STEM to STEAM: Effect of Visual Art Integration on Long-Term Retention of Science Content

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Abstract

The current focus on STEM education is based on the idea that science, technology, engineering and math be taught in an interdisciplinary and applied approach in grades K-12. There is growing attention to integrating the arts as an equal partner to STEM learning (STEAM). The purpose of this cluster random sample experimental study was to examine the effect of visual art instruction, specifically drawing, on long-term retention of science content. Fifty-five fifth and sixth grade students participated in this study, 31 in the experimental group and 24 in the control group. Both groups received instruction based on a modified science lesson developed by Arizona State University in cooperation with the National Aeronautics and Space Administration. The experimental group received instruction on art techniques to be used for drawing and the development of visual notes while the control group used traditional note taking and writing. A delayed post-test revealed that the drawing group scored significantly higher for retention of content. Implications for authentic arts integration revealed by this study suggest that the arts play a significant role in learning and content retention in art and science. More significantly, the participants in this study were at the level of proficiency and labeled gifted (minimum IQ of 130), demonstrating that arts integration is effective with a more diverse population than marginalized students studied in previously investigations.

Overview

Arts Integration is an approach to teaching in which students construct and demonstrate understanding through an art form. Students engage in a creative process which connects an art form and another subject area and meets evolving objectives in both (Silverstein & Layne, 2010). Burton, Horowitz and Abeles (1999) describe arts integration as balanced teaching in and across disciplines, collaborative and practiced with an awareness for learning possibilities beyond each discrete subject area. The arts are often viewed in a supportive role subservient to the high stakes subject areas (Mishook & Kornhaber, 2006). This perception of the arts fails to explore the significance they may hold for the development of the whole child.

STEAM education is a shift from traditional educational philosophy based on standardized test scores to a focus on the learning process where connections are made between standards, assessments, lesson design and implementation. Ghanbari (2015) and Mishook & Kornhaber (2006) argue that the arts are not supplementary and must be viewed as equal to other content areas. The proliferation of educational organizations casting a critical lens on STEAM education provides a foundation for research in experiential learning opportunities. The STEAM movement may shed light on role of the arts in developing a student who embraces learning and is able to retain information long term through his/her own mean making. However, few experimental studies have been conducted to support arts integration and none utilizing exclusively visual arts. In the absence of empirical evidence to support STEAM initiatives as an effective means of increasing science, technology, engineering, and mathematics knowledge among students the integration of the arts, in particular the visual arts, begs further examination.

Literature Review

Research studies support the relationship between drawing a visual representation (imagery) and comprehension that plays an important role in memory and cognition. Images are processed at a deeper level through dual coding that promotes increased comprehension and strengthened memory. Drawing was found to provide an individual process of consciousness and synthesis of thoughts and remembering. It may be the creative act or process that is the source of processing benefits where the act of physically making images is a means through which to encourage remembering and visualization (Cohen & Johnson, 2012; Rosier, Locker & Naufel, 2013; Minichiello, 2012).

Research suggests that focused training in the arts can improve cognition through its ability to strengthen the brain's attention system and increase cognitive capacities for attention, memory, and learning in general (Patterson, 2015). The inherent characteristics of the arts provide opportunities to acquire knowledge (Koroscik, 1984) and naturally support

a variety of long-term memory effects well known in cognitive psychology. One characteristic, proposed by Rinne, Gregory, Yarmolinskaya, and Hardiman (2011), as an effective way to increase retention of content through the long-term memory factor is pictorial representation. Pictorial Representation is described as the memory factor related to pictorial representation, commonly known as the picture superiority effect, that results in improved memory as pictures are processed more conceptually than words (McBride & Dosher, 2002). It is through the perception, appreciation and production of the aesthetic experience in art and interpretation that students gain retention benefits (Rinne et al., 2011).

Koester (2015) in a qualitative study concluded that drawing provided the pathway for previously failing, marginalized students to become more engaged and better remember content. In a 2012 quasi-experimental study, Cohen and Johnson found that the use of imagery creation (drawing) positively affected science vocabulary retention. Research by Wammes, Meade and Fernandes' (2016) examined encoding strategies focusing on the efficacy of drawing on memory for list words and found that the "drawing effect" demonstrated a superior and reliable advantage in memory performance. Several studies found relationships between the visual arts and learning for retention. An experimental study conducted by Rosier, Locker, and Naufel (2013) produced results that suggested the highly creative act of drawing activates various brain regions leading to greater receptivity of information. They noted that it was the creative component that would appear to be the critical element and that engagement in a highly creative act may lead to individuals processing information on a deeper level that may generalize to other tasks. It is suggested that skills learned through artistic engagement, drawing in particular, are transferrable to other academic areas and might be valuable as a studying technique. According to Minichiello (2012), in his study of visual stimuli in triggering memory, drawing provided an individual process of consciousness and synthesis of thoughts. It is the stimulus and visualization tool in memory recovery. One drawing study conducted by Cohen and Johnson (2012) found a significant positive effect on retention of science vocabulary. They concluded that engagement in highly creative acts may result in individuals processing information on a deeper level. Their findings were confirmed by Rosier, Locker and Naufel (2013).

Problem

Previous research investigating long-term retention has either employed multiple modalities or drawing alone. It has not explored the integration of visual art where drawing techniques have been used to develop a visual note taking symbol system exclusively to gather information and then employed to create a drawing that demonstrates application and understanding. Hardiman, Rinne and Yarmolinskaya's (2014) arts integration employed multiple arts disciplines with a low socioeconomic status (SES) population and noted a need for further research with diverse populations. Research with an intellectually gifted and moderate to high SES population may cast a lens on the effect visual art integration has on a student population at the proficient level. At present, there have been no studies illustrating a causal link between content taught through visual note taking and student produced drawings that demonstrate understanding and assess long-term retention. Embracing the arts as an equal partner to STEM education where diverse learners are able to acquire, retain, and apply knowledge in a meaningful manner may have wide-ranging implications for student learning and retention across disciplines.

Research Question

- To what extent do students retain content using visual art integration, specifically employing art techniques to develop visual note taking and drawing skills, in STEM learning, as compared to students taught using a traditional approach?

Rationale

This study seeks to bring to light empirical evidence that authentic arts integration will provide the learner with access to content and skills in art and science thereby increasing the likelihood of increased long-term retention of content. It is through the use of art techniques, drawing skills and the development of personally meaningful visual notes that participants will experience authentic arts integration into science content.

Methods

Participants in this study included 55 students enrolled in a small private school for the intellectually gifted in the northeastern United States. The participants were 28 fifth grade students and 27 sixth grade students with a minimum IQ of 130 working 1-3 years above grade level.

Research Design

This experimental study, using a cluster random sample of two heterogeneous intact fifth grade classes and two heterogeneous sixth grade classes, sought to examine the impact of teaching science through visual art integration on long-term retention of science content using an adaptation of the National Aeronautics and Space Administration's (NASA) extremophiles STEM lesson plan. The control group received traditional STEM instruction employing conventional note taking to gather information. Prior to science content instruction, the experimental group received instruction on developmentally appropriate drawing techniques to be used during the visual note- taking process and the development of illustrative and culminating drawings. An eleven-question multiple-choice test was administered to assess prior knowledge regarding extremophiles and again to assess content learning and retention immediately after instruction and one-month post instruction.

The Dependent Variables included participants' scores on Retention post-test/multiple distance post-tests. Participants were post-tested immediately following delivery

of content and then again at one-month post-delivery. Independent Variables included class grouping (5th or 6th grade). Since a convenience sample of two fifth and sixth grade art classes were used for this research, one class from each grade was randomly assigned to the control group (traditional STEM instruction) and the other class to the experimental group (visual art integrated STEAM instruction). **Covariates** included the categorical variables of retention rates related to gender, academic achievement measured by first and second trimester grades in science, and race.

Data-analytic procedure

A one-way repeated measures ANOVA using the current version of the Statistical Package for the Social Sciences (SPSS version 23) was conducted to compare the effect of visual art integration on long-term retention of content test scores immediately following delivery of the extremophile lesson and again at one-month post instruction.

Limitations

Instruction of a single science lesson in and through the visual arts may provide only a snapshot of its retention effect. A broader integration period may be indicated to fully realize visual arts effect regarding long-term retention of content. The small sample size may limit the ability to generalize findings to a larger population therefore a larger study may be indicated.

Findings

This study examined the effect drawing and visual note taking have on long-term retention of science content. The results demonstrated that the visual art integration (visual note-taking) group exhibited a higher retention rate on the delayed post-test (dependent variable) than the traditional note-taking group and that no significant differences were found between the fifth and sixth grade participants on the measures.

To determine the effect of visual art integration, specifically drawing and visual note taking, on the retention of science content an ANOVA was conducted and revealed that there was a statistically significant effect of the visual art integration condition (experimental) on post-test scores ($F(1,49) = 7.545$, $p < .001$, partial $\eta^2 = .23$). The Levene's test of homogeneity examines that variances are all equal for all samples when the data comes from non-normal distribution of groups. Levene's was not significant $F(1,50) = 3.154$, $p = .08$ indicating that there was no significant difference between fifth and sixth grade scores on the post-test ($F(1,49) = .010$, $p < .05$, partial $\eta^2 = .00$). Levene's $F(1,50) = .936$, $p = .338$.

An additional ANOVA revealed that there was also a statistically significant effect of the visual art integration condition on delayed post-test scores ($F(1,46) = 4.297$, $p < .05$, partial $\eta^2 = .085$). Levene's $F(1,48) = .004$, $p = .948$. There was no significant difference between fifth and sixth grade on the delayed post-test ($F(1,50) = .203$, $p < .05$, partial $\eta^2 = .004$). Levene's $F(1,51) = 2.555$, $p = .116$. Using the enter method, a significant model emerged: $F(1, 46) = 4.297$, $p < .05$. This model explains 28.2% of the variance (Adjusted $R^2 = .282$). Visual art integration was a significant predictor of content retention on the delayed post-test.

Discussion

This research is one of a few studies that has utilized drawing or visual note-taking, however, none have used both and none have employed the development of drawing techniques prior to learning methods in which to create visual notes and science content learning. Drawing techniques and visual notes were used to collect and apply content knowledge in the development of a culminating illustration in order to demonstrate an understanding and application of both art techniques and science content knowledge. The ANOVA also revealed that there were no significant differences between fifth and sixth grade participants' scores on the pre-test, post-test and delayed post-test suggesting that this intervention was not impacted by student grade level.

Previous research has found that participants from low SES groups who are not proficient in reading attained improved test scores (Hardiman et al., 2014; Koester, 2015), however, the results of the art integration (visual note taking and drawing instruction) employed in the current research demonstrated significant improvement in retention with a middle to high SES group of gifted students (IQ 130 or above).

The results of this study support the hypothesis that drawing and the creation of a personally meaningful visual vocabulary (visual notes) may lead to improved long-term retention (Edens & Potter, 2001; Hardiman et al., 2014; Koester, 2015; McBride & Dosher, 2002; Minichiello, 2012; Wammes et al., 2016). Visual note taking adds an additional layer where the development of art techniques is used to acquire and retain information.

Implications

Practical implications of this study point to the necessity that policy makers re-examine the validity of a fully integrated educational experience for students in order that learning is in and through the arts. The importance of this may be found in the results of this study as the participants gained a better understanding of content. Given that the findings in the current study where the participants were gifted individuals from middle to high SES, it may be necessary to re-examine the value of an authentic art integration with more diverse populations. The limited diversity in this and other studies necessitates that future research be conducted with a significantly greater population and

the inclusion of races other than those examined here. A longer period allotted for experimentation and practice may be warranted in future research. The 40-minute period designated for each of the art techniques may not have permitted enough practice to fully realize the application of skills with respect to the development of the visual notes and culminating drawings. The integration of art techniques and drawing should increase student efficacy and achievement. Going forward, larger studies with more diverse populations is warranted where instruction in art techniques and science content are taught by educators competent in those areas.

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