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Teachers' Perceptions on the Relationship between Mathematics and Music in Gweru Urban Schools and One Teachers' College: Case for Integration?

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Research Article

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ABSTRACT

There is strong research evidence that children perform better in mathematics if music is incorporated in it and vice versa. Mathematics and music are school subjects that are also useful and important as languages of communication in daily life situations. Previous research and this study have shown that mathematics and music are related in various known (and possibly unknown) ways so much that not putting the relationship to good use in and out of school could only be to our disadvantage. This paper argues for the use of the integration teaching approach at school level and encourages further investigation of the math-music relationship in and outside of school settings. The recommendations of this paper are supported by literature and by the study findings. The sample in this study included 14 qualified teachers in 9 schools and 1 teachers' college, 64 pupils and 36 college students all in Gweru Urban district. Using the survey design, questionnaires were administered to 10 teachers to tap their perceptions and suggestions while 4 teachers were interviewed. Using SPSS 11.5, mathematics and music marks of a total of 64 judgmentally selected primary and secondary pupils from 4 of the 9 schools, and 36 teachers' college students were used to investigate the math-music relationship by way of correlations. It was found that there is a moderate positive correlation at school level but low positive correlation at college level. Teachers believed that such relationship is more pronounced at primary school level where the structured and integrated approach was recommended in order to improve pupils' performance in the two subjects. Teachers and school authorities were challenged to equip their schools with different kinds of musical instruments and learning materials in order to improve performance in mathematics. The relationship outside the school setting involving mathematicians and musicians was also noted and recommended as an area for further research.

Keywords: mathematics, music, perceptions, relationships, correlations, music-math performance, integrated teaching.

INTRODUCTION AND BACKGROUND TO THE STUDY

It was on the fourth of June 2003 at home in Chikanga III in Mutare when half sleeping and half dreaming, I began to ponder that I could form my own musical band. What a foolish idea! How could I do that being a simple mathematics teacher and no musician at all? So could I double up as a musician-cum-mathematician?

Hence I began to list down the common concepts or characteristics and differences that I believed existed between mathematics and music. In mathematics we would call them axioms! These were that:

- math is beautiful and melodious and so is music,
- math and music are languages of communication,
- math and music can be enjoyed through participation in performing, analyzing, creating, communicating and listening,
- math and music were the first fruits of the civilization of man (e.g., when man was born or created, he started to cry, talk, sing, clap hands, and so on [music] and also to think, calculate, reason approximate, estimate, measure and solve problems [math],
- music can be made or produced by both living and non-living things. However, only living things can discover or construct mathematical knowledge from both living and non-living things,
- just as variables are discrete or continuous in math, so a musical note can be discrete or continuous in structure or performance respectively,
- math always 'tells' the truth but music sometimes 'tells' truths, half truths or completely false stories!

Does a relationship actually exist between mathematics and music? If there ever was, how can it be put to maximum use? There is some evidence that the relationship exists in various ways (Beer, 1998; Hedstrom, n.d.; Shah, 2010).

Beer (1998) has shown three different ways in which mathematics and music are related. He pointed out that the ancient Greeks put much importance on harmonic tones, tunings and numbers and considered music as a mathematical discipline. Secondly, there are math patterns such as Fibonacci numbers and golden section in musical compositions. Thirdly, some people have artistic attributes of mathematics such as mathematical thinking, creativity, mind-setting and problem-solving. Shah (2010) said music theorists use mathematics to develop, express and communicate their ideas while some mathematicians like Rene Descartes, Marin Mersenne and Leonhard Euler have also been music theorists. Hedstrom (n.d.) has observed that math and music are related in the sense that basic music notation has corresponding numerical values and mathematical patterns which include fractions, Fibonacci numbers, golden ration, and chord patterns. Some researchers have also shown that the frequencies of pitches produced by striking the piano keys can be modelled by a geometric sequence (The Crown in Right of Alberta, 2007).

Servais and Vorga (1971) suggested that math and music could have some common characteristics when they say,

> *puzzles in mathematics are somewhat similar to songs in music: short and self contained, not too ambitious and accessible to many. Some are the personal inventions of creators of mathematics; others are of unknown origin, becoming polished through centuries, emerging here and there in different variants like folk songs.*

Now with reference to the classroom situation, does it mean that one who performs better in mathematics at a certain grade level would also perform better in music at that grade level or vice versa? The use of "integration of subjects" as a teaching approach seems to support this viewpoint (Mickela, 1990; Still and Bobis, 2005; Wiberg, 2009). According to Ongong'a et al. (2010) the integrated approach to teaching and learning is described in education as an approach which avoids fragmentation of knowledge and leads to holistic understanding of concepts. It is also considered in psychology to be a superior organization for cognitive learning since the human brain rejects learning what is fragmented. Integration can be conceived at various levels such as the syllabus, skills, methodology, resources and assessment levels. By using integration, teachers move away from teaching isolated facts towards constructivism, which values in-depth knowledge of subjects (Ongong'a et al., 2010).

CONTEXTUAL FRAMEWORK

It would seem inadequate to investigate the educational relationship between math and music without first looking at their historical development and links. Boyer and Merzbach (1989) pointed out that Philolaus is reported to have maintained that, *"All things which can be known have number; for it is not possible that without number anything can be either conceived or known."* If we are to buy Philolaus' idea, music has to have number since it was conceived and was known by man. Stories actually exist that Pythagoras (the great Greek mathematician and philosopher) discovered some simple laws of music (Boyer and Merzbach, 1989; www.library.thinkquest.org/18160/mathmus.htm). He noticed that when lengths of vibrating strings are expressible as ratios of simple numbers (e.g., the ratio of 2 to 3, written 2:3, for the 5th string or 3:4 for the 4th string) the tones would be harmonious. For example, in descending order of the mathematical ratios and ascending order of the musical frequencies produced by some keys on the piano keyboard, we have 16:9 for D, 8:5 for E, 3:2 for F, 4:3 for G, 6:5 for A, and 16:15 for B. Pythagoras also concluded that the heavenly bodies in their motions emitted harmonious tones known as the "the harmony of the spheres."

In the 17th century, Galileo Galilei observed that the frequency of a note on a string is inversely proportional to the length of the string. The Greeks also observed that certain fractions of the length of a string seemed to give particularly pleasing notes when played together with original notes e.g., ½ - octave interval, 2/3 – a perfect fifth above the original and leads to a very nice chord, 4/5 – a third above the original (Budd, 2008).

In agreement with the above, Peterson (1996) says that Pythagoras, Galileo, Johanes Kepler, Leonhard Euler and 20th century music composers have also contributed information on the relationship between mathematics and music. For example, Johanes Kepler is said to have envisaged planetary motions and the music of the spheres. Pythagoras is said to have identified music with number, noting its scales, tempo and other regularities. Galileo Galilei speculated on the numerical reasons why some combinations of tones are more pleasing than others and Leonhard Euler considered the same problem in a treatise on consonance and whole numbers. Twentieth century music composers have applied sophisticated mathematical theory in their works although some people just take

music to be something to be enjoyed when relaxing at home and not something to be seriously studied or to be considered for business.

Should music and mathematics be studied seriously at school? According to Boyer and Merzbach (1989), Archytas (one of the later Pythagoreans) felt that music should play a greater role than literature in the education of children. He paid a lot of attention to the role of mathematics in the curriculum and came up with four branches in the mathematical quadrivium (or course). Quadrivium means a place where four roads meet. These branches are shown in Figure 1 and Table 1.

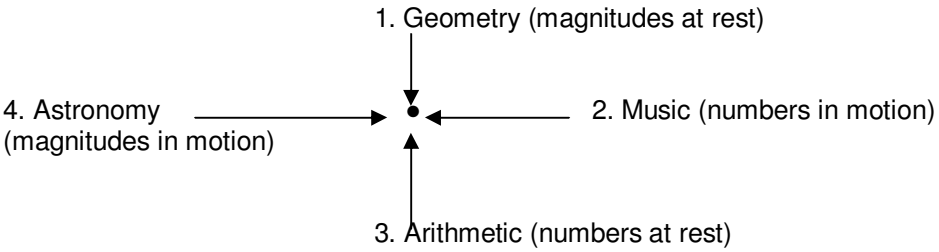

Figure 1: The Quadrivium (Adapted from Boyer and Merzbach, 1989)

Table 1: The Quadrivium (Adapted from Garland, 1995 as cited in Beer, 1998)

Mathematics			
Quantity (the discrete)		Magnitude (the continuous)	
Alone (the absolute) Arithmetic	In relation (the relative) Music	At rest (the stable) Geometry	In motion (the moving) Astronomy

Today's mathematics courses for schools have Geometry, Arithmetic and other branches like Algebra and Calculus but not Music and Astronomy. However, the music syllabus for primary schools in Zimbabwe supports an integrated approach to teaching at grades 1 through 7 where pupils combine music and acting or mime to convey themes from other subject areas in the curriculum (Ministry of Education, 1989). This is intended to help reinforce concepts because it is also believed that the subject matter of other areas makes music activities more interesting, meaningful and enjoyable. Whether the teachers actually use the integration approach and to what extent remains to be investigated.

Research has shown that music lessons can significantly improve the mathematics skills of primary school children and that a weekly structured music programme (using an interdisciplinary approach) can boost reading and maths skills in elementary school children (Thornburg, 1980; www.news.bbc.co.uk/1/hi/education/297073.stm). Researchers at a Los Angeles school found that 136 second year elementary school pupils who learned to play the piano and read music improved their numeracy skills. This could be so since learning of music emphasizes thinking in space and time and when pupils learn rhythm, they are learning ratios, fractions and proportions (www.news.bbc.co.uk/1/hi/education/297073.stm). An et al. (2013) used exploratory research to investigate the ways in which first and third grade teachers could integrate music into their regular math classrooms. They concluded that music-math interdisciplinary lessons had positive effects on three mathematical ability areas of modeling, problem solving and application.

A study done by Martin F. Gardner and Alan Fox of the music school in Providence, USA revealed that out of 96 five to seven year old grade 1 pupils in 8 public school classrooms, 48 pupils (in one group) who were exposed to a weekly structured music study emphasizing pitch, rhythm and others through music games had significantly improved their attitude and behaviour and had outstripped the other (control) group of 48 in mathematics (Peterson, 1996). However, it could be that the pleasurable aspects of the programme and the children's self-esteem could have motivated them to progress. It could also most likely be that knowledge gained in one area (music) could have assisted pupils in the development of mental skills such as ordering and addition. Though the results of such studies are tenable, they are also circumspect since there is no evidence of any triangulation done and the children (grades 1 and 2) could have lacked maturity and previous experience to tackle proportional and fractional calculations.

Hassam (n.d.) proposed that active engagement in music is beneficial because music is powerful and has positive impact on the social, intellectual and personal development of children and young people. It could be quite interesting to investigate what kind of math-music relationship exists at higher primary school grades , at secondary

school level or even at college level in Zimbabwe and to what extent the integration approach can lead to better results especially in Math; the most feared and failed subject.

PURPOSE OF THE STUDY

The study sought to investigate, through interviews and questionnaires, teachers' perceptions on the relationship between mathematics and music in Gweru Urban district schools. Test marks of pupils and college students were also used to investigate the relationship by way of correlations. The accompanying research questions were.

1. What are the teachers' perceptions concerning the relationship between mathematics and music at primary and secondary school levels?
2. Can the integration approach be used to lead to better achievement in mathematics and music in the schools?
3. Is there a significant positive correlation between achievement in mathematics and achievement in music at school or college level?

MATERIALS AND METHOD

Research Design

The research design used in this study was three-fold, namely survey, interview and correlational. The survey was mainly carried out using questionnaires to solicit respondents to state their perceptions concerning the perceived relationship between mathematics and music and suggestions on how to make use of that relationship in the classroom setting. Since the survey method is normally used to describe a prevailing phenomenon such as opinion, attitude, etc., without explaining causal relationships (Mhlanga and Ncube, 2003) it was felt that a correlational design had to be employed as well. Correlational designs are normally used to establish the relationship and strength/weakness between or among variables (Bless and Higson-Smith, 1995; Mhlanga and Ncube, 2003). However, correlation should not be misconstrued to explain causation. The correlational method was employed by way of collecting learners' achievement scores (test marks) in mathematics and music and computing correlations using computer package SPSS 11.5. The interview method was used to get more qualitative data through more probing to tap interviewees' feelings, beliefs, ideas and suggestions regarding the perceived math-music relationship and also to support or refute the questionnaire data since it was observed that the sample for teachers was small and generalization to a larger population would possibly be biased. It should be noted that the study was carried out during the economic-political hardships in Zimbabwe where travelling to unknown places was rather risky and dangerous and acquiring bond paper for printing was 'luxurious'.

Population, Sample and Data Collection Procedure

The population comprised of the following:

(a) qualified primary and secondary school teachers who had majored in music or mathematics at college. Mathematics and music college lecturers were also classified as qualified teachers.
(b) mathematics and music students at the teachers' college and pupils at secondary and primary school level.

The teachers were selected from schools in the city centre, from Mkoba township and from a teachers' college in Gweru Urban district. Due to financial and transport constraints compounded by the politico-economical problems at that time, only those schools which were easily accessible were sampled. The selected schools were two in the city centre (one secondary and one primary) and three in Mkoba area (two secondary and one primary). Questionnaires were given to the head of each school that was then tasked to distribute them to any Math or Music teachers who would be available on that day or on the following day.

Lecturers classified as qualified teachers at Mkoba Teachers' College in Mkoba Township were also visited. Questionnaires were given to four mathematics lectures and to two music lecturers. Out of 14 questionnaires which had been distributed ten (3 from primary school teachers, 3 from secondary school teachers and 4 from college lecturers), were returned.

Since the sample size for the questionnaires was small, interviews were conducted to provide more supplementary and qualitative data. So on a later date, some other four qualified teachers were chosen from the

selected schools using purposive sampling because it was judged that they could have expert knowledge of teaching mathematics and/or music. Their responses would be used to verify/refute or triangulate the data from the questionnaires or correlations.

The population also included eight groups of first year students of 2006 at Mkoba Teachers' College. The sixth group (Group F) was randomly sampled by picking a card from a hat with cards labeled A to H and 36 students from that group were similarly sampled. The group's professional studies syllabus B (PSB) marks in music and mathematics were then collected, entered into a computer and the statistical package SPSS 11.5 was used to run correlations.

It should be noted here that the original idea was that math and music marks of as many groups of primary and secondary school pupils as possible were to be collected. Most of the primary and secondary school teachers were on strike and so the researcher collected marks from one class/group at each of the 4 schools visited. There was also the need to later carry out the interviews with the teachers in order to cater for triangulation and authentication of the data.

Instruments

There were three instruments used for the collection of data. The main instrument used was a questionnaire. This questionnaire had seventeen questions asking about the relationship between math and music and how to make use of it in the classroom. It also had both open-ended and closed-ended questions and questions on biographical data. Some of the questionnaire items were adapted from those found in the literature and whose validity and reliability had already been tested (www.news.bbc.co.uk/1/hi/education/297073.stm). Bless and Higson-Smith (1995, p. 137) say, *"… researchers sometimes ask other social scientists with experience in the research area to evaluate the content validity of their measuring instruments."* Thus before administering the questionnaire to fourteen primary and secondary school teachers and college lecturers, it was first proof read, checked and edited by a PhD holder who is also a qualified math teacher thus ensuring some degree of validity.

The questionnaire items excluding questions on the bio-data were:

1 (a) Does a relationship between Mathematics and Music exist?
(b) If yes, briefly explain this relationship.
(c) State the topics or concepts that are common to both subjects in the school curriculum.

2. Do you believe that music lessons can improve mathematics skills of

(a) primary school children? (Justify your answer).
(b) secondary school children? (Justify your answer).

3. Do you believe that mathematics lessons can improve music skills of

a) primary school children? (Justify your answer).
b) secondary school children? (Justify your answer).

4. Does learning to play the piano improve pupils' numeracy? (Please explain).

5. Can the learning of rhythm symbols at grade 2 or 3 level facilitate the learning of numerical systems of fractions in mathematics? (Briefly explain your views).

6. A weekly structured music program can boost

(a) numeracy skills in elementary school children: Agree □, Undecided □, Disagree □.
(b) maths skills in elementary school children: Agree □, Undecided □, Disagree □.

7. There is a positive correlation between attitude towards mathematics and attitude towards music at

(a) secondary school level: Agree □, Undecided □, Disagree □.
(b) college level: Agree □, Undecided □, Disagree □.

8 In your opinion, which subject, music or maths is more useful to pupils in their real life? (Explain).

9. Which subject, maths or music is more difficult to pupils at

(a) primary school level? (Justify your response).
(b) secondary school level? (Justify your response).

10. Write down any views, comments or suggestions you have regarding the relationship between mathematics and music.

The second instrument was a secondary data schedule/profile for a set of previously written test marks for music and mathematics. Test marks were collected from 2 primary and 2 secondary schools in 2008. Those from first year (intake 7) students of Mkoba Teachers' College were for 2006. These were tests written by the same class during the same week and the scores were availed to the researcher by the teachers/lecturers. These sets of marks were to be used for the correlational part of the study.

The third instrument was the interview schedule with questions asking teachers about their beliefs, feelings and suggestions regarding the math-music relationship. In particular, to explain why they believed a math-music relationship existed, how music skills could improve performance in math and vice versa, how the integration approach could be used to teach the two subjects and the challenges the teachers and children were likely to face with suggestions for possible solutions.

Data Analysis Procedure

The first step was sorting out returned questionnaires by gender, age, qualification, and specialized subject. Then frequency counts, tabulations and transcribing of similar and different responses and checking for omissions or repetitions followed. The most common responses were noted. The second step was summarizing responses to interviews and generating and categorizing important themes. No themes had been pre-conceived but it was anticipated that they would emerge as the researcher probed for main ideas, beliefs and suggestions. These main themes would be compared or contrasted with questionnaire data and with findings from the review of literature. The last step was cleaning of quantitative data for math and music marks, entering of data onto the computer, and computing correlations using SPSS 11.5.

RESULTS AND DISCUSSION

Biographical Data of Respondents to the Questionnaire

The questionnaire for teachers had two sections A and B. Section A had six questions asking for biographical data. Table 2 shows the answers of respondents to questions 1 and 2. Eight (8) of the respondents were mature people of over 30 years of age while two were 30 years old and below. Also 6 were males while 4 were females.

Table 2: Showing frequencies for gender and age range of respondents (questions 1& 2)

	< 20yrs	21-25yrs	26-30yrs	31-35yrs	36-40yrs	> 40yrs	Total
Male	0	0	1	1	1	3	6
Female	0	1	0	1	0	2	4
Total	0	1	1	2	1	5	10

Answers to questions 3, 4, 5 and 6 are given in Table 3.

Table 3: Showing various responses to questions 3, 4, 5, and 6.

Question	Answers
3: Write down the grade/form you are currently teaching.	General Diploma, Diploma in ECD (early childhood development), Grade 7, Grade 6, Grade 4, Form 1, Form 3, Form 4, Form 6.
4: What subjects did you specialize in at college?	Mathematics, Music, Environmental Science.
5: What subject(s) are you currently teaching?	Mathematics, Music, All primary subjects.
6: What are your qualifications?	Certificate in Education (CE), Diploma in Education, Bachelor's degree.

In question 3, one of the respondents did not indicate the grade/form/level they were teaching or lecturing although their specialization was in mathematics. There were 4 male lecturers, 1 male 'A' level teacher, 1 female 'A' level teacher, 1 female 'O' level teacher and 2 primary school teachers. An 'A' level teacher is one who teaches high school or advanced level students (i.e. Form 5 to 6) and an 'O' level teacher teaches secondary school students from Form 3 to Form 4. The answers indicated that the respondents were primary school teachers (grades 4 to 7), secondary school teachers (Form 1, 3, 4 and 6) and college lecturers (general diploma and diploma in ECD).

Question 4 asked about subject specialization. Four male respondents had specialized in Math, 1 in Music and 1 in Environmental Science (ES). Three female respondents had specialized in Music and 1 in Math. It would be beneficial to also get the views and opinions of non-math and non-music specialists.

Question 5 asked about the subject(s) currently being taught. Five (4 male and 1 female) indicated Math, 4 (2 male and 2 female) indicated Music while 1 female indicated that they were teaching all primary school subjects.

Question 6 asked about respondents' qualifications. Two (1 male and 1 female) had obtained a certificate in education (CE), 3 (2 female and 1 male) had obtained a diploma in education while 5 (4 male and 1 female) had obtained a bachelors' degree. None had obtained a masters' degree or higher.

These statistics from Section A of the questionnaire are important in the sense that we would get responses from both male and female teachers and lecturers who are in different age groups, with varied experiences at different school and college levels and who had specialized not only in Math or Music but in ES as well. The sample, though small, would undoubtedly provide a varied range of information and beliefs or suggestions regarding the use of the relationship between mathematics and music.

Views of the Respondents on the Relationship between Mathematics and Music

Section B of the questionnaire had ten questions which were both open-ended and closed-ended. In this section a question-by-question analysis is going to be presented while giving views of the respondents.

In question 1, all respondents agreed that there exists a relationship between mathematics and music because music is "numbers in motion" and that they include common topics. Some of the common topics mentioned and corresponding number of respondents (in brackets) were number patterns, number bases and modulo arithmetic (n=4), time, graphs, speed, addition and subtraction (n=3), rational numbers, ratios and symmetry (n=1), division of beats (n=1) and simple harmonic motion (n=1).

In question 2(a), 9 of the respondents believed that music lessons could improve mathematics skills of primary school children and cited reasons such as: there are songs used to teach math concepts (like manipulating fractions) and calculations (such as division); math is the basis of music reading and apart from having same or similar concepts, music is measurable just like math. These findings agree with those cited in the literature (Thornburg, 1980; Tsapatori et al., 2009). For example, pupils who received school keyboard musical lessons performed better in mathematics and history than pupils who were not in the programme (Thornburg, 1980). The findings also agree with the beliefs and propositions given by the researcher in the introduction. In question 2(b), 6 of the respondents agreed, 3 disagreed and 1 did not answer on the assertion that music lessons can improve math skills of secondary school children. The common justifications given for those who answered YES to the question were that the combinations of musical waves provide mathematical patterns and that addition of fractions can be taught using music; thus making the learning of math enjoyable. Those who answered NO did not give any reasons.

Question 3(a) was similar to question 2(a) but mathematics and music had been interchanged because it would be quite beneficial to know the subject that influences (but not necessarily cause) the other. Eight of the respondents agreed that mathematics lessons could improve music skills of primary school children, 1 disagreed and 1 was undecided. Those who disagreed did not give reasons while those who agreed pointed out that, "maths has patterns which also help the child to easily catch notes in music; knowledge of division of fractions help pupils to improve music skills involving note values, chords, octaves, intervals". Certain topics like time, sequences and series, graphs and speed were repeatedly mentioned. These findings are quite interesting and warrant some further research since in the literature review (An et al., 2013; Peterson, 1996; www.news.bbc.co.uk/1/hi/education/297073.stm) evidence given was that music influences mathematics performance and not the other way round.

In question 3(b), 6 of the respondents agreed on the assertion that mathematics lessons can improve music skills of secondary school pupils while 2 disagreed, 1 said he/she did not know and 1 did not answer. No reasons were given for the NO responses while common reasons for YES responses were as follows: math topics like time and speed, squares and square roots help pupils deal better with intervals and octaves in music; children must understand fractions to help them in music concepts like note values and progressions. If these results were to be seriously considered, one would argue that a child who performs better/poorly in mathematics would also perform better/poorly in music and vice versa. However in real life situations , there are popular and talented musicians in

Zimbabwe but it is not known whether they are also mathematics specialists or whether they use any knowledge of mathematics in their music.

In question 4, 8 agreed, 1 disagreed without reasons and 1 was undecided on the question, "Does learning to play the piano improve pupils' numeracy?" The common reasons given for the positive response were that the piano needs reading and playing many notes to master it and that the order of the keys help in sequencing numbers thus the knowledge of notes, scales and chords help children improve numeracy. The one who was undecided mentioned that they had no idea of a piano.

Question 5 asked whether the learning of rhythm symbols at grade 2 or 3 level could facilitate the learning of numerical systems of fractions in mathematics. Eight said YES, 1 did not answer while 1 said he/she did not know. None responded NO to the question. Of those who responded YES, their common reasons were that: when children learn rhythm, they are also learning ratios, fractions and proportions thus double and triple rhythms are perceived as a grouping. For example, a semibreve can be divided into halves or minims, quarters are crotchets and eights are quavers. Respondents also said that rhythm helps in recognizing time values for musical notes.

In question 6(a), 7 agreed, 3 were undecided and none disagreed on the proposition that a weekly structured music program can boost numeracy skills in elementary school children. As a way of following up or checking, question 6(b) was a repetition of 6(a) but only "math skills" was put in place of "numeracy skills." Eight agreed, 2 disagreed and none were undecided. Results for 6(a) and 6(b) were consistent implying that the respondents stuck to their views.

Questions 7(a) and 7(b) were about whether positive correlations existed between attitude towards mathematics and attitude towards music at (a) secondary and (b) college levels. The results were: 5 agreed, 2 undecided and 3 disagreed for (a) and 5 agreed, 3 undecided and 2 disagreed for (b). So in both cases only 5 agreed. This could be so due to the fact that in most Zimbabwe secondary schools and colleges music is not perceived as an important and seriously studied subject like math. Perhaps this also explains why there was such a low but positive correlation between performance in music and performance in math at college level (see Results of Correlations of Students' Marks). This can also be attributed to the fact that there is usually high mathematics anxiety and negative attitude towards mathematics at secondary and college levels resulting in generally poor performance (Chirume, 1998).

On the usefulness of math and music to pupils in their real lives (question 8), 7 said math is more useful while 1 said music is more useful and 2 said both subjects are useful. The common reasons why math is more useful were that mathematics is part and parcel of one's daily life (the language of life) and its concepts like time, quantities, calculations, sets etc. are used in other subjects including music. Those who said music is more useful only pointed out that because it touches aspects of human life. These views probably coincide with those of the popular Zimbabwean musician Tongai Moyo Dhewa who sang, "Dhewa ane maths dzake dzokurarama" (Isigodlo, 2009) implying that one needs mathematics in order to help oneself live a good life.

The objective of question 9 was to find out which subject, math or music, is more difficult to pupils at (a) primary and (b) secondary school levels. For question 9(a), 7 said math is more difficult, 2 said it is music that is more difficult and 1 was undecided because he wrote BOTH which does not answer the question. The common reasons given for question 9(a) for math being more difficult were that math requires too much thinking and is also more abstract unlike music. Two respondents who said music is more difficult based their justifications on personal experience. At the secondary school level (question 9(b)), 5 said math is more difficult because the pass rate at grade 7 and 'O' level is usually low, 3 cited music as being more difficult to pupils because at primary school it is just interesting and mostly taken for enjoyment while at secondary school, it involves history and some computations. The other 2 were undecided.

Question 10 requested respondents to write down their general views, comments or suggestions regarding the relationship between mathematics and music. Nine responded while 1 did not respond. The most common views and suggestions of those who responded were that the relationship is more pronounced at the primary school level because at the secondary level pupils tend to specialize and leave out music. Both subjects were considered useful and important (although mathematics was rated highly) and both should be examined in schools. At times music is taught but never examined thereby gaining less respect. Also mentioned was the need to integrate these two subjects at school since they have common concepts and they both *"make the world tick".*

Results of Correlations of Students' Marks

Mathematics and music test marks were collected from 2 primary schools (labeled here as A and B), 2 secondary schools (labeled as C and D) and 1 teachers' college. These were tests written by the same class during the same week and the scores were made available to the researcher by teachers/lectures of those groups of students. Correlations between the two subjects were computed using SPSS version 11.5 . Table 4 shows the math - music

correlations for the test marks. With the exception of one correlation coefficient which was low (r=0.156 and not significant at p<0.05), all the other coefficients were moderate, positive and significant at p<0.05.

Table 4: Showing schools, sample sizes, correlation coefficients and p values

School/College	Number of students who took the tests	Correlation Coefficient	p value (2 tailed)
Primary A	17	0.644	0.007
Primary B	16	0.461	0.072
Secondary C	17	0.578	0.019
Secondary D	14	0.608	0.012
Teachers' College	36	0.156	0.365

The results do support the points raised in the questionnaires that the two subjects, math and music, are positively related. The teachers mentioned that the relationship should be more pronounced at primary school rather than at secondary or college levels and these results agree with that assumption. Low correlations were also found between mathematics grades and music theory grades among secondary school students in New York City (Bahna-James, 1991). In this study it could not be established why low correlations at college level were produced.

Judgmental Sampling with Interview Data, n=4.

Judgmental sampling was used to select four interviewees; two primary and two secondary school teachers. This was done because these teachers were qualified and had subject matter knowledge of math and music and were considered capable to provide required and less biased information. These teachers were given the following pseudo names: Ncube, Suzan, Tichafa and Melody. R stands for the researcher. The following are excerpts taken from the interviews.

Interview with Ncube (Male secondary school music teacher)

R: Is there a relationship between mathematics and music?
Ncube: Yes, a relationship is there and it is strong. I believe teachers should utilize it.
R: In your department, what is the composition of mathematics and music students and what can you say about their performance?
Ncube: Ok. In my department we teach music to maths and non-maths students. Most of the time, those good in maths are also good in music. But those more inclined in the Arts try to avoid, eeh, on the music question paper, questions with some maths applications or calculations. They would rather answer questions on history of music, traditional music instruments and so on which have no maths or no calculations of some sort. This leaves them mathematically worse off.
R: So what do you suggest should be done?
Ncube: Firstly teachers should have basic subject matter knowledge of mathematics and music. Then, why not integrate the teaching of these subjects at secondary level or do team teaching? Perhaps performance in both areas can be enhanced.
R: Mr [Ncube], thanks so much for your time but before you go, do you have any final word?
Ncube: Oh yes please. I think I would like to write a book on the intricacies and relationships between mathematics and music. Pythagoras numbers have been used to design the piano key board. In Zimbabwe schools we don't have many pianos but we have a lot of traditional instruments which produce sounds similar to the piano's. Yah, I think we can start exploring with what we have and then move on.

Interview with Suzan (Female - primary school teacher who likes to sing a lot)

R: [Suzan], what can you say about mathematics and music?
Suzan: Yah, I can say both math and music arouse our emotions. When mathematics gets inside you (sic), you become quiet, a person with few words like most mathematicians. You lose memory and become mad. Vanhu vemaths vazhinji vanopenga ndikuudzei (*most math people are mad I tell you*). Asi music inonakidza inochemedza vanhu kuita sevanopenga (*But a nice piece of music makes people cry as if they are mad*).
R: Oh really? That's quite interesting. So what's your suggestion to students?
Suzan: Well, Eh-- I think-- when children begin to worry much about mathematics, why not play them some moderate music to reduce some of their madness and lessen their crying to smiling? I think teachers can do it. Drive kids to a

state of math-music equilibrium which makes them think deeply but at the same time work problems while happy and smiling.
R: Sounds great. What about school heads? How can they help?
Suzan: Schools can help a lot. The headmasters must make sure that classrooms are equipped with math and music resources for use by teachers and kids to reduce the fear of mathematics and make it interesting through music. This will build the kids' confidence, and induce happiness and smiles. I think when kids play some music in class their body muscles are relaxed and their brain works faster and smarter…

Interview with Tichafa (Male primary school teacher)

R: At college you learnt about subject integration. Are you using it in your teaching of mathematics and music?
Tichafa: Yes, but only to a little extent.
R: Can you elaborate please?
Tichafa: I think it is fear and ignorance that keep teachers away from teaching maths through music or the other way round. They think they do not know enough information about this relationship so that they can use it to teach effectively. We also need enough teaching resources but we can't get them; they are expensive.
R: Let's say resources were somehow found, could you feel comfortable teaching these subjects together?
Tichafa: I would be happy to try but I think I need some staff development or training. The other thing is we are afraid to waste time teaching non-examinable material. We would not finish the maths syllabus especially those of us who are teaching grade 7.

Interview with Melody (Female secondary school teacher)

R: What can you say about the relationship between music and mathematics?
Melody: I have read in some papers that they are related but I think they also have some differences.
R: What could be those differences?
Melody: For instance, in maths you follow specified rules to get solutions of some equations but with music you experiment,… use trial and error to arrive at the best answer to what you want to compose. But I think similarities outnumber the differences.
R: Ok. Let us talk about school children. Is it possible for a kid to grow into both a musician and a mathematician?
Melody: Well, they are few of such cases (sic). Every Jack and Jill who can talk can also sing and is thus a musician whether we like their music or not but not every person who can talk is a mathematician. Many people like music but not maths.
R: What is your opinion about the teaching of these subjects?
Melody: I am a qualified maths teacher. I like music but am not qualified to teach it. I think people who know both subjects need to develop us on how we can use integration teaching methods at secondary school level. Maybe at primary level there are such teachers, I don't know.

After careful scrutiny of the interview excerpts, the following themes were generated: connection between mathematics and music, beliefs about the integrated approach and problems with teacher knowledge and skills. (This list is not assumed to be exhaustive). Table 5 gives a summary of the themes and the interviewees' opinions on those themes.

Table 5: Showing the 3 themes and the interviewees' opinions on the themes

Interviewee/**Themes**	**Connection between mathematics and music**	**Beliefs about integration**	**Problems with teacher knowledge and skills**
Ncube	Yes, strong	Yes, strong	Teachers lack knowledge
Susan	Yes, moderate	Yes, strong	Lack of resources to use
Tichafa	Yes, but teachers afraid to use it	Yes, moderate	Lack of knowledge on aspects of the relationship, and about how to use integration, Lack of resources
Melody	Yes, but mixed feelings about the relationship	Has little knowledge about integration	Lacks skills to teach music, thinks pupils rarely can become both mathematicians and musicians

From the interview excerpts the teachers believed that the relationship existed. They also perceived that teachers could not utilize the relationship because they lack specific knowhow about aspects of that relationship. Interestingly, research carried out to investigate perceptions of secondary school students showed that they believed there was no such relationship (Bahna-James, 1991). Research also suggests that teaching by integration educates the whole child and prepares them for life in an integrated world (Still and Bobis, 2005). While learning mathematics practically through playing music strengthens body muscles, students also gain benefits of accomplishment, appreciation, discipline, fun, active participation and maturing relationships (Mickela, 1990). It is believed that an active and social approach to the teaching and learning of mathematics might be a way to prevent undesirable and negative effects such as worry, anxiety and indiscipline, while the idea that music makes people smarter is another possible good reason for integration (Tsapatori et al., 2009). Winkel (2000) says music is believed to restore order and harmony in the universe while math is involved in every field of study known to mankind (David Jr, 1995). These and other possible good reasons for integration can be weakened by the fact that most teachers lack requisite knowledge and skills as echoed by the interviewees. The problem is worsened by shortage of resources for teaching/learning. The idea that school authorities should provide the resources and empower teachers with knowledge and skills to make effective implementation of the integrated approach also came out.

CONCLUSIONS AND RECOMMENDATIONS

This study sought to find out among other things, if a relationship between mathematics and music existed, and how and to what extent that relationship could be put to some good use in the teaching and learning of mathematics and/or music in some Gweru schools. Evidence collected from questionnaire data and from mathematics and music performance marks showed that there is a positive correlation between the two subjects. It was not possible to carry out regression analysis to determine the cause and effect relationship because of lack of sufficient knowledge or literature on which math or music performance could be the dependent and independent variable.

However, points raised in the literature review and results from questionnaire data and interview data answered the research questions and further highlighted important points which could be utilized by school teachers in order to improve children's performance in the two subject areas. For example, 80% of respondents agreed that music lessons with emphasis on rhythm and piano skills could lead to better performance in mathematics. However, few schools in Zimbabwe can afford to buy pianos but can afford simpler instruments with keys and/or sounds similar to those of the piano. Some respondents also agreed that mathematics lessons with emphasis on fractions, ratios, intervals, time, proportion and scales could lead to better performance in music. Nevertheless, it is hereby proposed that perhaps a well structured and integrated approach on teaching both subjects could lead to better performance in each of them. Harkins (2011) has similar view when he says:

> *Music and math go together in more ways than you may think. Using a holistic approach, math teachers can use musical lessons to illustrate the patterns and graphing of numbers. Middle school students, who already may be adept at basic mathematical concepts, can be further stimulated by music to recognize more complex equations involving permutation and fractions.*

Teachers who responded to the questionnaires believed that at secondary, college or higher levels of education the relationship could be less pronounced probably because of people's inherent negative bias towards music while math is perceived to be more useful and important although more difficult. It is also noted that music theorists often use mathematics to understand musical structure and communicate new ways of hearing music leading to musical applications of set theory, abstract algebra and number theory (Shah, 2010; Wright, 2009). It could be worthwhile and interesting to find out whether mathematicians have used or could use music to further understand or learn their mathematics. Researchers could also find out from popular and talented musicians in Zimbabwe whether they are also mathematics specialists or whether they use any knowledge of mathematics in their music.

Finally in the area of education our major goal as teachers is to improve children's performance. There is need to carry out further research to investigate impediments to integrated approach to teaching of mathematics and music in both primary and secondary schools. Schools need resources while teachers need in-service training or some workshops on how to teach these subjects through integration. It is also recommended that other research designs such as the experimental (e.g. actual teaching using integration) and survey (e.g. interviewing and testing musicians) could be used to tap more information about this relationship. Also further statistical analyses on correlation and regression could be used to test one's hypotheses.

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