Using Computer Game Software in a First-Year Seminar and its Effects on Students' Creative Self-Efficacy, Creative Personal Identity, and Insight Problem Solving Abilities

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Abstract

This article presents an experimental first-year seminar that uses game-based learning to develop the creative problem-solving abilities of first-year college students at a mid-sized university. A discussion on how the computer game, *The Witness*, was incorporated into the first-year seminar is given along with an overview of teaching practices. An exploratory study was conducted that tracked students' personal beliefs about their creative abilities and identities along with their performance completing a series of insight problems that have unexpected solutions. The quantitative data that was collected indicates that students' confidence in their creative problem-solving abilities increased during the course of the semester, while their beliefs regarding their creative personal identity decreased slightly. The results of this initial investigation are analyzed and discussed and future research directions for conducting a more significant study are proposed.

Introduction

How do first-year undergraduate students view themselves during the first year of college? In what ways do these views affect their ability to succeed within academia? Investigators have been interested in understanding how students' beliefs about themselves affect their success, especially during the first year of college (Chemers et al., 2001). Some educators have been particularly interested in developing the self-efficacy of first-year seminar (FYS) students (Hanson, 2019). While research has been conducted on understanding how first-year students view themselves *academically*, the purpose of this investigation is to better understand how first-year students view themselves *creatively.*

Recent studies from technology companies and professional associations have indicated that "soft skills" such as "creativity" and "problem solving" are highly sought after by employers within STEM fields (Society for Human Resource Management, 2020; Adobe, 2018). If we seek to address these particular skills, then a natural question for college educators to ask is *what kinds of experiences can we provide students to help them exercise, develop, and become more confident in their own abilities to creatively solve complex problems*? My goal in this investigation was to generate and examine an example of such an experience that is aimed toward first-year college students.

This paper presents an initial exploratory study on a first-year seminar aimed at developing students' creative self-concept, i.e., developing how students view themselves as creative individuals. To accomplish this, the FYS makes use of digital game-based learning by having students solve puzzles from the computer game called *The Witness* (Thekla, Inc., 2016). This game challenges the player to explore an island

filled with "line puzzles," which must be solved in order to make progress. An interesting aspect to these puzzles is that their rules are never explicitly stated to the player. Instead, the player must first *discover* and then *master* these rules. In addition, this game does not provide a procedure for solving the line puzzles, which means that it is up to the player to create their own strategies for solving them.

To understand the development of students' creative self-concept throughout the course of this FYS, I tracked students' *creative self-efficacy* (CSE) and *creative personal identity* (CPI), which were introduced by Tierney and Farmer (2002) and Jaussi et al. (2007), respectively, to study creativity in the workplace. Additionally, I also wanted to understand how students' "objective" creative problem-solving abilities changed throughout the semester. To do this, I had students solve a set of well-known insight problems found in the current literature (Chu & MacGregor, 2011; Dow & Mayer, 2004). The origins of insight problem solving stem from Gestalt psychology, and various connections between insight and creativity have been noted (Golnabi, 2016; Weisberg, 2006) and relationships between insight problem solving and CSE and CPI have been explored (Karwowski, 2014).

The structure of this paper is as follows. First, a brief literature review is given that provides background on CSE and CPI, insight problem solving, and digital game-based learning. The literature review is followed by a detailed description of the newly created first-year seminar, its learning objectives, and how *The Witness* was used to help develop students' creative problem-solving skills. I then propose two research questions regarding how the seminar affects students' views about their own creative abilities and identities and their "objective" abilities to solve complex problems. Finally, I discuss an initial exploratory study that was conducted to investigate these research questions. More specifically, the study used a pre/post survey to collect quantitative data on how students' CSE, CPI, and insight problem solving abilities changed between the start of the semester and the end. I also used an open-ended questionnaire to collect qualitative data regarding students' personal thoughts and feeling about their ability to problem-solve. I discuss the results of the study, which integrates the quantitative and qualitative data, and propose future avenues of research.

Literature Review

In this section, I provide some background on the psychological and pedagogical concepts that are used in this investigation.

Creative Self-Efficacy and Creative Personal Identity

According to the American Psychological Association (Carey & Forsyth, 2009), "Self-efficacy refers to an individual's belief in his or her capacity to execute behaviors necessary to produce specific performance attainments…Self-efficacy reflects confidence in the ability to exert control over one's own motivation, behavior, and social environment." Academic self-efficacy has been shown to be directly correlated to academic success in the first year of college (Chemers et al., 2001). Consequently, investigators have attempted to understand how educators can improve the self-efficacy of first-year students (Korgan, 2013).

Various forms of self-efficacy have been formulated and investigated. The *creative self-efficacy* (CSE) is the "perceived confidence to creatively perform a particular task" (Beghetto & Karwowski, 2017, p. 3), and has been studied by Tierney and Farmer (2002), Karwowski (2012, 2014, 2015), Beghetto and Karwowski (2017), Karwowski et al. (2018), and Intasao and Hao (2018), among others. Of course, an individual's CSE may not be correlated with their actual ability to creatively perform a task, and there exist several viewpoints among researchers regarding the degree to which CSE predicts actual creativity. The interested reader may refer to Haase et al. (2018) for a meta-analysis of how an individual's reported CSE is related to various measurements of creative performance.

While self-efficacy deals with perceptions of competency, personal identity is the "physical and psychological characteristics not wholly shared with others or making a person (or group) distinctly different from others, and involving a sense of continuity" (Dollinger & Dollinger, 2017, p. 50), and Eric Erikson's study of the development of personal identity was a major component of his life's work. A form of self-identity, called the *creative personal identity* (CPI) is the "belief that creativity is an important element of the individual's functioning" (Karwowski, 2012, p. 549) and has been studied by Jaussi et al. (2007), Karwowski (2012), and Dollinger and Dollinger (2017). The reader is encourged to refer to the book "The Creative Self" which contains an impressive compilation of articles written by various researchers who are studying both CSE and CPI and provides a detailed overview of what is currently known about these concepts (Karwowski & Kaufman, 2017).

The similarities and differences between CSE and CPI have been examined. According to Karwowski (2012), "CSE and CPI are conceptually related, yet not synonymous. CSE deals with the more dynamic perception of one's creative abilities in a specific task or situation, whereas CPI defines the importance of creativity in one's self-definition" (p. 549). It has been shown that both CSE and CPI are related to traits such as intelligence, motivation, self-esteem, and emotional intelligence (Karwowski et al., 2018), while other studies have shown that CSE is more strongly correlated with certain aspects of curiosity, such as stretching and embracing, than CPI is (Karwowski, 2012).

Various mechanisms for quantifying the CSE and CPI have been used in the field of creativity research. For example, Karwowski et al. (2018) developed the *Short Scale for the Creative Self* (SSCS) as a tool for measuring both the CSE and CPI of individuals and has been shown to be both reliable and valid. The SSCS has been used in studies to measure the CSE of secondary school students in Thailand (Intasao & Hao, 2018) and undergraduate students in China (Yang, 2020).

Insight Problem Solving

While CSE and CPI are subjective concepts which can be measured by the SSCS, *insight problems* can be viewed as an objective means of measuring an individual's creative problem-solving abilities. The concept of *insight* is often associated with the "aha!" moment one experiences when discovering a solution to a problem (Golnabi, 2016, p. 28). According to Dow and Mayer (2004), insight problems are "nonroutine problems in which the problem primes an inappropriate solutions procedure that is

familiar to the problem solver. In insight problems the problem solver must overcome the familiar way of looking at the problem and invent a novel approach" (p. 389). The problem below (Figure 1) is a classic example of an insight problem.

Problem: *The triangle shown below points to the top of the page. Show how you can move three circles to point to the bottom of the page.* (Dow & Mayer, 2004, p. 399)

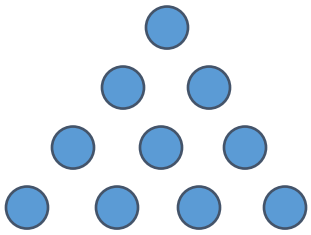

Figure 1. An insight problem

At first glance, one might think that moving all of the circles would be required to solve this problem. However, upon closer inspection, we gain insight into the solution (Figure 2).

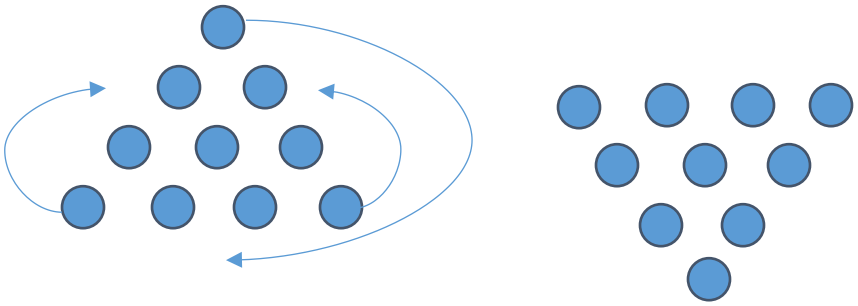

Figure 2. The solution

There has been work examining the relationships between insight and creativity (Golnabi, 2016; Dow & Mayer, 2004), and Karwowski (2014) has studied relationships between creative mindsets and insight problem solving. See Dow and Mayer (2004) and Chu and MacGregor (2011) for more examples of insight problems.

Digital Games and Education

How might we develop students' (subjective and objective) problem-solving abilities? In an article by Granic et al. (2014) titled "The Benefits of Playing Video Games" the authors argue that video games have the potential to positively affect an individual's problem-solving skills and creativity. Recently, the use of digital games in the classroom has become an active area of research within the education community. Digital game-based learning (DGBL) attempts to increase student motivation in the classroom by using games to facilitate learning (Prensky, 2003). As a result, researchers have developed best practices for assessing digital game-based learning (All et al., 2016)

and various meta-studies have been conducted in this area, e.g., Bakan and Bakan (2018) have studied recent trends within the DGBL research community.

The First-Year Seminar

The First-Year Seminar Program at a Mid-Sized University

Mid-Sized University (MSU) requires all incoming first-year students to enroll in First-Year Seminar (FYS). Each FYS has a particular theme (e.g., science fiction and philosophy) and is designed to operate as a learning community of no more than twenty students. The primary goals of FYS are to develop students' writing and critical thinking abilities. A complete description of the FYS program can be found on MSU's first-year seminar webpage.

In the fall of 2019, I taught an experimental FYS at MSU that focuses on how humans identify, reason about, and ultimately solve problems across various disciplines within the arts and sciences. The two primary outcomes of this FYS are (1) to better understand how experts solve problems within their respective fields and (2) to develop an appreciation for one's own creative problem-solving abilities. To achieve the first goal, class discussions on course readings such as *Thinking, Fast and Slow* by Daniel Kahneman, *Range: Why Generalists Triumph in a Specialized World* by David Epstein, and *All Life is Problem Solving* by Karl Popper were assigned. To achieve the second goal, the computer game *The Witness* was used to facilitate "puzzle solving sessions" that students participated in each week.

The Game: The Witness

Released in 2016, *The Witness* is a game that challenges the player to think through and solve puzzles creatively. It is not an "education game" nor was it designed to be used in the classroom. The game's director, Jonathan Blow, explains that *The Witness* behaves as a "metaphor for being a person in the real world just trying to understand 'What is the truth about where we are? Are there investigations we can undergo in games that get us closer to the truth about the world we live in?'" (Peckham, 2016).

The Witness places the player on an island filled with "line puzzles" that must be solved in order to progress. A line puzzle requires the player to draw a line through a maze. Each puzzle has at least one designated starting point (indicated by a large circular "bulb") and at least one ending point (indicated by small semicircle).

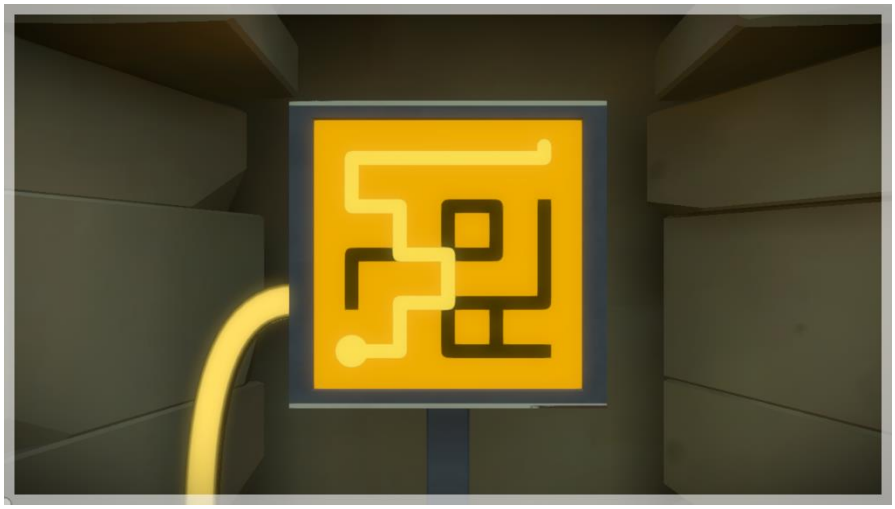

Figure 3. A simple line puzzle

The puzzle in Figure 3 is presented to the player near the beginning of the game in order to teach a foundational rule about all line puzzles: there is a starting and ending point to each line drawn. As the game progresses, the player must interact with more complicated puzzles that impose additional rules. An example of such a puzzle is shown in Figure 4, where the player must draw a line that separates the white and black squares. If the player draws a line that represents an incorrect solution, then the puzzle "panel" emits an error sound and flashes red, as shown in Figure 5.

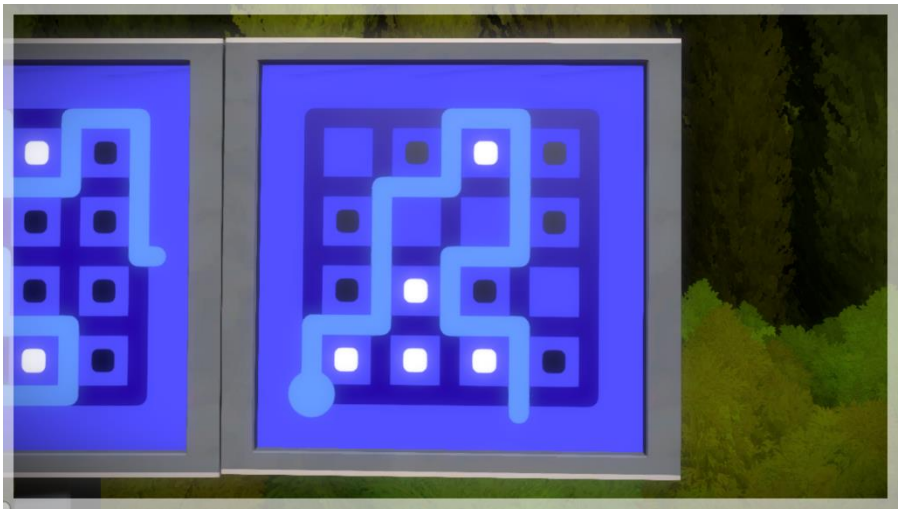

Figure 4. A more complicated puzzle

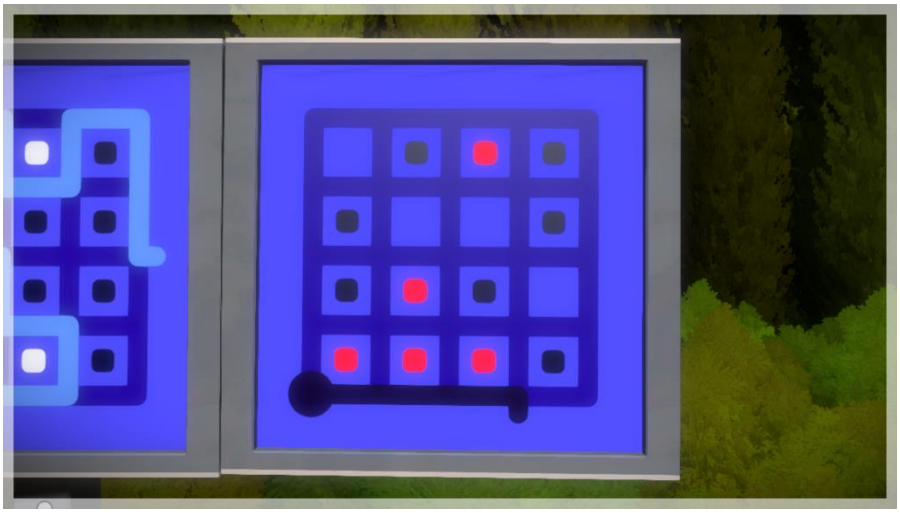

Figure 5. An incorrect solution

A key feature of *The Witness* is that it never explicitly describes any of its rules. The game expects the player to experiment with each type of puzzle in order to derive the rules for themselves. The player, then, must both discover the rules and master them. The puzzles found in the Witness often operate as insight problems. For example, the line puzzle in Figure 6 appears to have no solution. However, the player eventually discovers that the solution is revealed by viewing the puzzle through a wooden grating (Figure 7).

Figure 6. A wooden grating puzzle

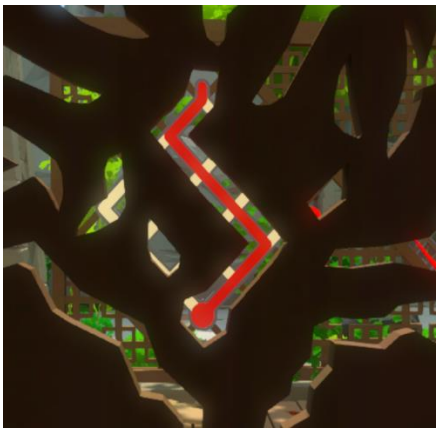

Figure 7. The solution

At this point, the player has established a procedure for solving these kinds of puzzles: *view the puzzle through the wooden grating from a particular perspective to reveal a pathway from the starting point to the ending point.* However, the puzzle shown in Figure 8 disrupts this procedure.

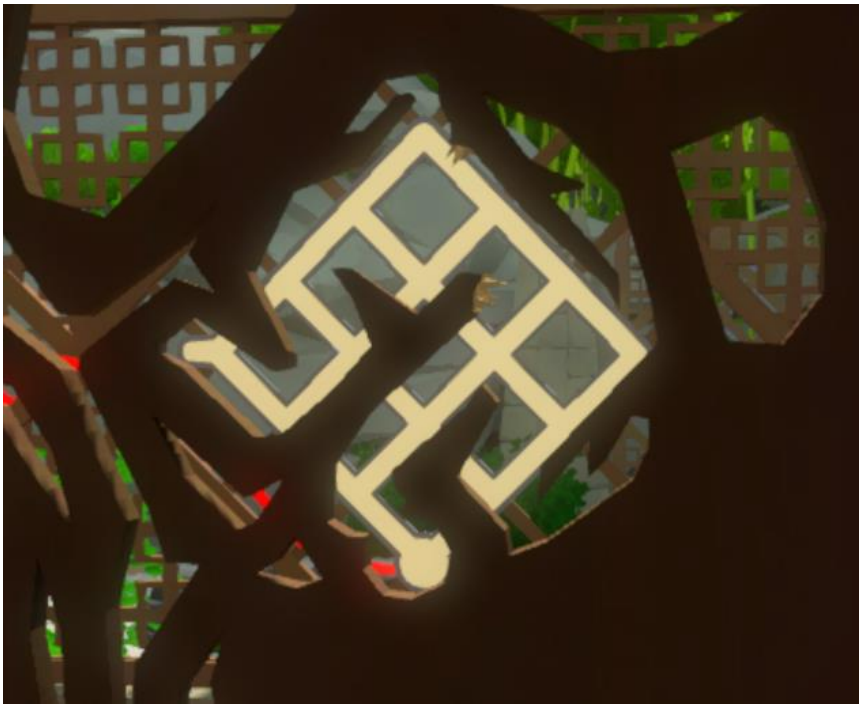

Figure 8. A disruptive grating puzzle

On the first attempt, the player generates a solution that uses the familiar procedure (Figure 9).

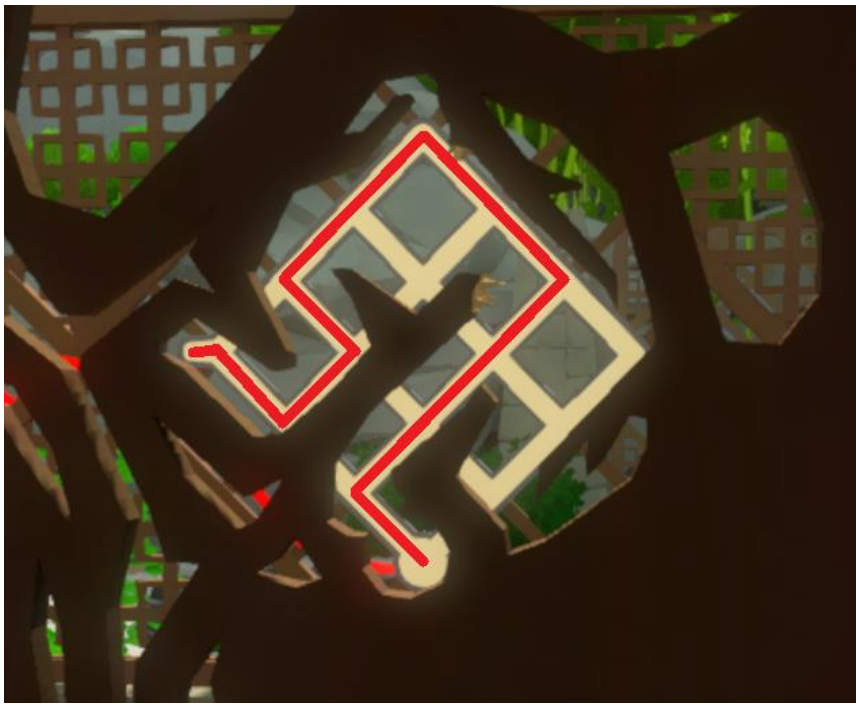

Figure 9. The familiar solution

However, the solution fails. This causes confusion for the player, since it appears that the expected solution procedure does not apply to this puzzle. Upon closer examination, one eventually discovers that the wooden grate is broken in a few areas (Figure 10).

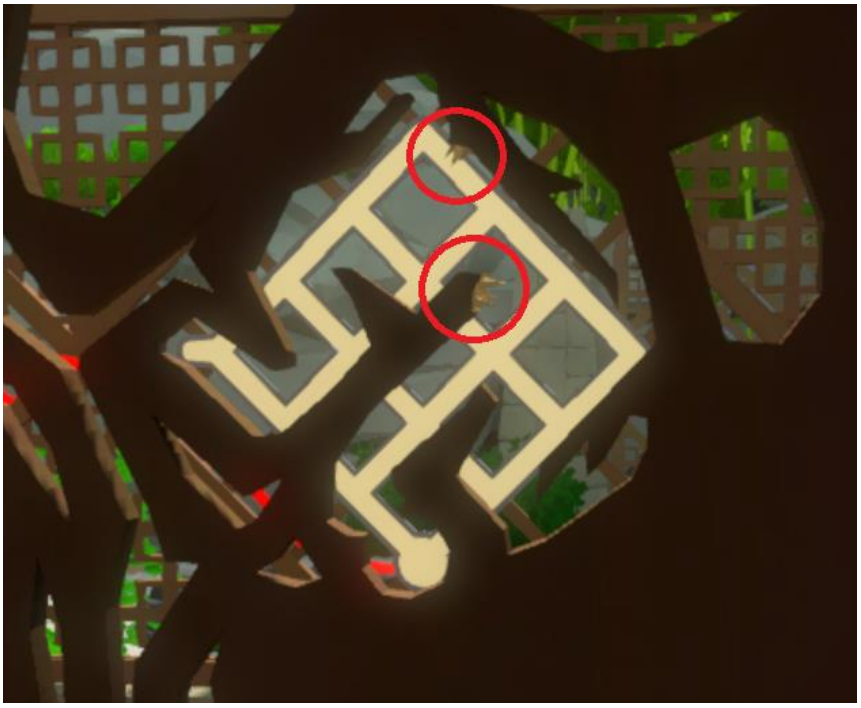

Figure 10. An observation

The observant player will find the the broken pieces of the wooden grate are on the floor (Figure 11).

Figure 11. Another observation

The player then discovers the correct solution by imagining what the grating would look like unbroken (Figure 12).

Figure 12. The correct solution

The solution procedure can now be updated: *view the puzzle through the wooden grating from a particular perspective to reveal a pathway from the starting point to the ending point, keeping in mind that parts of the grating may be broken and will need to be pieced back together.*

Puzzle Solving as a Component of the First-Year Seminar

The first-year seminar met twice a week for 75 minutes each. Our Tuesday meetings were used for discussing the weekly readings, which came from texts such as *Thinking, Fast and Slow* by Daniel Kahneman and *Range: Why Generalists Triumph in a Specialized World* by David Epstein. These readings and discussions helped students to learn about how other people in various fields go about developing problem solving techniques. For example, students read about Gunpei Yokoi, an engineer for Nintendo and the creator of the Gameboy, and his design philosophy which he labeled “lateral thinking with withered technology,” that allowed him to develop toys that were popular and innovative, yet could be mass produced on Nintendo’s limited budget. Other topics discussed included how scientists discover new theories and how humans tend to use heuristics, unconsciously, when reasoning about solutions to problems.

While Tuesdays were dedicated to a more traditional learning experience, our Thursday meetings were more experiential in nature. At the beginning of each Thursday meeting, I would provide students with a URL to a digital “puzzle lab.” These labs would inform the students which puzzles from *The Witness* they would be solving for the day, and it provided them with some minimal guidance regarding the puzzles they would be

interacting with. These labs also included discussion questions, where students would pause the game and discuss some aspect of the puzzles, and writing prompts to help them get started writing about their experiences in a weekly journal. The goal of these labs was to help students become more aware of their own problem-solving abilities and to show them that they are capable of developing new and creative techniques for solving difficult problems.

Balancing Challenge and Optimism. At the start of each lab, students were presented with a new kind of puzzle that they needed to derive the rules for. These puzzles were often simple, since they attempt to teach the player a few of the most basic rules. This caused students to begin the day with a sense of optimism and that all of the puzzles would be easy. However, as the day progressed, the puzzles slowly become more and more complicated. The strategies that students developed to solve the easy puzzles would no longer work with the more challenging puzzles presented to them toward the middle of the lab. This would cause some students to become frustrated and somewhat discouraged. However, once they had solved a particularly difficult puzzle, their optimism would be renewed and their confidence restored. I often saw students giving each other high fives and complimenting one another's role in developing a solution to the puzzle. As the semester progressed, students came to expect that there would be times during each lab when they would become stuck on a particularly difficult puzzle. However, they also became more optimistic that they would eventually be able to solve them, and it was a very rare occurrence when a pair of students could not solve all of the puzzles in the lab before the end of the class. I believe that this balancing of challenge and optimism was extremely important to the development of students' CSE, since they became aware of their ability to creatively problem solve in the face of difficult challenges.

The Instructor's Role in the Classroom. My role during these labs was to provide students with someone to talk to as they experienced both success and failure working through the puzzles. I did not want to provide students with solutions, but I would help them to identify which aspects of the puzzle were giving them trouble. Often times, just helping the struggling student to verbalize the problem they were facing enabled them to realize the solution on their own, giving them a sense of accomplishment. There were other times when I would remind the student of a strategy that they had used to solve a previous puzzle that could be used with the current puzzle. Throughout the semester, the students learned that I would not give away solutions to puzzles but that I was always available to help them talk through the problems they were experiencing. On occasion, this would frustrate some students who wanted to finish the labs as soon as possible, but, ultimately, I believe my attitude on this helped my students to become confident that they were capable of designing creative solutions to problems on their own.

Writing Assignments that Encourage Reflection. Once students had completed all of the puzzles from a particular lab, they were required to write a journal entry about their experience. While I provided some writing prompts at the end of each lab (e.g., "What approaches or techniques did you use to improve your understanding of the puzzle?"), I allowed them to write about any aspect of the lab that they found particularly interesting and worthy of writing about. For example, students would often write precise descriptions of the rules to each puzzle or the strategies they developed

for discovering a particular rule. *The Witness* also includes a light narration on various modes of human thought throughout history. This narration is conveyed through quotations from well-known scientists, philosophers, theologians, artists, and pieces of classic literature. Students would often write about these quotations and speculate as to how they relate to the puzzles they were attempting to solve. While students seemed to prefer playing *The Witness* to writing about it in a journal, I was pleasantly surprised by how insightful many of the journals were. Each entry that students wrote helped me to track their progress toward a more complete understanding of the meaning of the game, and I believe it helped them to become more aware of their own personal development throughout the semester.

By the end of the semester, I realized that these puzzle labs were students' favorite part of the course. Each week, students seemed to look forward to interacting with new puzzles and working together to develop solutions to them. It served as a nice break from a traditional lecture but also as an opportunity to develop confidence in their own problem-solving abilities. In the future, I would like to incorporate more writing during these puzzle labs that students can include in their journal entries.

Research Questions

One of the primary purposes of this first-year seminar is to provide my students opportunities to discover and develop their own problem-solving abilities. I am interested in knowing, then, how does this course affect students' views about their own abilities to creatively problem solve? Also, how does it affect students' "objective" ability to solve challenging problems? To investigate this, I analyzed the creative-self efficacy (CSE) and creative personal identity (CPI) of my students and their ability to solve insight problems. The specific research questions are the following.

- How are students' CSE and CPI affected by participating in this first-year seminar?
- How are student solution scores to eight insight problems affected by the first-year seminar?

To answer these questions, I conducted an exploratory study which involved the students of my FYS.

The Study

The participants of this investigation were 17 students enrolled in the FYS, which I taught in the fall of 2019. With their written permission, I collected quantitative data from them by having them respond to the Short Scale of Creative Self (SSCS) and write solutions to eight well-known insight problems. The Short Scale of Creative Self and eight insight problems were given to students on the first day of class (the pre survey) and again on the last day of class (the post survey), using a different set of eight insight problems. Throughout the semester, I also collected qualitative data from a questionnaire that asked students to write reflections on their experiences playing *The Witness*. I present an overview below of each tool that I used to collect data.

The Short Scale for Creative Self

Karwowski et al. (2018) developed the Short Scale for Creative Self (SSCS) to measure both the CSE and CPI, and is a well-known tool for measuring these concepts. The SSCS consists of 11 items and responses are given using a five-level Likert scale (i.e., definitely not, somewhat not, neither yes or no, somewhat yes, and definitely yes). The questions are shown below.

1. I think I am a creative person.
2. My creativity is important for who I am.
3. I know I can efficiently solve even complicated problems.
4. I trust my creative abilities.
5. My imagination and ingenuity distinguishes me from my friends.
6. Many times I have proved that I can cope with difficult situations.
7. Being a creative person is important to me.
8. I am sure I can deal with problems requiring creative thinking.
9. I am good at proposing original solutions to problems.
10. Creativity is an important part of myself.
11. Ingenuity is a characteristic that is important to me.

Items 3, 4, 5, 6, 8, and 9 measure the CSE and items 1, 2, 7, 10, and 11 measure the CPI.

Karwowski et al. (2018) showed that the CSE and CPI subscales contained within the SSCS have high internal consistency (CSE, $\alpha = 0.83$; CPI, $\alpha = 0.84$). They also showed that the results obtained before and after an eight-month intermission had attenuated correlations of $r = 0.6$ for the CSE subscale and $r = 0.75$ for the CPI subscale. Additionally, the authors found strong correlations between the SSCS and a different scale (Karwowski, 2011) that was previously used for measuring creative self-efficacy (CSE, attenuated $r = 0.55$; CPI, attenuated $r = 0.80$).

Insight Problems

Participants of this investigation were given a set of eight insight problems to solve on the first day of class and a different set of eight insight problems to solve on the last day of class. The insight problems used in this study were borrowed from previous studies by Dow and Mayer (2004) and Chu and MacGregor (2011). Specifically, on the first day of class, students were given the insight problems called “4 Dots,” “Smith Family,” “Divide Figure,” “Zoo,” “Horse Trading,” “Nine Dot,” “Socks” (Dow & Mayer, 2004, pp. 398-402), and a “matchstick arithmetic problem” (Chu & MacGregor, 2011, p. 122). On the last day of class, students were given the insight problems called “Triangle,” “Water Lily,” “Chain,” “Gold Coins,” “Put the Z,” “Frog,” “Next Term,” and “Earth Weight” (Dow & Mayer, 2004, pp. 398-402) One point was awarded for each correct solution and zero points for each incorrect solution, for a total of eight possible points.

Questionnaires

At various points in the semester, students wrote responses to an open-ended questionnaire (given to them as an assignment) that asked them to reflect on their

experiences solving puzzles from *The Witness*. Some of the questions included in this tool were:

- *Discuss the challenges you have encountered when solving puzzles in The Witness.*
- *When you see a new puzzle, do you feel confident that you will eventually solve it? Discuss how you become confident during the process of solving a puzzle.*
- *If you are having difficulty solving a puzzle, what steps do you take to find a correct solution?*
- *Since the start of this first-year seminar, have you become more aware of your own creative problem solving abilities? Do you think you have become a better problem solver? Explain why or why not.*

The purpose of this tool was to get a better understanding of the thoughts and feelings of my students as they encountered progressively more difficult puzzles to solve.

Methodology

A mixed methods approach was used to investigate the research questions stated above. A quantitative analysis was performed on the SCSS scores, which included a global measure of average change from pretest to posttest scores (sample change) and a repeated measures mean comparison (prediction of population change). A repeated measures comparison was performed on the total scores of the insight problems after adjusting them to a standardized z-score. Additionally, the study includes a qualitative analysis of themes presented in students' written responses to the questionnaires in order to triangulate with the pre/post survey results and gain insights into how students are developing their creative self-awareness by participating in the seminar.

Survey Results

After analyzing the data from the pre and post surveys, it was noted that the average of the total change in CSE scores (i.e., the average of the change in combined total scores of questions 3, 4, 5, 6, 8, and 9) increased by 1.53 points (see Table 2) and that the average change in score for each individual CSE question was positive (see Table 1). A paired difference test on the CSE scores revealed a 95% confidence interval of (-0.167, 3.23) (see Table 3).

On the other hand, the average of the total change in CPI scores (i.e., the average of the change in combined total scores of questions 1, 2, 7, 10, and 11) decreased by 0.76 (see Table 2) and the average change in score for each individual CPI question was negative, except for question 11, which was positive (see Table 1). A paired difference test on the CPI scores revealed a 95% confidence interval of (-2.578, 1.049) (see Table 3). We also noted that the average of the total change in all SSCS question scores was 0.76 (see Table 2).

For the insight problems, z-scores were calculated over the total number of points each student earned in the pre and post surveys. This was done in order to account for the possible changes in difficulty between the insight problems from the pre

and post surveys. The average of the changes over all of the individual z-scores from the pre and post surveys was nearly zero.

SSCS Question	Average Change in Score
1	-0.11765
2	-0.23529
3	0.058824
4	0.117647
5	0.352941
6	0.117647
7	-0.29412
8	0.529412
9	0.352941
10	-0.23529
11	0.117647

Table 1. Average Change of SSCS Question Scores

Average of Total Change in CSE Scores	1.529412
Average of Total Change in CPI Scores	-0.76471
Average of Total Change in All SSCS Question Scores	0.764706

Table 2. Change in Average Total CSE and CPI Scores

Table 3. Summary of Pre and Posttest Data for the CSE an CPI

	Pretest Mean	Posttest Mean	Average Mean Difference	95% Confidence Interval of the Difference		*t*	*df*	Significance (*p* value)
				Lower	Upper			
CSE	22.24	23.76	1.53	-0.17	3.23	1.91	16	0.07
CPI	18.12	17.35	-0.77	-2.58	1.05	-0.89	16	0.39
Total	40.35	41.12	0.76	-2.44	3.97	0.50	16	0.62

Discussion of Results

The increase in the average of the total change in CSE scores indicates that students in this sample became more confident in their own creative problem-solving abilities by the end of the semester. On the other hand, there was a decrease in the average of the total change in CPI scores, which indicates that students identified less as creative individuals by the end of the semester. This dichotomy is rather interesting and could be indicative of how CSE differs from CPI. It should be noted that the repeated measures t-test does not support generalizing these findings to the broader student population. However, this may be a consequence of the small sample size, which limits the statistical power of this analysis.

The increase in CSE may be attributed to students learning how to persevere through a puzzle lab. As mentioned above, it was a regular occurrence that students would face significantly more challenging puzzles toward the middle of the lab, and I would often see students visibly frustrated during this time. However, they were almost always able to solve all of the puzzles by the end of each lab. I believe this increased their confidence in their own creative problem-solving abilities, since they realized that, while they would face difficult challenges during each lab, no puzzle was beyond their abilities as long as they were patient and willing to work through them. The following quotations are responses from three of my FYS students to the questionnaires asking them to reflect upon their experiences playing *The Witness*. These quotations indicate that the student has become more aware of and confident in their own problem-solving abilities.

"I have also become aware that I am not the best at being creative and maintaining patience when struggling. I get frustrated when I don't know exactly how to do it, but since the start of the semester I have improved. I have started looking at the situations with an open mind and have begun looking for ideas that I normally wouldn't. The Witness has helped me become a better problem solver by pushing me out of my comfort zone."

"I think I have learned to not give up so quickly and just try. At the beginning of the year if I didn't know the answer right away, I wanted to just give up. But now I want to push through it because I know there is a solution and I can figure it out."

"I feel my problem-solving abilities have ultimately improved. I feel better prepared to attack real world problems keeping these tactics in mind and being persistent and patient when solving a difficult task."

The decrease in CPI indicates that students identified less as creative individuals. A possible explanation for this is that, by the end of their first semester, students were exhausted. Many first-year students at MSU have performed quite well during their high school years and experiencing their first semester of college may have been much more challenging than they would have expected. To succeed, they had to work harder than they did in high school. This lack of "academic ease" may have shaped the way they view themselves creatively: *If learning does not come easily, then I may not be a creative problem solver*. I addressed this issue in a lecture on fast and

slow learning. To understand a difficult problem conceptually, sometimes we need to slow down our thinking, which may take more time than simply identifying a procedure and "mindlessly" executing it.

Ultimately, the data collected shows that students became more confident in their creative problem-solving abilities but identified less as creative individuals. More investigation is needed to understand why this dichotomy exists. Do most first-year students experience an increase in CSE and a decrease in CPI by the end of their first semester? This question could possibly be explored by giving the SSCS to a control group of first-year students who are not enrolled in my FYS and comparing their results with first-year students who are enrolled in my FYS. Also, how might the FYS change in order to increase students' CPI? Can the focus of the course change in order to help students to identify more as creative problem solvers?

As mentioned in the previous section, there was no significant change in student performance on the insight problems that were given on the pre and post surveys. I believe that there are two possible explanations for this. First, it is possible that this FYS does not have a short-term effect on students' general insight problem solving abilities. While the puzzles found in *The Witness* often operate as insight problems, they are quite different than the insight problems found in the current literature (and the ones given on the pre and post surveys). Students may have mastered a particular category of insight problem from *The Witness*, but this does not mean that they have mastered the categories of insight problems provided on the surveys (see (Dow & Mayer, 2004) for a discussion of various categories of insight problems). The following quotation from one of my FYS students suggests a distinction between solving puzzles from *The Witness* and the insight problems given on the pre survey.

"Overall, I think I have been a better problem-solver. I think I've gotten faster at identifying similar problems and applying concepts to get the correct answer. However, most of my improvements are in the form of line/maze-like puzzles, so I am not sure how well it would apply to puzzles similar to what was given to us on a sheet of paper *(or maybe it was a packet?) on the first day of the course."*

The sheet of paper that the student mentions in the quote above is a reference to the insight problems given to students on the pre survey. Second, insight problems have varying degrees of difficulty, and it could be that the problems found on the post survey were more difficult than the ones found on the pre survey. More investigation is needed to better understand how to compare the difficulty of various insight problems in order to create a "fair" pre and post survey.

Future Research

The results of this study indicate a notable increase in the participants CSE scores and a slight decrease in their CPI scores, which is an unexpected, yet interesting, dichotomy that is worth investigating further. Also, it is natural to ask whether the change in these scores was caused by students' participation in the FYS or by their first-year experience in general. Finally, the change in the insight problem scores was nearly zero which indicates that students' "objective" problem-solving abilities did not change during the

course of the semester. Keeping these considerations in mind, the following adjustments to the method of the study may lead to more insightful results.

Obtain a Larger Sample Size

More data is needed in order to generalize the results of this study to the broader student population. The sample size was quite small (n = 17) for the initial offering of this course. However, after offering this course for several more years and combining the data collected from the pre/post surveys, repeating this study will have greater statistical power and the results should be more significant.

Collect Qualitative Data that Compares CSE and CPI

The dichotomy that exists between the CSE and CPI is rather interesting. It may be possible to better understand this by performing a more rigorous qualitative study on students' feelings regarding their ability to creatively problem solve versus their personal identity as a creative problem solver. The development of interview or written essay questions that targets both of these components will need to be developed.

Utilize a Control Group

Collecting additional data from a control group of first-year students who are not in the FYS will provide a better indication as to whether or not these changes to the CSE and CPI are caused by their participation in the FYS or by their first-year college experience in general. This will provide a more accurate indication of the degree to which the FYS affects students' perceptions of their creativity and problem-solving ability.

Develop Fair Insight Problems

The lack of change in students' insight problem scores needs further investigation. Can the puzzles from *The Witness* improve students' general insight problem solving ability, or do these puzzles only train students to solve a particular kind of insight problem? Also, are the insight problems from the pre survey more or less difficult than the ones from the post survey? Developing a more meaningful set of insight problems with comparable difficulties may help to answer these questions.

Conclusion

In this article, I described a first-year seminar that was developed to teach students creative problem solving using the computer game software *The Witness* as a teaching tool. The effectivity of this seminar was analyzed by investigating how students' creative self-efficacy, creative personal identity, and insight problem solving ability changed between the start and end of the semester. The results indicate that students' creative self-efficacy had a notable increase, while their creative personal identity had a slight

decrease. Also, students' performance solving a series of insight problems did not appear to have a significant change. Additionally, I analyzed these survey results and triangulated them with students' written responses to an open-ended questionnaire that asked them to elaborate on their personal thoughts and feelings regarding their ability to creatively problem solve. Finally, avenues for continued research and refinement were proposed and discussed for future iterations of the seminar.

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Ethics Approval: Approval from the Institutional Review Board (IRB) at Drake University was granted before conducting this study.

Consent to Participate: Informed consent was obtained from all individual participants included in the study.

References

Adobe. (2018). *Creative Problem Solving in Schools: Essential Skills Today's Students Need for Tomorrow's Age of Automation.* Retrieved from https://cps.adobeeducate.com/

All, A., Castellar, E. P., & Looy, J. V. (2016). Assessing the effectiveness of digital game-based learning: Best practices. *Computers & Education, 92-93*, 90-103.

Bakan, U., & Bakan, U. (2018). Game-Based Learning Studies in Education Journals: A Systematic Review of Recent Trends. *Actualidades Pedagogicas, 72*, 119-145.

Beghetto, R., & Karwowski, M. (2017). Toward Untangling Creative Self-Beliefs. *The Creative Self: Effect of Beliefs, Self-Efficacy, Mindset, and Identity*, 3-22. Retrieved from http://dx.doi.org/10.1016/B978-0-12-809790-8.00001-7

Carey, M., & Forsyth, A. (2009). *Teaching Tip Sheet: Self-Efficacy*. Retrieved May 15, 2020, from American Psychological Association: https://www.apa.org/pi/aids/resources/education/self-efficacy

Chemers, M., Hu, L.-t., & Garcia, B. (2001). Academic Self-Efficacy and First-Year College Student Performance and Adjustment. *Journal of Educational Psychology, 93*(1), pp. 55-64.

Chu, Y., & MacGregor, J. N. (2011). Human Performance on Insight Problem Solving: A Review. *The Journal of Problem Solving, 3*(2), 119-150.

Dollinger, S., & Dollinger, S. (2017). Creativity and Identity. *The Creative Self: Effects of Beliefs, Self-Efficacy, Mindset, and Identity*, 49-64. Retrieved from http://dx.doi.org/10.1016/B978-0-12-809790-8.00003-0

Dow, G., & Mayer, R. (2004). Teaching Students to Solve Insight Problems: Evidence for Domain Specificity in Creativity Training. *Creativity Research Journal, 16*(4), pp. 389-402. doi:10.1080/10400410409534550

Golnabi, L. (2016). Creativity and Insight in Problem Solving. *Journal of Mathematics Education, 7*(2), 27-29.

Granic, I., Lobel, A., & Engels, R. C. (2014). The benefits of Playing Video Games. *American Psychologist*, 69(1), 66-78.

Haase, J., Hoff, E. V., Hanel H.P., P., & Innes-Ker, A. (2018). A Meta-Analysis of the Relation between Creative Self-Efficacy and Different Creativity Measurements. *Creativity Research Journal, 30*(1), 1-16. doi:https://doi.org/10.1080/10400419.2018.1411436

Hanson, T. L. (2019). Increasing Self-Efficacy of First Year Seminar Students: A Case Study. *Research in Hight Education Journal, 36*, 1-12.

Intasao, N., & Hao, N. (2018). Beliefs About Creativity Influence Creative Performance: The Mediation Effects of Flexibility and Positive Affect. *Frontiers in Psychology, 9*(1810), 1-17. doi:10.3389/fpsyg.2018.01810

Jaussi, K. S., Randel, A. E., & Dionne, S. D. (2007). I am, I Think I Can, and I Do: The Role of Personal Identity, Self-Efficacy, and Cross-Application of Experiences in Creativity at Work. *Creativity Research Journal, 19*(2-3), 247-258. doi:10.1080/10400410701397339

Karwowski, M. (2011). It doesn't hurt to ask…But sometimes it hurts to believe: Polish students' creative self-efficacy and its predictors. *Psychology of Aesthetics, Creativity, and the Arts, 5*, 154-164.

Karwowski, M. (2012). Did Curiosity Kill the Cat? Relationships Between Trait Curiosity, Creative Self-Efficacy and Creative Personal Identity. *Europe's Journal of Psychology, 8(4)*, 547-558.

Karwowski, M. (2014). Creative Mindsets: Measurement, Correlates, Consequences. *Psychology of Aesthetics, Creativity, and the Arts, 8*(1), 62-70.

Karwowski, M. (2015). Development of the Creative Self-Concept. *Creativity, 2*(2), 165-179.

Karwowski, M., & Kaufman, J. C. (Eds.). (2017). *The Creative Self: Effects of Beliefs, Self-Efficacy, Mindset, and Identity.* Elsevier.

Karwowski, M., Lebuda, I., & Wisniewska, E. (2018). Measuring Creative Self-Efficacy and Creative Personal Identity. *The Journal of Creativity and Problem Solving, 28*, pp. 45-57.

Korgan, C. (2013). The Development of Academic Self-Efficacy among First-Year College Students in a Comprehensive Public University. *Higher Education in Review, 10*, pp. 11-37. Retrieved March

17, 2020, from https://www.semanticscholar.org/paper/The-Development-of-Academic-Self-Efficacy-among-in-Korgan/bbc92485326040c6a37216998b424206bd469974

Peckham, M. (2016, June 9). *'The Witness' Creator Jonathan Blow on Science, Language, and Reality*. Retrieved from Time: https://time.com/4355763/the-witness-jonathan-blow-interview/

Prensky, M. (2003). Digital Game-Based Learning. *ACM Computers and Entertainment, 1*(1), 1-4.

Society for Human Resource Management. (2020). *The Global Skills Shortage: Bridging the Talent Gap with Education, Training and Sourcing.* Retrieved from https://www.shrm.org/hr-today/trends-and-forecasting/research-and-surveys/documents/shrm%20skills%20gap%202019.pdf

The Witness (PC Version) [Video Game]. (2016) Thekla, Inc.

Tierney, P., & Farmer, S. M. (2002). Creative self-efficacy: Its potential antecedents and relationship to creative performance. *Academy of Management Journal, 45*(6), 1137-1148.

Weisberg, R. W. (2006). *Creativity: Understanding innovation in problem solving, science, invention, and the arts.* Hoboken, New Jersey: Wiley.

Yang, Y. X. (2020). Hope and creative self-efficacy as sequential mediatros in the relationship between family socioeconomic status and creativity. *Frontiers in Psychology, 11*(438), 1-8.