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Different Ideas, Lots of Ideas

A design course that enhances the creative abilities of college students

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This Creative thinking is the ability to generate a wide and detailed range of responses to a given stimulus. It is not a fixed skill; it can be improved through practice. Creative Problem Solving (CPS) is a design course that fosters these abilities. The challenge-based course utilizes a generative learning approach. Students are given a series of assignments that prompt them to 'do some-thing differently' (i.e., eat something different). In their quest towards designing unique solutions, the students are forced to define the contextual meaning of each challenge, and to question how cultural, social, and personal norms limit their ideas. The course integrates peer evaluations to encourage originality among the local group and to reveal alternative perspectives. The TTCT is used to measure their creative thinking skills at the beginning and end of the course. Analysing data from nine offerings of the course (n=445) suggests that CPS significantly improves the originality and fluency of student ideas. Considering that these skills are highly desired among the entrant workforce for industries both inside and outside design, a comparable course should be fundamental to the college experience for all students.

Keywords: creative problem solving; creative skills; creative thinking; design, design education

1. Introduction

It isn't a stretch to understand why creative skills are so highly desired. Creative skills are associated with individual attributes such as curiosity, openness to ideas, and willingness to take more risks (Csikszentmihalyi, 2014; Maksic and Pavlovic, 2001; Cecil, Gray and Thornberg, 1995; Torrance, 1988). These skills are also associated with a tolerance for ambiguity (Urban, 2007), and the intuition, perception and insight to think differently about a problem or situation (Turner, 2013; Sternberg and Lubart, 1995; Finke, 1995).

What *is* surprising is that creativity training is not emphasized more or required in college. While creativity courses have increased in popularity (Xu, McDonnell, and Nash, 2005), they have struggled to gain traction as a foundational learning experience that prepares students beyond higher education. The creativity of today's workforce has broad social and economic implications, so knowing how to effectively prepare entrant employees is an important responsibility of colleges.

This article describes the structure and outcomes of Creative Problem Solving (CPS), a design course that aims to foster creative abilities. Pre- and posttest data that was collected from nine different offerings of the course to measure how it improves specific creative abilities of the students. Before presenting the results of this study, this article first outlines the demand for creativity and how higher education fits into the larger picture. Second, it summarizes how creativity is defined and how it is measured. And third, it provides details about the methodology of the course.

2. Invaluable Skill, Essential Training

How one approaches or thinks about solving problems is generally tied to their educational, social, and cultural background. Solving problems can be understood systematically as a back-and-forth exchange of rules, practices, and information between domains, fields, and people, each driven by culture, the environment, and society (Csikszentmihalyi, 2014). However, the typical educational paradigm isn't exactly guided by this

systematic model. More commonly, students are taught how to solve problems in a high-stakes environment of structured learning which generally entails few exchanges, linear and expected thinking, and standardized assessments. This fosters a learning ecosystem that praises and rewards students on the basis of their ability to 'play by the rules,' and trains them to converge on singular answers and with little feedback from broader contexts. This approach does little to prepare students for the demands of our economic and social future. The contemporary workforce needs and desires people who can employ critical thinking skills and who are capable of generating, exploring, combining, integrating, and defining new ideas. Currently, entrants into the workforce lack creativity and innovation, the two very attributes that are argued as essential for success (Casner-Lotto and Barrington, 2006). And this is not isolated to industries and markets that are epitomized as 'creative' such as design and art. The need for creativity extends to sectors of public policy (Pattnaik and Banerjee, 2020), business, economics and law (Urquia-Grande and Estébanez, 2020), business informatics (Martz, Hughes, and Braun, 2017), chemistry (Hill et al., 2019), and tourism and hospitality (Trajanoska and Kostovski, 2016). Puccio and Cabra (2010) suggest that organizations lack creative individuals, creative processes, and the environmental attributes that engage employee creativity, and that without these attributes are less likely to produce internal and external innovation. Simply put, the deficiency makes it less likely that an organization will thrive.

Carnevale and Smith (2013) suggest the post-industrial era has resulted in "fundamental changes in the skill requirements of the US economic system," creating pressures to place a premium on "problem-solving and creative thinking… at all levels of an organization ". (p. 493; 495). Thus, if college students want to be "competitive, attract the right type of industry, and engage in the right type of talent in the new knowledge economy" (p. 497), they must learn how to think logically, employ critical thinking skills, generate new ideas, explore ideas, and combine, integrate, and reinvent the way they think. Students must also compete with computerization which is best countered if they can foster the skills that computers lack; creative and social intelligence (Frey and Osborne, 2017).

Puccio (2017) argues that creativity is a crucial survival skill for the 21st Century, and that meeting the demands of tomorrow are the responsibility of higher education. Puccio suggests that colleges thus far have played a problematic role by promoting a culture of 'conformity' rather than one of creativity. This has created serious consequences for our economic and social future. And the gap between higher education and industry has not gone unnoticed by employers. Urquia-Grande and Estébanez (2020) suggest that creativity and cognitive skills are grossly lacking in today's entrants who are hired right out of college and recommend that academic advisors prioritize guiding students toward training that ensures that they are adaptable to and prepared for the 'real world.'

Fostering the capabilities that are needed to address global change lies within curricula (Mosier and Kaiser, 2019; Drake and Reid, 2018), and that it should be prioritized early in a student's path towards a degree (Martz, Hughes, and Braun, 2017). When this emphasis is lacking, students miss a key aspect of how they might compete for employment. For example, Hill et al (2019) found that chemistry majors struggle to understand that prospective employers want entrants to have transferable skills beyond their discipline, and that such skills could actually improve a student's success in competing for jobs. They summarize, "it is not clear whether students recognize the development of these skills or understand their importance. Without such recognition of skill development, it could be argued that academics' efforts to incorporate them into their courses are, at least to some extent, wasted."

The world is rapidly changing, and the mission of the industrial world is constantly being transformed. Thus, students need transferable skills that go beyond their degree programs so they can be relevant and change agents in their field(s). Industries desire creative entrants, but they also report that these attributes are horribly lacking. While higher education is not the sole culprit, this deficiency can be addressed by providing students with opportunities to engage in a conscious process of *unlearning* the structured protocols from standardized paradigms of learning. However, this article contends that more aggressive measures are needed. Colleges should require students to take courses that train them to be voracious ideators and visionaries and cultivate their creative abilities.

3. Cultivating Creative Abilities

Researchers who study creativity and learning often asked how they measure it. This isn't surprising, as creativity is widely regarded as subjective (Haynes and Martens, 2011). As a descriptive word, creativity is often used in as a judgment of value, weighted against cultural and social contexts and norms. For this reason, calling something or someone creative may be resonant to one group but not another. Creativity is also a term that is broadly applied, yet not wholly defined for mainstream use. Glăveanu (2016) suggests that the

uncertain and broad use of the word devalues its meaning. This makes it difficult for people to conceptualize creativity as something that has quantifiable dimensions. Runco (2014) suggests that some of these complexities can be addressed by using the word as an adjective rather than a noun (i.e., creative thinking, creative process, creative product). Once the word 'creative' is applied to something discernible it becomes easier to understand how it can be defined and measured.

So, what does it mean to be a creative person? The literature suggests that they have a "special kind of human potential or aptitude." (Urban, 2007, p. 168). Creative people produce novel ideas which are uniquely appropriate for solving a problem (Sternberg, 1999). Creative people *create* (Hasirci & Demirkan, 2007), but what they create is *different* (Glăveanu, 2016; Runco, 2014). While these ideas about creative people shed some light on defining the attributes of a creative person, perhaps the most agreed understandings that the creativity of a person is objectively about *thinking*.

Over 60 years ago, Guildford (1957) suggested divergent thinking as essential to creative ability, and involving four major dimensions: originality, fluency, flexibility, and elaboration. Originality is the ability to come up with unusual or different ideas. Fluency is the ability to come up with lots of ideas. Flexibility is the ability to perceive alternative perspectives concerning an idea. Finally, elaboration is the ability to add details to ideas that enrich their meaning. Torrance (1988) used the four dimensions to develop the Torrance Test of Creative Thinking (TTCT). Today, the TTCT is the most widely used instrument for measuring creative thinking (Starko, 2013; Kim, 2006; Cropley, 2000), Psychometrically, the TTCT is reputable for its reliability and predictability validity (Starko, 2013; Althuizen, Wierenga & Rossiter, 2010; Kim, 2006; Cramond et al., 2005; Cropley, 2000).

The process of arriving at novel ideas typically involves iterating (Brennen, 2015; Feldman, 1999; Amabile, 1983). A creative process can be described as the operations that must be performed to result in a creative outcome or product. Engaging in activities that develop an idea in this way involves thinking and decision making which can be influenced by motivation, inspiration and perspective (Rhodes, 1987). Divergent thinking has long been regarded as the integral agent of any process that results in creative outcomes (Torrance, 1988). However, contemporary research suggests that convergent thinking also plays an important role in both generating and developing ideas (Cropley, 2006).

Wallas' Four Stages of the Creative Process (1976) is perhaps the most widely used (and adapted) model for explaining what a creative process looks like. The model suggests that creative process as a dynamic procedure collecting knowledge and allowing that knowledge to incubate. As ideas begin to form, the consideration for multiple perspectives and a myriad of possibilities allows one to synthesize the knowledge into something that can be presented to and judged by others. Usually this leads to re-entering a process of collecting, incubating, and synthesizing additional information and continues until a suitable solution or appropriate idea is defined. For architecture, this may be a school design. For product design, it may be an ergonomic device for the elderly.

The outcome of the process described above is generally regarded as 'creative' if it is unique, effective, or useful (Runco and Jaeger, 2012; Plucker, Beghetto and Dow, 2004). However, such criteria are often contextually dependent, especially in an organizational setting (Haynes and Martens, 2011, Reiter-Palmon, 2011). For instance, Barnard (2005) calls creativity for graphic design a 'cultural' production.

Evaluating the creativity of outcomes is often swayed by misconceptions. For instance, creative outcomes are often assumed to be physical artifacts. Even Rhodes (1987) suggests this, defining a creative product as a record of an idea that has manifested into a tangible form. However, a creative product can be more than something that you can touch; it can be an action or a behavior, an imaginative or playful approach to solving a problem, or a concrete object or idea (Runco, 2014; Mayer, 1999). As another example, particular activities and talents (such as art) are widely considered to have a claim on creative outcomes (Halpern, 2003). However, in reality anyone is capable of generating a creative product (Kaufman and Beghetto, 2009).

Teaching and researching in the field of creativity has fostered a broad understanding of this topic. Assessing the creativity of people, processes, and things is both imaginable and achievable. Evaluating the creativity of the exploratory steps (process) that one takes to move towards a solution is arguably the hardest to quantify. However, measuring creative skill (thinking) is fairly straightforward. Creative thinking is flexible; it can be developed through exercises and practice (Felsman, Gunawardena and Seifert, 2020; Scott, Leritz, and Mumford, 2004), and it can be taught (Hokanson, 2007). In other words, students can be trained to think more originally, to improve their fluency of ideas, to develop the ability to engage multiple viewpoints, and to develop details that enrich an idea.

So, what are the challenges of training college students, besides lacking curricula to do so? Johnson and Jablokow (2019) suggest that the students themselves could be a challenge; their cultural backgrounds have a strong influence on how they perceive creativity. However, their research suggests that creativity-related learning experiences that are carefully designed can intercept apathetic perceptions of creative abilities and

actually enhance student performance of these skills. Similarly, Chen and Yu-Jung (2019) suggests that students productive potential can be liberated through training, particularly by increasing their *innovative* creativity, which is the ability to produce new ideas that do not necessarily align with an existing cultural paradigm.

The stakes are high for overcoming the barriers and providing students with opportunities to enhance their creative thinking skills. Those who receive creativity training in college are more attractive to employers, but also benefit from the lasting effects of their enhanced skills (Martz, Hughes, and Braun, 2017; Im, Hokanson and Johnson, 2015; Scott, Leritz, and Mumford, 2004). Simply put, providing students with creativity training makes them more intent on *behaving* in an innovative way (Hidayat, 2019), and that is likely to enhance their experiences in ways beyond academics and employment.

The next section describes a design course driven by the notion of 'different' that provides creativity training for college students and results in enhancing their creative abilities.

4. Designed Around Different, Designed for Change

Creative Problem Solving (CPS) is a design course that is designed to foster creative abilities. The essential primer for course is 'do something different' (DSD), facilitated through a series of challenge-based assignments (i.e., eat something different). The DSD method is fitting for a couple reasons. First, in their quest towards designing unique solutions, the students are forced to define the contextual meaning of each challenge, and to question how cultural, social, and personal norms limit their ideas. This facilitates a more meaningful experience while helping students understand the role of creativity and innovation in their own work and in other disciplines. The course also integrates peer evaluations to encourage originality among the local group and to reveal alternative perspectives. Second, just simply asking a student to generate a solution that is different is shown to foster more creative outcomes (Mumford et al., 2020).

The broader goal of the course is to create lasting, permanent, and integrated connections between the student's personal life, their own creativity, and their field(s) of study. Thus, CPS is grounded in a generative approach to learning which encourages the students to be the author of their explorations. This approach is believed to foster creative skills that are more eminent (Yang and Cheng, 2010). The generative explorations challenge students to identify and change their own cultural, habitual, and normal patterns of behavior and also to appreciate the relationship of these variables to individual creativity. DSDs allow students to develop creative ability, but also encourage them to understand creativity as a social and cultural construct. For instance, if they are challenged to 'eat different,' they must first consider how norms influence what and how they (or others) usually eat, and also how those influences limit their ability to conceptualize novel solutions. This process typically challenges them to also deconstruct the concept of focus. For instance, what does eat mean, or does it mean to eat?

As a means to break free from normative practices to arrive at something truly new, the course structure consistently guides them through strategies that allow the students to both practice and apply their creative abilities. The students establish that there are a ridiculous number of possibilities (fluency), are pushed to approach and define the simple problem in unusual ways (originality), consider a wide range of perspectives that go beyond just understanding and experience of the topic (flexibility), and to embellish their ideas with a range of details that change or enhance the meaning of topic (elaboration).

Developing ideas that are truly unique and new require students to think beyond immediate or familiar contexts. CPS is built around the assumption that student behavior, habits and thinking are largely paralyzed by cultural, social, and personal norms. While an individual may be regarded as 'creative,' it may be because they live within a society or family that has particular limits. Thus, it is important that the students are guided to define, analyze, question, and deconstruct the contexts that define normal practices and circumstances as they approach the DSD challenges. And because 'different' is subject to what one knows or understands, the students must convey their exploration and outcomes to others for peer review and in-class discourse.

Creativity in CPS means debuting an idea to a world beyond a closed ecosystem of immediate experiences and knowledge; students are required to complete most of their assignments within the public sphere to fully engage in a rich exploration that engages others. The resulting explorations are often wild, eye-opening adventures. They can be both funny and serious, which means that they can also take people by surprise. In some extreme instances, the presentation of a DSD might require a trigger warning. That said, the explorations do have imitations. DSDs are limited by health, safety, legal, and economic concerns that protect the students and others. But these limitations also implore design constraints that are important for fostering creative thought and actions (Beghetto, 2019), and making the creative process less intimidating for students (Mumford et al., 2020).

Examples of the DSDs are difficult to capture in a paper as they are submitted as video files. However, stills from the videos and student reflections are able to depict the rich nature of the studies and the potential each DSD has to be a transformative learning experience. Figure 1 shows an exploration from DSD Take, in which one student reflected on the contemporary relevance of a primitive idea: taking from the environment. The student developed their idea into a field experience of collecting what they could forage from their immediate neighborhood and considering its usefulness to someone in need. They shared the following reflection:

> *This does point to how difficult it is to be a person… you know, if you do not have capital (social or otherwise). You still have to live like a human would have lived back many years ago but without the capability to trade with another person or to receive a gift from another person. You're basically left foraging in your environment which is impossible to do… you can't survive on your own without another person without taking something.*

Figure 3. Snapshots from the result of one student's DSD Take in which they reflect on contemporary relevance of a primitive idea: taking from the environment.

Another example that demonstrates the interpretive potential of the challenges is from DSD Make where a student gathered their friends for an unusual 'making' activity with clay (see Figure 2a). She challenged them to form the clay into difficult concepts to depict such as wealth, beauty, and fear and then talk through the meaning of their creations. The peers who reviewed this DSD reflected on its power to reveal insight about those you think you already know, and its potential as a therapy activity and unique conversation starter.

Figure 2. a) Stills from the result of one student's DSD Break in which they challenged their friends an impossible task: to 'make' things that cannot really be made out of clay such as wealth, beauty, and fear (left). b) Stills from a student's exploration interviewing people with questions that relate to the work of a parent (right).

Students often develop the DSDs into opportunities for drawing public awareness to an issue or concept. The example in Figure 2b shows a student who used the DSD Break challenge to interview strangers about work conditions. The participants did not know that the questions related directly to the work of a parent. Some questions included, "Would you work for 24 hours, seven days a week for free?" and, "Would you work in a job where the number of team members increase but instead of decreasing the stress of having more people to help you work, it would actually increase the stress?" and, "Would you continue to do a job if there were no upper mobility in the company or opportunity for promotion?" After revealing that they were describing a parent's work, she then asked her participants if they felt that parents needed a break. This yielded surprising

reactions from the participants (some of whom immediately after called their parents) and rich discussions. In their reflection the student wrote, “Millions of people perform these jobs that no one wants to do in this interview. They do it for free because of love, care, and support. They need a break!”
Creative Problem Solving also challenges students to apply their training to collaborate on a cross-disciplinary project. The projects range from developing elaborate material-functional designs such as Rube Goldberg machines to design interventions for wicked problems. Recent projects from the latter include the Consumption Clock which is an analog proposal for intercepting excessive use of social media, the vFume smartphone plug-in device which allows consumers to detect VOCs in textiles, and The Curve which suggests a design and access system for pop-up bio hubs on college campuses to support the mental health of students (see Figure 3). These projects demonstrate how the DSDs provide the preparation that students need to realize their potential as change agents.

Figure 3. The Consumption Clock (left), the vFume (middle), and The Curve (right).

Generating new ideas is a skill that can be used to develop a project of any type or size, but it must be developed through *practice*. Practice requires willingness to broaden how one thinks; to question norms, to reexamining habits, to encourage and embrace unique viewports, to value the findings that emerge from individual explorations, and to take risks to express ideas beyond personal bubbles. Dedicated practice increases students’ aptitude and frequency to engage in divergent thinking and to develop original ideas. Therefore, in addition to the practice that students receive from the DSD challenges, the course also introduces students to classic and new techniques for creative practice and has students exercise these techniques in class daily.

5. Analysis of Nine Courses

Creative Problem-Solving (CPS) is designed to improve the creative abilities of students. Thus, the course utilizes instrumentation to measure the creative ability of students at the beginning *and* end of the course. The Torrance Test of Creative Thinking (TTCT; Torrance, 1988) has been the primary method of assessment to evaluate the success of the course for all offerings between 2014 and 2019 and has been important for substantiating the value of the course to learners. The following section presents the findings that emerged by analysing the data from nine different offerings of the course.

5.1. Description of Sample

The data for this study was collected from students who were enrolled in nine different CPS courses between 2016 and 2019, yielding a large sample size (n=445). The nine courses were taught by two instructors who co-designed the course, and thus approached teaching it with the same structure and methodology. The creative ability of the students in all nine courses were assessed at the beginning and end of the course using the TTC. The TTCT was professionally scored by the Scholastic Testing Service Incorporated (the instrument’s publisher), providing a high level of reliability. The TTCT score reports include individual scores for performance and provide comparisons to standard scores, and rankings among the national percentile for grade (college) and local percentile (class cohort). The reports also include attributes of the students such as age and gender. There are two versions of the TTCT available: verbal and figural. The verbal version is a series of six exercises that spur written responses in periods of five to ten minutes, and it measures three dimensions: originality, fluency, and flexibility. The figural version is a series of three exercises that implore drawing, each completed in ten minutes for a total test of thirty minutes. It measures five dimensions: originality, fluency, elaboration, titles, and resistance to premature closure (shortened in this article as ‘closure’). Since 2014, both have been used among the two instructors of the course at their discretion. Three of the nine courses analyzed in this

study (n=124) used the *figural* version to measure the change in ability and the remaining three courses used the *verbal* version (n=321). Utilizing both versions limited the dimensions that could be analyzed across the entire sample. The two common measurements between the two versions are limited to originality and fluency.

Creative Problem-Solving has collected sufficient data to analyze how the design course has impacted the skills of the students. The analysis below substantiates how the abilities of students increased after taking the course. The sample is analyzed as a whole and also individually for each of the nine courses.

5.2. Distribution of Standard Scores for the Entire Sample

The creative abilities of students increase after taking Creative Problem-Solving. This is evidenced by the distribution of standard scores for the entire sample which indicate that fewer students have low scores after taking the course. Figure 4 illustrates the distribution of scores for test A (pre-test) and test B (posttest) for the dimensions of fluency, originality, flexibility, elaboration, titles, and closure. The plots do not capture data about students who experienced lower scores after taking the course. Thus, statistical analyses in the following sections are necessary to establish the statistical significance of these changes.

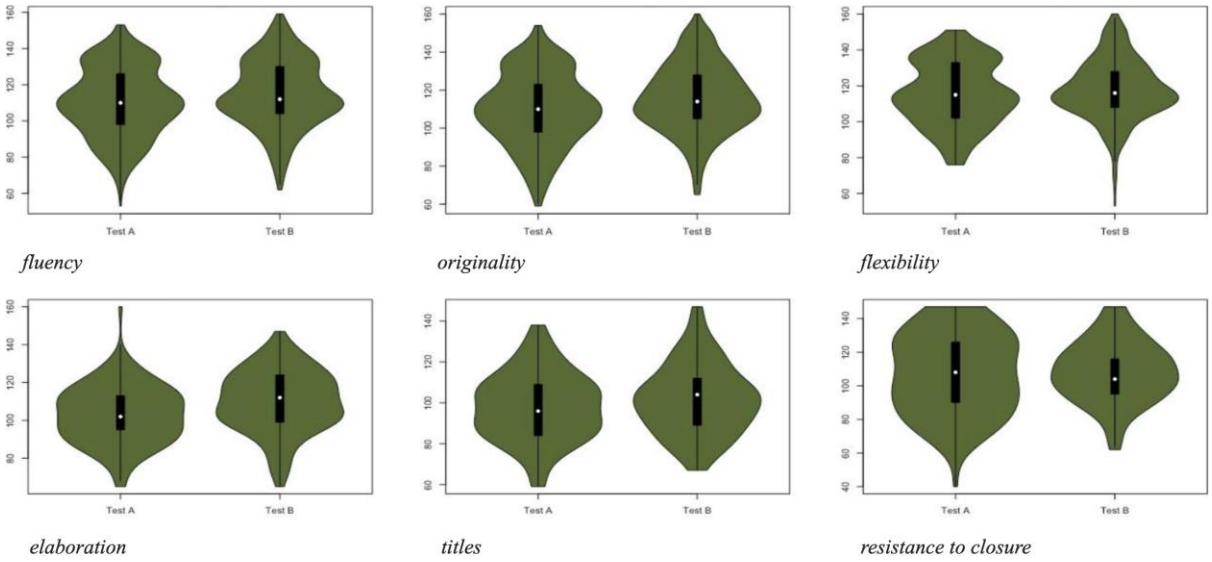

Figure 4. Distribution of standard scores for six dimensions of creative ability after taking CPS.

5.3. Significant Changes in the Standard Score and National Percentile for Each Course

The verbal TTCT assessed the changes for six of the courses and the figural version assessed the other three. The versions differ slightly. The verbal test measures originality, fluency, and flexibility, and the figural test measures originality, fluency, elaboration, titles, and closure. Most of the classes were in-person, but three were online (an attribute that is not explored in this particular study). Performing paired t-tests reveal the significance of changes in standard scores (Table 1) and national percentile (Table 2) for each individual course. The data demonstrates that there are significant increases in particular dimensions of creative abilities across courses.

The analysis of each individual course suggests conclusions about the learning gains from the course, but also reveal potential discrepancies among the different versions of the TTCT. First, the standard score and national percentile of originality for students in the in-person class increases with 95%+ certainty, despite which TTCT version is used to test the change. Second, the standard scores and national percentile for fluency increase with 99% certainty for the in-person courses, but for only those that use the verbal TTCT to assess the change. Some additional thematic gains are identified in each version of the TTCT. The verbal TTCT indicates a pattern of increased standard scores for flexibility (95% certainty). And the figural TTCT indicates a pattern of increased standard scores and national percentile for titles (99% certainty) and a pattern of increased standard scores for closure (with 95%+ confidence).

There are limitations to what can be learned from the above analysis. In statistics, sample size is important for determining correlations. This study aims to know if there is statistical significance to the gains in ability that are measured from taking Creative Problem Solving. For this reason, the final analysis clusters the TTCT data together to perform paired t-tests. The final analysis resolves if the changes are in fact significant for the

population of students who have taken the course.

Table 1. Significance of changes in the standard score for each course in Creative Problem Solving.

TTCT	Year	Dimension	Decrease	Unsure	Increase (% confidence)		
					90%	95%	99%
Verbal	2016	*fluency*					x
		originality					x
		flexibility				x	
	2017	*fluency*					x
		originality					x
		flexibility				x	
	2017 [OL]	*fluency*		x			
		originality		x			
		flexibility		x			
	2018	*fluency*					x
		originality			x		
		flexibility					x
	2019	*fluency*					x
		originality				x	
		flexibility				x	
	2019 [OL]	*fluency*	x				
		originality	x				
		flexibility	x				
Figural	2018	*fluency*				x	
		originality					x
		elaboration		x			
		titles					x
		closure					x
	2018 [OL]	*fluency*					x
		originality					x
		elaboration					x
		titles				x	
		closure				x	
	2019	*fluency*		x			
		originality					x
		elaboration		x			
		titles					x
		closure				x	

[OL] online course

Table2. Significance of changes in the national percentile for each course in Creative Problem Solving.

TTCT	Year	Dimension	Decrease	Unsure	Increase (% confidence)		
					90%	95%	99%
Verbal	2016	*fluency*					x
		originality					x
		flexibility				x	
	2017	*fluency*					x
		originality					x
		flexibility					x
	2017 [OL]	*fluency*		x			
		originality		x			
		flexibility			x		
	2018	*fluency*					x
		originality				x	
		flexibility					x
	2019	*fluency*					x
		originality					x
		flexibility		x			
	2019 [OL]	*fluency*	x				
		originality	x				
		flexibility	x				
Figural	2018	*fluency*			x		
		originality					x
		elaboration		x			
		titles					x
		closure				x	
	2018 [OL]	*fluency*					x
		originality					x
		elaboration					x
		titles				x	
		closure		x			
	2019	*fluency*		x			
		originality					x
		elaboration		x			
		titles					x
		closure				x	

[OL] online course

5.4. Significant Changes in the Standard Scores for the Entire Sample

Paired t-tests of the standard score for each dimension determine if there are significant increases or decreases in creative ability after taking the course, or if the changes are statistically uncertain. The level of significance is often expressed as a p-value between 0 and 1. The smaller the p-value, the stronger the evidence that the x variable can influence the y variable. For the purpose and hypotheses of this study, a low p-value ($p \leq 0.05$) indicates statistically significant evidence that the course results in increasing the creative

ability of students. The results are summarized in Table 3.

Table 3. The results of paired t-test modeling to determine if the increase in standard scores for six dimensions of creative ability is significant after taking Creative Problem Solving (when the alternative hypothesis is that the true difference in mean is not equal to 0).

Dimension	p-value	conclusion
Fluency	5.39e-08 [a]	increase
Originality	9.598e-12 [a]	increase
Flexibility	*0.0195* [b]	*increase*
Elaboration	1.419e-05 [a]	increase
Titles	0.05585	can't be sure
Closure	0.522	can't be sure

Significance codes: [a] $p < .001$ [b] $p < .05$

The changes in all dimensions of creative ability (except one) are significant. The standard scores for fluency and originality (n=445), and elaboration (n=124) increase with 99% certainty after taking the course. The standard scores for flexibility (n=321) increase with 95% certainty. The standard scores in titles (n=124) increase with 90% certainty after taking the course. On the other hand, there is no statistical evidence that the course results in an increase or decrease in standard scores for closure; it is uncertain that the course influences this dimension.

5.5. Summary of Analysis

Three analyses confirm that students who take Creative Problem-Solving experience increases in creative ability. Depending on the inquiry asked of the data, different conclusions are drawn. When the entire sample is modeled to simply show the before and after distribution of scores, it is visually and mathematically resolute that the standard scores for all dimensions are increased; there are fewer low scores at the end of the course than there are at the beginning. However, this method has limitations; because the data is grouped as a whole it does not reflect the individual circumstances in which scores were worsened. As a means to address the role of individual scores, two additional steps of analysis are explored.

As an initial extensive analysis, changes in the six dimensions of creative ability are examined for each individual course. The analysis reveals thematic gains per course, particularly for those that are taught in-person. The increase in standard scores and national percentile of originality and fluency of students who take the course is significant. For fluency, the data is more suggestive when the changes per dimensions are measured using the verbal TTCT. However, the gains in originality are consistent across both versions of the test. The analysis of the individual courses reveals other themes as well; the standard scores for flexibility increase for the majority of the courses as well as the standard scores and national percentile for both titles and closure. The evidence does not suggest that changes in elaboration are thematically significant when comparing the individual courses.

The nine courses were offered independently, at different times and from different instructors. However, when the standard scores for each of the six dimensions are combined (as if every student is taking the same course at the same time) it suggests that the increases in the scores for fluency, originality, and elaboration are the *notably* significant (with 99% certainty or $p < .001$) and that flexibility increases are significant (with 95% certainty or $p < .05$). While the analysis suggests that the scores for titles increase, the certainty is just shy of the typical threshold ($p \leq 0.05$).

In summary, the most significant gains from taking the course are evidenced by increases of originality and fluency. Creative Problem-Solving improves a student's ability to come up with different ideas, and a lot of ideas. The results and their limitations are discussed below.

6. Discussion

6.1. Creative Problem-Solving Increases Fluency and Originality

The results presented in this article suggest that the creative abilities of students are significantly increased by taking Creative Problem Solving (CPS). The course specifically increases student originality and fluency of ideas.

This is consistent with other researchers, especially those who have implementing unique teaching methodologies that foster exercising particular dimensions of thinking. Felsman, Gunawardena and Seifert (2020) found that regular improvisation exercises result in "relative gains in fluency… and originality." (p. 6). And this is fantastic for college students as the benefits go beyond college. The increased skills make them more likely to execute creative processes in their work and will also make them more likely to use the critique of their work (and their errors) as a launchpad for improvement (Mumford et al., 2020). Also, improved fluency increases the chance that students will arrive at more novel answers (Dippo and Kudrowitz, 2013). This is exactly what the workforce needs.

6.2. Successful Aspects of the Design Course

It is important to point out that this article does not present evidence for *why* Creative Problem-Solving (CPS) successfully enhances the creative ability of students. Based on the review of related literature, one might assume that the success relates to repeat exposure to creative thinking strategies and exercises. Indeed, the students practice a variety of thinking strategies as warm-up exercises at the beginning of each class. However, these opportunities are limited to intermittent course sessions twice a week. Perhaps there is something more about the design course that encourages students to avidly engage their creative skills training beyond the scope of classwork. Or, perhaps there is something about the assignments that encourage students to diligently engage an iterative process of working towards a solution, providing more opportunities to practice and develop fluency, originality, flexibility, and elaboration.

The 'do something different' challenges are the heart of the course, and they have distinct characteristics that might explain why methodologically they are especially fitting for creativity training. These characteristics are further discussed below. These are discussed below.

Defining the nature of a problem can impact whether or not a problem solver arrives at a creative solution. Some problem solvers may not even understand that a problem *warrants* a creative solution. Therefore, merely suggesting that particular problem is a creative opportunity will improve the chance of a creative solution (Mumford et al., 2020). This is a key characteristic of the Do Something Different challenges. As the name applies, the DSDs prompt students to strive for something new, unique, and novel. The sheer name of the challenge is a primer for students to realize that there is an opportunity to develop something new and novel, either for others or for themselves. And this is true even though the DSD challenges are extremely simple.

Constraints are commonly mis-represented to limit one's creativity. It is true that creative work can be squelched when constraints are too controlling or too numerous (Glăveanu et al., 2019). However, constraints can provide valuable support when there is also a tolerance for unplanned learning moments. The creative thinking and actions of students are facilitated when students can engage with a level of 'structured uncertainty' (Beghetto, 2019, p. 34) as they navigate guiding constraints. Allowing students to engage productively with this uncertainty requires instructors to resist predetermining four elements of a task: problem, process, outcome, and criteria of a task. The DSDs set general criteria for students so they know what is expected of them. For instance, one criterion is that students identify and challenge the norms and cognitive biases that are limiting their DSD, as this is shown to improve the quality of creative solutions (Todd et al., 2019). Also, the students are provided workshops that teach them a wide range of ideation strategies. Though students are not required to implement specific strategies, they are encouraged to use them to engage a richer process but not to control it. However, defining the problem, cultivating the idea, designing how the idea will be put into action, and analysing the meaning behind the explorations are left completely open for the students to develop. In this way, the DSDs are designed as unplanned lessons that "remove the ceiling" of possibilities for what students might do (Beghetto, 2019, p. 36).

To some students, the DSD challenges are laughably simple (i.e., eat different). However, the simple problems are familiar, approachable, and non-intimidating and allow the students to successfully identify and explore a breath of contexts that surround them (both in and outside of their own domains and norms). In turn, defining the complexities and constraints as a means to develop their work become tangible and even rewarding practices that the students wholeheartedly engage in. And placing themselves into the problem and defining its contextual meaning and perspective (self and other) make each DSDs a 'sociocultural act' which elevates the connection between their learning and creativity (Glăveanu, 2015). Some might argue that these sociocultural acts are the heart of generative learning. Hokanson and Nyboer (2017) summarize that generative learning is key to a creative problem-solving course because "making and creating solutions involves learners cognitively and deeply."

A student will understandably label a DSD challenge as 'boring' if they lack investment or interest in it, and they may feel unmotivated to devise an exciting solution if they are that disengaged. Life experiences suggest

that this is a logical concept. However, research supports this as well. Investment Theory (Sternberg and Lubart, 1995) suggests that creativity is driven by a deep, personal degree of motivation. Kaufman and Beghetto define creativity as a special type of creativity among the 4C model. Dubbed as 'mini-c,' these creative acts involve personally meaningful experiences or those that are personally novel. The relationship of mini-c to even online creative problem-solving courses with DSD challenges is observable. By interviewing students enrolled in the massive, international online version of this course, Lawrence and Hokanson (2016) found that the students related personal understandings to the development of their DSD solutions which lead to experiences they described as 'life-changing' beyond the scope of ordinary student learning outcomes. The DSDs prime students to be invested by encouraging autonomous, creative adventures that reflect on personal experiences and knowledge. And the students are prompted to question the role that those experiences have in channeling particular constructs of their behavior and thinking. This keeps them engaged, and it likely keeps them actively ideating and elaborating (and thus avidly exercising skills that increase their creative ability). Research suggests that creativity is eminent when students are affirmed of their creative abilities but also when they are the authors of their own ideas and solutions (Yang and Cheng, 2010). And Mumford et al. (2020) suggest that when people reflect on past experience it results in more creative problem solutions. These are essential attributes of the CPS course methodology. Students are asked to take a simple idea, to consider their relationship with the context, to define the norms that control or appropriate what usually happens, to ask what should happen, and to embrace an exploration that moves outside of the paradigm they know.

Several design courses may do all of the things outlined above. Surly, instructors from all disciplines ask students to reframe problems and question the contexts that surround ideas. However, the course evaluations associated with this class suggest that Creative Problem Solving is a unique course that is not easy compared to others (both within and outside of design), and that students attribute the gains they made in their creative abilities to the personal connections they made with their design solutions. Some students describe the DSDs as the most unusual assignments they have in college, and that often the challenges didn't feel like something that they could get credit for in school. Other students describe them as engaging and fun, and others as serious and deeply meaningful. Others describe the DSDs as the most important experiences they had as learners, that they wish they could take the course again, and that all students should take it too. And consistently, students shared how the course changed their life in surprising ways.

6.3. Limitations

The size of this study is favorable for performing analyses that conclude how the Creative Problem-Solving enhances the thinking abilities of learners. While there are limitations that may influence the results, they present opportunities to inspire exciting and important future studies.

First, the nine courses analyzed in this study are taught by two instructors at two different institutions who vary in teaching experience and general demographics (age, gender, etc.). While the two instructors approach teaching CPS in the same way and use the same protocols and methods, it cannot be ignored that instruction matters -- Who teaches, how they teach, where they teach, and unique dynamics of how one interacts or communicates with students.

Second, the courses vary in delivery. Three of the nine are online which means that the peer review experiences, daily exercises, and discussions are administered in a digital, primarily asynchronous environment. The online courses meet twice in person; at the beginning and the end of the course to take the TTCT. The courses protocols and methods are identical to the in-person course, but it is well documented that online instruction is perceived differently by students who crave social, in-person interactions. Students who felt disengaged because of the online delivery may have had an impact on their engagement with the course challenges and peer reviews. This might explain the disparity of results observed in Tables 1 and 2; in one case the creative ability in all dimensions measured decreased after taking the course. This is an area for further study; how does the delivery of the course influence the ability gains that correlate with the course.

Third, the version of the TTCT vary from course to course. This variance is the results of choosing one test of the other due to funding (one version is considerably less expensive), but also the choice to use the figural for populations that have more international students (to eliminate language barriers). Because the versions varied, this means that four of the dimensions (flexibility, elaboration, titles and closure) are impossible to statistically model across the *entire* sample of data. The large sample size of n=445 is beneficial for analysing the dimensions that are common to both versions of the test: originality and fluency. Future studies might expand the sample size to discover other additional conclusions about the other dimensions. Also, future studies might consider using one version of the TTCT.

Fourth, this study concludes that fluency and originality significantly increase after taking the course. However,

this study does not control the influence that other academic experiences and life in general have on students. It is possible that influencing factors beyond this course are related to the increase in these two abilities. Finally, performing a regression analysis to determine the attributes that influence the gains in ability would be a powerful extension of this research. International status of students, a student's year of study, and even the peer review scores for each DSD are all possible influencing variables. However, if the goal is to close the creativity gap between higher education and the workforce, the authors suggest that future work determine which disciplines experience the most substantial gains from the course. This will assist higher education programs with honing the skills training that they either integrate into curricula or require.

7. Conclusion

Considering the importance of creative ability to organizations who want to be competitive and relevant both today and tomorrow, creativity training is fundamental to college curriculum. This article presents findings that suggest that Creative Problem Solving significantly increases the ability to come up with more ideas, and different ideas. It may take time for creativity training to gain approval as a required course in college. However, our hope is that instructors from all disciplines find inspiration from this article to design opportunities for students to exercise and develop their creative abilities. As a final and related note, if colleges are to take responsibility in generating a more creative workforce, they must also acknowledge the role of faculty. Training that increases the creative abilities of instructors will empower them with the skills, strategies, and knowledge they need to foster the creative growth of their students.

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