Using Digital Art to Influence Students' Attitudes in High School Science Classrooms

Deborah Ezell
Walden University

Chris Cale
Walden University

Sunddip Panesar-Aguilar
University of St. Augustine

Michelle McCraney
Walden University

ABSTRACT

Whether the activity of creating digital art influences high school students' attitudes toward science is unknown. The purpose of this study was to determine if the creation of artistic digital chemoscans by high school students influences attitudes toward science. In this study, ninth- grade high school students' attitudes toward science were examined after participating in the creation of chemoscans in the science classroom. The theory of affective domain helped explain the process that leads to a person's behavior toward a certain phenomenon in the educational setting. The research questions concerned the use of chemoscan creation in the physical science classroom and if and whether implementation effected a change in students' attitudes toward science. Archival pre- and post-test data from the Test of Science Related Attitude was used to measure high school students' attitudes toward science in 7 categories. Archived student pre- and post-test data were treated with multiple regression for analysis. Key findings of this study showed that creation of artistic digital chemoscans (a) impacted one of the seven subscales of science attitude from the Test of Science related Attitude (TOSRA) entitled attitude toward the normality of scientists, (b) did not have an impact on the any of the other six subscales from the TOSRA and (c) was influenced by teacher effect. This study may contribute to social change by providing improved training for science teachers who implement digital art activities, which may lead to some students enjoying science more and then possibly going into science careers.

Keywords: digital art, chemoscans, attitudes towards science, high school science, science classroom instruction.

INTRODUCTION

Technology has become infused into all parts of modern society, and educators are looking for methods that use this technology to allow students to create, connect with others, and contribute to the world around them. Combining technology and art to create beautiful, artistic visualizations of scientific concepts is one-way teachers are trying to make learning more engaging (Sousa & Pilecki, 2013). Other methods include digital storytelling (Liao, Motter, & Patton, 2016), game design (Jenson & Droumeva, 2016), movie making (Liao et al., 2016), and virtual reality software (Herga, Grmek, & Dinevski, 2014), which allow students to use artistic design capabilities while learning scientific processes. The application of technology has become an important component for helping students acquire 21st century learning skills, including critical thinking, problem solving, communication, collaboration, creativity, and digital literacy (Liao et al., 2016). This idea applies to the science teacher and the use of technology to focus students on creative abilities while learning science concepts. Using technology can be an important method for teachers to encourage students to appreciate the connection between creativity, art, science, and technology. Both the International Society of Technology in Education (ISTE) and Next Generation Science Standards (NGSS) provide frameworks for student standards that suggest learning digital skills can transform education (ISTE, 2018; NGSS, 2019). Using technology and art to engage students in learning can lead students to finding more value in work and increasing cognitive abilities (Sousa & Pilecki, 2013). The goal of science, technology, engineering, arts, and math (STEAM) based education is to increase student interest in learning about science, which in turn, could lead to an increase in interest in science, technology, engineering, and math (STEM) careers (Wolter, B., Lundeberg, M., & Bergland, M., 2013). Calvert and Schyfter (2017) studied scientists as they worked to develop new technologies and found that when the scientists collaborated with artists, the results often created new dialogues and "what if" scenarios compared to the scientists that did not work with the artists. As Calvert and Schyfter (2017) argued, adding an artistic component to the technology design process could lead to more innovative thinking and discussions as well as better final products.

This study was needed to help determine if digital artistic activities can influence students' attitudes toward science. Learning more about the intersection of educational technology, science, and art is a unique approach that has not been previously studied with high school students. Teachers looking for new and innovative methods to incorporate technology into the classroom to improve students' attitudes might benefit from the results of this study.

STATEMENT OF THE PROBLEM

Declining attitudes toward science have been documented to begin as a student gets into higher elementary grades (Hasni, Potvin, & Sy, 2017) and continue into the middle school level and the high school level. These poor attitudes toward science have been found to lead to a decline in the number of students choosing science-related courses and, therefore, careers (Hasni et al., 2017). According to Krapp and Prenzel (2011), the problem of student interest in STEM could depend on the type of activities and the quality of the instruction. The U.S. does not have a sufficient number of students interested in following STEM careers (Belser, Prescod, Daire, Dagley, & Young, 2017). The U.S. simply does not have enough people with the type of training necessary to fill the open STEM vacancies. In 2016, there were almost 3 million STEM-related vacancies that could potentially not be filled due to lack of training (Belser et al., 2017). However, the AmGen Foundation (2016) found that it is not science kids dislike but science classes.

Although there is research discussing the combination of visual arts projects as part of science learning, the gap in knowledge was that little research has been done to show how the intersection of technology and the creation of artistic digital images impacts high school students' attitudes toward learning science. Whether the activity of creating digital art influences high school students' attitudes toward science is unknown. The results of this study could help with understanding why many high school students do not have a positive attitude toward learning science.

PURPOSE OF THE STUDY

The purpose of this naturalistic, quasi-experimental study was to determine if the high school student creation of artistic digital chemoscans influences attitudes toward science. In this study, if the independent variable of chemoscan creation impacts a change in attitude as measured by the dependent variable, the scores on the Test of Science Related Attitude (TOSRA) was examined. If artisitic endeavors, like chemoscans, are found to have a positive effect on students' attitudes toward science, it may develop into support for an expanded curriculum that includes art in the STEM or STEAM programs.

RESEARCH QUESTIONS

The qualitative research conducted in the study was guided by three questions. The questions addressed the experiences of the teachers, the self-efficacy of the teachers, and the desired professional development of the teachers. The research questions served as the foundation for the organization and analysis of the collected data. The following research questions guided this qualitative instrumental case study:

Research Question 1. What are the experiences of fifth-grade science teachers regarding STEM-focused professional development?

Research Question 2. How do these experiences affect fifth-grade science teachers' self-efficacy in implementing integrated STEM education?

Research Question 3. What types of professional development experiences did fifth-grade science teachers feel best supported implementing integrated STEM education?

RESEARCH QUESTIONS AND HYPOTHESES

RQ1: The creation of chemoscans in the physical science classroom will improve students' attitudes toward the social implications of science.

RQ 2: The creation of chemoscans in the physical science classroom will improve students' attitudes toward the normality of scientists.

RQ3: The creation of chemoscans in the physical science classroom will improve students' attitudes toward a career interest in science.

RQ 4: The creation of chemoscans in the physical science classroom will improve students' attitudes toward scientific inquiry.

RQ 5: The creation of chemoscans in the physical science classroom will improve students' attitudes toward the adoption of scientific attitudes.
RQ 6: The creation of chemoscans in the physical science classroom will improve students' attitudes toward the enjoyment of science lessons.
RQ 7: The creation of chemoscans in the physical science classroom will improve students' attitudes toward the leisure interest in science.

Null Hypothesis ($H_0 1_0$): Students' attitudes toward science are not affected by the creation of chemoscans.
Alternative Hypothesis 1 ($H_1 1_1$): Students' attitudes toward science will be affected by the creation of chemoscans.
Alternative Hypothesis 2 ($H_0 1_2$): Students' attitudes toward science are affected by the creation of chemoscans when considering teacher effect.

TORSA FRAMEWORK

In this study, students' affective attitudes were measured using an instrument entitled the TOSRA. The TOSRA was developed by Fraser (1981) and was designed to measure seven, distinct, science-related attitudes among secondary school students. These scales, which fall under the affective domain proposition, are: Social Implications of Science, Normality of Scientists, Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science. Fraser based the survey on a classification schema designed by Klopfer (1973) entitled, A Structure for the Affective Domain in Relation to Science Education. Fraser used Klopfer's scale to create the TOSRA, a survey which measures a student's change in attitude toward science. Table 1 shows each TOSRA scale and the corresponding constructs with Klopfer's (1971) classification.

In development of the TOSRA, Fraser (1981) aimed to create a tool to be used by educators, curriculum designers, and researchers to determine student progress towards certain science attitude goals. Fraser (1981) designed the TOSRA to be useful for educators in the classroom setting for determining the performance of groups or classes of students as they participate in various activities. The test was designed to provide information about attitudes at a particular time or in a pre- and post-test setting (Fraser, 1981). Each scale of the TOSRA includes different components of Krathwohl, Bloom, and Masia (1964) affective domain proposition using Klopfer's scale as the template.

The first category of the affective domain is *receiving* or *attending*, which refers to the student's willingness to pay attention to an activity or object used during the learning process (Klopfer, 1973). Ideas in this category range from the simple awareness that something exists to particular attention paid on the part of the learner (Krathwohl, Bloom, & Masia, 1964). The attending category of the Klopfer (1973) scale was entitled Enjoyment of Science Learning Experiences. Fraser (1981) renamed the category, Enjoyment of Science Lessons, on the TOSRA. The TOSRA survey statement terms that align with this category included: follows, gives, listening to discussions of controversial issues with an open mind, and respecting the rights of others (Fraser, 1981).

The third category of the affective domain is called *value* and looks at how the student values the science they are learning (Krathwohl et al., 1964). Value is defined as the idealization of a specific learning skill (Krathwohl et al., 1964). The Klopfer (1973) scale titled this category, Adoption of Scientific Attitudes, and the TOSRA kept the same title (Fraser, 1981).

The statements in the TOSRA range from issues concerning the students' desire to improves cooperative learning skills to the level of commitment to group work and problem solving (Fraser, 1981). Statements on the TOSRA include terms such as *attitude* and *appreciation* (Fraser, 1981).

The fourth category of the affective domain is *organization,* which is concerned with identifying different values and determining the conflicts between (Krathwohl, et al., 1964). The Klopfer (1973) scale titled this category, Acceptance of Scientific Inquiry, as a way of thought. The TOSRA used the title, Attitude to Scientific Inquiry (Fraser, 1981). The statements on the TOSRA for this category emphasize comparisons and relationships between science and the student (Fraser, 1981). The statements include terms such as, *adheres to*, *defends*, *identifies*, *relates*, and *realizes* (Fraser, 1981).

The fifth category of the affective domain is *characterization by a value* (Krathwohl et al., 1964). This category looks at the value system of the student and how it may affect behavior (Krathwohl et al., 1964). This category helps identify preconceived notions students may already have developed about science and feelings about how science can affect the world (Krathwohl et al., 1964). Klopfer's (1973) scale described this as Manifestation of Favorable Attitudes Towards Science and Scientists. In Fraser's TOSRA (1981), it is broken down into two subscales: Social Implications and Normality of Scientists. The TOSRA statements use terms like *influences*, *acts*, *discriminates*, *revises*, and *verifies*, which help to determine if a student's values concerning science influence behaviors in different situations (Fraser, 1981).

POPULATION AND SAMPLE SELECTION

The target population was ninth-grade students participating in physical science classes in one rural high school. Six physical science classes were used, which were taught by four different teachers. The typical class size was 25 to 30, which gave a possible participant pool of 150. The calculated sample size was 116, so this reached the minimum sample size necessary when excluding those students who did not participate and other attrition. The limitations in acquiring a nonrandom sample of students necessitated the use of the quasi-experimental method in this study. The participant pool was considered a convenience sample because they were from only one school in a rural school district.

The participants in this study were chosen based on convenience sampling. There were four teachers involved in the research project. Two teachers' classes were the control groups and did not experience the chemoscan lessons, while two other teachers' classes did experience chemoscan lessons. To check for teacher as the moderator, a dummy code was used to determine which teacher was teaching each class.

The school district administered the TOSRA for its own purposes and allowed access to the archival data for this study. The TOSRA was given to all treatment and control classes in the pre- and post-test format. The school district oversaw all population samples and was responsible for how the participant sample was drawn. The participants were not required to take the TOSRA, and the choice was determined on the student level and all parental consent forms, collected by the school, at the beginning of the school year, which are stored in a safe, secure location provided by the district. For purposes of the research, the participants were defined as any ninth-grader taking physical science classes in the test school. Students with Individualized Education Plan or 504 plans did not participate in the activity. These students worked with special needs teacher on Individualized Education Plan goals as mandated by district policy.

Teacher effect was analyzed by dummy coding. For instance, teachers were arbitrarily assigned a nominal variable: T1 through T6. For each class, a value of 1 was given to the specific teacher who taught that particular class, and a value of 0 to the other teachers as the data set was created. Repeating this procedure for each teacher allowed checking for teacher effect as a moderator using multiple regression calculation. Multiple regression is an extension of a simple linear regression (Creswell, 2014). This was used to predict the value of a variable based on the value of two other variables.

A power analysis, using G power (Faul, Erdfelder, Lang, & Buchner, 2007), determined the sample size of 116 with a predicted power of .75 and a predicted effect size of .3. When considering the analysis of research data, it was important to look at the power and effect size to calculate the sample size needed for the study. Effect size was used to determine the effectiveness of the lesson and was a measure of the difference between the study groups. Cohen (1988) provided ranges to help understand effect sizes which puts the effect size of .3 in the moderate range. The calculated sample size of 116 left enough attrition room for participants that are absent, have consent issues, or decide not to participate.

INSTRUMENTATION

Survey data for this study were provided by the school district, which gave the TOSRA to ninth-graders. Parental permission was given and maintained by the participating school district. The school district procedures for collecting student data for this study included ninth-grade students in physical science classes at the high school in the district. The school district kept parental permission forms on file.

The school district administered the TOSRA pre- and post-test in the physical science classrooms electronically on designated test days for the pretest and posttest during the 9-week study period. All testing procedures were administered by a district certified test administrator. No names were used to identify subjects, but random index numbers were used to separate pretest and posttest data. No student interviews were conducted to determine if the chemoscan process affected student interest in science.

The necessary permission forms for data access were given to students and parents at the beginning of the school year. The permission forms are maintained by the school district in each student's permanent record. The permission forms are discarded when the students graduate from high school. The procedure for gaining access to the data set for analysis takes place after the posttest was given. The district allowed access to the data after the study was finished. The archival TOSRA data directly from the school district was acquired. The data were maintained by the school district until after a student has graduated.

Fraser (1981) determined the TOSRA reliability coefficient from Cronbach Alpha for the seven subscales to help determine validity of the instrument (Table 1). The Cronbach alpha test as used to estimate the ability of TOSRA statement to measure specific attitudes when used over time (Fraser, 1981). Cronbach's alpha values from Year 7 ranged from 0.66 to 0.93 and 0.64 to 0.92 in Year 8. Year 9 had a range of 0.69 to 0.88 and Year 10 has a range of 0.67 to 0.93. Table 2 shows the values separately for each level of Cronbach's alpha coefficient for each TOSRA scale.

In this research study, the dependent variable was the change in subscale scores on the TOSRA. The TOSRA is a 45-minute survey that consists of 70 statements to discover students' attitudes toward science. The survey responses were strongly agree, agree, undecided, disagree, and strongly disagree. Sample TOSRA statements include: Money spent on science is well worth spending; Scientists usually like to go to laboratories when they have a day off; I would prefer to find out why something happens by doing an experiment than by being told. The subscale scores were calculated by adding the point value for each subscale answer.

DATA COLLECTION

Data were collected by the participating school district in the spring semester of 2019. The pre-test was given at the beginning of a 9-week grading period, and the post-test was given at the end of the 9-week grading period. The data provided, included ninth-grade students from four high school physical science classes. The response rate was 100% on the pre-test with 117 responses. The response rate for the posttest was 93% with 109 responses. The results for students that did not take the post-test were disregarded, which left 109 data sets for analysis. The demographic characteristics of the sample were not provided to protect participants from indirect privacy breaches. The research study was completed in a rural high school, a context which may not provide generalizable results to students in suburban and urban populations. Participants were limited to ninth-grade students; therefore, the results may be limited in applicability to students in other grades. The ages of the students were 14 and 15 years old.

DATA ANALYSIS

Archival data of 109 ninth-grade students was used in the analysis for this study. The archival data included scores of the TOSRA, both pre- and post-test. Half the students (n = 55) received the usual classroom instruction (i.e., the control group), while the other half (n = 54) received instruction that included the creation of chemoscans (i.e., the treatment group).

Preliminary Analysis

Prior to conducting the analyses to test the hypotheses, the subscales of the TOSRA were assessed for normality using z scores formed by dividing skewness by the standard error of skewness. Values within +/- 3.29 are indicative of normality in sample sizes between 50 and 300. Table 3 summarizes the statistics for the subscales. Results of basic univariate analysis show that the z scores were all well within the range, indicating that the subscale scores were normally distributed.

Hypothesis Testing

The hypotheses were tested against the RQ which included the seven subscales of the TOSRA. Each RQ depicts a different subset of the TOSRA and whether or not the null hypothesis failed or did not fail to be rejected. The data included with each RQ explains whether the null hypothesis failed to be rejected or not.

RQ1: the creation of chemoscans in the physical science classroom will improve students' attitudes toward the social implications of science. This was tested using a group (i.e., treatment vs. control) by repeated measures (i.e., pre-test vs. post-test) analysis of variance on the Social Implications of Science subscale of the TOSRA. The results are presented in Table 4.

The test of the repeated measure (i.e., pre- and post-test) indicated no significant change in the students' attitudes toward the social implications of science overall (F (1,107) = 1.20, p = 0.276). Averaging across the pre- and post-tests, no significant differences were found in attitudes between the treatment and control groups (F (1,107) = 0.13, p = 0.718). The repeated measure (i.e., pre- post-test) by group interaction effect was also not significant, indicating that the creation of the chemoscans had not improved students' attitudes toward the social implications of science (F (1,107) = 0.37, p = 0.545). Therefore, this data failed to reject null hypothesis.

RQ2 was, the creation of chemoscans in the physical science classroom will improve students' attitudes toward the normality of scientists. This was tested using a group (i.e., treatment vs. control) by repeated measures (i.e., pre- post-test) analysis of variance on the Normality of Scientists subscale of the TOSRA. The results are presented in Table 5.

The test of the repeated measure (i.e., pre- and post-test) indicated a significant improvement in the students' attitudes toward the normality of scientists for all students (F (1,107) = 7.55, p = 0.007). In addition, a significant difference was found between the treatment and control groups, averaging across the pre- and post-tests (F (1,107) = 6.01, p = 0.016) when looking at the subscale of normality of scientists (F (1,107) = 8.19, p = 0.005). The partial eta squared (η^2= 0.07) denotes a medium effect. These results support rejection of the null hypothesis and acceptance of the alternative hypothesis. Further illustration of the interaction effect is provided in Figure 1.

RQ3 was, the creation of chemoscans in the physical science classroom will improve students' attitudes toward a career interest in science. This was tested using a group (i.e., treatment vs. control) by repeated measures (i.e., pre- post-test) analysis of variance on the Career Interest in Science subscale of the TOSRA. The results are presented in Table 6.

The test of the repeated measure (i.e., pre- and post-test) indicated a significant change in attitudes toward a career interest in science for all the students, regardless of whether they had created the chemoscans (F (1,107) = 4.31, p = 0.040). Averaging across the pre- and post-tests, no significant difference in attitudes was found between the treatment and control groups (F (1,107) = 0.31, p = 0.579). The repeated measure (i.e., pre-post-test) by group interaction effect was also not significant, indicating that the creation of the chemoscans had not improved students' attitudes toward a career interest in science (F (1,107) = 3.28, p = 0.073). Therefore, the test failed to reject the null hypothesis.

RQ4 was, the creation of chemoscans in the physical science classroom will improve students' attitudes toward scientific inquiry. This hypothesis was tested using a group (i.e., treatment vs. control) by repeated measures (i.e., pre- and post-test) analysis of variance on the Attitude to Scientific Inquiry subscale of the TOSRA. The results are presented in Table 7.

The test of the repeated measure (i.e., pre- post-test) indicated no significant change in the students' attitudes toward scientific inquiry overall (F (1,107) = 0.80, p = 0.374). Averaging across the pre- and post-tests, no significant difference was found in attitudes between the treatment and control groups (F (1,107) = 1.66, p = 0.200). The repeated measure (i.e., pre-post-test) by group interaction effect was also not significant, indicating that the creation of the chemoscans had not improved students' attitudes toward scientific inquiry (F (1,107) = 0.76, p = 0.386). Therefore, this failed to reject the null hypothesis.

RQ5 was, the creation of chemoscans in the physical science classroom will improve students' attitudes toward the adoption of scientific attitudes. This was tested using a group (i.e., treatment vs. control) by repeated measures (i.e., pre- vs. post-test) analysis of variance on the Adoption of Scientific Attitudes subscale of the TOSRA. The results are presented in Table 8.

The test of the repeated measure (i.e., pre- post-test) indicated no significant change in the students' attitudes toward the adoption of scientific attitudes overall (F (1,107) = 0.43, p = 0.512). Averaging across the pre- and post-tests, no significant difference was found in attitudes between the treatment and control groups (F (1,107) = 0.22, p = 0.642). The repeated measure (i.e., pre- and post-test) by group interaction effect was also not significant, indicating that the creation of the chemoscans had not improved students' attitudes toward the adoption of scientific attitudes (F (1,107) = 0.01, p = 0.910). Therefore, this failed to reject the null hypothesis.

RQ6 was, the creation of chemoscans in the physical science classroom will improve students' attitudes toward the enjoyment of science lessons. This hypothesis was tested using a group (i.e., treatment vs. control) by repeated measures (i.e., pre- and post-test) analysis of variance on the Enjoyment of Science Lessons subscale of the TOSRA. The results are presented in Table 9.

The test of the repeated measure (i.e., pre- post-test) indicated a significant change in all the students' attitudes toward the enjoyment of science lessons, regardless of whether or not they had created the chemoscans (F (1,107) = 7.58, p = 0.007). Averaging across the pre- and post-tests, no significant difference in attitudes was found between the treatment and control groups (F (1,107) = 0.95, p = 0.331). The repeated measure (i.e., pre- and post-test) by group interaction effect was also not significant, indicating that the creation of the chemoscans had not improved students' attitudes toward the enjoyment of science lessons (F (1,107) = 2.18, p = 0.143). Therefore, this failed to reject the null hypothesis.

RQ7 was, the creation of chemoscans in the physical science classroom will improve students' attitudes toward the leisure interest in science. This was tested using a group (treatment vs. control) by repeated measures (i.e., pre- and post-test) analysis of variance on the Leisure Interest in Science subscale of the TOSRA. The results are presented in Table 10.

The test of the repeated measure (i.e., pre- and post-test) indicated no significant change in the students' attitudes toward the leisure interest in science overall (F (1,107) = 0.12, p = 0.733). Averaging across the pre- and post-tests, no significant difference in attitudes was found between the Treatment and Control groups (F (1,107) = 1.93, p = 0.167). The repeated measure (i.e., pre- posttest) by group interaction effect was also not significant, indicating that the creation of the chemoscans had not improved students' attitudes toward the leisure interest in science (F (1,107) = 1.54, p = 0.217). Therefore, this failed to reject the null hypothesis.

Exploratory Analysis

One-way analyses of variance were conducted to determine if there were differences in the amount of improvement experienced by students between the four teachers who conducted the classes during the study period. The dependent variables for these analyses consisted of gain scores, computed by subtracting the pretest scores from the post-test scores for each subscale of the TOSRA. Teachers 3 and 4 taught classes using the chemoscans, while Teachers 1 and 2 taught classes in the traditional manner. The treatment and control conditions were intentionally ignored so that differences between teachers within and across conditions would be treated equally. The results of the ANOVAs are presented in Table 11.

As shown, teacher effects were found for five of the seven TOSRA subscales. Post hoc pairwise comparisons with Bonferroni adjustments were conducted to determine the source of the significant differences; in other words, which teachers had students who improved more than which other teachers. The students in Teacher 4's classroom improved more in attitudes toward the social implications of science compared to students taught by Teachers 1 and 3 (F (3, 108) = 4.87, p = .003; Bonferroni p < .05). The students in Teacher 4's classroom also improved significantly more in attitudes toward the normality of scientists compared to students taught by all other teachers (F (3, 108) = 11.11, p < .001; Bonferroni p < .05). The students in Teacher 2's classroom improved significantly more in attitudes toward scientific inquiry compared to students taught by Teacher 3 (F (3, 108) = 3.69, p = .014; Bonferroni p < .05). Although there was a significant teacher effect found for the Adoption of Scientific Attitudes scale (F (3, 108) = 2.79, p = .044), none of the post hoc tests revealed significant pairwise differences. Finally, the students of both Teachers 2 and 4 improved significantly more in enjoyment of science lessons compared to students taught by Teacher 1 (F (3, 108) = 5.28, p = .002; Bonferroni p < .05). These results indicate that the teacher effect was not simply a function whether the chemoscans were used in the classroom, since differences in improvement were found between and across conditions. Both Teacher 3 and 4 used the chemoscans, but Teacher 4's students improved significantly more than students of Teacher 3 in some cases. Also, Teacher 2's students, who did not have the experience of creating the chemoscans, improved significantly more in attitudes toward scientific inquiry compared to students of Teacher 3, who did create chemoscans in the classroom.

FINDINGS

Normality of Scientists

The first key finding of this study was that the creation of artistic digital chemoscans impacted high school physical science students' attitude toward science related to the normality of scientists, if administered by a talented teacher. Attitudes related to the normality of scientists have been shown to change in elementary students, middle school students, and pre-service teachers and the results from this study show that attitudes can also change in high school students (Calvert & Schyfter, 2017). Changes in attitudes toward the normality of scientists have been shown after summer-long STEM experiences (Hasni et al., 2017), but the findings of the current study extend the literature to show that maybe lessons integrated into the traditional science classroom can influence high school students related to how they view scientists.

In this study, only Teacher 4's students improved substantially in attitudes concerning the normality of scientists, so they could have carried the effect for all the students in the treatment condition. The analysis demonstrated that making chemoscans in the science classroom did not have large effect on students' attitude toward science, but it did have some effect on the way students looked at the normality of scientists. There was a failure to reject the null hypothesis for 6 of the 7 RQ. There is no way to tell for sure, since there was no crossover between teachers and treatment/control. Regardless, the results of this study may show that attitude regarding the normality of scientists is worthy of continued study. Other studies that include art into the learning experience have been shown to influence how students view scientists. Ness (2015) found that many students do not associate science with creativity. It is possible that the art activity in this study, chemoscans, helped students see creativity as part of science and may have influenced the view of scientists.

Nonsignificant Changes in Attitudes Toward Science

The second key finding was that the creation of artistic digital chemoscans by high school physical science students did not impact students' attitudes toward science related to social implications of science, attitude toward scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, or career interest in science. There are several interpretations for the nonsignificant results of this study. First, the quantitative study design of this research was limited by what the TOSRA instrument measured and may not have captured how participants may have changed attitudes toward science. A qualitative research approach might help explore how, if at all, creating chemoscans influenced students' experiences in science class. A qualitative study may enable researchers to understand how students feel about experiences when creating chemoscans, enabling a researcher to understand more fully if the treatment affected the students' attitudes.

Second, the interpretation for the nonsignificant results could be that the TOSRA was not the correct instrument to use for measuring students' attitude after creating chemoscans in the classroom. Along this same line is the possibility that a modified version of the TOSRA without a neutral answer choice could have been a better measure for student attitudes toward science because it would require them to give a positive or negative answer. Katsioloudis, Dickerson, Jovanovic, and Jones (2016) used a modified form of the TOSRA that eliminated the neutral responses, forcing students to make a positive or negative choice. The researchers used the results solely to determine if students were interested in science or not to help teachers determine how to help them. Additionally, even if attitude toward science is not influenced by chemoscans, it is possible that the digital art activity influenced students in ways not related to attitude toward science and should still be explored.

Teacher Effect

The third key finding was that a large teacher effect in this study indicated that students' attitude toward science, as measured by the TOSRA, was influenced by the teacher independent of whether students created artistic digital chemoscans. Teacher effect influenced several constructs from this study, including social implications of science, normality of science, scientific inquiry, adoption of scientific attitudes, and enjoyment of science lessons. The results of this study may confirm what others have found, that teachers' interpersonal behaviors can affect student attitudes toward science (Katsioloudis, Dickerson, Jovanovic, & Jones, 2016). This may indicate that the teacher's style and method can affect students' attitudes toward what they are learning as much or more as the activity itself, which could mean that training teachers differently and assessing enthusiasm toward presenting chemoscans in class could be an effective teaching design method when trying to incorporate new classroom strategies.

All the participating teachers were trained the same way, but all have different teaching styles and levels of enthusiasm when presenting material. The way a teacher presented the chemoscan to the students could have had an effect on the lack of significant findings. The lack of significant results in this study could indicate that the participating teachers need more training in the production of chemoscans and how to most effectively implement art activities in the physical science classroom. It is possible that improved teacher training might yield different results. Mitchell (2013) found that teacher enthusiasm can have a profound effect on student motivation, so more teacher training would be needed to help participating teachers feel more comfortable about chemoscan creation.

The teacher's approach to chemoscan production during this study could have been affected by attitudes toward using art in the classroom. All teachers involved in the study were trained the same way, but the training did not include a discussion about the benefits of including art or STEAM activities in the science classroom. Herga et al. (2014) explored how teachers make sense of the use of STEAM in the classroom and concluded that many teachers find STEAM activities to be so different from normal methods of teaching that is takes extra time to implement effectively. The teachers from this study needed time to reflect on the activities in order to refine methods. The teachers also required a clear definition of STEAM in order to understand why they were using art when teaching science. This may explain why teacher effect seemed to have so much influence on student attitude.

CONCLUSION

If educators are to effectively prepare students for successful lives in the 21st century, then students should have the opportunity to learn technologies that help them have a more positive attitude toward science. Although the tools are currently available, they are not being used in schools to the degree they should be. An opportunity to enrich the quality of students' learning through the use of technology and art needs to be explored.

In this study, the use of chemoscans to increase student interest in science was investigated. By understanding this type of activity and its effect on students, teachers could be provided with a variety of methods to help students achieve a real love of learning. The need for technology-based educational activities is on the rise as schools become more focused on developing 21st century skills. In this research study, there was an attempt to create an opportunity for teachers using educational technology to share insight and identify methods to use new technology-based lessons in the classroom. Although the results did not show significant change in students' science attitudes, it could become the beginning of understanding how digital art can make the difference for students' attitudes towards science in the future.

The findings of this study may contribute to positive social change in several ways. First, at the individual level, teachers consistently need more innovative lessons to help increase student interest in science. The use of digital artistic images can be one method to help teachers in the classroom. There is also potential for change at the organizational level because school districts are always looking for methods to help teachers in the classroom that leads to students wanting to learn more about any subject. The results of this study could advance research concerning how to measure student attitudes toward science when using digital art in the science classroom to increase interest in science. This could advance knowledge in the field of educational technology. There is also the potential for the findings of this study to advance knowledge of how digital art technologies might help improve students' attitudes toward science. The results of the study could promote more studies that help the understanding of how digital art can improve students' attitude in the classroom.

This study also has potential implications for positive social change. The lack of significant findings does not diminish the need to discover how art and technology can be used to improve classroom teaching methods. The study of chemoscan creation using different experimental methods could lead to improved understanding of how technological tools might be used to improve students' attitudes in science. This could lead to improved classroom practice, possibly improving student interest in pursuing STEM-based careers in the future.

REFERENCES

AmGen Foundation. (2016). *Students on STEM*. Retrieved from https://www.amgeninspires.com/~/media/amgen/full/www-amgeninspires-com/pdf/stem_survey_brief.ashx?la=en

Belser, C., Prescod, D., Daire, A., Dagley, M., & Young, C. (2017). Predicting undergraduate student retention in STEM majors based on career development factors. *Career*

Development Quarterly, 65, 88–93. doi:10.1002/cdq.12082

Calvert, J., & Schyfter, P. (2017). What can science and technology studies learn from art and design? Reflections on 'synthetic aesthetics.' *Social Studies of Science, 47*(2), 195-215. doi:10.1177/0306312716678488

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. New York, NY: Lawrence Erlbaum.

Creswell, J. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Thousand Oaks, CA: SAGE.

Faul, F., Erdfelder, E., Lang, A., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39,* 175–191. doi:10.3758/BF03193146

Fraser, B. (1981). *TOSRA: Test of Science-Related Attitudes handbook.* Hawthorn, Victoria, Austrailia: Australian Council for Educational Research.

Hasni, A., & Potvin, P., & Sy, O. (2017). Using inquiry-based interventions to improve secondary students' interest in science and technology. *European Journal of Science and Mathematics Education*, *5*(3), 262–270. Retrieved from https://network.bepress.com/education/science-and-mathematics-education/

Herga, N. R., Grmek, M. I., & Dinevski, D. (2014). Virtual laboratory as an element of visualization when teaching chemical contents in science class. *Turkish Online Journal of Educational Technology, 13*(4), 157–165. Retrieved from http:// www.tojet.net/Herro, D., & Quigley, C. (2016). STEAM enacted: A case study of a middle school teacher implementing STEAM instructional practices. In *Proceedings of Society for Information Technology & Teacher Education International Conference 2016* (pp. 1499–1506). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE). doi:10.12973/eurasia.2016.1538a

International Society of Technology Education. (2018). *ISTE standards for students.* Retrieved from https://www.iste.org/docs/Standards-Resources/iste-standards_students-2016_research-validity-report_final.pdf

Jenson, J., & Droumeva, M. (2016). Exploring media literacy and computational thinking: A game maker curriculum study. *Electronic Journal of e-Learning*, *14*(2), 111-121. Retrieved from http://www.ejel.org/main.html Katsioloudis, P., Dickerson, D., Jovanovic, V., & Jones, M. (2016). Use of dynamic visualizations for engineering technology, industrial technology, and science education students: Implications on ability to correctly create a
sectional view sketch. *Journal of Technology Education*, *28*(1), 19-36. Retrieved from https://scholar.lib.vt.edu/ejournals/JTE/v29n2/pdf/katsioloudis_stefaniak.pdf

Klopfer, L. (1971). Evaluation of learning in science. In B.S. Bloom, J.T. Hastings & G.F. Madaus (Eds), Handbook on summative and formative evaluation of student learning. NY: McGraw-Hill, l97l.

Klopfer, L. (1973). *A structure for the affective domain in relation to science education*. Paper Presented at the Annual Meeting of the National Association for Research in Science Teaching. Detroit, Michigan.

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education, 33,* 27-50

Krathwohl, D., Bloom, B., & Masia, B. (1964). *Taxonomy of educational objectives handbook II: Affective domain*. NY: David McKay Co.

Liao, C., Motter, J., & Patton, R. (2016). Tech-savvy girls: Learning 21st-century skills through STEAM digital artmaking. *Art Education*, *69*, 29–35. doi:10.1080/00043125.2016.1176492
Mitchell, M. (2013). Teacher enthusiasm: Seeking student learning and avoiding apathy. *Journal of Physical Education, Recreation & Dance*. *84*(6), 19. doi:10.1080/07303084.2013.779536.
Ness, R. (2015). *The creativity crisis: Reinventing science to unleash possibility.* New York, NY: Oxford University Press.
Next Generation Science Standards. (2019). *The next generation science standards.* Available from http:// https://www.nextgenscience.org
Sousa, T., & Pilecki, D. (2013). *From STEM to STEAM.* Thousand Oaks, CA: Corwin Press.

APPENDIX

Table 1
Name and Classification of Each Subscale in TOSRA Aligned to Klopfer's Classification

TOSRA Scale Name	Klopfer's (1971) Classification
Social implications of Science (S) Normality of Scientists (N)	Manifestation of favorable attitudes towards science and scientists
Attitude to Scientific Inquiry (I)	Acceptance of scientific inquiry as a way of thought
Adoption of Scientific Attitudes (A)	Adoption of 'scientific attitudes'
Enjoyment of Science Lessons I	Enjoyment of science learning experiences
Leisure Interest in Science (L)	Development of interest in science and science related activities
Career Interest in Science I	Development of interest in pursuing a career in science

Note. Reprinted from *TOSRA: Test of science-related attitudes handbook* (1981) by B.J. Fraser Hawthorn, Victoria, Australia: Australian Council for Educational Research. Reprinted with permission of B.J. Fraser.

Table 2

Cronbach's alpha values for TOSRA scale year 7 to 10

Scale	Cronbach's alpha values			
	Year 7	Year 8	Year 9	Year 10

Social Implications of Science	0.81	0.82	0.75	0.82
Normality of Scientists	0.72	0.70	0.72	0.78
Attitude to Scientific Inquiry	0 .81	0.82	0.81	0.86
Adoption of Scientific Attitudes	0.66	0.64	0.69	0.67
Enjoyment of Science Lessons	0.93	0.92	0.87	0.93
Leisure Interest in Science	0.88	0.85	0.87	0.89
Career Interest in Science	0.90	0.88	0.88	0.93

Note. Reprinted from *TOSRA: Test of science-related attitudes handbook* (1981) by B.J. Fraser. (1981), Hawthorn, Victoria: Australian Council for Educational Research. Reprinted with permission of B.J.Fraser.

Table 3

Summary Statistics for TOSRA Subscales

TOSRA subscales	*M*	*SD*	*Skewness*	*SE*	*z*
Pre-test					
Social Implications of Science	33.20	6.08	-0.24	0.23	-1.04
Normality of Scientists	30.45	3.50	0.03	0.23	0.13
Career Interest in Science	27.87	6.61	0.14	0.23	0.61
Attitude to Scientific Inquiry	36.20	6.55	-0.22	0.23	-0.95
Adoption of Scientific Attitudes	34.21	5.33	0.26	0.23	1.14
Enjoyment of Science Lessons	30.04	7.30	-0.22	0.23	-0.97
Leisure Interest in Science	27.02	6.37	0.06	0.23	0.25
Post-test					
Social Implications of Science	34.06	4.90	-0.35	0.23	-1.50
Normality of Scientists	31.73	3.78	0.47	0.23	2.05
Career Interest in Science	29.57	6.14	-0.32	0.23	-1.39
Attitude to Scientific Inquiry	36.94	5.81	-0.14	0.23	-0.61
Adoption of Scientific Attitudes	34.72	5.54	-0.31	0.23	-1.32
Enjoyment of Science Lessons	32.84	6.79	-0.72	0.23	-3.12
Leisure Interest in Science	27.31	6.67	-0.01	0.23	-0.05

Table 4

Treatment vs Control on Improvement in Attitudes Toward the Social Implications of Science

		Pretest		Posttest		Analysis of variance				
Group	*N*	*M*	*SD*	*M*	*SD*	*Source*	*F*	*df*	*p*	η^2
Treatment	54	33.09	6.93	34.43	4.55	Pre Post	1.20	1, 107	0.276	0.011
Control	55	33.31	5.17	33.69	5.23	Group	0.13	1, 107	0.718	0.001
						Pre Post * Group	0.37	1, 107	0.545	0.003

Table 5

Treatment vs Control on Improvement in Attitudes Toward the Normality of Scientists

		Pretest		Posttest		Analysis of variance				
Group	*N*	*M*	*SD*	*M*	*SD*	*Source*	*F*	*df*	*p*	η^2
Treatment	54	30.37	3.86	33.02	4.12	Pre Post	7.55	1, 107	0.007	0.066
Control	55	30.53	3.14	30.47	2.92	Group	6.01	1, 107	0.016	0.053
						Pre Post * Group	8.19	1, 107	0.005	0.071

Table 6

Treatment vs Control on Improvement in Attitudes Toward a Career Interest in Science

		Pretest		Posttest		Analysis of variance				
Group	*N*	*M*	*SD*	*M*	*SD*	*Source*	*F*	*df*	*p*	η^2
Treatment	54	27.37	5.48	30.57	4.57	Pre-Post	4.31	1, 107	0.040	0.039
Control	55	28.36	7.58	28.58	7.28	Group	0.31	1, 107	0.579	0.003
						Pre Post * Group	3.28	1, 107	0.073	0.030

Table 7

Treatment vs Control on Improvement in Attitudes Toward Scientific Inquiry

		Pretest		Posttest		Analysis of variance				
Group	*N*	*M*	*SD*	*M*	*SD*	*Source*	*F*	*df*	*p*	η^2
Treatment	54	36.0	6.66	36.02	4.66	Pre-Post	0.80	1, 107	0.374	0.007
Control	55	36.4	6.50	37.84	6.67	Group	1.66	1, 107	0.200	0.015
						Pre-Post * Group	0.76	1, 107	0.386	0.007

Table 8

Treatment vs Control on Improvement in Attitudes Toward the Adoption of Scientific Attitudes

		Pretest		Posttest		Analysis of variance				
Group	*N*	*M*	*SD*	*M*	*SD*	*Source*	*F*	*df*	*p*	η^2
Treatment	54	34.00	5.45	34.59	5.32	Pre Post	0.43	1, 107	0.512	0.004
Control	55	34.42	5.26	34.84	5.79	Group	0.22	1, 107	0.642	0.002
						Pre Post * Group	0.01	1, 107	0.910	0.000

Table 9

Treatment vs Control on Improvement in Attitudes Toward the Enjoyment of Science Lessons

		Pretest		Posttest		Analysis of variance				
Group	*N*	*M*	*SD*	*M*	*SD*	*Source*	*F*	*df*	*p*	η^2
Treatment	54	29.70	6.55	34.04	5.19	Pre-Post	7.58	1, 107	0.007	0.066
Control	55	30.36	8.01	31.67	7.93	Group	0.95	1, 107	0.331	0.009
						Pre Post * Group	2.18	1, 107	0.143	0.020

Table 10
Treatment vs Control on Improvement in Attitudes Toward the Leisure Interest in Science

		Pretest		Posttest		Analysis of variance				
Group	*N*	*M*	*SD*	*M*	*SD*	*Source*	*F*	*df*	*p*	η^2
Treatment	54	27.07	6.14	28.48	4.92	Pre Post	0.12	1, 107	0.733	0.001
Control	55	26.96	6.65	26.16	7.92	Group	1.93	1, 107	0.167	0.018
						Pre Post * Group	1.54	1, 107	0.217	0.014

Table 11
Teacher Effects on Improvement in Attitudes Toward Science

	Control				Treatment						
	Teacher 1 (*n* = 28)		Teacher 2 (*n* = 27)		Teacher 3 (*n* = 29)		Teacher 4 (*n* = 25)				
Gain Scores	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	*Post Hoc*
Social Implications of Science	-0.21	6.54	1.00	7.91	-2.31	9.29	5.56	6.79	4.87	0.003	T4> T1, T3
Normality of Scientists	0.07	4.35	-0.19	4.34	-0.10	5.51	5.84	3.37	11.11	< .001	T4 > T1, T2, T3
Attitude toward Scientific Inquiry	8.54	9.52	13.30	9.48	6.48	7.43	11.80	7.04	3.69	0.014	T2 > T3

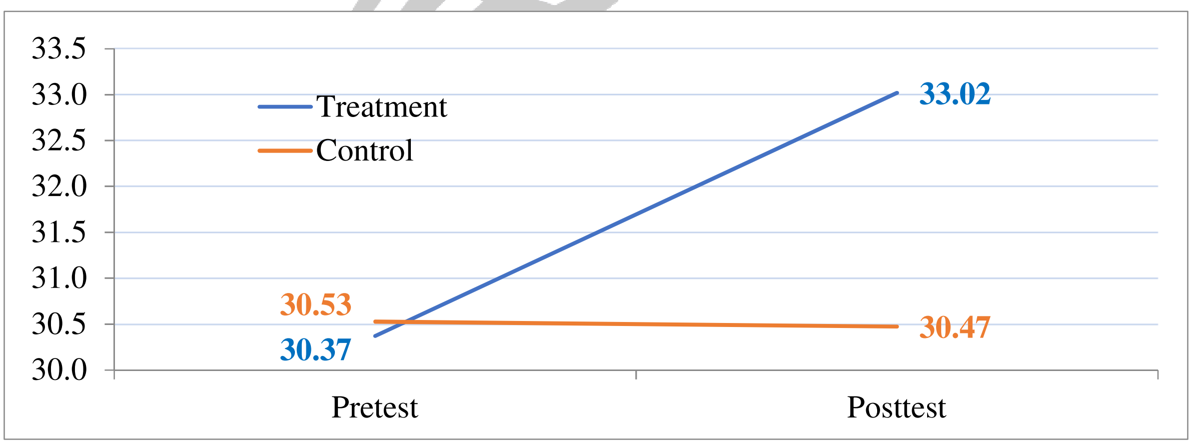

Figure 1. Improvement in attitudes toward the normality of scientists after the creation of chemoscans