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A Quantitative Examination of the Impacts of Modeling on Creativity

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ABSTRACT

Modeling has frequently been shown to be a very effective and valuable educational technique. However, it remains underutilized, largely as a result of the common belief among educators that it reduces student creativity. Prior observation has led experts to theorize that modeling has an impact on student creativity, yet there is no agreement on whether modeling helps or hinders creativity, and, so far, there have been no rigorous, quantitative studies done to examine the relationship between modeling and creativity. In an attempt to answer this question, I utilized a novel metric for scoring the creativity of balloon choices made by children ages 3-10 and compared the mean scores of groups with a model to the mean scores of groups without a model. By using a t-test, it was determined that there was no probabilistic basis to determine that modeling has an impact on creativity, thereby going against both sets of established hypotheses. These findings indicate that it is unlikely that creativity has a major impact on creativity if it has an impact at all, thus modeling should likely be more widely utilized in classrooms.

Literature Review

Academic Modeling

Before it is possible to understand how modeling relates to creativity, it is first essential to understand what modeling is, why it is used, and what its limitations are.

According to Abdullahi Salisu, professor of surveying and geo-informatics at the Federal Polytechnic in Bauchi, Nigeria, and Emmanuel Ransom, professor of education at the Federal College of Education in Pankshin, Nigeria (2014), modeling is any point at which a student learns how to complete a task or solve a problem by observation (p. 54). This is most often done when educators demonstrate or provide an example of how a task should be completed, and then prompt the student to do it for themselves. It is important to understand that, in most cases, academic modeling is an explicit explanation of how a task should be done (Coleman, 2020). This gives the student a relatively specific understanding of how a task should be completed.

Why Modeling is Effective

The primary reason educators use modeling as an academic tool is because of its effectiveness. Modeling is effective for a variety of reasons; however, the main one that must be noted is evolutionary. Vladas Griskevicius, professor of marketing and psychology, and Douglass Kendrick (2013), professor of psychology, found that two of the fundamental challenges that humans faced during evolution, avoiding physical harm and making friends, forced people to become very good at replicating each other's behavior (p. 378). Since mimicking the behavior of another person is perhaps one of the most basic forms of using a model, this would indicate that humans have evolved to learn from models. Associate professor of music education Warren Haston (2007) supported this result, as he found that "people learn naturally by imitating models" (p. 26), citing the fact that his students were able to pick up concepts faster and with less frustration when exposed to models as opposed to not being exposed to models. In short, human evolution has made humans able to learn effectively through imitating models.

Effects of Modeling

Many studies have shown a strong relationship between models and student learning. Educational psychologists Nathaniel Gage and David Berliner found that using a model improved conceptual understanding of complex systems, such as ecosystems and planetary orbits, by as much as 57 percent when compared to a very similar group without a model (1998, p. 12). In addition to increasing the depth of understanding, modeling also reduces student stress and frustration. When taught with a model, students, particularly struggling and disadvantaged ones, generally "experience less anxiety and confusion" because modeling "provides a clear picture in the student's mind as to how to handle a task" (Coleman, 2020). This likely contributes to an improved student experience, thus leading to students who are overall more willing to learn. Between improved student understanding and student experience, it is clear that modeling is a very valuable academic tool.

Limits of Modeling

Despite this, models and modeling are not used widely; in fact, they are often underused. Warren Haston (2007) found that music "teachers only use modeling between 10 and 25 percent of the time during rehearsals" (p. 26). The effect extends beyond music. Carlos Brigas (2019), professor of education and innovation at Polytechnic Institute of Guardia, found that, in science education, modeling is used "very sporadic[ally]" (p. 3). Additionally, elementary school principal Michael Coleman (2020) described it as "often forgotten" among K-5 educators. In short, modeling is a generally underutilized tool despite its proven efficacy.

While there are many potential reasons for this, there are two main theories. The first explanation for modeling's underuse lies in some teachers' ability or inability to effectively use it. Ken Alford and Tyler Griffin (2019), professors of education at Brigham Young University, found that many educators fail to adequately use models, leading them to deem them ineffective and thus abandon them. While this also poses a major problem, it likely does not fully account for the minimal role of modeling in education. The second major theory states that educators actively avoid modeling over the fear of its potential side effect: reduced student creativity. While there is no strong, empirical evidence supporting a causal relationship between modeling and reduced creativity, many believe that such a relationship exists. For example, developmental psychologist and professor of cognition and education at the Harvard Graduate School Howard Gardner (1994) argued that "modeling and imitation exercises can inhibit a child's creativity" (as cited in Haston, 2007, p. 27). However, Gardner failed to provide quantitative evidence to back up this claim. Despite this lack of evidence, the fact that modeling remains scarcely used indicates that many educators agree with this theory. This implies that the relationship between modeling and creativity should be critically examined to determine how modeling should be used going forward.

Creativity

However, properly examining this relationship is impossible without first better understanding creativity. Although there is not a universally accepted definition of creativity, this research will accept a popular one among educational psychologists. By this definition, creativity is "the production of novel thoughts, solutions, or products" (Gandini as cited in Carter as cited in Cole, Sugioka & Yamagata-Lynch, 1999, p. 3). Abiding by this definition, a creative person or idea is one that deviates from the ideas of others and produces a new one rather than conforming to or replicating the thinking of others.

Value of Creativity

It is important to note that creativity is not simply some niche topic of academic interest, but rather an essential ability to be productive in a modern environment. Darnell Cole, Heather Sugioka, and Lisa Yamagata-Lynch (1999), professors of educational psychology at Indiana University, assert that as “the degree of complexity and the amount of information in our society continue to increase, society’s problems require more creative solutions” (p. 3). Furthermore, according to professor of leadership and organizational behavior at Norwegian Business School Øyvind Lund Martinsen (2003) and master of education Laura Czarniecki (2020), this complexity has continued to increase exponentially, thus progressively increasing the importance of creativity. If the point of education is to prepare students to be productive members of society, it is clear that developing creativity should be a fundamental part of a modern educational system.

Development of Creativity in Schools

Despite this, current educational practices generally pay little attention to creativity. Educational scientist Mel Rhodes (1961) argued that the general lack of emphasis on developing creativity in schools comes from it being widely viewed as a static and innate quality, an antiquated view even in 1961 (p. 306). If an educator believes that each student has a set amount of creativity, they would naturally not allocate time or effort to developing creativity in their students. However, this view of creativity proved false. Czarniecki (2020) found that it is neither a static nor fully genetic quality. As such, creativity is an attribute that can be developed in an individual and can be both improved and reduced in students. The idea of static creativity levels, however, remains prevalent. This results in most school environments either failing to support or suppressing creativity in their students (Cole, Sugioka & Yamagata-Lynch, 1999, p. 3).

Unfortunately, the reason for the lack of creativity-promoting practices is primarily a result of poor teaching practices. In an observational study of eighteen teachers, psychologist Anton Furman (1998) found that the behaviors of teachers, such as not supporting many of the students’ questions and giving very strict assignments, made their students feel as if “creativity is not allowed during teaching-learning interactions” (as cited in Czarniecki, 2020, p. 46). While this is not generalizable to the entire teaching population, as some educators certainly make their classrooms very open to creativity, it does indicate a major problem. With creativity’s value increasing, it is clear that educational practices and environments that hurt student creativity can no longer be considered optimal. As such, they must be replaced.

While many current educational practices are counterproductive in terms of developing creativity, studies have shown other, albeit lesser-used, methods have shown to have the opposite effect. For example, Frank Lilly, professor of education at California State University, and Gillian Bramwell-Rejskind (2004), professor of education and counseling psychology, found that when educators reduce their emphasis on grading and evaluating their students are more willing to take risks and be creative. A similar result was replicated by Cole, Sugioka, and Yamagata-Lynch (1999). Although this seems like a very promising way to improve student creativity, it is not likely that such a strategy will be widely employed throughout the United States given how integral grades are to the current system.

In addition to reducing the importance of grades, it has been found that teacher behaviors have major impacts on student creativity. Psychologist Ellis Paul Torrence and Teachers’ Choice Award and the Golden Eagle Award winner Robert Myers (1970) found that student creativity is vastly increased in “responsive classroom environments” in which teachers are “respectful or unusual questions, respectful of imaginative and unusual ideas, show [students] that their ideas have value” (as cited in Cole, Sugioka & Yamagata-Lynch, 1999, p. 4). In short, when teachers respect and appreciate their students showing creativity, the students are more likely to be creative. While attempting to make classroom environments more responsive would be a major step toward making classrooms more creative, it would be difficult to enact, as it would require a likely costly teacher retraining program for teachers to learn to make their classrooms more responsive. Considering how costly such a program would be, it is highly unlikely that it would come to fruition.

Perhaps the most practical way to improve creativity in education systems is not through changing a fundamental part of the system, as it would prove too difficult, or through changing the behaviors of teachers, as it would prove too costly, but rather by changing how content is presented. A team of researchers led by professor of psychology Richard Koestner (1984) found that changing how a painting task was presented to a group of first and second-graders had substantial effects on how creative the paintings turned out to be. The results of the study showed that students who were given fewer limits on how they should paint ended up having far more creative paintings than students who were given more limits (Koestner et al. as cited in Czarniecki, 2020, p. 84). This indicates that simply reducing the amount of limiting instructions a teacher gives a student in conjunction with an assignment can have significant impacts on the creativity of the responses. Such a strategy should be used widely.

In addition to providing a specific way to improve student creativity, Koestner's study also provides another, more general insight: the intentional use of specific teaching strategies can improve student creativity. By being deliberate in the way they teach their students, teachers would be able to prompt more creative and novel thoughts from their students.

Gap in Prior Research

However, this insight alone is useless without knowing which teaching strategies are conducive to creativity and which are not. As such, all major teaching methods need to be examined. While minimal research exists on this topic in general, there is a noticeable lack of research done on the connection between modeling and creativity. Although many have proposed theoretical connections (Haston, 2007; Salisu & Ransom, 2014; Brigas, 2020), there is yet to be a rigorous, empirical study to determine the relationship between modeling and creativity.

Therefore, due to the rigorously proven effectiveness of modeling as an educational strategy and the clear importance of creativity, in this study I will examine the effects of modeling on creativity to determine how modeling should be used in education going forward.

Hypotheses

Based on theories and anecdotal evidence, there are currently two leading and conflicting hypotheses surrounding how providing a model impacts creativity. This study aimed to prove which one, if either, proves accurate. The first, based on observations of students in science classrooms, implies that modeling leads to greater understanding overall, thus opening the door for students to be more creative (Brigas, 2019, p. 1). In contrast, the second leading hypothesis, based on general observations of students in modeling heavy music classes, implies that modeling restricts the range of possible thinking and thus will reduce creativity (Haston, 2007, p. 26). While both of these hypotheses seem logically founded, the generality and subjectivity of their data make it difficult to determine the accuracy of these assumptions. Additionally, the mere fact that polar opposite hypotheses exist led me to believe that modeling does not have a consistent, statistically significant impact on creativity. As such, when running a hypothesis test, I predicted that I will not find a significant difference between the two groups and thus will fail to reject the null hypothesis.

Method

To try to capture the extent to which modeling impacts creativity, I used a novel method specifically created to avoid capturing variables that I do not intend to study as well as avoid subjectivity in either data collection or analysis.

Given that past studies have proven that there are many variables at play in a classroom that substantially impact creativity, it was essential to design a method that was outside a strictly academic setting. Even though the results of this study will be most useful in classrooms, conducting a study surrounding creativity in a classroom runs a high risk of capturing unintended variables. Since the effect of models on creativity was predicted to be small and I was forced to work with a relatively small sample size, as I am a high school student with insufficient resources to procure a large one, such a skew had to be avoided. For this reason, I had to use an unorthodox method.

To determine how models impact creativity in children, I collected data on children's requests for balloon animals. My sample was divided into two groups, one group that has the presence of a model (model group) and one that does not (no-model group). The model group was presented with a sign showing images of a few different balloon animals that they could choose from (a red balloon dog, a blue balloon cat, a yellow balloon giraffe, and a brown balloon monkey). For this study, the images on the sign were the models as they let the subjects observe different ways to complete their task of deciding what balloon animal/design to request. From the two major groups, the sample was further subdivided into sets, with each set being a specific event where I gathered data. For each set, I collected what balloon animal/design each child requested (known as the child's choice) and the order of the requests.

Once I collected the data, I compared each choice to the choices made before it in the set (prior choices) and the models (if present), and created a score for each choice based on how similar it is to other designs chosen. Completely novel choices, sharing no similarity to either prior choices or the models were considered highly creative. The more similar the choice is to either the prior choices or the model the less creative the choice is. By using this method to evaluate creativity, I ensured that the metric for creativity is objective and consistent. I was then able to utilize statistical analysis to compare the results of each group to establish how providing a model impacted creativity.

Population

The sample for this study consisted of children primarily ages four to ten years old attending community events with 20-100 children. This younger age group was chosen intentionally because they have spent less time in school than other age groups. As a result, they are less conditioned to react to models in a specific way, thus representing a more natural response. Consent for children to take part in the study was provided by the organizers of the events. No personal information on the participants was collected so all participants are fully anonymous and no potentially private information was collected. While this limited my study to a more general view of how modeling impacts creativity without insight into the other factors that impact how much modeling impacts creativity, it was deemed a necessary sacrifice to have a sufficient sample size to get reliable results. Future studies would do well to collect more data (gender, age, grade) about each participant to better understand the nuances of this issue.

Data Collection

For each subject in a set, participation in the study depended on whether they wanted a balloon (they were not required to get one). If they did, I recorded their request and then I made the requested balloon for them. If the child asked what they could have or a question with the same meaning, I followed a scripted response based on their group. If they were in the model group, I would explicitly state, "you can have all sorts of things like a dog, a cat, a giraffe, a monkey", directly reflecting what was shown on the model. If they were in the no-model group, I would state, "you can have all sorts of things: an animal, something you can hold, something you can wear", reflecting vaguely the type of balloon they could request. In both cases, further inquiry would result in me repeating the statement and then saying, "be creative". By having specific, scripted responses I can ensure all participants have conditions that are as consistent as possible. I collected all of the choices into a data table giving specific care to the order of the choices as it is relevant for the data analysis. See Table 1 for an example data table (specifically the data from the second set in the model group). It is important to note that there were no incentives for the children to be creative. Given that classrooms rarely have incentives for students to be creative it seemed unreasonable to provide them in this study.

Table 1. Model Data Set 2

D1	D2	C1	C2	C3
Giraffe		Yellow		
Sloth		Red	Orange	
Sword		Blue		
Sword		Red		
Octopus		Pink		
Dragon		Yellow	Orange	
Dragon		White	Blue	
Sloth		Red	Yellow	
Sword		Green		
Lightsaber		Green	Red	
Lightsaber		Orange	Brown	

Data Analysis

Each request was broken down into 5 aspects. The primary design (D1) was the main aspect of the design (dog, cat, sword, flower, etc.). The secondary design (D2) was an additional design requested to go along with the original (a leash for a dog, a branch for a monkey, etc.). Color one (C1) and color two (C2) denote the primary and secondary colors of D1 and color 3 (C3) denotes the color of D2. Any field that was not applicable to the request was left empty. All of the data was collected and stored in a Google Sheets spreadsheet. To view the complete data set, see Appendix A. In order to analyze the data, I ran it through a Java program that I created specifically for this study. The program analyzed the similarities between choices and calculated a similarity score. The score is in a range of 0 to 18 with 18 indicating an identical choice and 0 indicating a completely novel choice. Similarity for color and design were calculated separately and then added together to get the similarity score (ss).

Color Similarity Score (css) was calculated using the number of similar colors (sc) between the two designs and a conditional variable(x) by the following equation: $css = 3(\frac{sc}{x})$. If the number of colors in the current choice (ccc) is greater than the number of colors in the prior choice (pcc), the value of x was set equal to ccc. In any other case, the value of x was set equal to pcc. For the design similarity score (dsc) please refer to Figure 1.

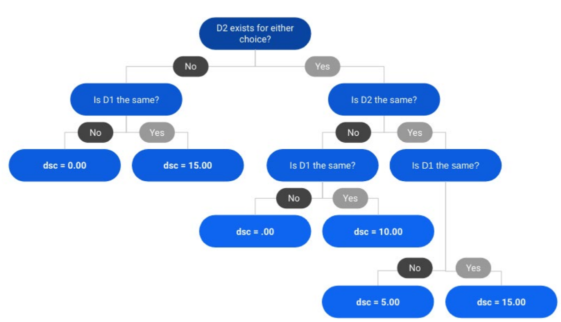


Figure 1. Design Similarity Reference Chart

By using this method to calculate the similarity between choices, the more primary parts of the choice are weighed higher than the less significant aspects. Additionally, all similarity scores are calculated on the same scale (0-18) regardless of how many attributes the choice has, thereby reducing unintentional variability in the data. For an example of ss calculation, see Figure 2.

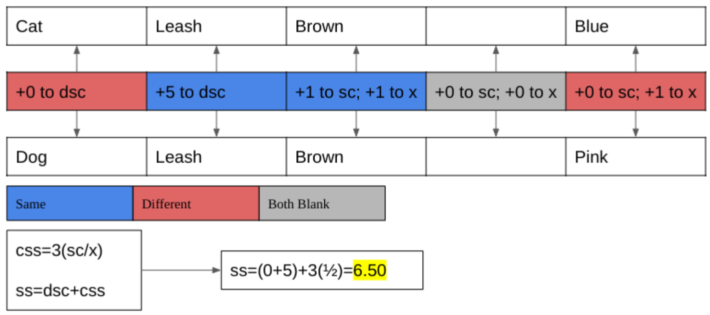


Figure 2. Example ss Calculation

The average choice similarity score (acss) was then calculated for each choice by summing the similarity scores of the current choice with each of the prior choices and models (if present models behave like a prior choice) in the set and then dividing by the number of prior choices (if in the modeling group, the number of prior choices will increase by one to avoid division by zero error). By doing this, each choice will have a single average similarity score on the same 0 to 18 scale thereby ensuring greater consistency. Once a score for each choice was calculated, I found the average score for each group (the sum of the average choice similarity scores divided by the total number of choices) and then compared the model group to the no-model group. For an example acss calculation, see Table 2. To see the program used containing the exact calculations, see the full program in Appendix B.

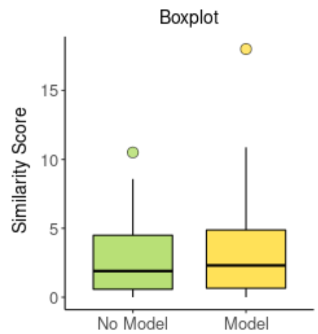
Table 2. Example acss Calculation

D1 (10.00)	D2 (5.00)	C1 (1.00)	C2 (1.00)	C3 (1.00)	Design Similarity	Color Similarity	Overall Similarity
Unicorn		White	Purple		100% 15.00	100% 3.00	18.00
Wolf		White			0% 0.00	50% 1.50	1.50
Unicorn		White	Purple		50% 7.50	75% 2.25	54.17% 9.75
Lightsaber		Red	Orange		Not Calculated	Not Calculated	Not Calculated

Choice in Question	Similar to Choice	Later Choices	Average Similarity

*Choices 1-4 from no-model set 2

Results



Descriptive Statistics:

Group	Sample Size	Mean	Std. Dev.
No Model	170	2.66	2.33
Model	165	3.10	3.00

Figure 3. Comparing Model and No Model Similarity Scores

Figure 3 shows the comparison of the model group and the no-model group based on means and standard deviations. Out of a potential difference of 15.34, the model group mean was 0.445 points greater than the no-model group, indicating that the model group made, on average, slightly less creative choices. The model group also had a standard deviation of 0.667 greater than the no-model group, indicating that the model group had slightly greater variation in responses than the no-model group. Given that these differences were seemingly small, in order to avoid making a type 1 error (rejecting the null hypothesis when the null hypothesis should not be rejected or, more simply, assuming that there is an effect when there is no effect), I calculated a P-value and a confidence interval to determine if these findings were statistically significant. For both the t-test and the confidence interval, μ_1 refers to the mean no-model group while μ_2 refers to the mean of the model group.

Significance Testing

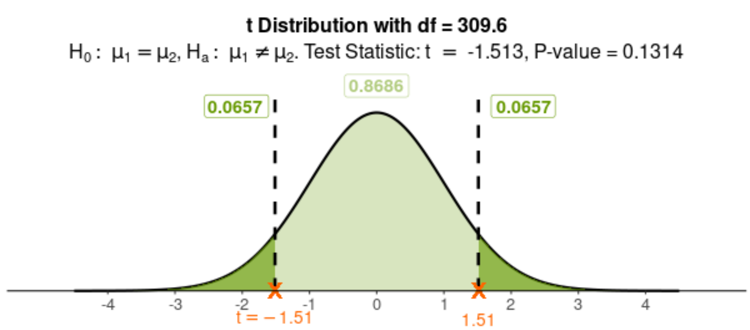


Figure 4. *t-test for Significance of Group Means*

After running a standard two-tailed t-test on the data to check for statistical significance of this difference between these two means, I found the P-value to be 0.1314, well above the commonly used 0.05 threshold for statistical significance (thus indicating that these differences are not statistically significant). Given that the P-value is 0.1314, it means that a difference in means this large or larger could have occurred by chance 13.14% of the time. As such, it is fairly likely that I would have observed a difference between my sample means this large or larger if there was truly no difference in the population. Therefore, I do not have a probabilistic basis to reject the null hypothesis that the means of the model and no-model groups are exactly the same. From a substantive perspective, this indicates that providing a model likely has no significant impact on child creativity.

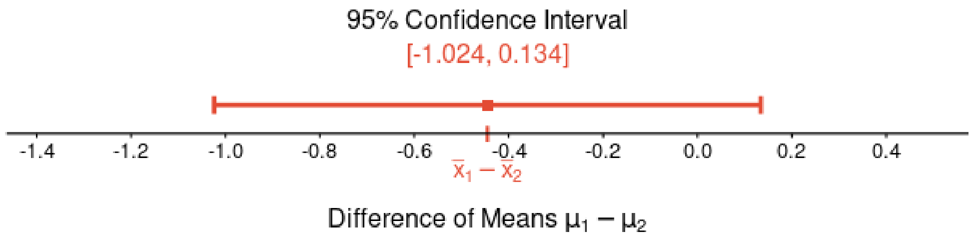


Figure 5. 95% Confidence Interval Difference of Means

The computed confidence interval supported the same conclusion; the two groups were approximately the same. The confidence interval indicates that I am 95% confident that the true difference between the two means ($\mu_1 - \mu_2$) falls between -1.024 and 0.134. Given that this is a very small range that includes 0, it would be reasonable to assume that modeling has no significant effect on creativity.

Power Analysis

In order to protect against making a type 2 error (failing to reject the null hypothesis when the null hypothesis should be rejected or, more simply, assuming there is not an effect when there really is one), I ran a post-hoc power analysis. With the calculated means and standard deviations and an alpha value of 0.05, the power of the study was 32.1%, meaning that with the given sample size I had only a 32.1% chance of detecting an effect (thus rejecting the null) if there was truly an effect. Assuming the calculated means and standard deviations are accurate for the population, a sample size of 880 (440 for each group) would be required to have sufficient power of 80%. Given this, I cannot assume that there truly was no effect since the probability of detecting one was so low. Unfortunately, as a high school student, I am unable to attain a sample size this large so I simply have to settle with this suboptimal power.

Overall Findings

In summary, the findings are overall inconclusive. Due to insufficient effect sizes, I failed to reject the null hypothesis. However, due to insufficient power, I cannot accept this null hypothesis.

Conclusions and Future Directions

In spite of the fact that the data does not hold any clear conclusions, this study still provides meaningful information. Primarily, it indicates that if using modeling as an educational strategy impacts creativity, its impacts are neither clear nor major. As such, unless further research comes to a different conclusion, educators should not actively shy away from using modeling in fear of it dramatically reducing student creativity. Given that prior research has shown that modeling is a very effective educational tool, and the results of this study indicate that the impacts of modeling on creativity are limited if they exist at all, I will tentatively recommend wider use of modeling in classrooms. However, it is important to note that this is a highly tentative recommendation and that further studies need to be done to confirm this.

Future Research

It is important to note that this study had three primary shortcomings that ideally would be addressed in future studies. The first is the issue of low power (low probability of detecting an effect if there really is one). Future research would do well to attempt to achieve at least a sample size of 880 total choices (440 for each group) to have sufficient power (80% being the standard number) to detect an effect if there really is one. This would dramatically reduce the ambiguity of potential findings.

Secondly, it would be relevant to collect data from a broader range of age groups. The results of this study are relevant for all ages that are currently part of the educational system. In the US, this can include any age from 3 years old in preschool to over 26 years old with graduate education. Since all of these groups can stand to benefit from educational practices that are more creativity friendly, it is important to determine how modeling impacts creativity for all of these groups.

Lastly, it would be highly beneficial to collect more data on each of the participants in the study. Due to limited time and resources, I had to assume that every participant was fundamentally the same and that my sample was representative of the population. However, it is possible that there are demographic differences in how modeling impacts creativity. Understanding these differences would allow educators to specifically cater their educational strategies to their group of students to optimize learning ability. This would also allow researchers to be cognizant of collecting a demographically diverse population. As a result of not collecting this data, I am running the risk of drawing conclusions from an unrepresentative sample. Consequently, any subsequent study would be wise to take this into account.

Conclusion

This study sought to empirically determine if modeling had a significant impact on creativity through quantitative means. While prior research has examined this connection qualitatively, there has been no reputable quantitative study into this relationship. Perhaps as a result of the complexity of quantitatively measuring creativity, this study was unable to firmly confirm nor deny a relationship between modeling and creativity with the time and resources available. However, this study can tentatively conclude that modeling as an educational tool should be more widely used and provide a basis for future research into this area.

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