Journal of Mathematics Education
December 2015, Vol. 8, No. 2, pp. 115-125

Using Live Reggae Instrumental Acoustic Music to Influence Students' Mathematics Test Scores

Glenroy Pinnock
University of Technology, Jamaica

In this study, one group of university introductory precalculus and calculus students (n=61) displayed differing levels of mathematics competency. These students participated in a mathematics workshop with background music for duration of 180 minutes. The mathematics performance (i.e., standard mathematics exam results) of the students was measured. Their pre- and posttest mathematics scores were examined. The correlation between the mathematics pretest and the mathematics posttest was found to be statistically significant. In addition, the mean differences from the paired samples t-test were statistically significant, favoring the posttest scores. The implications for positive social change include informing local teachers, parents, policy makers, and students an innovative approach to impact students' mathematics scores positively. As a result, it is hoped that international students' performances will be increased and greater mathematics achievement realized.

Key words*:* mathematics achievement, background music, cooperative learning group, brain-based learning, mathematics anxiety, and cognitive skill.

Music is an art form within the medium of sound and silence. In this case, the considered elements of music are melody and tempo (i.e., a combination of beats, tones, or chords). Some scholars believe that music can stimulate learning. According to Merriam (2006), some traditional forms of learning need to be reshaped. She asserted that educators in both adult and nonadult institutions should be looking at a more student-centered learning approach rather than a teacher-centered method. One way to do this is through a somatic way of learning, for example, which is a spiritual form of learning through music and poetry. In addition, according to Church, Mercado III, Wisniewski, and Liu (2012), training can improve perceptual sensitivity, that is, there is a relationship between stimuli and responses. Rhythmic abilities vary widely in the general population because of auditory and motor areas that are involved in the process (Grahn & Schuit, 2012).

For many years, theorists have been advocating for the use of arts in learning. In fact, they argue that arts are integral for the education of the whole child (Catterall, 1998; Eisner, 1998; Gardner, 1999a, as cited in Gullatt, 2008). According to Rauscher and Shaw (1997, as cited in Harris, 2008), a connection linking music lessons to improved spatial-temporal reasoning abilities in 4- to

6-year-olds has been demonstrated. While musical intelligence is viewed as a separate intelligence, there is a high correlation between mathematics and music (Yoon, 2000, as cited in Harris, 2008). In 1993, a study was conducted at the University of California, Irvine that showed a temporary improvement of IQ scores when students listened to 10 minutes of a Mozart sonata. The specific area of increased intelligence was spatial-temporal reasoning.

Likewise, studies at the Medical Investigation of Neurodevelopmental Disorders (MIND) Institute have shown dramatic mathematics and cognitive enhancements as a result of simultaneous musical instructions. Students enrolled in this program received approximately 20% higher scores than students who were not in the program. In fact, the students' scores continued to increase the longer they spent in the program (MIND Institute, 2004). Online courses are usually presented with music at the start, before the presenter starts speaking. Recently, e-learning has become very popular, and most online podcasts and videos are highlighted with instrumental music. Thomas and Amit (2007) asserted that these learning-style instruments do enhance student learning.

Specifically, cognition is imperative to determine students' performances in exams (Huang & Charyton, 2008). Carter and Russell (1993, as cited in Huang & Charyton, 2008) used a pre- and posttest design to show significant improvement for students who were initially performing poorly. Lane (1998, as cited in Huang & Charyton, 2008) compared two experiments (i.e., E1 and E2) of simple tones (16 Hz to 24 Hz) through headphones to show positive outcomes. Olmstead (2005, cited in Huang and Charyton, 2008) demonstrated students' improvement in the WISC-111 arithmetic by using an experimental research study. According to Moreno et al. (2011), it was proven that two interactive computerized training programs (i.e., visual arts and music) administered to preschool children enabled them to improve their verbal performance after 20 days of training sessions. According to Kimble and Protivnak (2010), music intervention can be used by schools' counselors to correct behavioral problems of adolescents in the classroom.

Theoretical Frameworks

According to Courey, Balough, Siker, and Paik (2012), the music intervention program helped 33 third-grade students from Northern California to perform better at computational fractions than those students who were taught by strictly regular mathematics instruction methods. However, the music intervention program did not help the students to understand the concepts of fractions. According to Standley (2008), music intervention affect children's reading skills in a strongly moderate and significant manner, and effect sizes were shown to be 0.44 and 0.66. Although these values seem to be high for educational research, Kostenius and Ohrling (2009) posited that the attitude of children whose lives demonstrated stressful situations can actually be corrected, if they are relaxed. Later on in life, these children will be less stressed. According to Taylor and Rowe (2012), the Mozart's music (i.e., an instrumental background music played while students did a major trigonometry test) impacted positively a sample of 69 trigonometry students in six major trigonometry mathematics tests. The scores for these students were proven to be significantly higher than a sample of 59 trigonometry students who had no background Mozart music during their tests.

A previous study explained the association between behavioral self-regulation and children's experiences being developed during the program called Kindermusik (Winsler, Ducenne, & Koury, 2011). According to Darrow, Novak, Swedberg, Harton, and Rice (2009), the findings for the dependent variables indicated the participants' self-esteem scores in the music intervention mentorship groups from pre- to posttest, which was more than the control group's score, although not significantly. Shafi (2010) asserted that various methods of poetry therapy can be used to satisfactorily treat schizophrenic symptoms. Kostenius and Ohrling (2009) posited that children's lived experiences of being stressed can be coped with and ultimately transformed if they are relaxed. This transformation can enable these children to become powerful.

The optimum frequency range for cognitive development is 15 Hz to 18 Hz (Othmer & Kaiser, 1995). Holonomic brain theory provides the understanding of how music or sound stimulates neurons in the brain. Various audible frequency ranges can stimulate delta, theta alpha, beta, and gamma brain waves (i.e., as a result of the vibrations of the neurons). Additionally, it is believed by researchers that a frequency of approximately 16 Hz is the minimum value at which neurons vibrate during engaged mathematical reasoning. Goodin et al. (2012) claimed that this frequency is the threshold indicator for cognitive abilities, particularly mathematical reasoning in human beings. In this research, my major focus was using instrumental live acoustic background music to impact students' practice time and hence mathematics test scores by administering an intervention program workshop. In this case, intervention theory was considered for administering self-developed treatment sessions.

Research Background

At a small urban university where I work as a lecturer, the pass rate for any mathematical module is less than 70%, which means failure to have less than 70% of the students passing such module, then for quality assurance purpose, an anomaly report must be submitted to the dean of faculty. In addition, at the secondary level, only 50% of the mathematics students pass their final standardized exam. Of course this reflects Jamaicans' dismal numeracy competency. Some likely influencing factors for this poor performance, particularly at the university level, may be poor mathematics instruction strategies, violence, and economic depression. These low results could account for Jamaica's low gross domestic product (GDP), which was in the single digits at the time of this study. The 2014 to 2015 budget targeted an ambitious 7.5% of GDP primary surplus, because in former years the GDP was at most 4.3% (Country Report, 2014).

Because of economic depression, there exists the definite need for reforming mathematics education is necessary. Although this change is needed, the prevalence of high mathematics failure rate continues to persist locally. Despite the gap in the practice of intervention programs to correct or minimize mathematics failure rates locally, practitioners have been conducting many studies internationally in using arts education to develop a more engaging mathematics classroom setting. According to Furner and Gonzalez-Dehass (2011), many students tend to be affected by mathematics phobia; as a result, they freeze up and cringe when they are to do any form of computational exercise. In addition, there are some others who dread taking mathematics classes at the college level. According to Boyne (2011), the World Bank identified other disincentives to growth, such as poor quality of education and poor fiscal policies and budget management practices over four decades. In addition, he stated that for the last 20 years, the real per capita GDP in Jamaica has increased on average only 1%.

According to Douglas (2010), all the improving countries have one thing in common, and that is a good mathematics educational policy. For this reason, the minister of education, Ronald Thwaites, has called for more scientific research in the field of mathematics education. Scientific research indicated that the researcher should conform to standardized guidelines during his or her studies (i.e., researchers should use either scientific quantitative or qualitative inquiry to investigate educational problems). Walker and Wachs (2007) claimed that developing countries need intervention programs to stimulate cognitive development because of the prevalence of risk factors in these countries. In addition, the researchers asserted that intervention programs can minimize the number of students failing mathematics.

Research Objectives and Research Questions

The purpose of this study was to administer an intervention music workshop to impact students' mathematics practice time, thereby increasing procedural mathematics learning and improving precalculus and calculus test scores.

1. To improve mathematics students' test scores through live instrumental reggae acoustic music innovation
2. To create a national awareness of the "edutainment" concept of learning in the mathematics classroom
3. To improve standardized mathematics test scores by implementing an engaged mathematics learning environment

4. To initiate the platform for more mathematics and music research-based studies to be done by practitioners in mathematics education

The research questions guiding this study were the following: (a) What is the mean for the differences of the paired test score of university students practicing with the aid of live background music? (b)What is the relationship between pre- and posttest mathematics scores?

Methods

Research Design

For this quantitative repeated measure action research design, there were two major analysis techniques: the Pearson product moment correlation and the paired sample *t*-test, which I used in a sample of 61 participants in a mathematics workshop at the small urban university. These participants were adult introductory students at least 20 years of age. For this study, there were two data collection instruments: first, introductory pre- and posttests (dependent variables), and second, intervention acoustic background music treatment. I assumed that accurate numeric data would be provided from the administration of a preestablished tests that were used to collect pre- and posttest scores. The duration of the pre- and posttests was 60 minutes. The group was also treated by being exposed to live instrumental reggae acoustic music for approximately two and a half hours.

Research Setting, Sample, and Methods

The research study was conducted at a small urban university. This institution is situated in the city of Kingston (the largest city in Jamaica) and is funded by the Jamaican government. The student population was approximately 3,000, with students' average age being 21 years. Most of the students complete their first degree within 4 years.

To conduct this research workshop, permission was granted by all stakeholders (the urban university's dean, president, research coordinator, research committee, lecturers, and students). Particularly, the dean sanctioned the timing of the intervention workshop session for the students. In this scenario, a quantitative research method of a repeated measure was employed by the researcher to a group of students who attended a mathematics workshop. The group was a combination of different mathematics classes (precalculus and calculus). In this mathematics workshop, there were approximately 61 students from a population of approximately 1,000 introductory natural and social science students at the small urban university.

Data Collection Instruments and Materials

The numeric data for this quantitative study are collected by data collection instruments that include preestablished calculus and precalculus tests with internal consistency of 0.76. In addition, the materials used in the study were (a) unplugged acoustic guitar and (b) three-piece acoustic drums.

Instrument (College Mathematics 1A and Calculus) including following items:

- Name of instrument—precalculus and calculus (introductory tests)
- Type of instrument—preestablished
- Concept measured by instrument—participants' mathematics performances
- Description of precalculus and calculus tests—15 multiple-choice questions plus one objective-type question before and after the study began.
- Specimen mathematics tests.

Data Collection Procedures

The participants were all introductory students participating in the mathematics workshop. First, all the participants took both calculus and precalculus pretests for one hour before the acoustic band played unplugged low-volume instrumental reggae. Second, the participants were treated with live music for two and a half hours. During this time, the students practiced in groups of four or five. When students experienced difficulties the presenter assisted them in keeping the momentum of the mathematics practice session going. At the end of this session, the students were given a 30-minute refreshment period. Subsequently, the students converged to do the posttests that lasted for a maximum of 60 minutes. After this period, all posttest scripts were collected for grading.

Reliability and Validity

The test retest reliability of the precalculus test (October 2012) was calculated from the following formula: s.d $(1\text{-}r)^{1/2}$ = SEM (standard error measurement). This value was found to be 0.7965 from a study. The internal consistency of the items of the mathematics test revealed that the scores for each item/question are equally distributed. Lastly, the content validity revealed that the questions and scores from these questions are a representation of the possible questions of the specified content.

Results

The overall data analyses (i.e., correlations and *t*-test) are presented in tables and figure (i.e., scatter plot). In addition, footnotes were provided to further explain symbols and abbreviations so that consumers of research will be able to fully interpret the research findings. Of course, these analyses will be appropriately presented, disseminated, and corresponded to the theoretical and conceptual frameworks of the study. In addition to descriptive and inferential statistics, both significance levels and standard errors are presented, which follows social science research data presentation standards. Preestablished instruments' reliability was also considered.

Internal reliability (or internal consistency) for the mathematics test was acceptable, with Cronbach's alpha coefficient of 0.79. Table 1 shows the descriptive characteristics of the sample (i.e., gender and ethnicity) of the research study and the difference in mean for the research group, that is, the workshop group. Table 2 provides the mean difference between the group's pre- and posttest. The mean difference was statistically significant at the specified .001 level, with appropriate effect size (*d*), that is, t (60) = -4. 21, p < .000, 95% CI (-9.60, -3.42), d = 0.34. Thus, research question (a) was answered affirmatively, which signifies that there was a significant difference in scores received by students in pre- and posttests during the workshop. In addition, effect size suggests the difference between pre- and posttest scores. Finally, the mean and standard deviation found for the posttest group was 47.82 (17.79), and that for the pretest group was 41.31 (19.04).

In summary, the results (i.e., from the *t*-test, correlation, and descriptive statistics) of this research explain the guiding research questions, that is, to compare mean differences between pre- and posttests, and the positive correlation between pre- and posttests showed that the students received mean mathematics test scores with appropriate standard error measures after being exposed to music.

Table 1
Descriptive Characteristics of the Sample

			Pre-cal Group		Calculus Group	
	n	Percent	n	Percent	n	Percent
Female	42	68%	26	62%	13	68%
Male	19	32%	16	38%	6	32%

Table2
Paired t-test Analysis of Mathematics Achievements of the Group at the End of the Workshop

n=61	Mean	SD	*t*	*p*	*d*
Pretest	41.31	19.04	-4.21	<.000	.34
Posttest	47.82	17.79			

Discussion

The guiding research questions were answered affirmatively using the proposed analytic method. In other research, scholars support the present findings (i.e., music aiding mathematics learning) provided by this intervention program study. In most cases, the presented findings were consistent with current research given below.

This research contributes to an intervention program of using reggae instrumental music to treat students, such as improving the average mathematics performance at the K-16 level. Previous study conducted by Bradshaw, Donaldson, Jacobson, Nakamura, and Chapman (2011) revealed that listening to music can stimulate emotional responses, and engaging cognitive attention.

The descriptive statistics of the students' mathematics test scores revealed that their mean mathematics scores improved after the intervention program was administered. To discuss the findings of the research, one important point was examined from a descriptive statistics figure. The comparison of the students' scores is shown from the box plot in Figure 1. Pannese (2012) argued that neuroscientific evidence confirms that the aesthetic response to music is automatic, for example, motor synchronization and increased heart rate. In these cases, students' performance is impacted positively. Based on the findings of this research study, students' mathematics incompetence can be addressed globally, because we all listen to music, hence with the necessary educational policy enforcement; collectively, the high mathematics failure rate can be reduced. According to Foster (2009), "music is a powerful medium, its effects can calm us, persuade us, especially when we cognitively impaired" (p. 1). Hence, music can be used as a tool to improve cognition.

As a far-reaching effect, other mathematics teachers could administer similar musical intervention program by using live schools' bands during mathematics tutorial practice sessions. Alternatively, educators can encourage their students to access the website (www.themusicofmath.com) through internet availability to listen to brain entertainment mp3 instrumental music through headphone sets.

The limitations of this study are that (a) results may vary since not all students like acoustic instrumental music, (b) accurate results depend upon the students' honesty on working on their own in pre- and posttests, (c) an experimental design with a control group would reflect a more direct benefit of music intervention, and (d) this research study is best to be applied to a tutorial session rather than a teaching session. Next, the occurrence of treatment infidelity or poor treatment implementation could impact the statistical conclusion validity of the results.

Conclusion

Based on the findings of this research study, the implications for social change are reflected in the mathematics test–taking experience of precalculus and calculus 1 at K-16 levels. Therefore, other mathematics educators can introduce a musical intervention program to their students based on the genre that is preferred in their society.

In summary, the outcomes of the research are twofold. First, after the music intervention, the students' posttest scores have shown significant increased differences. Second, the students' pretest mathematics scores were directly proportional to the posttest mathematics scores. Based on the findings obtained in this research, I think similar musical intervention programs could be recommended to stakeholders of institutions so that it can be introduced to students doing modules with high failure rates. This approach would help many students who are mathematically anxious to perform better in their mathematics examinations. Finally, although it has been said that music interventions can help students to develop social, behavioral, and communicative skills (i.e., autism), there is still more research to be done (Simpson & Keen, 2011).

Acknowledgments

I would like to thank Bernard Raymond and Stephen Ayre who played acoustic guitar and repeater drum respectively, during the mathematics workshop session. Finally, I wish to thank all the students who have participated in this research workshop, particularly for their support to an innovative idea in mathematics education.

References

Andrade, P. E., & Bhattacharya, J. (2003). Brain tuned to music. *Journal of the Royal Society of Medicine, 96*(6), 284-287.

Bishop, M. J., Amankwatia, T. B., and Cates, W. M. (2007). Sound's use in instructional software to enhance learning: a theory-to-practice content analysis. *Educational Technical Research Development, 2008*(56), 467-486.

Bolduc, J. (2008). The effects of music instruction on emergent literacy capacities among preschool children: a literature review. *Early Childhood Research and Practice, 10*(1), 1-6.

Boyne, I. (2011). World Bank unlocking Jamaica's growth. Retrieved from http://jamaica-gleaner.com/gleaner/20110626/focus/focus4.html

Bradshaw, D. H., Donaldson, G. W., Jacobson, R. C., Nakamura, Y., & Chapman, C. R. (2011). Individual differences in the effects of music engagement on responses to painful stimulation. *The Journal of Pain, 12*(12), 1262-1273.

Church, B. A., Mercado III, E., Wisniewski, M. G., & Liu, E. H. (2012). Temporal dynamics in auditory perceptual learning: impact of sequencing and incidental learning. *Journal of Experimental Psychology, 39*(1), 270-276.

Courey, S. J., Balogh, E., Siker, J. R.., & Paik., J. (2012). Academic music: music instruction to engage third-grade students in learning basic fraction concepts. *Educational Studies in Mathematics, 81*(2), 251-278.

Creswell, J. W. (2009). *Research design: qualitative, quantitative, and mixed methods approaches.* Los Angeles, CA: SAGE Publications, Inc.

Darrow, A., Novak, J., & Swedberg, O. (2009).The effect of participation in a music mentorship program on the self-esteem and attitudes of at-risk student. *Australian Journal of Music Education, 2,* 5-16.

Douglas, Luke. “Holness wants campaign to improve mathematics scores.” (2010, February 26). *Jamaica Observer*. Retrieved from http://www.jamaicaobserver.com/news/luke-mathematics---fri_7449630

Foster, B. (2009). Music for life’s journey: the capacity of music in dementia care. A*lzheimer’s Care Today, 10*(1), 42-49.

Furner, J. M., & Gonzalez-Dehass, A. (2011).How do students’ mastery and performance goals relate to mathematics anxiety? *Eurasia Journal of Mathematics, Science & Technology Education,7*(4), 227-242.

Goodin P, Ciorciari J, Baker K, Carrey A-M, Harper M, Kaufman J (2012) Correction: A high-density eeg investigation into steady state binaural beat stimulation. *PLoS ONE* 7(4): 10.1371/annotation/89b655ea-6877-411d-abee-e1f4806f5f78.

Grahn, J. A., & Schuit, D. (2012). Individual differences in rhythmic ability: behavioral and neuroimaging investigations. *Psychomusicology, Music, Mind, and Brain, 22*(2), 105-121.

Gullatt, D. E. (2008).Enhancing student learning through arts integration: implications for the profession. *The High School Journal, 91*(4), 12-25.

Harris, M. (2008). The effects of music instruction on learning: in the Montessori classroom. *Montessori Life, 3,* 24-31.

Huang, T. L., & Charyton, C. (2008).A comprehensive review of psychological effects of brainwave entertainment. *Alternative Therapies in Health Medicine, 14*(5), 28-50.

Jamaica: 2014 Article iv Consultation and Fourth Review Under the Extended Fund Facility and Request for Modification of Performance Criteria-Staff Report; Press Release; and Statement by the Executive Director for Jamaica. (2014). (Country Report Publication No. 14/169). Retrieved from www.imf.org/external/pu

Kostenius, C., & O’hrling, K. (2009).Being relaxed and powerful: Children’s lived experiences of coping with stress. *Children & Society, 23,* 203–213.

Merriam, S. B., Caffarella, R. S., & Baumgartner, L. M. (2007). *Learning in adulthood: A comprehensive guide*. San Francisco, CA: John Wiley and Sons.

The MIND Institute. (2004). Retrieved from http://www.mindinst.org

Moreno, S., Bialystok, E., Barac, R., Schellenberg, E. G., Cepeda, N. J., & Chau, T. (2011). Short-Term music training enhances verbal intelligence and executive function. *Psychological Science, 20*(11), 1425-1433).

Othmer, S., Othmer, S. F., & Kaiser, D. (1995). EEG Biofeedback training for attention deficit disorder: A review of recent controlled studies and clinical findings. Retrieved from http://www.eeginfo.com/research/articles/general_1.htm.

Pannese, A. (2012). A gray matter of taste: sound, perception, music cognition, and Baumgarten's aesthetics. *Studies in History and Philosophy of Biological and Biomedical Sciences, 43*(3), 594-601.

Pribram, K. (2007). Holonomic brain theory. *Scholarpedia*, *2*(5), 27-35. Retrieved from http://www.scholarpedia.org/article/Holonomic _Brain _Theory?iframe=trueandwidth=100%andheight=100%

Shafi, N. (2010). Poetry therapy and schizophrenia: clinical and neurological Perspectives. *Journal of Poetry Therapy. 23*(2), 87-99.

Simpson, K., & Keen, D. (2011) Music interventions for children with autism: narrative review of the literature. *Journal of Autism Development Disorder, 41*(11), 1507–1514.

Standley, J.M. (2008). Does music instruction help children learn to read? Evidence of a meta-analysis. *Applications of Research in Music Education, 27*(1), 17-32.

Taylor, J.M., & Rowe B. R., (2012).The "Mozart Effect" and the mathematical connection. *Journal of College Reading and Learning, 42*(2), 51-66.

Thomas, H. F., & Amit, S. J. (2007).Using learning style instruments to enhance student learning. *Decision Sciences Journal of Innovative Education, 5*(1), 1-19.

Walker, S. P., & Wachs, T. D. (2007). Child development: risk factors for adverse outcomes in developing countries. *The Lancet, 396*(9556), 145-157.

Winsler, A., & Ducenne, L. (2011). Singing one's way to self-regulation: the role of early music and movement curricula and private speech. *Early Education and Development, 22*(2), 274–304.

Author:
Glenroy Pinnock
University of Technology, Jamaica
Email: gpinnock@utech.edu.jm