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Abstract

Results from a number of studies indicate that the use of different types of music can influence cognition and behavior; however, research provides inconsistent results. Considering this, a quasi-experimental study was conducted to identify the existence of statistically significant effects on sectional view drawing ability due to the impacts of music. In particular, the study compared the use of three different types of music; classical, rock, heavy metal and whether a significant difference exists towards sectional view drawing ability, among engineering technology students. According to the results of this study it is suggested that the impact of music provides no statistically significant differences.

Introduction

Research indicates that performance of verbal, mathematical, or visuospatial tasks can increase in students who received music lessons before the tests, in comparison with students who followed nonmusical courses (Bilhartz, Bruhn, & Olson, 2000; Costa-Giomi, 1999; Rauscher et al., 1997). When using auditory material, several studies reported performance differences in adult musicians compared to non-musicians (McAdams & Drake, 2002; Zatorre & Peretz, 2001). Cabanac, Perlovsky, Bonniot-Cabanac, and Cabanac (2013) found that listening to pleasant music while performing an academic test helped students overcome stress due to cognitive dissonance. It also helped students devote more time to stressful and complicated tasks, as well as score higher grades overall (Cabanac et al., 2013). Therefore, there is a prospect that music processing depends on cognitive styles that vary between individuals, as well as between situations and contexts of listening (Chamorro-Premuzic & Furnham, 2007).

The issue remains controversial as some studies show that such benefits tend to disappear after a few years in comparing musical students with students who have not received music lessons (Costa-Giomi, 1999). In addition, most of the observed differences rely on top-down cognitive abilities, such as spatial memory, rather than on lower-level processes (Brochard, Dufour, & Despres, 2004).

The purpose of the current study is to identify whether listening to different kinds of music can increase or decrease spatial ability performance for engineering technology students.

The following was the primary research question:

> Is there a difference in sectional view drawing ability, as measured through technical drawings, among the impacts of music on dynamic visualizations for engineering technology students?

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The following hypotheses will be analyzed in an attempt to find a solution to the research question:

> H_0: There is no difference on sectional view drawing ability, as measured through technical drawings, among the impacts of music on dynamic visualizations for engineering technology students.
>
> H_A: There is an identifiable difference on sectional view drawing ability, as measured through technical drawings, in the impacts of music on dynamic visualizations for engineering technology students.

Review of Literature

Effects of Music on Learning

As technology evolves so does the environment in which students learn. A student-centered approach seems more logical from what has traditionally been a teacher-centered approach in the classroom (Donnellan, 2008). Griffin (2006) states that "educators should be constantly searching and evaluating the correlation between environmental conditions, classroom facilities and student outcomes" (p. 5). In addition, Leung and Fung (2005), suggest that "lighting, temperature, ventilation, noise, decoration and space management should all be considered" when designing learning environments for success (p. 586). Research has also explored the environment containing music and its relationship on cognitive functions during learning. Hetand (2000), reported a relationship between those learning to play an instrument and spatial-temporal ability. Rauscher, Shaw, and Ky (1993) found a significant relationship between listening to music and cognitive task performance in spatial reasoning and mathematics.

Hallam, Price, and Katsarou (2002) reported that "calming relaxing music" showed a positive effect on the quantity of mathematical problems completed, recall from reading sentences, and pro-social behaviors. Furthermore, music considered to be arousing, unpleasant, or aggressive showed a negative effect on memory task performance, and resulted in lower levels of pro-social behaviors (Hallam et al., 2002). Research published by Southgate and Roscigno (2009) indicated that music involvement (playing an instrument, attending musical performances, etc.) inside and outside of school has an impact on math and reading performance for both elementary and high school students.

Although the diffusion of the idea that listening to music, specifically that of Mozart, could improve academic performance (Rauscher et al., 1993), researchers have challenged these findings and debated that such an existence in learning environments was possible (O'Sullivan & Donnellan, 2008). The temporary enhancement of spatial-temporal reasoning abilities found in the Rauscher et al. (1993) study ignited a great

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deal of interest in increasing academic performance using music. Other researchers challenged this outcome and more recent studies have found that music actually affects mood and arousal, which indirectly impacts learning (Husain, Thompson, & Schellenberg, 2002; Jaušovec, Jaušovec, & Gerlič, 2006; Steele, Bass, & Crook, 1999; Thompson, Schellenberg, & Husain, 2001). Additional research suggests that the influence of background music on behaviors and mood creates the relationship to spatial reasoning, thus academic performance is enhanced by behavior and/or mood (Griffin 2006; O'Sullivan, 2008).

Thompson et al. (2001) reported that a significant impact on performance by *Mozart Effect*® was found when the music condition of Mozart's K448 (an upbeat allegro) was used versus a minor key, such as the use of a slower adagio like Abinoni's Adagio. This has led to the belief that rather than a "true" *Mozart Effect,*® findings may indicate the tempo of the music is actually the stimulating effect. Nantais and Schellenberg (1999) found significantly higher scores in students following the music stimuli, however, there was no significant difference in the music of Schubert versus that of Mozart. Rauscher and Hinton (2006) used a meta-analysis to determine that there is scientific importance among studies, which "suggest that music and spatial task performance share common elements and may be psychologically and neurologically related" (p. 237). Ignoring these links between music and cognitive performance may result in overlooking educational intervention that could be important in the enhancement of learning (Rauscher & Hinton, 2006).

Spatial Ability

Spatial ability is believed to be an independent ability, autonomous of general intelligence (Höffler, 2010). It allows the learner to relate to their environment (Hegarty & Waller, 2005) in order to form and retain a mental model and manipulate the object(s) to create a three dimensional representation on paper or in computer-aided design (CAD) software. Extensive research of spatial ability continues as new technologies develop to enhance spatial ability, as well as new teaching methodologies and tools to improve students' spatial skills (Domínguez, Martín-Gutiérrez, González, & Corredeaguas, 2012).

Spatial ability is a fundamental skill for first-year engineering students and their associated career choice in engineering, as well as in other technical fields. Design and sketching coursework still use hand sketching, alongside computer-based software (e.g. CAD) to train engineering students in 3-D design (Harris & Meyers, 2007; Mohler, 2006; Mohler & Miller, 2008; Sorby, 2001). The success of spatial ability development is well documented and considered a key component to ensure professional performance in technical and engineering fields (Carrera, Martín-Dorta, Saorín Pérez, & Cantero, 2015; Domínguez et al., 2012; Leopold, Górska & Sorby, 2001; Martín-Gutiérrez, Domínguez, & González, 2015; Miller, 1996; Mohler, 2006; Mohler & Miller, 2008; Sorby, 1999; Sorby & Baartmans, 2000; Sorby & Górska, 1998; Sorby, Nevin, Mageean, Sheridan, & Behan, 2014).

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Spatial Ability and Music

Research suggests that music may have a significant impact on academic performance, specifically in spatial reasoning and mathematics (Southgate & Roscigno, 2009). The term *Mozart Effect*®(ME) was first recognized in the academic field by Rauscher, Shaw, and Ky in 1993 when they presented research on the effects of music (background music) in spatial task performance. This famous study was published in the prestigious science journal, *Nature*. Participants in the study were given a paper folding and cutting task to measure spatial awareness abilities. Participants listened to Mozart's *Sonata for Two Pianos in D Major* (K.488) for 10 minutes (Perham, Lewis, Turner, & Hodgetts, 2014). Findings of this study revealed that subjects performed better on spatial reasoning tasks after listening to Mozart compared to the group who listened to a relaxation piece or the group who received the no music (silence) condition. However, many feel the *Mozart Effect*® has been "misnamed," as more recent research has discovered that mood can be influenced by classical composers other than Mozart, or even other categories of music (Bertsch, Knee, & Webb, 2011).

Since Rauscher et al. (1993) first presented the term *Mozart Effect*® other studies have replicated the study, as well as contradicted the original study findings (Perham et al., 2014; Perham & Withey, 2012; Rauscher et al.,1993; Rauscher, Shaw, & Ky, 1995). More recent research suggests that the effect of music on spatial ability is indirect, whereby music enhances mood and brain function. It is, therefore, a possibility that there is an endorphin in the limbic system of the brain that impacts blood pressure, body temperature, and pulse rate, which then reduces stress and anxiety and enhances the learning environment and the performance of students in such an environment (Swan, 2003).

Several studies have been performed testing the theory of music and its ability to enhance spatial ability. Bertsch et al. (2011) found two related variables in their study: the participants' sex and the mood and emotion enhanced by the music. The study did not produce significant findings in spatial rotation scores between the groups exposed to music and those who did not receive the music treatment. However, there was an interaction found regarding the sex of the participants and the enhancement of the mood and emotion produced by the music. The impact of music on spatial rotation performance, related to the mood-inducing effect on both men and women, produced a small effect size. From the study it was determined that type of music, type of spatial rotation task, subjects with music backgrounds, and the sex of the participants play a role in music's impact on spatial rotation performance (Bertsch et al., 2011).

Ivanov and Geake (2003) conducted research on primary school students in natural classroom settings. The control group was given no additional stimuli aside from the natural sounds occurring in the classroom. The experimental group received music before and during the Paper Folding and Cutting test (PFT) from the Stanford-Binet tests. Results showed that the mean scores for the experimental group were significantly higher than for the control group.

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Other research studies have suggested that music chosen by the student (music that enhances student mood, e.g. regardless of upbeat tempo and major key) may improve cognitive performance (Cassileth, Vickers, & Magill, 2003; Rickard, Toukhsati, & Field, 2005; Siedlecki & Good, 2006). However, there is little research on a learner's music preference and its association with learning. There is also little research that tests music's ability to significantly impact spatial reasoning performance and learning in engineering education and 3D modeling.

Methodology

Subjects in this study were exposed to a range of musical styles. Selection of music for this study took into consideration impacts of music based on the presupposition that most students listen to a particular genre of music that can arouse mood and emotions. A quasi-experimental study was used as a means to perform the comparative analysis of sectional view drawing ability during the Fall of 2016. The study was conducted in an engineering graphics course, as part of the Engineering Technology program. The participants from the study are shown in Figure 1. Using a convenience sample, there was a near equal distribution of the participants between the three groups.

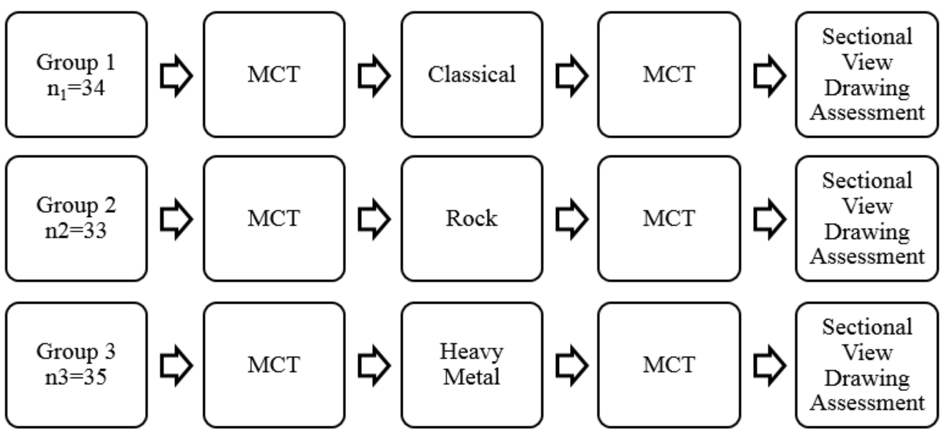

Figure 1. Research Design Methodology

The engineering graphics course emphasized hands-on practice using 3D drafting software in the computer lab, along with the various methods of editing, manipulation, visualization, and presentation of technical drawings. In addition, the course included the basic principles of engineering drawing/hand sketching, dimensions, and tolerance principles.

Students who attended the course during the Fall semester of 2015 were divided into three groups. The three groups (*n1*=34, *n2*= 33 and *n3*=35, with an overall population of *N* = 102) were presented with a visual representation of an object (visualization) and were asked to create a sectional view. All three groups (*n1, n2, n3*) received a dynamic 3D printed triacontahedron (see Figure 2) visualization, self-rotated at 360 degrees on

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the top of a motorized base at about four rounds per minute (slow rotation was used to prevent optical illusion and distortion of the original shape) and were asked to create a sectional view while listening to a different type of music, (classical, heavy metal, rock) respectively. Since music was used as a part of the study treatment, and to prevent bias for students using hearing aids, all participants were presented with several sound clips (varying from 30-50dB) and were asked to report whether they could hear the music or not. No students were identified as having difficulty listening to the music sound.

In addition, all groups were asked to complete the Mental Cutting Test (MCT) (College Entrance Examination Board [CEEB], 1939) instrument two days prior to the completion of the sectional view drawing in order to identify their level of visual ability and show equality between the three groups. The MCT was not used to account for spatial visualization skills in this study. The only purpose was to establish a near to equal group dynamic based on visual ability, as it relates to mental cutting ability. According to Nemeth and Hoffman (2006), the MCT (CEEB, 1939) has been widely used in all age groups, making it a good choice for a well-rounded visual ability test. The Standard MCT consists of 25 problems. The Mental Cutting Test is a sub-set of the CEEB Special Aptitude Test in Spatial Relations and has also been used by Suzuki (2004) to measure spatial abilities in relation to graphics curricula (Tsutsumi, 2004).

As part of the MCT test, subjects were given a perspective drawing of a test solid, which was to be cut with a hypothetical cutting plane. Subjects were then asked to choose one correct cross section from among 5 alternatives. There were two categories of problems in the test (Tsutsumi, 2004). Those in the first category are called *pattern recognition problems*, in which the correct answer is determined by identifying only the pattern of the section. The others are called *quantity problems*, or *dimension specification problems*, in which the correct answer is determined by identifying, not only the correct pattern, but also the quantity in the section (e.g. the length of the edges or the angles between the edges) (Tsutsumi, 2004).

Upon completion of the MCT, the instructor of the course placed identical models of the dynamic 3D triacontahedron for groups *n1, n2 and n3* in a central location in three different classrooms. The three groups were asked to sketch a sectional view of the triacontahedron (see Figures 3 and 4). Sectional views are very useful engineering graphics tools, especially for parts that have complex interior geometry, as the sections are used to clarify the interior construction of a part that cannot be clearly described by hidden lines in exterior views (Plantenberg, 2013). By taking an imaginary cut through the object and removing a portion, the inside features could be seen more clearly. Students had to mentally discard the unwanted portion of the part and draw the remaining part. The rubric used included the following parts: 1) use of section view labels; 2) use of correct hatching style for cut materials; 3) accurate indication of cutting plane; 4) appropriate use of cutting plane lines; and 5) appropriate drawing of omitted hidden features. The maximum score for the drawing was 6 points. This process takes into consideration that research indicates a learner's visualization ability and level of proficiency can easily be determined through sketching and drawing techniques

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(Contero, Company, Saorin, & Naya, 2006; Mohler, 1997). All students in all groups were able to approach the visualization and observe from a close range.

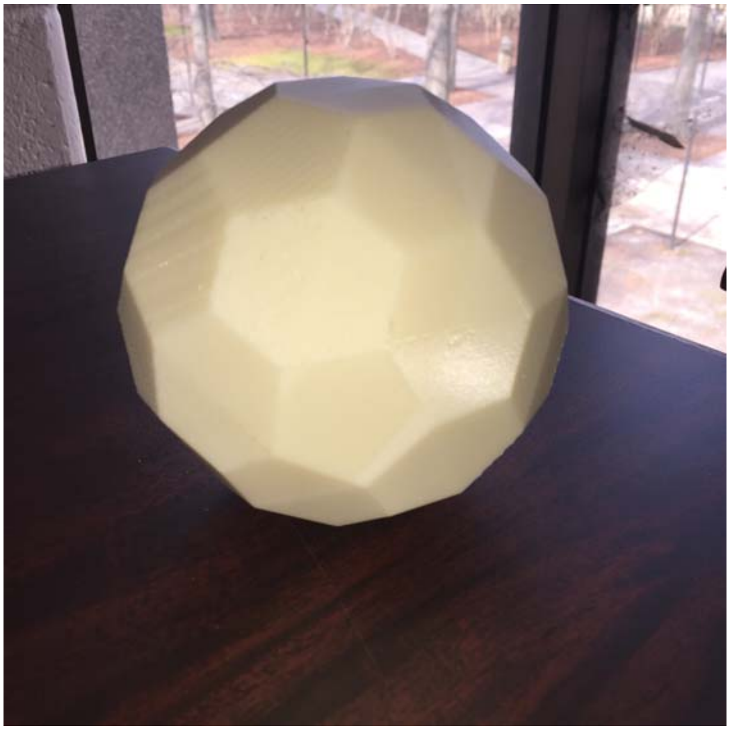

Figure 2. Triacontahedron Model

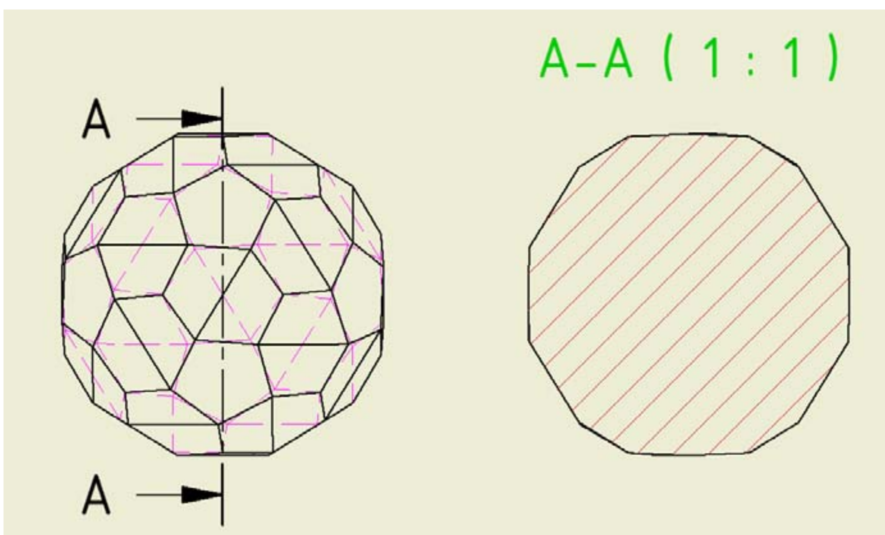

Figure 3. Triacontahedron Sectional View

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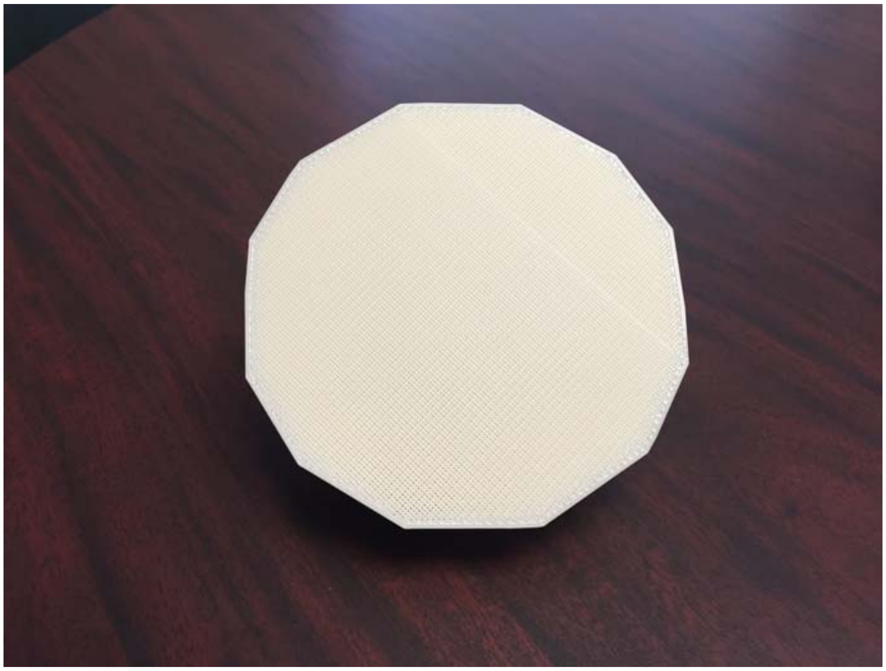

Figure 4. Triacontahedron Sectional View Model

Data Analysis

Analysis of MCT Scores

The first method of data collection involved the completion of the MCT instrument prior to the treatment, to show equality of spatial ability between the three different groups. The researchers graded the MCT instrument, as described in the guidelines by the MCT creators. A standard paper-pencil MCT pre and post were conducted, in which the subjects were instructed to draw intersecting lines on the surface of a test solid with a green pencil before selecting alternatives. The maximum score that could be received on the MCT was 25. As can be seen in Table 1, scores for the pre-test were *n1*=14.92, *n2*=14.03 *and n3*=15.16. The post-test overall means were higher: *n1*=15.254, *n2*=14.704 *and n3*=17.683. A noticeable difference was seen for the group that was listening to heavy metal music (15.16 to 17.683). A one-way ANOVA was run to compare the mean scores for significant differences, as it related to spatial skills among the three groups. There was no significant difference between the three groups in regards to spatial ability, as measured by the MCT instrument (see Table 1).

In addition, after treatment was completed, a one-way ANOVA was run to compare mean scores between pre and post treatment, as measured through the MCT. There was a significant F (5.049) = .0008, p< 0.01 difference between the three groups' levels of sectional view drawing ability between pre and post treatment, as measured by the MCT instrument (see Table 2).

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Table 1
MCT pre and post-test Descriptive Results

	N	*Mean Pre-test*	*Mean Post-test*	*SD*	*Std. Error*	*95% Confidence Interval for Mean* *Lower Bound*	*Upper Bound*
Group 1	34	14.912	15.254	4.0703	0.6981	13.492	14.332
Group 2	35	14.029	14.704	4.5857	0.7751	12.453	14.604
Group 3	32	15.156	17.683	3.6818	0.6509	13.829	16.984
Total	101	14.683	15.547	4.1302	0.4110	13.868	15.306

Table 2
MCT pre and post-test ANOVA Results

Quiz	*SS*	*df*	*MS*	*F*	*p*
Between Groups	103.369	2	51.685	5.049	*0.008
Within Groups	1003.205	98	10.237		
Total	1106.574	100			

* Denotes statistical significance

The second method of data collection involved the creation of a sectional view drawing (see Figures 3 and 4). Examples of student drawings can be seen in Figures 5 and 6. As shown in Table 3, the group that listened to classical music (*n* =34) had a mean observation score of 3.964. The groups that listened to rock music (*n* = 35) and heavy metal music (*n* = 32) had lower scores of 3.743 and 3.781, respectively. A one-way ANOVA was run to compare the mean scores for significant differences among the three groups. The result of the ANOVA test, as shown in Table 4, was not significant, F(0.297)= 0.744 p< 0.01. The data was dissected further, through the use of a post hoc Tukey's honest significant difference (HSD) test. As can be seen in Table 5, the post hoc analysis shows no statistically significant difference between the Rock vs. Classical (*p* < 0.753, *d* = -.2571), the Rock vs. Heavy Metal (*p* = .994, *d* = -.0384), and the Heavy Metal vs. Classical music (*p*=.821, *d*=-.2188*).*

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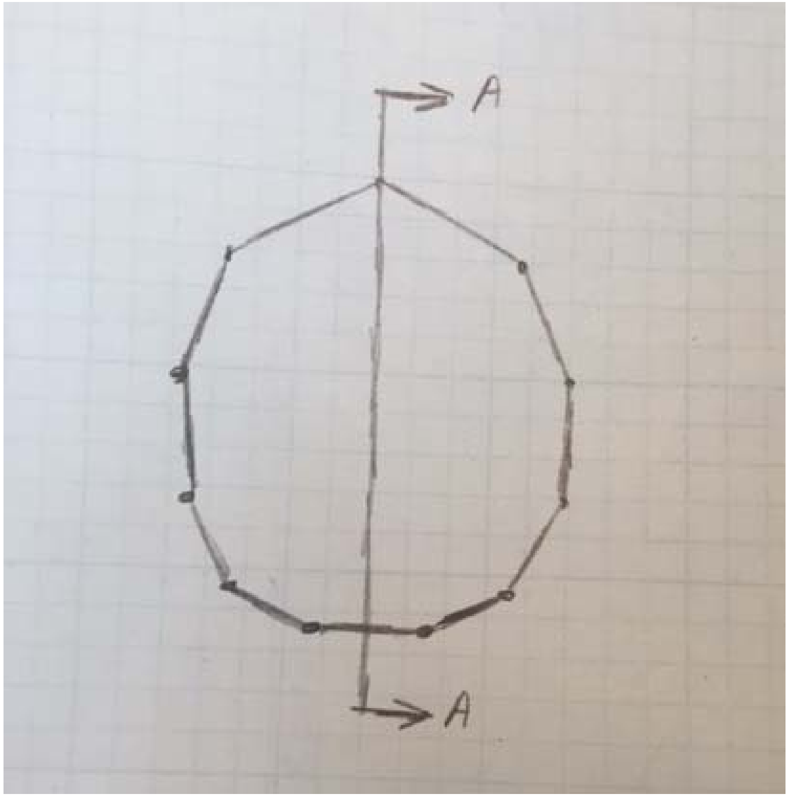

Figure 5. Examples of students' drawing

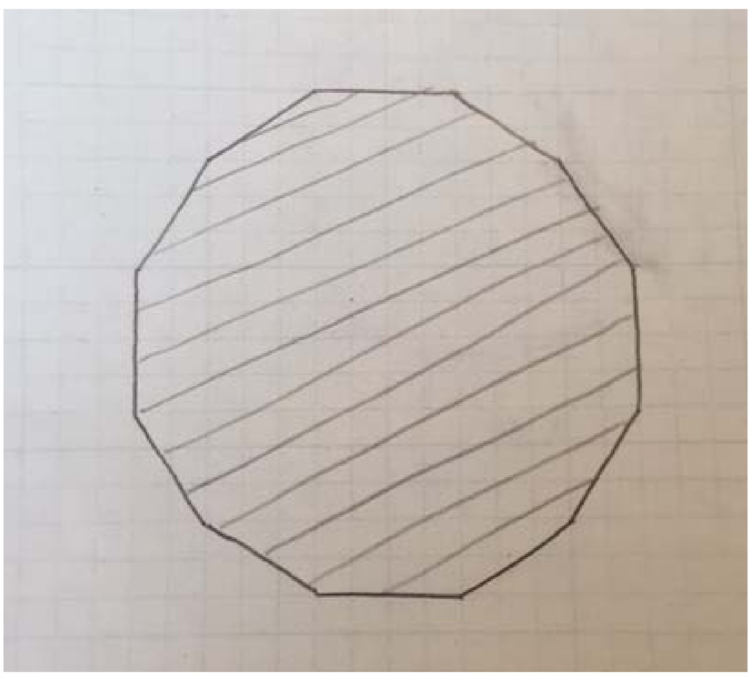

Figure 6. Examples of students' drawing

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Table 3
Sectional View Drawing Descriptive Results

	N	*Mean*	*SD*	*Std. Error*	*95% Confidence Interval for Mean*	
					Lower Bound	*Upper Bound*
Classical	34	3.964	1.6143	.2769	3.437	4.563
Rock	35	3.743	1.4213	.2402	3.255	4.231
Heavy metal	32	3.781	1.4081	.2489	3.274	4.289
Total	101	3.842	1.4747	.1467	3.550	4.133

Table 4
Sectional View Drawing ANOVA Results

Quiz	*SS*	*df*	*MS*	*F*	*p*
Between Groups	1.311	2	0.655	0.297	0.744
Within Groups	216.154	98	2.206		
Total	217.465	100			

Table 5
Sectional View Drawing Tukey HSD Results

	Visual Aids (1 vs. 2 vs. 3)	Mean Diff. (1-2)	Std. Error	*p*
2 vs 1	Rock Vs. Classical	-.2571	.3576	.753
2 vs 3	Rock Vs. Heavy Metal	-.0384	.3632	.994
3 vs 1	Heavy Metal Vs. Classical	-.2188	.3658	.821

Discussion

This study was done to determine significant positive effects related to sectional view drawing ability. In particular, the study compared the use of three different types of music; classical, rock, heavy metal and whether a significant difference exists towards sectional view drawing ability, among engineering technology students. As it can be seen in Table 1, students that listened to Heavy Metal music, outperformed their peers during the completion of the Mental Cutting Test. In addition, the Anova test between

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pre and post MCT shows significant difference within the three groups, suggesting positive gains for the post-test F (5.049) = .0008, p< 0.01 (see Table 2).

However, during the sectional view drawing, even though not statistically significant, students who listened to classical music outperformed the other groups (see Table 3). The main difference between the two measures is the fact that the MCT contains multiple choice questions, where the drawing of the sectional view does not. According to Perlovsky, Cabanac, Bonniot-Cabanac, and Cabanac (2013), multiple choice tests require holding and evaluating contradictory cognitions, and students are expected to experience cognitive dissonances (CD) that result in stress (Liebert & Morris, 1967; Suinn, 1965). Cognitive dissonance (CD) is a discomfort caused by conflicting cognitions (Festinger, 1957; Harmon-Jones, Amodio, & Harmon-Jones, 2009). This is among the most influential and extensively studied theories in psychology (Alfnes, Yue, & Jensen, 2010). An assumption can also be made that classical music was perceived as pleasant music for the specific group. According to Perlovsky et al. (2013), pleasant music helps keep in mind contradictory cognitions in stressful thinking; as indicated in his study, the pleasant music condition has a positive correlation. In addition, as it can be seen in Table 1, a difference between the pre and post MCT was observed for all groups. Even though the difference was not statistical significant, it can be suggested that all groups benefited from the addition of music.

Evaluating results in Table 4, the Anova test did not show any significant difference between the three groups F(0.297)= 0.744 p< 0.01 when measuring the sectional view drawing results. Even though a positive difference in the mean of the classical group was observed, it was not statistically significant enough to promote a stronger positive correlation. Nevertheless, this could be due to the short treatment time, as previous studies have suggested that long-term exposure to music and sensitivity to musical emotions are likely to be important for cognitive abilities (Perlosvky et al., 2013). The current paper contributes to understanding the power of music as an instructional tool that promotes learning. If the pleasure of listening to music helps to overcome CD-related stress and devaluation associated with learning (Perlovsky et al., 2013), this subject deserves further research.

Limitations and Future Plans

In order to have a more thorough understanding of the impacts of music related to spatial visualization ability for engineering technology students and the creation of sectional views, as well as to add additional information to the body of knowledge, it is imperative to consider further research. Future plans include, but are not limited to:

- Repeating the study to verify the results by using additional types of music.
- Repeating the study using a different population such as technology education, science, or mathematics students.

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- Repeating the study by comparing male versus female students, as it has been suggested that males tend to do better on spatial ability tasks than females (Carriker, 2009).
- Repeating the study with different populations to identify whether individuals with less exposure to spatial visualization content can benefit from the use of additional music types.

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