of what creativity is and its place in higher education (Jahnke et al., 2015). In order to develop creative thinkers, it is critical for university educators to create space for creative inquiry, such as providing opportunities for learning through social interaction and collaboration, and to give open-ended assignments leading to unexpected outcomes (Alencar et al., 2017). Establishing an environment that fosters creativity allows teachers to incorporate creative methods into their teaching (Katz-Buonincontro, Hass, et al., 2020; Katz-Buonincontro, Perignat, et al., 2020).

In order for creativity education to be useful and effective, students must be open to facets of creativity with which they may not be familiar or comfortable. For instance, developing problem solving skills and the ability to synthesize information from multiple sources to advance entirely new solutions requires that students place themselves in a state of uncertainty, which is uncomfortable (Sandri, 2013). Further, students from different disciplines may not only be more or less willing to embrace creativity

education—they may in fact perceive it and experience it in very different ways. For instance, engineering students in programs where they have previously worked only within highly structured classroom environments may not see value in working collaboratively or in incorporating artistic methods into their process (Costantino et al., 2010; Kazerounian & Foley, 2007). In contrast, students in the humanities or arts may be more familiar, and therefore more comfortable, with teaching and learning methods that incorporate uncertainty, self-reflection, discussion, and visual arts (Costantino et al., 2010; Knowlton & Sharp, 2015). Therefore, understanding the perceptions of creativity that are held by students in different fields of study is essential for deciding how to better integrate creativity into higher education. However, there are limited studies of higher education students' views on creativity drawing on students from a variety of academic disciplines (Dlouhy, 2012; Snyder et al., 2020), therefore, there is a need for this research study.

Statement of the Research Problem

Global and technological advances in society have led to a need for universities to prepare students to become skillful employees who are ready to contribute to society and develop creative solutions to complex problems (Jackson, 2004). Creative students can think outside of the box to solve problems, and these skills are lacking in students as well in employees currently in the workforce (van der Wal et al., 2017; Zhou et al., 2013). Thus, this research study is critically needed to identify how university-level students perceive creativity in a higher-education setting and how perceptions differ among students from different disciplines. In conjunction with other studies it will help to

narrow the gap in our understanding of how to recognize and reward students' creativity, how to measure and assess creative learning skills, and the most effective ways of fostering and advancing creativity in higher education.

Purpose of the Study

This quantitative study gathered and analyzed data to compare how undergraduate students majoring in science-, engineering-, and arts-related disciplines perceive creativity as measured by a survey developed by Dlouhy (2012). This research study will help to advance our understanding about perception of creativity in higher education. The results of this research study will communicate to professors, instructors, and administrators in science, engineering, and arts disciplines about how students in their programs perceive creativity. Further, the recommendations provided in Chapter 5 will help university educators understand how to recognize, encourage, and reward students' creativity, how to measure and assess creative learning skills, and the most effective ways of teaching and fostering creativity in higher education. These insights are derived from the creativity literature, my own experiences, and the perspectives of students themselves as reflected in the results of this study, lending benefits to the institution of higher education and contributions to the creativity education literature.

Methodology and Research Questions

The research question addressed in this quantitative study asked: "How do undergraduates in science-, engineering-, and arts-related disciplines compare with regard to their perceptions of creativity, their creative self-perceptions, and their views about the role of creativity in education?" To answer this multi-part question, I conducted a

quantitative study at a university in the northwestern United States. I used an instrument on creativity measurement developed by Dlouhy (2012) to assess how undergraduate students majoring in science-, engineering-, and arts-related disciplines perceive creativity and used quantitative analysis (principal component analysis, correlation analysis, and multiple linear regression) to compare their responses across disciplines. I also collected demographic data from all participants including gender, age, academic level, language, and ethnicity/race. Participants were students in science, engineering, and the arts.

Positionality

I went to school in different countries that had a variety of cultural understandings, and I grew up with an idea of improving creativity at schools. When I initially attended a geometry course, I noticed that my teacher graded my work not only on how well I knew the geometry theories, but how creative I was in learning the topic. This teacher graded my work by evaluating my process of resolving problems rather than simply checking and grading the correctness of my solutions. This experience led me, later in life, to succeed at my current work as a senior-level budget analyst. I face many tight deadlines, but I use many creative ways to resolve problems in a short period of time. I truly believe that my geometry teacher prepared me to work in the real world, and because of him, I am successful at my job. Over time I found that creativity was less valued as I progressed through more advanced education in the United States and I have lived with a vision of promoting creativity within school settings. I believe that teachers should teach classes by incorporating creativity and creating a student-centered

environment. I feel that grading should include evaluating how creatively students solve problems in order to prepare them for a work environment in the future. I perceive that creativity is valued less at academic institutions in Western cultures, as they tend to prioritize the application of scientific approaches. Furthermore, I believe that a lack of creativity in academic institutions is an issue that needs addressing because students do not know how to solve problems when demands within society are higher than the available resources in this informational era. Thus, I am highly motivated to contribute to finding solutions to what has been recognized to be a global problem.

Summary

The development of a creative citizenry and workforce is a global concern (Bloom & Dole, 2018). As society becomes more complex and technology more sophisticated, higher education has a responsibility to prepare students to become skillful workers who can contribute to society and develop innovative solutions to complex problems (Jackson, 2004). Chapter 1 introduced the problem of a crisis in creativity, its impact on higher education, and the purpose and implications of the study. In Chapter 2, I review and synthesize the relevant literature on creativity, creativity in higher education, and approaches to teaching creativity, as well as the literature on student perceptions of creativity, their self-perceptions of creativity, and their perceptions of the role of creativity in higher education. In Chapter 3, I describe the methods used to carry out this research study. In Chapter 4, I present the results of this study. Finally, in Chapter 5, I discuss the implications of the results and provide recommendations for instructors and future researchers.

Chapter 2: Literature Review

This chapter synthesizes and critiques the body of research literature related to creativity in higher education in order to develop a justification for the research study. Sources included in the literature review are: research articles, research reports, and research-related books with a focus on approaches and measurable outcomes of teaching and fostering creativity in higher education and on the perceptions of college students of creativity in general and of their own creativity. To locate relevant literature, I used search keywords relevant to creativity in databases and libraries and I developed three different themes (Figure 1) related to the research topic. The review is organized around a background on creativity and its importance in our current society followed by two primary sections: (a) creativity in higher education and (b) perceptions and self-perceptions of creativity in an educational context.

Figure 1

Themes and Keywords for Locating Relevant Literature

Theoretical Framework

This section presents a theoretical framework (as Ravich & Riggan, 2012) for investigating perceptions of creativity in higher education. The theoretical framework (Figure 2) guides describing, explaining, and justifying the need for creativity in higher education by exploring existing theories, practical knowledge, and applied research. First, the literature review establishes that there is a global need for creative citizens and workers by presenting a background on creativity. Then it examines the premise that creativity is important in education and should be a goal across higher education fields, as well as highlights research that has identified successful methods for teaching creativity and the outcomes from integrating creativity in teaching at the post-secondary level in a section on creativity in education. Finally, the third section of the review addresses the importance of making higher education instructors aware of the ways their students

perceive creativity by examining different aspects of the perceptions of creativity of undergraduate students.

Figure 2

Theoretical Framework

In his research on perceptions of creativity, Dlouhy (2012) identified three areas related to higher education students' creativity perceptions: a) perceptions of creativity; b) creativity self-perception; and c) perceptions of the role of creativity in higher education (Figure 3). Dlouhy (2012) also developed a survey instrument for understanding these components of the creativity perceptions of higher education students. Dlouhy's survey and the three components of creativity perceptions form a groundwork from which I developed the primary research question for this study: How do undergraduates in science, engineering, and the arts compare with regard to their perceptions of creativity, their creative self-perceptions, and their views about the role of creativity in education?"

Figure 3

The Three Components of Creativity Perceptions

Note. Adapted from Dlouhy (2012).

It is worth noting that the literature reviewed may contain aspects that overlap categories, e.g., one study may discuss both student perceptions of creativity in general and their perceptions of creativity in higher education, which is to be expected given the nature of studies on students' perceptions of creativity. In those cases, the literature is placed within the category it fits most fully.

Background on Creativity

Definitions of Creativity

Creativity has been described as the way the human brain uses prior information to produce innovative ideas, which is accomplished in three ways: bending (modifying existing ideas), breaking (breaking existing ideas to create a new one), and blending (marrying two ideas to create a new one) (Brandt & Eagleman, 2017). Brandt and Eagleman (2017) stated, "Bending, breaking and blending – the three B's – are a way of capturing the brain operations that underline innovative thinking" (p. 49). For example, in bending, an original building can be reshaped in a creative way to provide a modern and unique look; in breaking, an empty bottle can be recycled to create a new item; and in blending, several items are merged, such as a camera, computer, and phone to create a smartphone. All of these skills require creativity, and they use different aspects of creativity to innovate. Brandt and Eagleman (2017), who investigated diverse creative skills, illuminated the shared characteristics of creative actions across intuitively creative (creation of art, storytelling) and indirectly creative (space programs at NASA) pursuits. Another way of viewing creativity and its place in society was described by Kaufman and Stenberg (2007, as cited in Mulholland, 2016, p. 180), who defined creativity in terms of

four-Ps, which relate to person, product, process, and press/environment. In this definition, the study of the creative person explores creativity skills, such as the motivation level of the individual or personality, while the other three Ps focus on the experience of being creative, in addition to other factors, such as environment, which enhances creativity skills as well (Mulholland, 2016, p. 180).

Creativity in Society

The topic of understanding creativity has been growing among employers and educators, as society is facing future challenges because of many complexities that cannot be resolved with knowledge alone (Mulholland, 2016, p. 178). Thus, the concepts of understanding creativity and knowing how to apply it have become increasingly important for society as we move from an industrial economy to a “knowledge economy” (Costantino et al., 2010, p. 50). As society advances in technology and globalization, higher education has been facing challenges in preparing students to work in this newly complex world (Jackson, 2004, p. 1). Therefore, it is essential for teachers in higher education to understand not only how to teach creativity but also how to measure and define success in preparing students to be creative, so students are more adaptable for change and prepared to contribute to and participate in society (Jackson, 2004, p. 2). Incorporating creativity in higher education will prepare students to cope with uncertainty, work under tight deadlines by communicating effectively, to demonstrate skills of collaboration and confidence, and to learn and adapt continuously (Williamson, 2011, p. 33). Thus, for higher education students in our complex world, creativity is

extremely important and has come to be considered a survival skill that needs to be nurtured (Alencar et al., 2017, p. 555).

Happiness, which is also critical for both individuals and a functioning society, has been found to be linked with creativity, which has been documented in several ways. Eurich (2017) found a causal link between individual happiness and creativity through a meta-analysis on self-awareness, both in terms of how we can understand ourselves and how others see us. Self-knowledge helps to improve work performance, career satisfaction, leadership potential, and relationships; thus, people who know themselves are happier, which boosts creativity (Eurich, 2017, p. 4). Observing play is another way that researchers have explored the link between creativity and happiness. Brown and Vaughan (2009) compared and observed human and animal play to understand its essentialness in fueling individual happiness. They used observation coupled with the science of human development to determine that play is a biological drive and, just as sleep and nutrition, is necessary for humans to remain healthy and happy.

In addition to happiness, other factors can increase both creativity itself and the effectiveness of creativity for solving problems. Changing life routines can boost creativity for solving problems by tricking the brain (Glei, 2013). Being open-minded has also been shown to help promote creativity because open-mindedness suggests the consideration of various perspectives, as concluded by O'Leary and Bingham (2007, p. 22) through their study on group creativity. They found that group problem-solving and creativity led to innovative solutions for federal, state, local, and international-level government projects (p. 35).

Teaching Creativity

Finding effective ways of introducing, teaching, and cultivating creativity in higher education is a global concern and one that has been approached in different ways through different eras of educational paradigms. One of the challenges to enhancing creativity in higher education is the traditional framework that students have a structured and limited timeframe to complete a degree and demonstrate very specific knowledge, and, thus, opportunities to develop creative skills are very limited (Mulholland, 2016, p. 188). Although this is a modern-day problem, the challenge of incorporating creativity into education is one that has been historically approached in different ways and for different reasons.

The roots of creativity in higher education spring from the history of creativity in early childhood education, and, therefore, it is worthwhile to briefly look at creativity education for children. In the early 19th century, the child study movement linked the idea that a child's creativity was a God-given and inherent trait and, therefore, should be fostered in the classroom (Feldman & Benjamin, 2006). Friedrich Froebel, the German philosopher who created the institution of Kindergarten, believed that creativity was a natural impulse that must be nurtured through fine-motor skill development and opportunities for imitation, and this belief was built into child-centered education in the US in the late 1800s and early 1900s (Feldman & Benjamin, 2006). Later developments, championed by G. Stanley Hall and John Dewey, moved toward including gross-motor skills and informal play, and Arnold Gessell developed an age-stage framework for early-childhood and elementary education that explicitly included creativity, fantasy, and

representational play that was popular in American classroom through the 1960s (Feldman & Benjamin, 2006).

Despite its popularity through the middle of the 20th century, creativity in American classrooms became less popular in the 1980s as K–12 educators attempted to improve lackadaisical test scores and adopted newer cultural-history theory and focused on standards (Feldman & Benjamin, 2006). This movement toward assessing students based primarily on test scores and meeting rigid benchmarks, and basing their admission into institutions of higher learning on these scores and benchmarks, set the stage for a higher educational system that is less a cultivator of innovative minds and more an assembly line of in-the-box thinkers holding degrees.

Understanding the role of creativity in society, as well as its role in education, is a critical step toward improving higher educational philosophies, teaching tools, and outcomes for students as they leave the ivory tower. Students will venture out into a world of globally connected citizens, ever-changing technology, environmental and social upheaval, and challenges that will test their abilities to think critically and creatively, to develop solutions for complex problems, and to find their place in a society that is both more fragmented and more connected than ever before. It is ever more important to foster creativity that will help students succeed both inside and outside of academia, but in order to do so, better understanding of the role of creativity in higher education is needed.

Creativity in Higher Education

Importance of Creativity in Higher Education

Leaders of higher education are faced with a challenge to change ways of teaching, learning, and training by embracing creativity as the world moves from an older era to a new one that requires agile, flexible, and innovative citizens. To thrive in the workforce and society, students need opportunities to develop creative and innovative thinking skills that will sustain them in the modern world (Mulholland, 2016, p. 179). Schools that support and teach creativity inspire teachers, parents, and policy makers to be open-minded and rethink the real nature and purpose of education (Sanders, 2016), which facilitates further emphasis on creativity skill integration into coursework for students. In turn, improving students' creativity has been found to help students become more imaginative, original, curious, and willing to try new things (Zhou et al., 2013, p. 239), thereby better preparing them for post-education careers and endeavors. Fostering these vital thinking skills and students' abilities to use subjective judgment and to synthesize multiple sources of information to come up with solutions to problems is within the ability, and arguably the responsibility, of higher education practitioners (Mulholland, 2016, p. 185).

One study that illustrated the importance of teaching creativity was that of van der Wal et al. (2017), where the researchers interviewed 14 professional engineers about their educational experience and how it has served them in their careers. Through qualitative assessment, they identified techno-mathematical literacies that are necessary for modern engineers, which included problem-solving, creativity, technology skills, critical

thinking, and complex communication skills (p. S89), all of which can include aspects of creativity. Interviewees related that they felt their mathematics education had been an “island” (p. S98), which meant that they were not trained to understand mathematical concepts within the context of real-life problems to solve. Thus, when faced with engineering problems, they were ill-equipped to think creatively and innovatively while applying their training in mathematics (p. S98). The researchers concluded that teaching mathematics in the context of problem solving for real-life situations would better prepare engineers for the workforce and that other creativity-related skills, such as technical drawing skills, are infrequently identified as important for engineering education (p. S100).

It is not only important to recognize the importance of creativity in education—teachers must be trained and empowered to teach, and able to recognize, creativity. Further, understanding of how teacher perceptions about creativity vary across disciplines can also contribute to better integrating creativity in higher education. With the goal of understanding how courses can be designed to include creativity, Jahnke et al. (2015) analyzed teacher’s conceptions of creativity in higher education by interviewing and surveying 296 teachers from a variety of disciplines (63% from social, cultural, and art-related disciplines, 37% from math, science, and engineering-related disciplines), from European universities (p. 90). Their study used a 6-facet model that identified six different areas where teachers observed that students were using creativity: self-reflective learning, independent learning, showing curiosity and motivation, producing something, showing multi-perspectives, and reaching for original, entirely new ideas (p. 91). They

found that responses differed among teachers from engineering versus social sciences. For example, both groups highly valued independent learning. However, there was a difference in their focus on what the outcomes of creativity should be. Social science teachers highly valued self-reflective learning such as reflective thinking, deeper development of a thought, making cross-links between concepts, and applying theory to real-life situations, which the authors interpreted as a focus on *finding the problem*. In contrast, engineering teachers more highly valued when students produced something (website, software, podcast, brochure, etc.), that showed multi-perspectives (unconventional thinking, looking beyond boundaries of a discipline), and reached for entirely new ideas (development of new empirical methods, extraordinary ideas, new solutions for problems), which the authors interpreted as a focus on *finding a solution to the problem*. Jahnke et al. (2015) concluded that creativity depends on the individual person and on the position of the observer—in other words, the unsurprising conclusion that in an educational context, as in other contexts, creativity is subjective, not objective (p. 89).

Toward better understanding of the ways higher educational practitioners perceive creativity, Alencar and Oliveira (2016) interviewed 20 graduate professors from a variety of fields (Communication, Information Science, Administration, Education, Anthropology, Psychology, Geoscience, Mathematics, Transports/Engineering, Animal Sciences, Molecular Biology, and Molecular Pathology) in a Brazilian university (p. 556). Like Jahnke et al. (2015), they found that professors across disciplines were aware of the importance of creativity. Interviewees shared views that there is a societal demand

for people who are innovative, motivated, and ready for change, and some also felt that creativity should be taught from elementary school on (p. 557). Further, it was suggested that for improving teaching of creativity at the graduate level, institutional barriers should be removed and policies that value and facilitate creativity should be implemented (p. 557). The authors suggest that students who benefit from creative teaching will, in turn, be better teachers of creativity in the future (p. 559).

Perceptions of creativity may be highly context dependent and may vary not only across programs of study but also across cultures. Zhou et al. (2013) used a questionnaire to quantitatively examine teachers' conceptualizations of creativity in three different countries (China: $n = 326$, Germany: $n = 139$, and Japan: $n = 50$). Interestingly, their results showed that in Western culture (Germany), perceived creative characteristics were dependent on incorporating humor and artistic insights, whereas Eastern cultures (Japan and China) highlighted creativity characteristics as more relevant to "social and moral aspects of creativity" (p. 240). The authors posit that creativity "contributes not only to personal learning and knowledge construction, but also to the transformation of a society" (p. 239).

Approaches to Teaching Creativity in Higher Education

Universities still struggle to foster students' creativity and prepare them for the world of work; rather, the common instructional model is to concentrate on specific disciplines to move students toward the singular goal of getting a degree and graduating (Alencar et al., 2017, p. 559). Fostering creativity in higher education has been an international focus with disparate geographic regions, such as Hong Kong, Great Britain,

China, Japan, and the US, calling for university systems to include creativity in their curricula (Alencar et al., 2017, p. 555). In an empirical study on the success that 113 different countries have had in teaching creativity, Crosling et al. (2015) found a strong correlation between a country's creative learning ecosystem, the quality of its overall education system, and its students' innovative capacity. They found that Switzerland, Singapore, and Finland had the strongest systems for fostering innovation and creativity in higher education students (pp. 1155–1156). Switzerland, for instance, has established top-down encouragement for creativity in education through a dedicated governing body (the Swiss University Conference) and has invested in “state-of-the-art learning environments” and “research-led curriculum” with the specific goal of fostering a creative and innovative society (p. 1155). Strong quality assurance, cracking down on academic corruption, providing high salaries for teachers, and a focus on interdisciplinary learning are also factors that have made Singapore and Finland's higher educational systems successful environments for fostering creativity.

In addition to fostering an environment that supports creativity and innovation, successful teaching of creativity requires embracing uncertainty (Sandri, 2013). This uncertainty comes from the need for teachers to step away from complete control over the teaching and learning process and embrace open-ended questions that allow for creative thought exploration (Sandri, 2013, p. 774). Although this uncertainty may be unsettling for both teachers and students who are more accustomed to a lecture–exam style of teaching and learning, it is necessary for creating space for creative inquiry, learning through social interaction and collaborative exploration, and the generation of unexpected

outcomes (p. 774). To this end, Alencar et al. (2017) presented a list of suggestions for implementing creativity education for university students, drawing on the work of multiple scholars and researchers. Their recommendations included, among others: creating space and time for the exploration and expression of creativity and providing a wide range of activities to allow all students to be creative; challenging students and giving them opportunities to think creatively on a diverse range of topics and real-world problems; providing encouragement to explore, even when that includes what could be perceived as failure, without judgment or a narrow set of pre-defined expectations (i.e., providing a safe space for students to think, create, problem solve, and experiment); and creating an educational environment that constantly discusses, learns, and tries new aspects of implicit and explicit creativity education (p. 558). However, while these conceptions of creativity education are imperative to the inclusion of creativity in higher education, there are challenges to implementation that the authors also presented. For instance, instructors themselves may not have received creativity instruction as students and, therefore, are unfamiliar with how to integrate creativity into their own teaching. “The tendency is to reproduce in the classroom the pedagogical practices teachers experienced as students” (p. 557). The authors also related the responses of 90 teachers to an email questionnaire about challenges to creativity education, which revealed that heavy workloads, insufficient time to prepare, high student-to-teacher ratio, and not enough resources were all barriers to integrating creativity into their teaching (Fryer, 2007 as cited in Alencar et al., 2017, p. 556).

In addition to creating an environment that fosters creativity and allows teachers to incorporate creative methods into teaching, academics have pointed out the need to recognize the ways in which modern students engage or disengage from learning. McWilliam et al. (2008) made the case for teaching methods that move away from the objectivist model of “sage-on-the-stage,” or professor-centric teaching (p. 229) and toward a more creative pedagogy. They posit that students of the digital age are not afraid of rigorous learning, but rather, they become bored quickly and disengage from traditional modes of learning. Because students are receiving information at lightning speeds via social media and other 24-hour digital information streams, learning “facts” is not as effective as opportunities for hands-on engagement in activities. The authors concluded that activities and teaching strategies allow students to feel part of a greater world and “potential team members” (p. 231) when they allow for self-motivation, facilitate both leading and following, provide scaffolding rather than “command and control,” and allow for, and even embrace, error through a “support and direction model” (p. 232). The authors also, however, acknowledge that change at an institutional level must happen from the top down, and that creativity will also be key to making widespread pedagogical changes that can, ultimately, affect students at the individual level (p. 233).

Building on broad concepts of creative educational strategies, some specific ideas for teaching creativity were suggested by Seechaliao (2017) based on semi-structured interviews with 11 experts in instructional strategies that support innovation of education in Thailand. The researcher found that systematic development is key in supporting

creativity (p. 204), using design-based learning, problem solving, creative problem solving, creative thinking, research-based learning, problem-based learning, project-based learning, science, and innovative teaching processes. From these strategies, specific activities were then identified. Some of these included:

- Stimulate critical ideas: brainstorming, collaborating, discussing, questioning, and using techniques proposed by Edward de Bono for groups to plan their thinking systematically.
- Encourage thinking outside the box: thinking of alternatives, thinking of new ideas.
- Provide challenging questions to stimulate creative thinking.
- Introduce competitive activities with feedback and reinforcement: using learning-centered games with prizes as positive reinforcement.
- Balance among teaching methods: lecture, demonstration, small-group discussion, using simulations, field trips, induction, and deduction.
- Create motivation for learners: attention, relevance, confidence, and satisfaction.
- Use up-to-date technology: embrace social media as a way for students to learn on their own or prepare for class and to enhance collaborative learning (Seechaliao, 2017, pp. 204–205).

The researcher concluded that using strategies that allow for learning creatively and thinking innovatively should be implemented gradually and although teaching creativity

is challenging, these strategies will better prepare students for success in future work environments (p. 207).

STEM-to-STEAM for Teaching Creativity. There appears to be much to learn about how to teach and foster creativity at the post-secondary level as well as how to accomplish large-scale system-wide change; however, improvements to current approaches to teaching creativity in higher education have been achieved through the introduction of a new educational framework: STEAM. In 2008, the framework of science, technology, engineering, and mathematics (STEM) education was transformed with the addition of art (STEM to STEAM) toward teaching students to learn in multi-disciplinary ways (Yakman, 2008, 2012). STEAM is defined as “Science and Technology, interpreted through engineering and the arts, all based in Mathematical elements” (Yakman, 2012, p.15), and was developed because of the author’s belief that “...the fields of the arts [are] important to the overall creation of knowledgeable and well-rounded citizens” (Yakman, 2008, p.15). STEAM uses integrative teaching to familiarize students with multiple aspects of a topic, rather than focusing only on a discipline-specific paradigm. For instance, in her original description of the framework, Yakman (2008) gives the example of teaching a unit on biotechnology and including aspects of the basic science involved, the technology of machines for producing and transporting it, the engineering involved in designing it, the mathematics needed to understand it, the history and social context, and the language arts for communicating about it. Integrating study and techniques from the arts into STEM disciplines also improves inclusivity in education by bringing in student populations who are traditionally

underrepresented in STEM fields (Peppler & Wohlwend, 2018). The STEAM framework is often applied and studied in K–12 settings (e.g., Yakman, 2011). The framework is, however, also intended for higher-level students (Yakman, 2008 p. 19), and other researchers have noted that nurturing creativity skills in higher education students can also benefit from STEAM education (Peppler & Wohlwend, 2018).

An example of STEAM being integrated into higher education is given by Madden et al. (2013), who developed a multidisciplinary curriculum at the State University of New York at Potsdam. Through “engaging learners in team-based multidisciplinary problem solving through mentoring, learning communities, research projects, and partnerships with outside agencies” (p. 541), the authors aimed to create a model for other institutions and promote the education of students who would be well-prepared for modern society. They identified six qualities they wished to develop in students through STEAM education: (a) good communicators, (b) good organizers, (c) motivators of others, (d) discerning learners, (e) creative and innovative thinkers, and (f) self-motivated, life-long learners. Faculty from a wide range of disciplines conducted an extensive literature review and collaborated on the curriculum. They concluded that teaching creativity is not the best way to frame creativity in education; rather, they suggest that creative thinking strategies be integrated into all instruction (p. 543). Activities should be engaging and tied to real-world problems. Like Alencar et al. (2017), they suggested that the fear of evaluation should be reduced by assessing students more flexibly and by allowing the freedom to explore the learning process instead of limiting students to strictly defined successful outcomes (p. 543). Learning should be iterative and

promote creative thinking (e.g., writing assignments instead of reading assignments) and should combine approaches to facilitate learning for a diverse range of students' learning strengths (p. 543). Their resulting curriculum, which they placed in their university's Student-Initiated Integrated Major, consisted of three components: (a) Domain Knowledge; (b) Integrated Learning Modules; and (c) Problem Solving Workshops. Students progressed through the program with a cohort of peers, which further facilitated the development of creativity through developing a safe, comfortable community within which students could freely explore, experiment, learn, and create (p. 544). Thus, rather than proposing specific teaching methods, Madden et al. (2013) proposed a completely changed environment and paradigm for allowing the development of creative skills.

In another example of STEAM education in practice, Radziwill et al. (2015) described a case study of a capstone class of honors undergraduates at James Madison University in Harrisonburg, Virginia. Students were from the Integrated Science and Technology and the Media Arts and Design programs, and they created a technology–art media piece in the form of a zonahedral dome that incorporated sound and light functions that responded to presence and movement (p. 2). Teachers used creative teaching techniques including interactive, collaborative, and dialogic learning with the goal of creating learning through a network, rather than teach-to-student learning. Through their experience and surveying students at the end of the course, they proposed a model for STEAM learning. First, they proposed that learning happens at four levels: accumulating knowledge, creating flows of knowledge, changing self-perceptions of learners, and changing other people's perceptions of the learner. Then, they suggested that

organizations (e.g., universities) should see themselves as “custodians of talent” rather than creating talent (p. 4). Next, it should be recognized that learning happens at time scales other than those determined by academic years but in “moments and decades and lifetimes” (p. 4). They point out that the career benefits of STEAM learning may not be immediately apparent, but that learning in this way provides opportunities for personal growth in the ability to ask questions.

Outcomes from Teaching Creativity

There is evidence that fostering creativity in the classroom has measurable, positive effects on students' educational outcomes, and that modern movements toward increased creativity strategies in higher education has led to improved critical thinking and problem solving. For instance, Williamson (2011) studied the creative problem-solving skills of arts and science students through cognitive skill testing of 116 (51 arts and 65 science) final-year undergraduates from a university in the United Kingdom. The tests included questions that tested the students' skills in four areas: convergent thinking, divergent thinking, preferred learning style, and creative problem-solving skills. In direct contrast to earlier research (e.g., Kolb, 1984, as cited in Williamson, 2011, p.38), the study found no differences between the problem-solving skills of arts and science students. This result led Williamson to investigate the context within which these students showed no difference in problem-solving skills where past studies had found differences. Semi-structured interviews with 13 students (6 arts and 7 science) revealed that although students expected there to be differences between arts and science students in their divergent or convergent thinking, respectively, there were two primary reasons

why both groups may have similar problem-solving skills and learning-style preferences.

First, their university allowed them to take courses that spanned the arts and sciences toward the beginning of their time at university, thus, giving them a broad educational foundation. Second, the students had been exposed to a wide range of open learning experiences “such as practical sessions, discussions and projects” that encouraged divergent thinking and real-world problem solving (Williamson, 2011, p. 40).

Cropley and Cropley (2010) also recognized a range of positive outcomes from teaching creativity at the post-secondary level. They conducted a literature review to establish a foundational base of positive outcomes, and then they designed and carried out a case study to evaluate the experience of teaching creativity to university engineering students. Through their literature review, they found that teaching creativity, and more specifically, functional creativity where the focus is on an end product, can lead to valuable problem solving (p. 349). For instance, novelty alone, although a hallmark of creativity, is insufficient to truly creative thinking and problem solving. Novelty must be combined with relevance and effectiveness, that is, solutions must be meaningful and actually solve problems. Elegance, that is, solutions should be pleasing and acceptable to the intended audience or users, must include what the authors termed “genesis,” or the ability to look forward past the immediate problem and anticipate new ones (pp. 349–350). When this range of skills is taught, creative thinking in students can lead to innovative solutions to real-world problems. The case study to put these ideas into practice was carried out with 61 male undergraduate engineering students (ages 18–25) at an Australian university. Students were given practice in designing for solving problems

as well as systematic and extended training (8 weeks) based on real-world scenarios and innovative products. Along with this formal training, the students were asked to work collaboratively in groups to build a “wheeled vehicle powered by the energy stored in a mousetrap and capable of moving at least 1 m” (p. 355). The resulting designs ranged in their degree of functional creativity as defined by the four criteria described above, but all designs contained aspects of creative thinking. Perhaps the most important outcome of this semester-long case study was the insight that although one semester was not long enough to thoroughly teach the students to incorporate all four aspects of functional creativity, it was enough to allow the students to innovate, to succeed and fail to certain degrees, and to recognize the strengths and weaknesses of their creativity, innovative thinking, and problem solving (p. 356). Thus, they came away from a single course that both implicitly and explicitly taught creativity as more insightful and self-reflective thinkers who also had an increased ability to develop creative solutions.

Similarly, Nordstrom and Korpelainen (2011) found that teaching creativity, in this case by requiring that students present final projects made in creative ways (i.e., disallowing the use of PowerPoint for final presentations) in an engineering course imbued students with a greater sense of self-efficacy in their learning and helped build their collaborative and problem-solving skills. The authors taught a 7-week Health Technology Microbiology course at a university in Finland to 26 graduate-level students that incorporated more traditional lecture and exams with more creative group work and personal portfolio assignments (p. 441). Students were surveyed at the beginning, middle, and end of the course on their learning goals and feedback (p. 442). At the end of the

course, students not only reported that they had learned the scientific facts necessary for success in the course (19 out of 19 respondents), they had also learned skills in group work and innovativeness (18 out of 19 respondents) and that they were “motivated to... learn continuously and question... discuss and ponder...at a deeper level” (p. 443). Final presentations ranged from a short play and video presentations to prototype models, and when students were asked to assess their own and their group’s performance, they overwhelmingly assigned high scores (p. 447). The authors concluded that providing a creative learning space for the students improved their engagement and overall learning experience. The students’ self-perception also played a role in their success. Students who did not believe they were capable of solving problems or arriving at a “correct” answer were less successful than students with a greater sense of confidence in their abilities (p. 449). Thus, teaching and facilitating creativity and innovativeness is a process that must occur continuously and incrementally (p. 449).

Gap in the Literature about Creativity in Higher Education

Much literature exists on the essentialness of creativity at schools and the need for improving teaching of creativity at higher education institutions. Egan et al. (2017) stated, “There is an abundance of literature highlighting the need to focus on enhancing students’ creativity in higher education” (p. 21), but the literature review reveals that there is a gap in the literature regarding how to recognize and reward creativity skills in students, how to measure and assess creative behaviors, and the most effective ways of teaching and instilling creativity in higher education students. There is also gap in our understanding about evidence-based initiatives at higher education institutions, the

methods they are using to teach creativity, and what the outcomes are. In fact, there is not even consensus on whether creativity *can* be taught (Egan et al., 2017, p. 22).

Furthermore, there are indications that creativity education and practice are uniquely experienced by individual students (Jahnke et al., 2015, p. 89), which implies that the perceptions of students about creativity may play an important role in individual student success in creativity-driven higher education programs.

Perceptions of Creativity by Higher Education Students

Understanding the ways in which creativity is perceived is critical to defining the role of creativity in higher education. In this section, the reviewed literature examines students' perceptions of creativity, their self-perceptions of their own creativity, and their perceptions of creativity in higher education. It also seeks to identify current knowledge about whether there is a difference in how students majoring in science, engineering, and the arts disciplines perceive creativity. To do so, relevant literature was reviewed and synthesized through the lens of three components of creativity perceptions drawn from a survey on student perceptions of creativity developed by Dlouhy (2012).

Perceptions of Creativity

Understanding the perceptions of creativity by students is critical for framing the potential for better integration of creativity into higher education; however, there are not many studies into, specifically, higher education students' views on creativity. In one study, Dlouhy (2012) identified the need for a valid and reliable instrument to measure the attitudes of undergraduate students toward creativity in higher education and conducted a scale-development research project. The researcher designed and

administered a 16-question survey to measure the attitudes of post-secondary students in order to inform curricular development for instruction and assessment of creativity in higher education (p. 59). The 160 respondents (142 female, 18 male; mean age 32) (pp. 74–75) were all undergraduate students taking any course in Psychology, Educational Psychology, Human Development and Family Studies, and Health Education at a large research university in the southwestern United States (pp. 60–61). Dlouhy (2012) successfully validated the survey instrument for undergraduate perceptions of creativity by using confirmatory factor analyses. Because this instrument was found to be valid and reliable to measure undergraduate attitudes towards creativity, the author proposed that other researchers may confidently use this tool.

Another study that aimed to identify students' perceptions about creativity was conducted by (Katz-Buonincontro, Hass, et al., 2020), who measured beliefs about both creativity in general and teaching for creativity through a quantitative study. A survey of 149 undergraduate and graduate (master's, PhD, and EdD) students in a teaching program at a US university asked respondents to rate their agreement with statements pertaining to creativity mindset (pp. 6–7), or the degree to which respondents believed that creativity is fixed (unchangeable) or malleable (a growth mindset). The study revealed that students in the teaching program rated themselves highly in creativity beliefs, including both creative self-efficacy and a growth creative mindset. They also highly rated the value of teaching for creativity; however, they perceived their teaching environments to be unsupportive of teaching for creativity (p. 12).

In a further study on teaching students' beliefs about creativity, Katz-Buonincontro, Perignat, et al. (2020) conducted in-depth exploratory interviews to understand epistemic beliefs about creativity mindset and teaching creativity (p. 3). The researchers conducted semi-structured interviews with 16 in-service and pre-service teachers in a teaching program at a US university (p. 4). They used qualitative content analysis to identify 5 themes about epistemic beliefs about teaching creativity (pp. 6–9): teaching for creativity as a component of teaching success, discordant beliefs about creative teaching abilities, diverse beliefs about student creative potential, the importance of creativity for student learning, and freedom to express new ideas. The study revealed that there is no one definitive answer whether students believed creativity is innate or can be cultivated in a classroom (p. 8). The teachers' beliefs ranged from believing that creativity is innate or related to a talent (e.g., singing, visual arts) to believing that it is teachable (e.g., imagination, unconventional thinking and problem solving). Some of the participants took a combinatory view that incorporated both perspectives depending on the context or definition of creativity (p. 10). Overall, the teachers' beliefs centered around their individual personal identities and not on socio-cultural reflections about the freedom they experienced around cultivating creativity, which the authors posit may reflect a Western or Americanized perspective that may be different for teaching students from other cultural backgrounds (pp. 10–11). It is noteworthy that even within a small group of students from a single university and in a single discipline, understanding of the meaning of creativity, student self-perceptions of creativity, and the context within which creativity was seen to play a role in teaching varied by the individual.

Creativity Self-Perception

Current research offers evidence that postsecondary students who study art and design may perceive themselves as more creative than students in STEM fields do (Mulholland, 2016, p. 184). However, there is currently only limited literature pertaining to research on students' self-perception of creativity. One facet of self-perception of creativity that has been studied is the link between self-perceived creativeness and entrepreneurship. Zampetakis and Moustakis (2006) surveyed students from two engineering schools and hypothesized that high levels of self-perceived creativity, favorable university environments for creativity, and family environments that encourage creativity would all promote entrepreneurial intention (p. 416). Creativity has been shown to be an essential facet of enterprising personalities as well as part of personality traits like independent judgment and autonomy, which also support entrepreneurship (p. 424). Through a questionnaire ($n = 181$) and statistical modeling (structural equation modeling), they found that university environments were not correlated with entrepreneurial intention, which may be related to the fact that creativity courses are lacking in entrepreneurship curricula (p. 425). However, they found that both self-perceptions of creativity and family environments that supported creative thinking were predictors of entrepreneurial intention, underscoring the idea that self-perceived creative people are more likely to, in fact, pursue creative or, in this case entrepreneurial, activities (p. 422). There were no differences between male and female respondents.

A related concept is that when students aspire to succeed, are motivated, and are self-confident, that their performance may improve. Sunley et al. (2019) used a personal

narrative from one first-year student who participated in a 12-week course that was intentionally designed to foster creativity to show how self-perception of creativity affected the student's experience. The course was held in a business school and was intended to help develop students' "soft skills" through self-awareness, teambuilding, problem solving, listening, self-reflection, communication, and collaboration (p. 175). They found that this student moved through a progression from skepticism, both of the class and his own abilities, to accepting the course's usefulness and feeling more confident. Early in the course, the student said he had "no sense of myself as a creative person" (p. 176), but later he said, "Taking my first step towards creativity helped me learn the most about myself" and "Positive feedback from students and staff helped me conclude I was more creative than I ever imagined" (p. 176). At the end of the study, the student also said, "I have seen an improvement in the characteristics of creativity, I have become more self-confident, my problem-solving skills have improved and I have learnt how to improvise" (p. 179). The researchers suggest that personal responses to creative challenges can be motivational to students and that incorporating creativity into learning can actually help students perceive themselves as creative, which, in turn, can help their performance (p. 179).

Through quantitative assessment of survey data from over 400 engineering, science, and humanities students (sophomore through senior) and 75 instructors, Kazerounian and Foley (2007) found that students in all three groups saw themselves as valuing creativity. However, engineering students felt that their instructors did not value creativity, whereas humanities students thought their instructors did value creativity

(science student results were inconclusive). Interestingly, instructor answers were in opposition to student answers. All instructors reported valuing creativity, humanities instructors viewed their students as creative, but engineering and science instructors did not see their students as creative (p. 765). The researchers concluded that although engineering instructors felt they were giving students opportunities for creativity, the students did not perceive those opportunities. Therefore, although they saw themselves as people who value creativity, they did not perceive opportunities to use creativity in class and, in fact, they felt that they had no knowledge of how to think divergently, to problem solve or think outside of sets of pre-determined solutions. They also did not see failure as a possibly positive outcome or that ambiguity could be a positive in a classroom setting (p. 767).

Similarly, He and Wong (2021) investigated gender differences in creative self-efficacy, which is the “self-belief about one’s ability to produce creative outcomes” (p. 42), which has been shown to have a positive influence on creative outcomes and achievements. The participants were 398 undergraduate students in Hong Kong, with 49.5% of participants female and 50.5% male. The authors used the Creative Self-Efficacy (CSE) subscale to collect quantitative information and discovered that males scored slightly higher than females in creative self-efficacy, which the authors believe corresponds with the fact that males have historically had higher levels of creative achievement despite no evidence in gender differences in creativity ability (p. 41). Likewise, Álvarez-Huerta et al. (2021) found differences in the relationship between creative self-concept and student engagement among genders, as well as both academic

level and discipline. The results of both studies underscore both the potential for gendered and other demographic differences in self-perceptions of creativity and a link between creative self-perceptions and creative achievements.

Perceptions of Creativity in Higher Education

Not only do the perceptions of creativity in general vary among students, but their perceptions of creativity as it applies to higher education varies and may influence individual experiences of teaching for creativity at the university level. To better understand how students perceive creativity and higher education, Ehtiyar and Baser (2019) conducted a qualitative, phenomenological analysis (Ehtiyar & Baser, 2019, p. 113). Data were collected in 2018 through a focus group interview and analyzed by using thematic analysis (p. 118–119). Participants were 10 academically strong 4th-year students in the field of tourism at a state university in Turkey (p. 118). The researchers found that students largely found their university education to be lacking in creativity, and that at least in the first two years, the focus was largely on memorization and testing that prevented creative thought. One student suggested that serving an internship early on would stimulate creativity (p. 121), and students suggested that their creativity would be better fostered in an environment with less memorization, less attendance requirements, more contact with professors, and more interesting lessons (p. 123).

In addition to assessing how students perceive their overall educational experiences in terms of creativity, it is important to know how students perceive explicit creativity curricula, which was researched by Costantino et al. (2010). These researchers created a pilot study for undergraduate environmental engineering students at the

University of Georgia with the goal of “making explicit the cultivation of creativity and artistic thinking” (p. 51) in pursuit of identifying and expressing aspects of real-world problems through collaborative learning by art ($n = 11$) and engineering ($n = 9$) students. Through being introduced to big ideas with open ended solutions, visual analysis of art, and creating their own collage art around the central theme of food sustainability, students experienced collaborating with students from a different discipline and thinking about a real-world situation for which creative and innovative thinking is needed. The outcome was that students expressed that they felt overwhelmed at the beginning of the exercise, but that through the process they gained confidence and saw the value in “coming up with our own problem instead of being given one” (p. 52). The researchers followed up with a survey and focus group, and the majority (five out of nine) of engineering students reported finding collaboration with art students beneficial. Several engineering students recognized the value of multiple perspectives for problem solving and that learning to think outside traditional engineering topics of math and science helped them find visually appealing and creative ways of communicating with an audience (p. 52). An interesting finding, however, was that engineering students wished that art students had given them more direct creativity strategies. They also had the impression that art students thought the engineering students perceived art primarily as a marketing tool. The researchers concluded that more collaboration is needed between students of different educational disciplines and that cultivating creativity and innovative thinking should be used as a conceptual framework for interdisciplinary teaching.

In another case study on the perceptions of students in a course that explicitly taught creativity, Knowlton and Sharp (2015) found that although students enjoyed and valued more out-of-the box teaching strategies, the activities they were more familiar with (reading an assigned text and writing assignments) were the activities they valued the most (p. 7). The researchers had given a summer-semester graduate-level course on creativity for nine students from various disciplines. The course used techniques such as daily stream-of-consciousness writing, bi-weekly journaling, weekly self-assessments, creativity updates via Twitter to engage classmates, and completing an open-ended project that encompassed creativity (defined by the researchers to include novelty and value within specific contexts, in this case, within the student's personal or professional life; p. 5). The students perceived all of the activities and assignments to enhance their creativity, and all activities except the weekly self-evaluation were ranked, on average, at or better than the "moderate" level (p. 6). The authors concluded that students' perceptions of a course that was designed specifically to encourage and foster creativity, that veered away from the traditional professor-centric model, and that provided opportunities for individual ownership over decisions about learning and assessment were strongly positive.

An important line of investigation leading to the improvement of creativity education in universities has been understanding how the perception of creativity differs among students in different university departments. Although two studies reported on the effects of creativity on students in different departments including engineering, only Kazerounian and Foley (2007) and Costantino et al. (2010), compared the perceptions of

students in engineering, science, and the humanities (as in the current proposal).

Kazerounian and Foley (2007) found that both instructors and students in all three groups saw themselves as valuing creativity, and instructors thought they gave their students opportunities to develop creativity. However, whereas humanities students thought their instructors did value creativity, engineering students did not perceive opportunities to use creativity in class, to think divergently, to problem solve, or think outside of sets of pre-determined solutions. Results for the science students were inconclusive.

Summary of Literature Review Findings

This section summarizes and presents the highlights from the review of current research, showing the major strands of thought in the research literature on creativity in higher education, with an emphasis on studies relevant to the research question.

There is a global crisis in creativity and, therefore, creativity has become a worldwide area of concern (Bloom & Dole, 2018). As society becomes increasingly dependent upon more and more advanced technology, there is a great need for workers and decision makers who are innovative and who can use the tools of creativity to solve the problems of the modern world (Costantino et al., 2010; Mulholland, 2016). To develop creative global citizens, it is important that institutions of higher learning work to develop students who are critical thinkers and innovative, creative problem solvers (Jackson, 2004).

Improving students' creativity has been shown to help students become more imaginative, curious, and able to think outside of narrowly prescribed constraints (Zhou et al., 2013). Therefore, it is essential for professors in higher education to teach

creativity and develop new ways of measuring and assessing student creativity. For this change to occur, educational institutions will need to adopt policies, develop curricula, and indeed change the longstanding culture of teacher-to-student one-way knowledge transfer. Developing creativity in today's students will likely lead to more creative teachers, so it is important that this process be started in order for our future educational system to truly foster creativity. The STEM-to-STEAM transition in pedagogical thinking is a good start to this process (Yakman, 2008), but there are gaps in our understanding of how to recognize and reward students' creativity, how to measure and assess creative learning skills, and the most effective ways of teaching and fostering creativity in higher education.

Although it is clear that there are differences in the ways students from different disciplines, as well as individuals within disciplines, view creativity (Katz-Buonincontro, Hass, et al., 2020; Katz-Buonincontro, Perignat, et al., 2020), the literature review also shows that fostering self-perceptions of creativity can help students improve their performance (Sunley et al., 2019). However, even when students feel that they themselves value creativity, they find their university environments do not necessarily foster creativity (Ehtiyar & Baser, 2019; Kazerounian & Foley, 2007), and when presented with explicit creative teaching strategies, some professors have difficulty becoming comfortable with them (Costantino et al., 2010; Knowlton & Sharp, 2015). The purpose of this research is to provide information to university professors that may help them better understand their students' views regarding creativity, so that they may be more strongly motivated to make the kinds of changes in their instructional practices

that may be needed. The study builds on the body of literature by investigating the research question: How do undergraduates in science, engineering, and the arts compare with regard to their perceptions of creativity, their creative self-perceptions, and their views about the role of creativity in education? As explained in the next chapter, a valid and reliable survey instrument developed by Dlouhy (2012) was used to measure the attitudes of university students along these three dimensions, in addition to five demographic measures: gender, age, academic level, language, and ethnicity/race.

Chapter 3: Methodology

This study investigated how undergraduate students majoring in science-, engineering-, and arts-related disciplines compare as to their perceptions of creativity. I sought to understand the ways they (a) view creativity as playing a role in their lives; (b) perceive themselves as creative individuals and learners; and (c) view the role of creativity in higher education. I took a quantitative approach to this study in order to allow for any emergence of differentiation between groups of students in the different disciplines through statistical analysis. I hypothesized that students in the arts would score higher in their perceptions of creativity than students in engineering who, in turn, would score higher than students in science versus the null hypothesis that there would be no difference among groups.

This chapter provides details about the research methods used to carry out this study. It includes descriptions of participant recruitment methods, the survey and its administration, data analysis and statistical methods, the steps I took to protect the data, and the potential biases and limitations of the research. All methods met the requirements of human subjects Institutional Review Board (IRB) and were approved by the IRB at the institution where the study was conducted prior to implementation.

Research Design

To answer my research questions about differences in perceptions of creativity among undergraduate students in different academic disciplines, I used a survey instrument originally developed by Dlouhy (2012). This survey provides valid and reliable measures for the three areas of interest in this study: perceptions of creativity,

creativity self-perception, and creativity in higher education (see Appendix A, Figure A1 for survey instrument). I received permission from Dr. Dale Dlouhy to use the full instrument with some slight modifications for demographics. The survey included questions to gather demographic information about age and academic level. I added demographic questions to gather data about ethnicity/race, and language (i.e., “do you speak two or more languages?”). I also added choices for *other (non-binary/third gender and prefer not to say)* to the original choices of *male* and *female* to bring the survey up to date with current institutional standards, policy and procedures (Figure A1). I administered the survey to university students who volunteered to participate. I then used statistical analyses to assess whether there were differences among the different groups regarding their perceptions of creativity, which also helped me to develop recommendations and information to share with university instructors regarding fostering creativity at the undergraduate level.

Site

The site for this quantitative study was at a university in the northwestern United States, which is left unnamed to protect the anonymity of the participants. As of 2020, approximately 19,000 undergraduate students attended the university. As an organization, this university expresses motivation for fostering creativity and innovation and currently has an office that supports faculty in this mission. Furthermore, it offers a wide range of majors and classes that include creative and not-traditionally-creative fields that support innovation. The university also has a reputation for promoting creativity through its design, creativity and performance pathways that are available to students. Hence, this

university served as an appropriate site for this study. As expected of a large university, a wide range of non-art-related majors are offered as well.

Participants and Recruitment

The study’s participants were undergraduate students at the study university, and to test my hypothesis about perceptions of creativity of students from different academic disciplines, I collected quantitative data from three groups: (a) students from science-related disciplines; (b) engineering-related disciplines; and (c) arts-related disciplines (Table 1). Recruitment did not include any demographic limitations (e.g., age, gender, ethnicity/race, language, etc.). The target sample size was 100 students from each group, as this sample size was sufficient to serve as a representative sample for the population of undergraduate students in the three targeted discipline groups at the study university.

Table 1

Majors Included in Each Academic Discipline

Academic Disciplines	Majors
Arts	Architecture, Art, Design, Film, Music, Theater
Engineering	Civil Engineering, Computer Engineering, Computer Science, Electrical Engineering, Environmental Engineering, Mechanical Engineering
Science	Biology, Chemistry, Environmental Science and Management, Physics

I used a combination of two non-probability sampling techniques to recruit participants: Purposive Sampling and Voluntary Response Sampling. Purposive Sampling involves defining groups of interest to the research study and directing recruitment efforts within those groups (McCombes, 2019). I defined the groups of interest to be undergraduate students who were enrolled in a course in one of the three disciplines of sciences, engineering, or the arts. Voluntary Response Sampling involves providing the opportunity to participate in the research study to a large number of potential subjects, who then self-select to participate as respondents (McCombes, 2019). In this case, students in courses in the three target areas were provided the opportunity to participate in the research study, but they had to decide voluntarily to participate.

I undertook the following steps to recruit participants:

- I contacted faculty and instructors who were teaching courses in the target disciplines to ask them to distribute my recruitment email (Appendix B) to the students in their courses. The recruitment email appealed to the students' willingness to help a fellow doctoral student by spending 15 minutes completing a survey on creativity.
- I shared with them the email letter with the survey link, which also included a due date for completion of the survey.
- I asked the faculty and instructors to remind students about the opportunity to participate in the research study by redistributing the recruitment email.
- I contacted program coordinators, who also advertised the survey widely.

Survey Instrument and Data Collection

To collect data for this study, I used a quantitative survey that contained 16 statements about different aspects of creativity (Figure A1). Each statement had answer choices that fell along a 5-point Likert scale (Likert, 1932) including: *strongly disagree*, *disagree*, *neutral*, *agree*, and *strongly agree*. The survey was developed by Dlouhy (2012), and it provides valid and reliable measures of all three of the constructs in this study: perceptions of creativity, creativity self-perception, and creativity in higher education. The 16 statements were as follows:

Perceptions of Creativity Items

Creative ideas are original.

Creativity can be applied to all aspects of life.

Creative people make innovative products.

“Thinking out of the box” is creative.

What is creative in one culture may not be in another.

Creative Self-Perception Items

I have creative hobbies.

I am artistically creative.

I apply my creativity in everything I do.

Being creative is important to me.

I am a creative person.

I have a creative idea every day.

I use my creativity to make things.

Creativity in Higher Education Items

Creativity is a necessary skill.

Teachers need to teach students to be creative.

Teaching people to be creative is important.

Creativity should be an important goal in education.

To administer the survey, I created an online version that could be completed via the Qualtrics platform (shown in Figure A1). To offer additional insight into factors that may influence student perceptions about creativity, and to provide covariates for controlling the primary factor of interest (i.e., academic discipline), demographic information was also collected (age, language, ethnicity/race, and academic level). Information gleaned from the major and academic department categories were used to determine which of the overall areas of study (i.e., science, engineering, and the arts) to assign each participant. Hereafter, these categories are referred to as academic discipline.

Data Analysis

The collected survey data consisted of categorical data on the Likert scale. Responses were ordered from least to most agreement, but there were no definable distances between each response level. There has been controversy over whether parametric or non-parametric statistical tests should be used with Likert-scale data, but according to some researchers, parametric tests are appropriate to use as long as the sample size is large enough (at least 5–10 samples per group) and the data are at least somewhat normally distributed (Harpe, 2015; Sullivan & Artino, 2013). My sample size

ranged from 90 to 162 per group, giving a large enough sample size to use parametric tests.

Before conducting statistical analysis, I explored the descriptive data and formatted it for analysis. I exported the survey response data from Qualtrics, a commonly used platform that was available for my use at Portland State University, and assessed the data through examining pivot tables in Microsoft Excel. I created pivot tables for each individual variable to look for overall results. I then visually examined charts of the response data to examine trends and patterns in creativity over the categories of independent variables. For all of the statistical tests that follow, I used the Statistical Software Package for the Social Sciences (SPSS®; version 28.0.0.0 [190])

Dependent Variable

To elicit the most parsimonious approach for testing my hypothesis, I examined whether the results for the 16 different statements about creativity should be analyzed separately or together. The survey statements fell within three dimensions of creativity: (a) perceptions of creativity; (b) creative self-perceptions; and (c) views about the role of creativity in education. Survey data could be analyzed in three different ways: as 16 separate data sets, one for each statement; grouped by creativity component; or grouped as one single creativity factor across all statements. If there was no relationship between responses to pairs or groups of survey statements, then I would analyze all 16 statements separately. If responses to survey questions, when applied to this study's population of interest, appeared to group together, then I would thematically group them for analysis.

However, if responses to all questions were highly correlated with each other, then analyzing them as a single unit would provide the most appropriate analysis.

Principal Component Analysis. To determine the best analysis approach, I performed a principal component analysis of the 16 survey statement scores across all survey participants ($n = 432$). First, I assigned the Likert-scale values that corresponded with the survey response categories: strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5. These numerical values allow for categorical data to be used as ordinal data in correlation and regression analyses. Then, I ran correlation analysis to assess how closely related each of the 16 statements were with each of the other questions. This analysis revealed that all 16 statements were strongly, positively correlated with each other, with a range in correlations between .62 and .90 and all p -values $< .05$. Finally, a principal component analysis of the 16 statements showed that 78% of the variation in summed creativity scores was explained by including just one single statement in the analysis, and very little additional variation was explained when additional statements were added (Table 2). Further visual assessment of a scree plot confirmed that eigenvalues, which are analogous to the amount of variation explained in a principal component analysis, were high for only the first component, followed by a sharp elbow (Figure 4). These results indicate that responses to the 16 individual statements are best represented by a single response (dependent) variable, rather than three principal components, as might have been expected based on how Dlouhy categorized the items, or some other clustering of the items. Therefore, all further analyses were run with the creativity score as the single response variable.

Table 2

Variance in Creativity Explained by Survey Statements

Component	% Variance Explained	Cumulative % Variance Explained
1	78.62	78.62
2	4.63	83.25
3	2.70	85.95
4	2.48	88.43
5	2.00	90.43
6	1.68	92.11
7	1.54	93.65
8	1.17	94.82
9	0.91	95.73
10	0.77	96.50
11	0.70	97.20
12	0.65	97.84
13	0.62	98.46
14	0.59	99.05
15	0.51	99.56
16	0.44	100.00

Figure 4

Scree Plot

Note. Component number indicates the number of principal components, in this case equal to the number of survey statements included in analysis. Eigenvalues represent the variation explained by each subsequent component added to the analysis.

Based on the results of the correlation analysis and principal component analysis, I calculated an *overall creativity* score for each participant by totaling their scores across all 16 statements. I defined *overall creativity* as an individual's perceptions of creativity, including their ideas about the nature and importance of creativity, their self-perception as a creative individual, and their perception of the value of creativity as a goal in higher education. In all analyses from this point on, I used overall creativity (or just creativity) as the single response (or dependent) variable in this study.

Independent Variables

Next, I prepared the independent variable data, including data for academic discipline, gender, age, language, ethnicity/race, and academic level. To ensure that data were analyzed within meaningful ranges and with sufficient datapoints within grouping ranges, I combined the levels of some categories for some variables and removed some categories from analysis (see Table 4 in Chapter 4 for final categories and sample sizes). Where there were too few data points in categories or where logical breaks occurred, I combined categories. For example, where respondents chose *other* for other discipline but did not provide a major field of study that could be assigned to any of the three academic discipline categories investigated in this study (i.e., science, engineering, and the arts), responses for that participant were not included in the analysis for effect of academic discipline on creativity score; however, that participant's data remained in analyses for other independent variables. Where a category was not interpretable or where there were too few data points or the category could not be logically combined with another category, I eliminated that category. For example, where respondents selected *prefer not to say* for gender, their data were not included for analysis of the effect of gender on creativity score, but their data were included for all other analyses.

Correlation Analysis. Next, I used a correlation analysis to assess correlations between paired independent variables. First, I created dummy variables for all categorical factors to allow for quantitative analysis. When defining dummy variables, one fewer dummy variable is assigned than the number of variables (i.e., $k - 1$; SAGE, 2015). For example, engineering was assigned a dummy value of one and science was assigned a

dummy value of two, which allows all remaining data to be assigned the dummy variable of zero, indicating the arts. I computed all between-variable correlations, while controlling for the effects of the remaining covariate, using partial correlation and created a correlation matrix. Partial correlation is a method that is appropriate for use with categorical variables that are coded with dummy values (Yang et al., 2017). Variables with a correlation of $|r| \geq .50$ would be considered strongly correlated if that correlation also had a significance level of $p \leq .05$. In that case, only one of the correlated independent variables would be included in linear regression modeling (see description of linear regression model building below). Although there were some significant (i.e., with $p \leq .05$) correlations between paired variables, none were strongly correlated (Table 3).

Table 3

Correlation Matrix of Independent Variables

	Discipline	Level	Gender	Age	Ethnicity/Race	Multilingual
Discipline	–					
Level	–0.14**	–				
Gender	–0.07	0.26	–			
Age	–0.09*	0.22***	0.04	–		
Ethnicity/Race	0.04	–0.16***	–0.05	–0.16***	–	
Multilingual	–0.08	0.12**	–0.04	0.10**	–0.41***	–

Note. Discipline = Academic Discipline. Level = Academic Level.

* = $p < .05$, ** = $p < .01$, *** = $p < .001$.

Multiple Linear Regression Modeling

To understand the relationships between the independent variables and the dependent variable, creativity score, I performed multiple linear regression analysis. Multiple linear regression was an appropriate analysis technique to assess whether variation in any of the six independent variables predicted variation in the response (dependent) variable. For participants whose responses fell in an eliminated category, I did not include their creativity score in further analysis for that independent variable. However, those participants' creativity scores were still included in all other analyses.

I confirmed that the data met the assumptions of linear regression (SAGE, 2015). First, data are independent from each other. Participants were individuals who anonymously completed surveys and their responses could not be related to each other. Second, the data's residuals are normally distributed, which I confirmed through visual assessment of a probability–probability (P–P plot; Figure 5). I assessed the data for homoscedasticity through Levine's statistic, which produced an adjusted (for unequal sample sizes) test statistic of 2.24 ($p = .11$), indicating that the variance of the data's residuals has the same distribution across the range of the data. I also verified that there were no observable patterns through visual assessment of a scatterplot of the residuals (Figure 6). Finally, I assessed the independent variables for multicollinearity by building a global linear regression model (i.e., a model that included the response variable and all six independent variables) and evaluated the variance inflation factors (VIF) for each independent variable. Multicollinearity can weaken the ability of a multiple linear regression model to detect significant effects of independent variables on the dependent

variable by inflating the standard errors of the variables (Zuur et al., 2010). All VIF scores were <3 , indicating that there was no multicollinearity (Table 4; Zuur et al., 2010).

Figure 5

Probability–Probability (P–P) Plot to Assess Data Normality

Note. Cum Prob = Cumulative Probability. Plot produced in SPSS software.

Figure 6

Scatterplot of Residuals

Note. Plot produced in SPSS software.

Table 4

Variance Inflation Factors (VIF) for Independent Variables

Variable	VIF
Academic Discipline	1.03
Academic Level	1.12
Gender	1.02
Age	1.08
Ethnicity/Race	1.30
Multilingual	1.30

Note. A VIF score <3 indicates no multicollinearity.

To build the model, I used forward stepwise selection to determine, after the independent variable that explained the most variation in creativity, how much additional variance was explained by each additional variable. To do so, I built 6 univariate linear regression models. I identified any independent variables that, on their own, significantly explained the most variance in creativity score. Next, I would have built multiple-regression models with the most-influential variable first in the model and additional variables following; however, there was only one variable with a statistically significant regression coefficient. Therefore, I followed this analysis by conducting a one-way analysis of variance (ANOVA) with Tukey's test of Honestly Significant Difference (hereafter, Tukey's test) to compute post-hoc differences among categories. The 1-way ANOVA tests for differences in means among 3 or more groups and is analogous to a univariate linear regression, and the post-hoc Tukey's test is a series of pair-wise tests between group means that adjusts significance values to account for the increased rate of Type I errors (i.e., rejecting the null hypothesis when there is not actually a difference between means) associated with multiple tests.

Data Management and Privacy Protection

I managed all data and protected the privacy of the respondents in accordance with IRB rules. All surveys were completed anonymously, and I did not collect participant names. Upon receiving survey responses, I assigned a number to each participant. I created a spreadsheet that contains the survey responses linked with participant numbers but does not contain names or other identifiable information. The password-protected spreadsheet is kept on a hard drive in my home to ensure participant

confidentiality. I will keep the data for five years before destroying it, as is required by Portland State University IRB rules.

Validity and Reliability of the Survey Instrument

Validity in a quantitative study is defined as “the extent to which the results really measure what they are supposed to measure” (Middleton, 2020). The survey instrument used in this study (Appendix A, Figure A1) was validated by Dlouhy (2012) both in content and construct. Content validity was established by ensuring that the questions were easy to read, appropriate for the age and reading level of the respondents (undergraduate students), and that each item contained only one question. Construct validity was ensured by making sure that the questions were firmly grounded in the literature on creativity to ensure validity of the questions themselves, and this validity was tested using exploratory principal component analysis. Thus, my use of Dlouhy’s previously validated survey instrument ensured the validity of the instrument for this study as well. Thus, the survey was a valid instrument for the collection of data about the perceptions of undergraduate students regarding creativity in order to compare among different academic disciplines.

Reliability in a research instrument is defined as, “the extent to which the results can be reproduced when the research is repeated under the same conditions” (Middleton, 2020). Dlouhy ensured the reliability of the survey instrument by conducting a confirmatory factor analysis with 160 undergraduate students and assessing Chronbach’s alpha, which were >0.7 for all factors and determined sufficiently reliable (Dlouhy, 2012, p. 6). Thus, the survey instrument as used in this study is also reliable and would

enable future researchers to duplicate this study on undergraduate student perceptions of creativity with a similar study population.

Role of the Researcher

Although I have a strong bias in favor of creativity and its importance in higher education, my role in this research did not bias the results. My positive view of creativity in education could potentially bias my interpretation of the results of the study, and, therefore, it is beneficial that this study is quantitative in nature. Rather than recruit participants personally, recruitment was done through email and via university faculty, instructors, and department staff. Student participants, who did not meet me in person, answered survey questions on a pre-defined Likert scale, which produced data that are not mis-interpretable. Further, I used well-tested statistical methods to assess the presence or absence of differences among groups, so any biases I hold did not influence my calculations or interpretation of the results.

Summary of the Methods

A survey with Likert-scale responses was administered to undergraduate students in different disciplines at the study university, followed by statistical analysis to test my hypothesis about the differences in perceptions of creativity among students in engineering, sciences, and the arts. The quantitative approach used was appropriate for this research because it provided a means for directly comparing groups of students and offered both statistical evidence and visual interpretation of patterns in creativity perceptions. The use of the previously developed and validated survey instrument by Dlouhy (2012) provided an opportunity to further our understanding of student

perceptions of creativity, how those perceptions differ among students from different disciplines, and how higher education instructors and institutions may benefit from better understanding how students perceive and value creativity in higher education.

Chapter 4: Results

Introduction

This research study addresses a problem in higher education: There is a global crisis in creativity and a simultaneous growing need for creative individuals to address global problems facing humanity (Bloom & Dole, 2018; Egan et al, 2017). Higher education has an important role to play in meeting this need, and creativity is known to contribute to strong scholarship. However, there is a lack of understanding about how, and even whether, creativity can be taught, rewarded, and assessed in institutions of higher learning (Egan et al, 2017). Further, because creativity teaching and learning are experienced differently by individual students (Jahnke et al., 2015), it is critical that educational policies and practices are developed with an understanding of the perceptions of students about creativity, how they see themselves as creative individuals, and their perceptions of the inclusion of creativity in their educational journey.

The purpose of this study was to assess differences in perceptions about creativity of undergraduate students in science-, engineering-, and arts-related disciplines (Table 1) and to offer insights to university instructors in these disciplines about teaching and learning creativity. I hypothesized that students in the arts would score higher in their perceptions of creativity than students in engineering, who in turn would score higher than students in science, versus the null hypothesis that there would be no difference among groups.

To test my hypothesis and provide insight toward improved integration of creativity in higher education, I took a quantitative approach to gathering and analyzing

data to understand perceptions of the target population by comparing their responses to an instrument on creativity measurement developed by Dlouhy (2012; Appendix A, Figure A1). First, I administered the survey instrument to gather quantitative data on the perceptions about creativity of undergraduate students in science, engineering, and the arts. The data reflected students' (a) perceptions about creativity in general; (b) self-perceptions about themselves as creative individuals; and (c) perceptions about the use of creativity in education. I also gathered demographic data to assess whether individual factors, including gender, ethnicity/race, ability to speak multiple languages, academic level, or age, influenced students' creativity perceptions or mediated the effect of academic discipline on their perceptions. I then used statistical techniques to assess relationships between creativity and academic discipline, as well as with other demographic factors, to better understand the differences among student perceptions of creativity.

Collection and Analysis of Data

To answer my questions about the differences in perceptions about creativity of undergraduate students in the sciences, engineering, and the arts, I gathered data through administration of the instrument on creativity measurement developed by Dlouhy (2012). The survey captured the perceptions of undergraduate students of creativity in general, their self-perceptions of creativity, and their perceptions of creativity in education. I used Purposive and Voluntary Response sampling methods (McCombs, 2019) to recruit participants for an anonymous, online survey, who answered 16 statements about creativity scored on a 5-point Likert scale.

I then used two analysis steps: In the first step, I used principal component analysis to determine whether all 16 survey questions should be analysed separately, grouped into the three components of creativity perceptions, or grouped into a single creativity score. Results showed very high correlations among responses to all 16 questions, hence I determined that a single score of creativity should serve as the response variable. I defined *overall creativity* as an individual's perceptions of the nature and importance of creativity, the value of creativity as a goal in higher education, and their self-perception as a creative individual. I then calculated a creativity score for each participant by summing their responses to all 16 survey questions. This creativity score served as a single response variable for all following analyses.

In the second step I prepared the independent variables for analysis by removing uninterpretable data and combining categories where warranted. I converted categorical variables into ordinal data to allow for regression-type analyses. Then I used correlation analysis to determine whether any independent variables were strongly correlated with each other. I then assessed the relationship between creativity and academic disciplines, as well as the relationships between creativity and demographic factors, through multiple linear regression. After verifying that my data met the assumptions of multiple linear regression, I used forward stepwise model building to ascertain the best model to predict creativity. Only one independent variable was a significant predictor of creativity, therefore I followed up this analysis with a one-way analysis of variance (ANOVA), to allow for post-hoc testing to assess the differences in creativity among groups via Tukey's Honestly Significant Difference (HSD) test.

Presentation of Results

Participants

The population of interest for this study was undergraduate students at the study university majoring in science, engineering, and arts disciplines. My target sample size was 300, with a target of 100 students per academic discipline. There were 497 respondents who began the survey; however, 64 respondents did not complete the academic discipline category, and one participant did not consent to take part in the study. All survey data for these 65 respondents were removed, leaving a sample size of 432 survey participants. This sample size exceeded my target; however, participants were not evenly distributed among academic disciplines. Respondents represented a variety of majors and included 162 science students (38% of total participants), 117 engineering students (27%), 90 arts students (21%), and 63 students from other academic areas (14%). However, three students majoring in computer science had selected the *other* academic discipline category. At the study university, students majoring in computer science are in the same department, hence for this study, all students majoring in computer science were considered engineering students. Therefore, I moved the data from those three students into the engineering discipline, bringing the sample size of engineering students from to 120 (28%) and students from other academic areas to 60 (13%; Figure 7). Regarding ethnicity/race, most participants were White (65%), followed by Asian (14%), two-or-more-races (9%), Hispanic/Latino (8%), Black/African American (3%), and American Indian/Alaska Native and Native Hawaiian and Other Pacific Islander (0.5% each). Participants ranged in age from 15 to 70 years of age (mean age = 37, mode age = 22;

Figure 8). For gender, 49% of participants identified as female, 43% as male, and 6% as non-binary or third gender, while 2% preferred not to say. Participants also ranged in their academic level, with 22% in the first two years of college, 67% in their third year or beyond (graduating seniors), however 3% were graduate students who were eliminated from the research study and were not included in analysis (Table 5).

Figure 7

Participants by Academic Discipline

Note. Surveys completed by students in other majors were not considered in the analysis of the relationship between creativity and academic discipline. However, data from these surveys were included in analyses of relationships between creativity and demographic factors.

Figure 8

Age Distribution of Study Participants

Table 5

Survey Participants by Response Category

Response Category	Number of Participants (<i>n</i>)
Academic Discipline	
Arts	90
Engineering	120
Science	162
Other	60
Gender	
Female	211
Male	188
Non-binary / third gender	25
Prefer not to say	8
Age	
10 to 19	55
20 to 29	270
30 to 39	73
40 to 49	21
50 to 59	8
60 to 70	2
Multilingual	
Yes	204
No	228
Ethnicity / Race	
White	275
Asian	61
Black or African American	11
Hispanic or Latino	33
American Indian or Alaska Native	2
Native Hawaiian and Other Pacific Islander	2
Two or more races	41
Academic Level	
Freshman	35
Sophomore	59
Junior	112
Senior	177
Graduate	14
Other	36

Note. Sample sizes for academic disciplines reflect the movement of three students majoring in computer science from the *other* category to the *engineering* category.

Descriptive Survey Results

On the online survey, participants responded to 16 statements about creativity by indicating how much they agreed with each statement on a categorical scale from *strongly disagree* to *strongly agree*. The 432 participants responded to all statements except in the case of Statements 1, 2 and 15 ($n = 431$) and 5 ($n = 430$). The number of responses in each category for all survey statements is given in Table 6.

Table 6

Survey Responses for Each Statement

Statement	Response Options (Number of Responses)					Total (<i>n</i>)
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
1. I have creative hobbies.	5	22	51	149	204	431
2. Creative ideas are original.	6	43	106	200	76	431
3. Creativity can be applied to all aspects of life.	0	4	21	94	313	432
4. I am artistically creative.	16	56	84	151	125	432
5. Teachers need to teach students to be creative.	7	39	102	180	102	430
6. I apply my creativity in everything I do.	4	69	126	162	71	432
7. Being creative is important to me.	0	20	53	179	180	432
8. Creativity is a necessary skill.	2	25	65	193	147	432
9. Creativity should be an important goal in education.	2	12	61	193	164	432
10. I am a creative person.	7	28	72	196	129	432
11. What is creative in one culture may not be in another.	19	38	73	173	129	432
12. Teaching people to be creative is important.	1	14	82	209	126	432
13. I have a creative idea every day.	17	114	136	115	50	432
14. Creative people make innovative products.	2	18	69	195	148	432
15. "Thinking out of the box" is creative.	1	14	59	198	159	431
16. I use my creativity to make things.	4	25	41	211	151	432
Totals	93	541	1201	2798	2274	

Overall, students scored highly in their perceptions of creativity. The most frequently selected level of agreement across all questions and participants was *agree* (40.5%), followed by *strongly agree* (32.9%), then *neutral* (17.4%). Combined, *disagree* and *strongly disagree* only received 9.2% of responses. (See Appendix C for visual reports of all answers by academic discipline.) In order to calculate descriptive statistics, I used the dummy variables assigned to each of the qualitative categories (i.e., 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). I then computed the creativity score for each participant by summing across all of their 16 statement scores as described in Chapter 3. Mean creativity score was 63.3 (maximum of 80) with a standard deviation of 7.7.

When examined by the three creativity components of (a) perceptions of creativity; (b) self-perceptions of creativity; and (c) perceptions of creativity in higher education, results were similarly distributed across perception components within groups, including academic discipline (Figure 9), gender (Figure 10), ability to speak more than one language (Figure 11), ethnicity/race (Figure 12, and see Figure C1 for creativity score broken out by individual ethnicity/race categories), age, and academic level (not pictured).

Figure 9

Creativity Score for Creativity Components by Academic Discipline

Figure 10

Creativity Score for Creativity Components by Gender

Figure 11

Creativity Score for Creativity Components by Ability to Speak More Than One Language

Figure 12

Creativity Score for Creativity Components by Ethnicity/Race

Dependent Variable

Analysis of Creativity Components. I used two methods to determine whether the results for the 16 different statements about creativity should be analyzed separately, in groups, or all together (See Figure C2 for responses to individual statements). A correlation matrix of the survey statements about creativity showed that, for this study's population of interest, undergraduate students in science, engineering, and arts programs at the study university, responses to all 16 statements were strongly, positively correlated with each other ($r = .62-.90$, all p -values $< .05$).

The second step was a principal component analysis of the 16 statements, which showed that 78% of the variation in overall creativity scores was explained by including a single statement in the analysis, with little additional variation explained with additional statements (see Table 2 in Chapter 3). This result was visually confirmed through a scree plot (see Figure 4 in Chapter 3). These results suggested that it was appropriate to group all 16 individual statements into one single component for analysis and to use overall creativity as the single dependent variable in subsequent analyses.

Independent Variables

Assessment of data for the 6 independent variables, including academic discipline, gender, age, language, ethnicity/race, and academic level showed that within some variable, some categories were not appropriate for analysis and needed to be removed (Table 7). To test the primary hypothesis of this study, that creativity measures would differ among students in the sciences, engineering, and the arts, the study population included only students from majors that fell into those three academic disciplines. Therefore, I removed data from the *other* category of academic discipline for testing that hypothesis, with the exception of the three students majoring in Computer Science, who I moved to the engineering discipline category. For gender, it was not possible to analyze creativity for students whose gender was unknown; therefore, I removed data from the *prefer not to say* category for gender analysis. For age, there were very few participants who were over age 50 ($n = 10$), making the distribution of ages highly unbalanced. In order to avoid analyzing a vast spread of data (e.g., 15–29 and 30–70), I removed data points for ages 50 to 70, from age analysis. Finally, for academic

level, “graduate students” and “other” categories fell outside the population of interest, so I removed data in those categories from analysis. However, the participants who fell into the removed categories were not removed from analysis altogether. Their responses were still included in analyses for all other independent variables.

For some categories of some variables, there were insufficient responses to warrant separate analysis; therefore, I collapsed them to allow for more robust analysis and inference (Table 7). For example, age was originally divided into six decade-long categories, but respondents had a wide spread and were unevenly distributed among them. Although combining categories meant that I would lose some ability to interpret the results at a fine scale, combining them provided more balanced sample sizes and more degrees of freedom in regression analysis. Likewise, the ethnicity/race category was originally divided into 7 categories, but most (75%) participants selected *White*, with a range of 2 to 61 participants in each of the other categories. Therefore, to mitigate the unbalanced, small sample sizes, I combined all non-White categories into one for analysis. (See Appendix C for creativity score results for individual ethnicity/race categories.)

Table 7

Independent Variable Initial and Final Categories

Initial Category	Initial sample size (<i>n</i>)	Final Category	Final Sample Size (<i>n</i>)
Academic Discipline			
Arts	90	Arts	90
Engineering	117	Engineering	120
Science	162	Science	162
Other	63	E: cannot interpret	–
Gender			
Female	211	Female	211
Male	188	Male	188
Non-binary/3 rd gender	25	Non-binary	25
Prefer not to say	8	E: cannot interpret	–
Age			
10 to 19	55	C: 15 to 29	325
20 to 29	270		
30 to 39	73	C: 30 to 49	94
40 to 49	21		
50 to 59	8	E: insufficient data	–
60 to 70	2	E: insufficient data	–
Multilingual			
Yes	204	Yes	204
No	228	No	228
Ethnicity / Race			
White	275	White	275
Asian	61	C: Non-White	150
Black or African American	11		
Hispanic or Latino	33		
American Indian or Alaska Native	2		
Native Hawaiian and Other Pacific Islander	2		
Two or more races	41		
Academic Level			
Freshman	35	C: First two years	94
Sophomore	59		
Junior	112	C: Years three & four	289
Senior	177		
Graduate	14	E: Outside study population	–
Other	36	E: cannot interpret	–

Note. C = combined category. E = eliminated category. Initial sample size for the engineering discipline was 117, but three participants majoring in Computer Science who indicated *Other* for academic department were combined into the engineering discipline, bringing the final sample size to 120.

Creativity Score

The overall creativity score for each participant is a single measure whereby a student's overall perceptions of creativity in general, of themselves as a creative individual, and of creativity in education is represented by a single value. Mean creativity score across all participants and categories was 63.3 (± 7.7 SD).

Multiple Linear Regression Modeling

Multiple linear regression modeling showed that, in support of my hypothesis, there was a predictive relationship between academic discipline and creativity score. The Pearson correlation coefficient between these variables was small but significant ($r = -.191, p < .05$). The more sensitive multiple linear regression analysis showed that major explained 3.7% of the variance ($p < .0001$) in overall creativity (Table 8). No other covariate was significantly related to creativity score (at the $\alpha = .05$ level), and so they were not included in the final model.

Table 8

Linear Regression Final Model Summary

Predictor Variable	Response Variable	Correlation (r)	Coefficient of Determination (r^2)	Standard Error of the Estimate	p -value
Academic Discipline	Creativity Score	-.191	.037	7.53	<0.0001

The follow-up one-way ANOVA allowed post-hoc analysis to test the differences among the three academic disciplines (i.e., science, engineering, and the arts). I conducted the one-way ANOVA on the original categories (i.e., not the dummy variables), and the results confirmed the findings of the linear regression of a significant relationship between academic discipline and creativity ($F [2, 366] = 10.3, p < .0001$; Table 9).

Table 9

One-Way ANOVA Summary

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	p -value
Between Groups	1122.36	2	561.18	10.3	<.0001
Within Groups	20096.32	369	54.46		
Total	21218.68	371			

The Tukey's HSD post-hoc test of differences between groups supported my hypothesis that students in arts-related disciplines would score higher than students in the sciences and engineering in their perceptions of creativity. Contrary to my hypothesis, there was no difference in creativity score for students in science and engineering disciplines (mean difference = 0.08, $SE = 0.89$, $p = .97$), although there was slightly greater variability in the science data than the engineering data (Figure 11). In contrast, arts differed from both science (mean difference = 4.02, $SE = 0.97$, $p < .0001$) and engineering (mean difference = 4.10, $SE = 1.03$, $p < .0001$; Figure 13).

Figure 13

Tukey's Honestly Significant Difference Post-Hoc Test between Academic Disciplines

Note. Boxes encompass the first and third quartiles, whiskers extend to the minimum and maximum range, circles represent outliers (measured as $1.5\times$ smaller than the first quartile), and the horizontal line is the median. Plot created in SPSS software.

Interpretation of Findings

I asked whether undergraduate students in science-, engineering-, and arts-related fields differed in their perceptions of creativity, and I hypothesized that students in the arts would score higher than those in the other two academic disciplines. The results clearly support this hypothesis and demonstrate that undergraduate students in arts-related programs in my sample have higher perceptions of creativity than those in science and engineering programs have. These findings suggest that the teaching and learning that takes place in arts-program courses at the study university may be promoting creativity in students. In addition, these results may indicate that students who have high perceptions of creativity may be more drawn to enroll in art programs than in science and engineering programs. However, the mean differences in creativity score between the arts and the other two disciplines was only ~4 points, with students in the arts scoring 6.6% higher than students in engineering and 6.4% higher than those in science-related programs. This relatively small difference could show that although there is a detectible significant difference in perception of creativity among students in the three areas, students at the study university, an institute of higher learning with formalized goals pertaining to the promotion and inclusion of creativity campus and program-wide, may have high perceptions of creativity across disciplines.

Although not statistically significantly, creativity score varied among categories of the different independent variables (Table 10, Figure 14). Notable apparent differences with >1 point difference were in ethnicity/race, with White students reporting higher perceptions of creativity than non-White students; age, with older students

reporting higher perceptions of creativity than younger students; and gender, with non-binary identifying students scoring 1.85 points above female students and 3.23 points above male students. With additional research and larger sample sizes, significant effects of both age and gender on perceptions of creativity could potentially be found.

Interestingly, participants who responded as *other* for their academic level also scored higher in perceptions about creativity, however the data was not interpretable for this research study. These observed differences are interesting and warrant further exploration; however, small, unequal sample sizes affected my ability to detect differences among groups within most individual categories. Although the difference between students in the arts and other fields is significant, as predicted, the actual difference is slight, indicating that students in all three academic disciplines had high perceptions of creativity (see Table 10 and Figure 14).

Table 10

Average Creativity Scores by Grouped Independent Variables

Category	Mean Creativity Score (SD)	Number of Participants (n)
Academic Discipline		
Arts	66.38 (6.1)	90
Engineering	62.34 (7.6)	120
Science	62.36 (7.7)	162
		Total: 372
Gender		
Female	63.82 (7.2)	211
Male	62.44 (8.2)	188
Non-binary	65.67 (6.6)	25
		Total: 424
Age		
15–29	63.19 (7.7)	325
30–49	64.33 (7.8)	94
		Total: 419
Multilingual		
Yes	63.24 (7.7)	204
No	63.37 (7.7)	228
		Total: 432
Ethnicity / Race		
White	63.65 (7.7)	275
Non-White	62.44 (7.7)	150
		Total: 425
Academic Level		
Years 1 and 2	63.75 (7.2)	94
Years 3 and beyond	62.94 (7.6)	289
		Total: 383

Figure 14

Average Creativity Scores by Grouped Independent Variables

Furthermore, there were weak correlations between some of the independent variables that could affect their relationships with perception of creativity. For instance, age, which was weakly correlated with creativity score, was also weakly, but significantly, correlated with both ethnicity/race ($r = 0.16, p < .001$) and language ($r = 0.10, p < .01$). These latter two variables were also moderately correlated with each other ($r = .44, p < .001$). These correlations might suggest a potential interactive effect between age and populations of students that could become more apparent with larger sample sizes. Also, because I needed to group ethnicity/race into only two categories,

White and non-White, this analysis was not able to account for the differences that could arise because of the varied perceptions of creativity that may be present across cultures.

Limitations of the Study

There were several limitations to this research study. First, this research was conducted with a population of undergraduates who were attending one specific university in the northwestern United States; therefore, this research study cannot be generalized outside of the study university. To generalize the results to a larger population, the study would need to involve more participants at different universities and in different geographic locations.

Next, this study used voluntary selection methods in recruitment, which leads to the potential for voluntary selection bias. That is, students with stronger feelings about creativity, whether positive or negative, might be more likely to respond to the survey than students without strong opinions about creativity. A more random recruitment method would provide a sample of the population without any possibility of voluntary selection bias; however, for studies that employ surveys for data collection, a truly random recruitment method is unlikely to be achieved.

Restrictions related to the Covid-19 pandemic also introduced limitations into the study. All recruitment and data collection were done virtually; therefore responses were collected from only students who had internet access. Additionally, students were attending classes virtually, and being in a location outside of campus without in-person interaction with faculty, staff, and other students for the entire academic year could have

affected their perceptions of the three components of creativity. An identical study conducted during non-pandemic times may yield different results.

A further limitation of this survey was that because it was a quantitative study limited to student perceptions about creativity, it did not provide rich descriptions of individual participant views and perceptions about creativity; therefore, the results of this study cannot provide insight into factors that may influence student perceptions of creativity that were not specifically collected through the survey instrument.

Regarding statistical analysis, small sample size, and unequal sample sizes among groups, could limit statistical power to identify influential factors on perceptions of creativity. A larger study involving more participants equally distributed among groups could provide greater statistical power; however, given the population of interest (i.e., undergraduate students in three specific academic disciplines at a single university), it would be difficult to obtain a larger sample size. Additionally, studies that use surveys to collect data often lead to unequal sample sizes among groups because of the nature of voluntary participation.

Finally, I have a strong bias in favor of creativity and its importance in higher education. This position could potentially bias my view of the results of the study and, therefore, it is beneficial that this study is quantitative in nature. Nonetheless, I recommend further research by diverse researchers who have a variety of views about creativity.

Summary of the Results

This chapter described the results of this quantitative study, which sought to assess differences in the perceptions of creativity, self-perceptions of creativity, and perceptions of creativity in higher education of undergraduate students in science, engineering, and arts disciplines through administration of a 16-question survey. I also sought to explore the relationships of demographic covariates (i.e., gender, age, academic level, ethnicity/race, and language) with creativity perceptions. Through descriptive and statistical analysis of the survey response data, I found that for the population of interest, the three components of creativity were strongly correlated and could be analyzed as a single response variable of overall creativity. I also found that arts students had significantly higher perceptions of creativity than engineering or science students, although all three disciplines exhibited high levels of creativity perceptions. Although I was not able to identify statistically significant effects of demographic covariates on creativity score, there are several factors that warrant future research. Additional insights from larger sample sizes would be useful for age, which was weakly correlated with creativity, with the older population in the sample scoring higher in their perceptions of creativity. Gender identity also may be an important factor to explore further, with participants who identified as non-binary and third-gender scoring higher than both male- and female-identified participants. These areas for future research present opportunities for further strengthening our understanding of the different ways students perceive creativity, which will provide insights for higher education instructors

and decision makers to better incorporate creativity into their instruction and academic programs.

Chapter 5: Discussion

Introduction

In this quantitative study I gathered and analyzed data to understand creativity perceptions of undergraduate students majoring in sciences, engineering, and the arts. To guide my research, I created and followed a theoretical framework (Figure 2). I established that: (a) there is a global need for creative citizens to innovate and solve problems in our increasingly technologically advanced world; (b) creativity is important across disciplines in higher education, which is a vehicle for producing creative citizens; (c) research has uncovered a variety of methods for successfully fostering creativity in teaching and learning in colleges and universities; and (d) understanding the perceptions that undergraduate students have about creativity is critical for higher education decision makers and instructors. To facilitate this understanding, I undertook a study by administering a survey developed by Dlouhy (2012) and gathered data on undergraduates in different academic disciplines by asking them to respond to a survey to determine their perceptions of creativity. This methodology provided a path for investigating the research question: “How do undergraduates in science, engineering, and the arts compare with regard to their perceptions of creativity, their creative self-perceptions, and their views about the role of creativity in education?”

This study had two primary findings. First, through principal components analysis, I discovered that for this study population, the three components of creativity were strongly correlated. The participating students' perceptions could be measured through an *overall creativity* score, defined as an individual's perceptions of the nature

and importance of creativity, their self-perception as a creative individual, and their perception of the value of creativity as a goal in higher education. Second, through linear regression analysis, I found that arts students had significantly higher perceptions of overall creativity than both engineering and science students, and that students in the latter two groups perceived creativity at very similar levels. I did not find any statistically significant demographic (i.e., age, academic level, gender, ethnicity/race, language) to be predictors of creativity perception in this study's sample, which was made up of undergraduate students at a university in the northwestern United States, although age, gender, and ethnicity/race categories showed small trends that warrant additional research.

In this chapter I discuss the broader implications of these results and provide recommendations to recognize, encourage, and reward students' creativity, to measure and assess creative learning skills, and to explicitly and implicitly teach and foster creativity in higher education. I derived these insights from the body of creativity literature, my own experience, and this study's survey results, which reflect the perspectives of students themselves. These recommendations lend benefits to the institution of higher education and contribute to the creativity education literature. I also recommend future research directions to explore the drivers behind creativity perceptions. I also recommend further qualitative research through interviews and focus groups to discover the reasons students in these three different academic disciplines perceive creativity differently. The findings of this research study help to improve our understanding about the ways higher education students perceive creativity, illuminate

the potential for instructional practices to increase student creativity across disciplines, and provide preliminary evidence of potential trends in other demographic categories that may inform future research directions. I hope that the data and insights from this study will help instructors establish future priorities around the importance of teaching and fostering creativity.

Synthesis of Findings

The results of this study clearly demonstrate that for this study's population of interest, undergraduate students studying science, engineering, and the arts at one university in the northwestern United States, those in arts-related disciplines have higher perceptions of creativity than students in the other two academic disciplines. My hypothesis that students in the arts would have the highest perceptions of creativity was supported. This finding of higher creativity perceptions of students in the arts suggests that art-related classes might be effective in promoting and fostering creativity in students. Alternatively, or in conjunction, this finding could reflect that more creative students tend to apply to art departments rather than to science and engineering departments.

In addition to identifying a difference in creativity perception between the disciplines, another important finding was that although the arts students scored significantly higher than the science and engineering students (6.4% and 6.6% higher, respectively), the difference in overall creativity scores was small (~4 points out of a total of 80), and students in all disciplines scored their perceptions highly (mean = 63.3 ± 7.7 *SD*, range = 62.34 [± 7.7]–66.38 [± 6.1]). That should be interpreted as good news at a

university that has strong support for creativity in all fields. This creativity-supportive environment may, in fact, be the driving force behind the other important finding of this study, that for this population, the three components of creativity perception were highly correlated. There is the possibility that when applied to a different population of students in a less creativity-focused environment, the three components could show differences in their contributions to overall creativity perceptions within groups of students. However, for this population of students, it is clear that students in science, engineering, and the arts all highly perceive all three components of creativity, with arts students having small but significantly higher creativity perceptions than students in the other two disciplines.

Broader Implications and Recommendations

The primary finding of this study, that students in arts-related disciplines scored higher in their perceptions of creativity, has the potential to inform institutions of higher learning about the usefulness of incorporating creativity teaching across disciplines.

Yakman (2008) proposed that “the fields of the arts [are] important to the overall creation of knowledgeable and well-rounded citizens” (p.15). Creativity skills, such as the ability to problem solve creatively, to innovate, and to work collaboratively, transcend the arts to contribute to a wide variety of fields. Students who develop these skills will bring them into the workforce, creating a culture of innovation and solving societies most important problems.

Identifying that arts students have higher perceptions of creativity than students in engineering and science disciplines is an important step toward understanding variability in creativity perception and, therefore, the variability in potential outcomes of integrating

creativity into non-arts teaching methods. Identifying the drivers of these differences in perception is a critical next step. This study is not the first to find that postsecondary students who study art and design may perceive themselves as more creative (Mulholland, 2016, p. 184); however, further investigation is needed in order to answer the question “why?” Another study that found difficulties in identifying specific drivers of creativity perceptions was Katz-Buonincontro, Perignat, et al. (2020). The authors tried to understand the reasons why some students perceive themselves to be more creative than others but found that there was no one definitive answer (p. 8), with creativity perceptions being developed and expressed in highly individual ways. Further, van Broekhoven et al. (2020) identified that there were differences in creativity perceptions between students in the arts and science, with those in the arts viewing novelty as a marker of creativity to a greater degree than science students. The authors inferred the influence of individual personality traits, such as openness to new experiences and higher creative self-efficacy that were common to students in the arts, but, like this study, did not identify specific drivers of the differences in creativity perception.

Understanding differences in creativity perceptions among other demographic groups, such as gender, age, and ethnicity/race, may also inform educators about the best ways to integrate creativity into their teaching. For instance, this study did not find any strong relationships between creativity perception and gender or age, but there were some indications that weak trends may have been present. Similarly, He and Wong (2021) found that creative self-efficacy, which is analogous to the self-perception of creativity

measured in this study, was slightly higher in males than in females. However, they also found that the variability in self-efficacy scores was higher for males, suggesting that factors other than their gender were influencing males' self-perceptions of creativity to a greater degree than that of females. Likewise, Álvarez-Huerta et al. (2021) found differences in the relationship between creative self-concept and student engagement among genders and academic level, as well as among academic disciplines. These studies, supported by the small indications of possible creativity perception trends I found among genders and ages, suggest that we have much to learn about the way individuals and groups perceive creativity, but that an approach to teaching creativity should consider that different students, even within disciplines, may perceive, process, and implement creativity in very different ways.

In addition to potential differences in overall creativity perception among demographic groups that warrant further research, it is worth noting that across disciplines, as well as across genders and ethnicities/races, that self-perception of creativity received higher scores than either perceptions of creativity in general or perception of creativity in education, with the latter receiving the lowest scores by all groups. This could be an artifact of a study population at a school that promotes individual creativity in a city that is known for its artistic and highly individualistic culture, or it could be a reflection of a self-development-focused, reflective period of individuals' lives: the college years. Another interesting observation is that statements related to creativity in education received the lowest scores from participants, regardless of discipline. Could this reflect a greater appreciation for intrinsic or perceived "inborn"

creativity than creativity intentionally developed or trained? Could it indicate that students across disciplines do not see a clear link between creativity and the skills they need to succeed in a university system that can sometimes seem overly test-based or formulaic? Or does it suggest that students do not feel that it is the responsibility of their teachers to help them hone their creativity skills? Because these results are not statistically significant and are based on a small effect size and unequal samples, I can only speculate that the small differences could indicate potential trends that should be investigated further.

Although there is a gap in our understanding about the drivers of differences in how individuals and groups perceive creativity, how perceptions may differ among different demographic groups, and the differences in perceptions regarding the three creativity perception components, there are, nonetheless, insights to be gained simply from understanding that those differences exist that can help educators effectively integrate creativity into their teaching and develop creativity skills in their students.

Recommendations for Educators

From this study's result that arts students had higher perceptions of creativity than science and engineering students, from my own experience, and from synthesizing the broader educational creativity literature, I present several recommendations for higher education instructors, administrators, and policy makers. It is my hope that these recommendations will provide insights toward the importance and usefulness of integrating creativity into the educational experience and expectations for undergraduate students.

Recognize, Encourage, and Reward Students' Creativity. Recognizing, encouraging, and rewarding student's creativity will help students across disciplines develop creativity skills. Fostering a supportive environment that encourages creativity and innovation can also mean embracing uncertainty for both students and teachers (Sandri, 2013). Uncertainty, although potentially uncomfortable, facilitates the building of creativity skills that enhance students' ability to think independently, to build confidence in their own abilities to think through problems, and to bravely try innovative strategies that may fail. When teachers step away from complete control over the teaching and learning process and embrace open-ended questions that allow for creative thought exploration, and for learning through failure, students can truly develop lasting creativity skills, regardless of their discipline.

I suggest that teachers and universities can prepare students to be successful at their future jobs by rewarding and encouraging students' creativity approaches. STEAM (science, technology, engineering, art, and mathematics) teaching practices substantiate this idea by showing, for example, that encouraging and rewarding problem solving and integrating opportunities for open-ended assignments and collaborative work (Madden et al., 2013) can lead to creative and innovative work by students in the present and develop their ability to carry those skills into their future careers (Radziwill et al., 2015).

Although, there is still disagreement about how, and even whether, creativity can be taught in institutions of higher learning (Egan et al, 2017), there is evidence that when incorporated in teaching and rewarded, students can benefit (O'Leary and Bingham, 2007).

Measure and Assess Creative Learning Skills. As society becomes more complex and technology more sophisticated, higher education has a responsibility to prepare students to become skillful workers who can contribute to society and develop innovative solutions to complex problems (Jackson, 2004). Therefore, I propose that educators grade and assess students' work by evaluating not only the final product but also how creatively students solve problems and complete assignments. For example, I had a particularly forward-thinking geometry teacher who graded my work by observing how creative I was in learning the topic and by evaluating my process of resolving problems rather than simply grading the correctness of my solutions. My personal experience was that this opportunity to develop my critical thinking skills and to embrace the process and not only the end product led me, later in life, to succeed at my current work as a senior-level budget analyst. This recommendation to alter the traditional grading paradigm is supported by the creativity education literature. For instance, both Alencar et al. (2017) and Madden et al. (2013) suggested that teachers should reduce students' fear of evaluation by allowing students the flexibility and freedom to explore the learning process instead of limiting students to strictly defined successful outcomes. Providing an environment where failure and alternative outcomes are acceptable, and even celebrated, is especially important in the context of fostering creativity skills because of the specific anxieties associated with performing creatively (Daker et al., 2019).

Explicitly and Implicitly Teach and Foster Creativity in Higher Education. I propose that teachers incorporate creativity in their courses, fostering the ability of

students to creatively solve problems in order to prepare them for a work environment in the future. In their study on the links between creative self-confidence and student engagement, Álvarez-Huerta (2021) concluded that it is critical for students in higher education to participate in collaborative learning, interact with faculty, and have integrative learning experiences to promoting and fostering lasting creativity skills. For instance, open-ended assignments are often used in arts courses, whereby students can fulfill the requirements of an assignment in a multitude of ways, sometimes without a specific defined end-goal. Students in an environmental science course could, for instance, be assigned the topic of environmental sustainability, with the freedom to decide what their final project might be. Some students may produce a musical performance piece, others a detailed report on their university's carbon footprint, and still others a robot engineered to measure temperature fluctuations as it rolls over different substrates (e.g., concrete or grass) and report them on a website. Group and collaborative work is another area that is frequently used in arts-related courses that can be applied to teaching in any discipline. Students may balk at having to work with other students on projects, but there is evidence that working in groups can stimulate creativity, leading to innovative solutions (O'Leary and Bingham, 2007). Even when working alone, students across disciplines can benefit from teaching that incorporates creative problem solving, problem-based learning, and simply being encouraged to think outside the box.

Integrating creative learning can be implemented across disciplines. STEAM teaching techniques, which enhance creative thinking and teach students to learn in multi-disciplinary ways (Yakman, 2008, 2012), have been shown to change students'

perceptions of their own creativity and their own ability to innovate and problem solve (Sunley et al., 2019). Further, they have been shown to close gender gaps, improve the learning experiences of female students in STEM courses, where preconceptions of gender differences may affect experience, and could potentially lessen gender discrimination in the classroom (Conradty & Bogner, 2020). I propose that teachers and universities explore the STEAM framework toward incorporating creativity approaches into their teaching techniques. STEAM's use of integrative teaching to familiarize students with multiple aspects of a topic, rather than focusing only on a discipline-specific paradigm fosters creativity, which then enhances professional and personal development among students (Conradty & Bogner, 2020). Both explicit teaching of creativity, through facilitated classroom activities and assignments, and implicit teaching of creativity, by fostering an environment where contemplation and trying alternate paths are encouraged, and even failing is not reprimanded, are ways to provide arts and non-arts students alike the tools to integrate creativity into their learning and lifelong skills.

Future Research

This study's results suggest that students in the arts know the secret of improving creativity in themselves, which could be valuable for providing examples for other students in how to improve their own creativity. The drivers of the differential perspectives between arts students and those in other disciplines, such as engineering and science programs, are, therefore, an important direction for future research that could be carried out through qualitative studies. In-depth interviews would provide rich descriptions of the reasons and context for creativity perspectives. Research similar to

this study but in other locations and with larger sample sizes could provide greater diversity in participants and greater statistical strength to identify the drivers of differences in creativity perceptions. Another approach could be to investigate and measure perceptions of creativity of individuals before and after taking art classes to assess the effects of different aspects of art classes on students' perceptions of creativity. Further, this research study was conducted during the COVID-19 pandemic, but the novel condition of solely virtual learning was not integrated into the research design. Future research could measure differences in perceptions of creativity among students who take online, hybrid, and onsite classes, which could offer insight into the question of whether different educational approaches influence perceptions of creativity both as direct effects and as interactive effects with students from different academic disciplines.

Summary and Conclusions

This quantitative study inquired into how undergraduate students in science, engineering, and arts programs of study at a university in the northwestern United States responded to a survey instrument on creativity measurement developed by Dlouhy (2012). In this study I asked: How do undergraduates in science, engineering, and the arts compare with regard to their perceptions of creativity, their creativity self-perception, and their views about the role of creativity in education? Through the administration of a survey that included 16 statements about creativity perceptions, followed by statistical analyses, I found that academic discipline was a significant predictor of students' perceptions of overall creativity, with students in the arts scoring 6.4% higher than students in science disciplines and 6.6% higher than students in engineering disciplines.

However, the difference in creativity scores was smaller than expected (only ~4 points out of an 80-point scale). The fact that engineering and science students scored nearly as high as the arts students points to the possibility that the environment at the study university may already be one that supports creativity. Repeating this study at a different institution may elicit more noteworthy differences between students from different academic disciplines. Additionally, further investigation is recommended to identify the drivers of art students' higher creativity perceptions, as qualitative context of these higher perceptions was outside the scope of this study. However, this study substantiates the idea that creativity, which is widely recognized to be important in learning across fields, is more highly perceived in arts disciplines than in science and engineering fields. Because creativity is so critical for innovative problem solving, university instructors, as well as administrators and policy makers, may consider looking to the arts for ways to encourage and teach creativity in less traditionally creative fields. Fostering creativity may just be the way to develop the next generation of society's innovators.

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Appendices

Appendix A: Survey Instrument

Instructions for completing the survey:

For each of the 16 statements below, please indicate the extent to which you agree or disagree with the statement, using the following response options: “strongly disagree,” “disagree,” “neutral,” “agree,” and “strongly agree.” Please indicate only one response for each question, including the descriptive questions. All questions are voluntary, and you are not required to answer any question you do not wish to. Demographic and major information will be used to understand if and how perceptions of creativity differ among students from different disciplines. No survey answers or demographic information will be linked to you personally, and all survey answers will be anonymous and confidential.

Figure A1

Survey Instrument

Undergraduate Perceptions of Creativity Survey						
Academic Level	Freshman____ Sophomore____ Junior____ Senior____ Graduate____ Other____					
Academic Department/ Major	Check one and specify major:					
	Science_____		Major: (specify):_____			
	Engineering_____		Major: (specify):_____			
	Arts_____		Major: (specify):_____			
Other (specify)_____		Major: (specify):_____				
Gender	Male_____		Female_____		Other_____	
Age	Please write in your age:_____					
Please indicate extent to which you agree or disagree with each of the following statements:		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I have creative hobbies.					
2	Creative ideas are original.					
3	Creativity can be applied to all aspects of life.					
4	I am artistically creative.					
5	Teachers need to teach students to be creative.					
6	I apply my creativity in everything I do.					
7	Being creative is important to me.					
8	Creativity is a necessary skill.					
9	Creativity should be an important goal in education.					
10	I am a creative person.					
11	What is creative in one culture may not be in another.					
12	Teaching people to be creative is important.					
13	I have a creative idea every day.					
14	Creative people make innovative products.					
15	"Thinking out of the box" is creative.					
16	I use my creativity to make things.					
Language	Do you speak two or more languages? Yes____ No____					
Ethnicity/Race	What is your ethnicity? Hispanic or Latino____ Not Hispanic or Latino____					
	Select one or more races to indicate what you consider yourself to be:					
	American Indian or Alaska Native____ Asian____ Black or African American____ Native Hawaiian and Other Pacific Islander____ White____					

Note. The survey instrument was modified from Dlouhy's (2012) survey to add demographic information to allow selection of one of the three academic categories and to bring the gender categories up to date with current standards. Permission for these modifications was obtained from Dlouhy.

Appendix B: Study Invitation Email

Dear [name],

My name is Dildora Beaulieu, and I am researching undergraduates' perceptions of creativity for my doctoral dissertation at Portland State University. The working title of my study is *Creativity in Science, Engineering, and the Arts: A Study of Undergraduate Students' Perceptions*. I am interested in developing and providing recommendations for university educators about how to recognize, encourage, and reward students' creativity, how to measure and assess creative learning skills, and the most effective ways of teaching and fostering creativity in higher education, from the perspectives of students themselves. The survey process will take no more than approximately 5 to 15 minutes to complete. Please follow this link, which will take you to the survey [link]. Please complete the survey by this due date [due date]. All information relating to this study will be kept both anonymous and confidential.

I thank you in advance for considering participating in this research study.

Sincerely yours,

Dildora F. Beaulieu

Ed.D. Candidate in Educational Leadership: Postsecondary Education

Portland State University

Appendix C: Supplemental Survey Response Figures

Figure C1

Total Creativity Score for Non-White Ethnicity/Race Groups

Figure C2

Survey Responses for Each Question by Discipline

Science Students