

**The correlation between music aptitude and mathematical achievements of  
students - a case study of six individual students from a High School in  
Johannesburg, South Africa**

by

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## DECLARATION

I, Mario Maxwell Müller, hereby declare that the thesis for the Doctorate degree hereby submitted by me, at the University of Venda, has not been submitted previously for examination for a degree at this or any other university, that it is my work in design and execution, and that all reference materials contained herein have been duly acknowledged.



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## ABSTRACT

A gap existed in the literature focusing on research overall between music aptitude and mathematical achievement within a South African context. The purpose of the study was to investigate the effect of music aptitude on mathematical achievement and to evaluate the most appropriate instruments for measuring musical talents and juxtaposing them with mathematical achievement using Gordon's AMMA tool to establish the connection between musical acumen and mathematical achievement in randomly selected learners. This study presented data that is now available for use by other researchers. The researcher used exploratory designs to generalise, assess, and test qualitative exploratory results, and to see if they could be generalised to a sample and a population as outlined in this dissertation. This research was evaluated in both qualitative and quantitative phases. The researcher focussed on how students of different ages, gender, intelligence levels, and musical abilities reacted to the AMMA (music aptitude test). The gathered information confirmed what students achieved in the different elements of music such as pitch and rhythm making this study valuable for music educators.

The findings revealed that the music aptitude test impacted the mathematical achievement of all the students in Grades 8 and 9 in a High School in Benoni, Johannesburg. This confirmed the hypothesis, that music aptitude impacted their mathematical achievement, and contributed to their educational performance despite their socioeconomic backgrounds, gender, age, and race. In South Africa, most students obtained excellent results in mathematics, and played at least one

instrument proficiently. The new literature available on whether one impacted the other, and what implications it would have on their education was underpinned in this study which also identified existence of these connections, using the Advanced Measures of Music Audiation (AMMA) test, which confirmed that a close relationship existed between music and mathematical achievement. The study used mixed research methods to answer the research questions and enlighten prospective researchers, and show their connections, associations, and relations.

## **KEYWORDS**

*Advanced Measures of Music Audiation, Correlation, Mathematical achievement, Music Aptitude, Rhythm, Tonality.*

## DEDICATIONS

This thesis was written for my late mother, Eileen Theresa Müller, a senior music lecturer at Dower Training College of Education in Port Elizabeth, who died suddenly of endometrial cancer on the 30<sup>th</sup> December 2009, and my amazing dad, Douglas Müller, who passed away eight years ago of a severe stroke on the 23 November 2015 and the memory of my late brothers Fabian and Sebastian Charles Müller. My mother inspired me in music so much over the years, from the first piano lesson at the age of six to my taking up the cello at thirteen. Upon my return to South Africa, after living abroad in Israel I continued with my music education at the University of Port Elizabeth, the same University at which she completed her degree and post-graduate studies during the years of Apartheid. Her grace and presence will always fill my heart with joy, as I cherish all the musical moments we shared. My dad has always been a role model to me and always consistently supported me emotionally, financially or mentally. He was the inspiration to always deliver my best. His tragic death has been a surprise but his memory and abundance of love for his family will always live in our hearts. This thesis is dedicated to you all my dear friends around the globe, close to my heart and family for all the years of compassion and understanding.

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The Almighty Father “God” has given me the strength, power, tenacity, and motivation to conclude this PhD study.

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## LIST OF ACRONYMS

ABRSM	Associated Board Royal School of Music
AMMA	Advanced Measures of Music Audiation
DoE	Department of Education
GS	Government School
IEB	The Independent Examination Board
IMMA	Intermediate Measures of Music Audiation
NSC	National Senior Certificate
PMMA	Primary Measures of Music Audiation
PS	Private School
LCM	London College of Music, West London University
MANCOVA	Multivariate Analysis of Covariance
MAP	Musical Aptitude Profile
MLT	Music Learning Theory
LSS	Liverpool Secondary School
RSL	Rock School London

RSA	Republic of South Africa
TCL	Trinity College of Music London
T and R	Tonal and Rhythm
UNISA	University of South Africa

## KEY CONCEPTS

- Aptitude
- Audiation
- Gauteng
- Edwin Gordon
- Johannesburg
- Intelligence
- Mathematical Melody
- Musical Ability
- Note duration
- Pattern
- Pitch
- Rhythm
- South Africa
- Tonal

## CHAPTER 1

### INTRODUCTION AND BACKGROUND TO THE STUDY

*“Music gives a soul to the universe, wings to the mind, flight to the imagination and life to everything.” — Plato*

#### 1.1 INTRODUCTION

After returning to South Africa and accepting a new position at Liverpool Secondary School, and working with magnet music schools the researcher discovered that students were brilliant in both mathematics, and music. This is a school where the ratio of African students has increased remarkably and produced excellent results overall to the academic demands of the Department of Education and stakeholders of the school. According to the Principal in an interview:

The reason why students were obtaining excellent results is due to the constant commitment, devotion and consistent hard work of dedicated teachers ensuring that most students were ready for their final examinations despite where they came from, their gender, race or culture? Students in comparison to some of the private schools were obtaining 6 – 7 A results for subjects including mathematics. Half of the time these students never had access to extra tuition, study leaders guiding them further but had a high level of perseverance, and competence and continued to progress in obtaining results, which made the school leaders proud of their achievement overall and testimony that anything is definitely possible (Maharaj, 2018).

The researcher was intrigued to see that most of the music students in the secondary school could compose with ease without prior knowledge of composition thus demonstrating an excellent theoretical background, which was prevalent in his discussions with colleagues. Having studied the previous school curriculum, they were exposed to since their childhood in primary school, the researcher could not find any relevant material linked to composition, form, structure or even analysis. Conversations with colleagues in the mathematical department revealed that the same students were doing extremely well academically in their mathematical subjects. This raised further questions for the researcher; was this merely a coincidence or was this increase in academic achievement due to the impact of their music studies?

Most parents in the community encouraged their children to attend private schools and went out of their way financially to provide for a good education reinforcing good will and intentions to foster a brighter future for these learners. For students to achieve excellent results, aptitude played a prominent role in their musical development. In the most diverse multicultural classroom settings in South Africa, most students studied mathematics but only a portion explored music through the arts program available, with arts and culture selected modules, sharing information whilst learning about other disciplines with an emphasis on dance, drama, and visual arts. An article by Taylor (2021) emphasised:

The ultimate goal of primary school mathematics, as specified in successive South African curricula over the past few decades, is to nurture amongst students a flexible understanding of proportional reasoning and the faculty to work with rational numbers. This is the central idea required to explore fully all the principal topics in the high school curriculum: the algebraic and graphical representation of polynomial functions, differential and integral calculus, trigonometry, probability and the geometry of similarity. High school students may obtain a 'pass' on the National Senior Certificate (NSC) mathematics examination, but this does not necessarily mean they have mastered the concepts listed in the curriculum. For example, students in Grade 12 may be able to calculate the gradient or derivative of a function by more than 30 times on each primary school child than Uganda, the countries' Southern and Eastern African Consortium for Monitoring Education Quality (SACMEQ) scores have tracked each other closely over nearly two decades (Taylor, 2021:1-2).

Mathematics, Science and English are all listed as core or compulsory subjects, especially at secondary level as outlined by the South African Educational System (Government Gazette, no 32743, DoE, n.d). In all secondary schools in the district of Benoni music was taught with rigid guidelines as part of the Arts and Culture modules; however, some students had the option to choose music as a subject at their matric level. This raised many questions to the researcher as to whether music was somehow connected and had a close relationship to mathematics. A child should overall display a level of intelligence for understanding the theoretical aspects of music as discussed and reiterated by Gordon (2003:374). These also applied to understanding mathematics through the logical processes involved for equations, multiplication, subtractions and other core elements of mental arithmetic (Lim, 2003:3; Motluk, 1997:17). Surely, the pupils that displayed an excellent

understanding of composition should have had a level of music ability surely. Several researchers agreed that music and mathematics were very similar and were both connected to abstractions and associated with making patterns of ideas (Beer, 2005; Chirume, 2014; Du Toit, 2007; Rather, 2000; Shah, 2001; Storr, 1992; Taylor, 2021). This raised more questions related to the topic regarding a correlation between musical aptitude and mathematical achievement. Brown (2012:1) with reference to Spatial-Temporal Skills (STM) argued:

Research has also found a causal link between music and spatial intelligence, which means that understanding music can help children visualise various elements that should go together as they would do when solving a maths problem ... These skills come into play in solving multistep problems one would encounter in architecture, engineering, maths, art, gaming, and especially working with computers.

Having studied the various literature related to the topic, the researcher could not find recent or current research literature within a South African context to be associated with music and mathematics (Agawu, 2001; Mapaya, 2012, 2014; Merrian, 1977; Nettl, 1991; Taylor, 2021; Waterman, 1991). A gap existed in the literature that was available in Africa particularly focussing on South Africa. There were two entities that needed to be evaluated and described through this study; namely musical aptitude, and mathematical achievement with their own definitions, theories and research that was previously conducted. Several conclusions and facts could be concluded from the discoveries made around musical aptitude tests by a

variety of researchers including Buttall (2007); Drake (1954); Gilleece (2005); Gordon (1965, 1967a, 1989a, 2003); Hankinson et al., (1999); Humphreys (1998); Jang (2000); Karma (2007); Milovanov (2009); Müller (2012); Seashore (1919, 1960); White (1931); and Wing (1948). There was a distinction between musical aptitude and musical abilities with reference to the literature that was consulted and studied. The most prominent scientists, and mathematicians were great musicians. Albert Einstein, who was a prominent scientist, and a former Nobel prize winner, displayed a high level of musical intelligence, with a great sense of passion for the string instrument, the violin. His music works are not published but evidence thereof exists in archives in Europe, and still played and used today.

As Foster (2005:1) described:

Albert began to learn the violin at the age of six, while his family was still living in Munich. However, he toiled under the imaginative tuition until discovering the joys of Mozart's sonatas at the age of 13... Music was not only a relaxation to Einstein; it also helped him in his work.

According to the Gordon Institute for Music Learning (GIML) musical aptitude, is best described as “the potential or capacity for musical achievement” (Gordon, 2003:372).

Gordon had a history of 18 years of research focusing on several ideas depicting the ideology of “music learning theory” particularly noted with the use within education, which he claimed was based upon psychological principles and extensive research

completed (Byrd, 1991:59; cited in Müller, 2012). Researchers (Leonhard and Colwell, 1976; Brink, 1983; Miklaszewski, 1986) shared the same passion for critically evaluating Gordons theories and practical usage and application to specific reference particularly to classroom instruction, thus focussing on music aptitude. According to a critical evaluation presented by Byrd (1991:59-60, cited in Müller, 2012), which reaffirmed the following:

Gordon is ambiguous in much of his description of the process; he often tells what things are not as opposed to what they are. Examples, which clearly illustrate his sequential musical learning processes, are few in number.

Miklaszewski (1986:85) argued further that “students enjoy the combined use of tonal and rhythmic aspects of music though he feels that the basic skill acquisition is not seriously affected”. As with any academic discipline or subject you must acquire a particular skill at the end of a school year or course. This equates to the following questions: did this phenomenon impact their understanding of music theory? Swindle (1970) and Bell (1981) examined and provided insight into the applicability of Gordon’s Primary Measures of Music Audiation, and his Iowa’s Tests of Musical Literacy in relation to his cumulative work presented for the classroom. These studies were all geared towards the Primary Music Education of students: how did these impact learners’ developments academically when they entered secondary school? Music aptitude tests enhanced students’ theoretical

understanding with reference to the rudiments of music theory used for both the primary and secondary school learners. DiBlassio (1984:67) shared his views on the four methods applicable to tonal and rhythm pattern instruction which imminent effects on developmental tonal and rhythm aptitude of the sixteen respondents who participated in the study. DiBlassio's (1984) study clearly emphasised the use of the elements of music, focusing theoretically only on the tonal and rhythm areas. It can be argued on a theoretical basis with reference to music theory that these music educators were rather harsh and biased towards Gordon's work with years of research and investigations concluded, focussing on the teaching aspects, and learning attributes of music. Students can understand music by exploring its different elements, through means of revision, constant practice of concluding theory as part of music lessons. In South African secondary schools, most teachers teach a portion of music theory in their arts and culture classes, as per the requirement in their syllabus suggests where students are trained to read western notation. By introducing ethnomusicology, the learners are introduced to a small portion of African instruments where they classify them accordingly into membranophones, idiophones, chordophones, electrophones, and aerophones (De Villiers and Saul's, 2017).

These are all imminent facts about the development of Musical Aptitude tests that are readily used within international schools abroad. Especially in primary and

secondary education, within South Africa, a gap existed where students were not exposed to Music Aptitude tests; privileged students were given the opportunities to learn a musical instrument through their parents paying additional funds for private tuition and lessons or having the possibility to join an after- school music club, which came at an additional cost to parents. In April 2000, Prof Wei-Chin Jane Chuang from the Department of Music Education at the National Pingtung Teachers College tested Taiwanese students through the Musical Aptitude Profile (MAP), which was a standardised music aptitude test as designed by the late Professor Edwin Gordon, and especially used for American students intending to study in the United States of America. Her research involved testing solely Taiwanese students, focusing on their music environments and their level of musical abilities as estimated by their parents, teachers, and peers (learners). She included 1723 participants in her study from the fourth to the twelve grades in Central Taiwan of the three divisions of the MAP. She only used Tonal and Rhythm Imagery to measure the tonal and rhythmic aptitudes of her students and three questionnaires were administered to the selected (n=1066) parents, students and music teachers (Chuang, 2000:794). Her findings revealed that the Tonal and Rhythm division of MAP were valid measurements of music aptitude shown in the study of the selected Taiwanese students. The information gleaned from the MAP could be used to improve teaching overall in most secondary schools with the positive impact it had on academic results (Chuang, 2000: 811 –

813). These findings drew attention to the importance of future research, hence the reason why this researcher wanted to incorporate the current facts from Chuang's findings into his own research, with the intention of preparing new literature available for South African educators to access and familiarise themselves with. The importance of using music aptitude tests within their primary and secondary schools, would benefit the students substantially, empowering them with the opportunity to learn a new skill by exploring new music instruments. Chuang (ibid:812) revealed furthermore that students in Grade 7 – 8 were not particularly aware of their own musical abilities because they were never given the opportunities in their classroom settings. Similarly, in South Africa, as Arts and Culture had a combination of different art disciplines projected together including visual arts, drama, dance and music. Is this a constant phenomenon for students at this age or are they born gifted? As this research was directly linked to the researcher's current interests, which encouraged him to investigate how students reacted to The Advanced Auditory Test of Edwin Gordon, and how the results impact on their academic acumen for the subject mathematics, whilst learners studied arts and culture, that was enrolled in grades 8 and 9 in a government school in the district of Benoni.

## 1.2 RATIONALE

The basic aim of any research project is often to learn and understand phenomena by studying, comprehending, evaluating, synthesising, demonstrating, and critically evaluating previous research conducted in terms of identifying current trends and developments made before drawing any conclusions to have created a basis for one's own research. The first process was finding links between music and mathematics, what was already researched, and what areas needed more refinement, and further exploration to encompass a research study to elaborate further findings relevant to music education programs in South Africa, and how music aptitude tests benefited students in the secondary schools.

Howes (cited in Butall 2007:4) explained:

The analogy between mathematics and music has been recognized from antiquity and through all attempts to press the analogy, or even to define it, soon break down, it is still recognized by musicians and mathematicians and the rest of us who are neither as a way of thinking relationships, abstractions there is an obvious similarity.

Butall (2007) takes a positive view of the connections and relationships that exist between music and mathematics when he pointed out that: "Traditionally a connection between mathematical aptitude and musical ability is said to exist". Other researchers (Hodges and O'Connell, 2005:11) shared a strong viewpoint with

reference to music and mathematics and argued: “The subject of mathematics is generally taught in isolation from other subjects and often lacks any creative or artistic flair”. This can be argued further with the directive that in most schools within a South African context, and even in other countries, the subject of mathematics was always given first preference before music; despite the fact that connections existed with reference to mental arithmetic, and comparably when one thinks of how the brain worked when one does mathematics or music, the basis remains the same in theory (Buttall, 2007; Drake, 1954; Gilleece, 2005; Gordon, 1965, 1967a, 1989a, 2003; Hankinson et al., 1999; Humphreys, 1998; Jang, 2000; Karma, 2007; Milovanov, 2009; Müller, 2012; White, 1931; Wing, 1948). Vaughn (2000:149-166) reaffirmed these phenomena through his strong views that: “However, there is a connection between music and mathematics; both subjects’ areas use numbers, repeating patterns and ratios”.

Mathematics and music aptitude share a few decades of prevalent research and findings, exploiting and enriching their combined relationship. A rather large majority of research studies revealed that there were some positive effects of music on mathematical achievement; however, only a few studies have found no effect (Hodges and O’Connell, 2005:11). The area of research between music and mathematical achievement was limited to a few academic findings with connection to a South African context. Further investigations of the effects of a music program

Research on the mathematical achievements of preschool children concluded that a high level of difference existed between the mathematical achievements of those that belonged to a music group in comparison to a non-music group (Geoghegan and Mitchelmore, 1966). Conclusions were made that: “children in [that all belonged to] the music program scored significantly higher in mathematics [than those who were not part]”. According to Hodges and O’Connell (2005) who mentioned that: “further analysis revealed that the difference in mathematics achievement has been a result of the children’s home musical background rather than the music program itself”. One can clearly argue with reference to this statement that children’s attainment in mathematics is somewhat connected to their exposure to music. To be able to differentiate the theoretical aspects of music one must use the fundamentals of mathematics. A perfect example would be how to work out how many rests are needed to complete a bar where rests are required to be filled in accordance with the time signature given, this involves mathematical reasoning.

To have a clear picture of the research and studies previously conducted it was important to divide the section of Middle and Secondary (High) school.

### 1.2.1 MIDDLE AND SECONDARY (HIGH) SCHOOL

Cheek (1999: 759-761) investigated whether music training had a direct correlation between the achievements of levels attained by eighth-grade students. Her methods involved the data collection of samples by using the IOWA Test of Basic Skills (ITBS). Through surveys, she obtained information about the student's musical background, type of instruments they were exposed to, number of years of musical instruction they received, and number of years of private tuition concluded with fitting sampled demographics. Her conclusion showed no difference between the ITBS mathematics scores of the students who received private tuition/music lessons (Cheek, 1999).

Further research by Christian O'Donnell in 2011, a researcher who completed his DPhil degree entitled: *An investigation of the effect of instruction in Edwin Gordon's tonal and rhythm patterns on secondary students' advanced measure of music audiation scores with the University of Oklahoma in the USA*. The purpose of his research was to determine the use of Gordon's patterns in Music Learning Theory, used twice a week for one semester could affect the tonal and rhythm scores of the [AMMA] Advanced Measures of Music Audiation (O'Donnell, 2011).

In March 2013, a student, Joshua Robert Boyd completed his PhD in Education at the Liberty University in Lynchburg, the United States of America with his thesis titled

*“The relationship between music participation and mathematics achievements in middle school students”*. The purpose of his research was to fill the gap in the literature in relation to music participation and its correlation to mathematics and middle school students (Boyd, 2013:90). His research revealed that there was a positive correlation between students’ participation in music and their achievements in mathematics (Boyd, 2013:60).

Boyd (2013) outlined the significance for future research due to the gap in the literature that existed. This researcher’s intentions are to demonstrate and find that music aptitude impacted mathematical achievement overall. Leading to the significance of both entities by comparing, contrasting, evaluating, defining, discussing, and evaluating the responses of learners in Grades 8 and 9 through applying and using the Advanced Measures of Music Audiation (AMMA) Test designed by Prof Edwin Gordon, with reviewing their significance about mathematical achievement. This research conducted created future opportunities for other research scholars to explore as the previous research focused merely on music participation and mathematical achievement.

### 1.3 STATEMENT OF THE PROBLEM

In South Africa, most students studying mathematics lack the opportunity to engage in music activities, and even among those who do, their musical aptitude still needs to be assessed. Furthermore, South Africa needs a universally accepted method for quantifying music aptitude. In an ideal scenario, every student enrolled in mathematics should have the opportunity to participate in music endeavours, fostering a holistic educational experience. Moreover, regular assessments of their musical aptitude could provide valuable insights into the potential cognitive and creative intersections between mathematical and musical skills. Such an approach promises to uncover beneficial cross-disciplinary relationships and enhance overall academic development. Music aptitude test tools' value must be recognised, undermining their potential to uncover latent talents and cognitive strengths. This oversight limits the accurate assessment of individuals' musical potential and the cognitive advantages of musical proficiency. This discrepancy could result in uneven allocation of resources for different subjects, potentially leading to inequitable educational budgets. Additionally, it could perpetuate academic disadvantages for specific students, creating disparities in their educational experiences. Regular and consistent administration of music aptitude tests could unveil a positive correlation between music engagement and mathematical achievement. Such an understanding has the potential to shape budget allocations by government

departments, recognising the valuable contribution of music education to overall academic performance.

#### **1.4 AIMS OF THE STUDY**

The aim of this study is to determine the degree to which a statistically significant correlation exists between students' music aptitude and their achievements in mathematics.

#### **1.5 OBJECTIVES OF THE STUDY**

Objectives of the study were:

- To ascertain the prevailing sentiments regarding the correlation between music aptitude and mathematical achievement.
- To test the hypothesis derived from the survey suggesting the potential existence of a correlation between music aptitude and mathematical achievement.
- To assess the existing music aptitude testing programs.
- To develop a suitable music aptitude test that would offer educational benefits to students within a South African context.

## 1.6 RESEARCH QUESTIONS

The main research question guiding this study was – Does the AMMA music aptitude test corroborate the mathematical achievement of students?

Secondary research questions related to the main research question were:

- What are the predominant attitudes and perceptions concerning the potential relationship between music aptitude and mathematical achievement?
- Can the hypothesis, stemming from the survey, be substantiated, indicating a potential correlation between music aptitude and mathematical achievement?
- How effective are the currently available music aptitude testing programs in accurately gauging individuals' musical potential?
- How can an appropriate music aptitude test be formulated to provide educational advantages for students within the specific context of South Africa, enhancing their learning outcomes?

## 1.7 RESEARCH METHODOLOGY

This study used mixed research methods as outlined by Creswell (2003, 2009). The researcher used the explanatory design, where the researcher wanted to generalise, assess, or test qualitative exploratory results, to determine if they could be generalised to a sample and a population. These were applicable when the researcher had time to conduct the research in two phases (quantitative, with six respondents and a further 30 respondents (music teachers), and qualitative, with seven respondents). The researcher identified a new emergent research question based on the quantitative results that cannot solely be answered with qualitative data (Creswell, 2009:87).

Data collection took place through information gathered from the high school, Liverpool in Benoni. Furthermore, the researcher liaised with fellow teachers in South Africa and Internationally on a regular basis via Google forms, and Skype. Many of the tests were concluded by the researcher except for the interview held with the music teacher through an electronic platform. All the research was documented with findings carefully presented whilst all the participants were available in person, excluding the one music teacher, who completed an online detailed questionnaire, and to be considered as part of this project, using the survey monkey research instrument. As part of the study a questionnaire was sent to 30

different respondents, who answered questions related to the topic on music aptitude and mathematical achievement with 10 questions being posed (this has been discussed in much detail in Chapter 3).

## 1.8 RESEARCH APPROACH

The design overall was concluded in two processes, quantitative (n=6) with an extended study being concluded (n=30), and qualitative (n=7), which constituted a mixed-method approach, with a strong *Sequential Explanatory Design*. Quantitative methods included the survey with detailed questionnaires completed online during school hours and forwarded electronically as outlined by Mouton (2002:149-151). As part of the study the researcher forwarded a google form document to 30 respondents from different parts of the South Africa and internationally. The qualitative section, which constituted empirical research, included the case study of one country of South Africa and the city of Johannesburg this has been discussed in much detail in Chapter 3).

## 1.9 RESEARCH DESIGN

This thesis was of the nature of a case study, using mixed research methods. The researcher used a *Sequential Explanatory Design*. This study overall was based on

the three research instruments used: a listening test (AMMA music aural test), and a detailed online questionnaire (survey) for subjects (learners) to have completed, during class sessions the researcher forwarded an electronic questionnaire in the form of google forms (see Appendix K). The researcher focussed on the seven respondents and one music teacher who participated in this research project. They were all tested accordingly, using the AMMA test, these scores were converted using the Gordon *Manual for Rhythm and Tonal*, where percentile scorings were allocated accordingly and converted to raw scores (see Appendix H and I). Furthermore, 30 music teachers participated as part of the quantitative survey.

The nature of using mixed research methods and popularity could be easily documented by using journals, articles, conference proceedings, books, and the formation of special interest groups (Creswell and Plano Clarke, 2010). It is known as the “third methodological movement” incorporating quantitative and qualitative research (Tashakkori and Teddlie, 2003:5). Johnson and Obwuegbuzie (2004:15) described it as the “third research paradigm”. Mayring (2007:1) described it as “a new star in the social science sky”. A mixed research method was an intuitive way of doing research that was constantly displayed in everyday lives. Greene (2007:20) viewed these methods as “multiple ways of seeing and learning” (this has been discussed in much detail in Chapter 3).

### **1.9.1 SAMPLING STRATEGY (RESEARCH PARTICIPANTS)**

At the time of the study all the students who participated in this research project were in Grades 8 and 9 at Liverpool Secondary (High) School in Benoni, Johannesburg in South Africa. As per the quantitative analysis, six respondents participated, and as per the qualitative analysis and the interpretation of data, seven respondents were actively involved. Most participants were aged 12 – 14 years, and of mixed (boys and girls) gender. Although the focus was on the six respondents, the data of the other students was used to conduct an average and provide validated statistical data. They only stated their age, gender, musical experiences/backgrounds, and school, on their initial AMMA test. The researcher liaised via Skype calls and regular email correspondences with the music teacher, who was a colleague and teacher at Liverpool Secondary School. Before Covid19 the researcher conducted a pre-and post-test interviews to establish students' responses towards the AMMA as part of his duties as an educator at Benoni High school as outlined by the Department of Education. As part of the study 30 teachers from different provinces of South Africa and the rest of the world participated in this study to give their input by expressing their viewpoints with regards to the connection between music aptitude and mathematical achievement. This was a further quantitative study being concluded using a questionnaire, and presenting through google forms in a form of a survey (this has been discussed in much detail in Chapter 3).

## **1.9.2 TRIANGULATION OR VALIDATION OF THE RESEARCH**

The study formed a level of triangulation, as the researcher used both quantitative and qualitative methods. In the view of Rowley (2002: 23) who stated, “one of the great strengths of case studies as compared with other methods is that evidence can be collected from multiple sources”. Triangulation used evidence from different sources to corroborate the same facts or findings. Guion et al. (2011) believed that methodological triangulation involved the use of both qualitative and quantitative methods. These may include results from surveys, focus groups, and interviews that could be compared to determine if similar results were found. If the conclusion for each of the methods were the same, then validity was established.

## **1.10 DELIMITATIONS OF THE RESEARCH**

This research focussed on how students of different ages, gender, intelligence levels and musical abilities reacted to the AMMA (music aptitude test-listening). The gathered information provided and confirmed what students achieved in the different elements of music such as pitch (tonal) and rhythm, where their data was analysed using their given raw scores, and then converted using the AMMA test manual. The author hoped to demonstrate a clear understanding as to why students showed better results in music and mathematics to expand on the possibilities of the direct

impact between music aptitude and mathematical achievement overall. This research answered the questions the researcher had since his arrival back in South Africa. Previous research has shown that music and maths were somehow connected. This study made data available and provided new research available for future researchers/scholars. For a possible further study, the researcher would like to test other schools in the area to make a comparable study.

### **1.11 ETHICAL CONSIDERATIONS**

All information that was gathered from the participants in South Africa was treated with the utmost confidentiality. Participants had the choice to withdraw at any time during the research project. For the follow-up detailed questionnaires (survey), participants only had to write down their age, gender, and the school they attended. The researcher was hoping to conclude a further study with other schools in different regions on a larger scale in future. Their names overall remained anonymous at all stages of the data collection. For the AMMA test, they only had to provide their age, school's name, and gender. The researcher had to comply with all the statutory requirements for approval letters with the Ethical Clearance department for the University of Venda (UNIVEN), and ensured that everything was concluded as expected, and outlined in the approved research proposal. Once permission was granted for the study using Covid19 protocols (most of the data was collected as part

of the pre-test, before Covid19. The interviews were conducted online using the appropriate Covid19 protocols and safety guidelines as outlined and recommended by the University of Venda.

All consent letters were addressed to the respective heads of the various school/principal, parents, and students, who participated in this study. On their mathematical SAT, the students only had to declare their age, and gender. As suggested by the NRES (2008):

Most surveys are completed anonymously thus ensuring confidentiality – though researchers should be aware of the risk of substantial qualitative data identifying the respondent. Whilst anonymization is standard practice, some researchers choose to code questionnaires so that a nil response can be chased (NRES, 2008:1).

Most of the data collected from all research participants was treated with the utmost confidentiality to ensure that the research questions were answered after all permission and consent letters were approved. Concerning the teachers, the researcher liaised with them regularly through Skype, and emails, and using the survey programme online tool, survey monkey ([www.surveymonkey.com](http://www.surveymonkey.com)).

## **1.12 VALUE OF THE STUDY**

The research conducted was valuable for music educators and schools who intended to use the advanced measures of music audiation (AMMA) by Gordon imminently. The research findings could be used to assist others in their research in

similar fields or academic disciplines, who wanted to research the effects of using aptitude tests. The purpose was to enlighten future researchers on the impact resulting from music aptitude and mathematical achievements, and the benefits to be gained.

The previous research of Boyd (2013) stated recommendations for future research:

The focus of this study was on years of music participation and mathematics achievement, but the researcher did not differentiate by varying degrees of individual student achievement in musical activities or varying differences in mathematical domains. Future research should be conducted to understand how achievement in music affects individual mathematics scores... In a future study, one could compare how music participation affects individual domains of mathematics achievement (Boyd, 2013: 106-107).

This research project did not negate the existing research conducted by others (Boyd, 2013; Du Toit, 2009; Gordon, 2011; Shah, 2010; Stringham et al., 2011; Sweeny, 2006; O'Donnell, 2011), but comes with supportive evidence confirming the impact musical aptitude had on mathematical achievement, the importance of utilising aptitude tests, and the importance of schools integrating aptitude tests as part of the Arts and Culture offered within South Africa by the Department of Education.

### 1.13 LAYOUT OF THE THESIS

**Chapter 1:** Provided orientation and background for the study. It included the personal motivation and purpose of this concluded study. This chapter also introduced the research question and sub - questions, and explained the research design, and methodology used.

**Chapter 2:** Included the literature review, which were discussed and furthermore outlined the seven areas used for this dissertation. The first section included “Intelligence and Musical Ability” with the second section explaining “The Music Aptitude over Decades” followed by the third section, providing a detailed discussion of “Audiation”, followed by the fourth section, “Music Theory Learning”, followed by the fifth section, discussion of “The Advanced Measures of Music Audiation”, followed by the sixth section, “The Impact of Music Education” and finally ending with the seventh section, “Music Education on Academic Achievement” with a detailed summary at the end. The Theoretical Framework for this study was discussed at great length focusing on the “Theory of Sound”. These would also include defining the key concepts/terminologies used, with a short discussion of previous research conducted concerning music aptitude, etc.

**Chapter 3:** Provided a detailed outline of the research design and methodology used in defining and conceptualising the research question, the sample design, various

methods that were used for data collection, and a discussion on the uses of questionnaires and interviews.

**Chapter 4:** Presented the findings related to the research question and sub-questions posed, including data capturing, and analysis, the sample profiles, the presentation and a discussion of the results, with concluding interpretations.

**Chapter 5:** This final chapter included a summary of the study overall- the theory of this thesis was established and outlined and so were the limitations, shortcomings, and relevance of this research project, with recommendations and suggestions.

## CHAPTER 2

### LITERATURE REVIEW AND THEORETICAL FRAMEWORK

*“Music is a great blessing. It has the power to elevate and liberate us. It sets people free to dream...”* - Nelson Mandela (Tata Madiba)

#### 2. GENERAL INTRODUCTION

The literature reviewed for this research project focused on the theory of Intelligence and musical ability, music aptitude over decades, audiation, music theory learning, the advanced measures of audiation (AMMA), and the impact of music education. Various sources were consulted to present an in-depth literature review: journal articles, books, newspapers, media reports, academic dissertations and thesis, and information available on the Internet.

#### 2.2 DEFINING THE KEY CONCEPTS/TERMINOLOGIES

**Aesthetics** - A branch of philosophy dealing with the nature of beauty, art, and taste, and with the creation and appreciation of beauty. Links are usually associated with the Philosophy of Art.

**Assiduity** – Can be defined as the persistent application or diligence, and close attention to what an individual is doing.

**Assimilations** - A common phonological process by which the phonetics of a speech segment become more like that of another segment in a word. Understanding information or ideas or a particular concept.

**Audiation** - The ability to assimilate and comprehend sound in our minds that may or may not be physically present. It is neither imitation nor memorization. Audiation is to music what thought is to language (Gordon, 2003).

**Auditory** – This involves the process of hearing and listening to different sounds.

**Aural Perception** – When someone hears music where the sound is physically present (for example, when you listen to a live orchestra perform).

**Behavioural Traits** - Can be described to distinguish one character from another. For example, you could be looking at the behavioural traits of a particular student in your music class.

**Case studies** – Strategy of inquiry in which the researcher explores a program, event, activity, and process of one or more individuals in-depth, which involves a variety of data collection strategies.

**Classification** - A tonality or metre.

**Classroom Activities** - Traditional activities that take place in the band, choir, and orchestra outside of learning sequence activities.

**Content Learning Sequence** - Tonal content learning sequence includes all tonal classifications and functions.

**Developmental Music Aptitude** - Music potential that is affected by the quality of environmental factors. A child is in the developmental music aptitude state from birth to approximately nine years old, focusing on the earlier years of life (Gordon, 1993).

**Discrimination Skills** - The cognitive and sensory capacity or ability to see fine distinctions and perceive differences between objects, subjects, concepts, and patterns, or possess exceptional development of the senses.

**Ecological Validity** - A form of validity in a research study. For a research study to possess ecological validity, the methods, materials and setting of the study must approximate the real-life situation that is under investigation.

**Empirical** - Denotes information gained using observation or experiments.

**Exploratory study** - A type of research conducted for a problem that has not been clearly defined. Exploratory research helps determine the best research design, data collection method and selection of subjects. It encourages a better understanding of an existing problem.

**Harmony** - The use of simultaneous pitches (tones, notes) or chords, and arrangement of different parts of music (Soprano, Alto, Tenor and Bass).

**Homogeneity** - The state or quality of being homogeneous, which could be all the same kind.

**Hypothesis** - A proposed explanation for an observable phenomenon.

**Intelligence** - A term describing one or more capacities of the mind.

**Intensity** - A widely used term, which can refer to strength, amplitude, level, or magnitude.

**Interview** - A conversation between two people (the interviewer and the interviewee) where questions are asked by the interviewer to obtain information.

**Keyality** - The pitch name of the tonic (A reality is audiated, whereas a key signature is seen in notation). You could also refer to a particular key, as something written in major will be in the keyality of F. C is the keyality in C major, in C harmonic minor and Aeolian, in C Dorian, in C Phrygian, and so on. A tonic is associated with a keyality, whereas a resting tone is associated with a tonality (Gordon, 1998).

**Learning Sequence Activities** - Those activities include skill-learning sequence, content learning sequence (tonal and rhythm), and pattern learning sequence (tonal and rhythm). The eight sequences constitute learning sequence activities that take

place during the first or last ten minutes of class or rehearsal. These will be all the activities presented in the music curriculum.

**Melody** - A linear succession of musical tones, which is perceived as a single entity with a combination of pitch and rhythm.

**Multi tonal** - Music in which two or more tonalities are represented.

**Musical ability** - The ability to “make sense” of music, which develops in most people.

**Music Achievement** - Accomplishment in music.

**Music Aptitude** - The student’s potential to achieve in music/The ability to intuitively learn or appreciate music.

**Music Learning Theory** - The analysis and synthesis of the sequential manner in which we learn music (Gordon, 2003).

**Musical memory** - Refers to the ability to remember music-related information, such as melodic content and other progressions of tones or pitches.

**Observation** - An activity of a living being (such as a human), consisting of receiving the knowledge of the outside world through the senses, or the recording of data using scientific instruments.

**Off-key** - A term often used to denote musical content that is not at the expected frequency.

**Parameters** - A quantity that serves to relate functions and variables using a common variable when such a relationship would be difficult to explicate with an equation.

**Pilot study** - A small-scale preliminary study conducted before the main research, to check the feasibility or to improve the design of the research.

**Pitch** - Represents the perceived fundamental frequency of a sound. It can be described as a high or low note. It is one of the major auditory attributes of musical tones along with duration, loudness, timbre, and sound source location.

**Pitch discrimination** - The ability to differentiate between the various tones used.

**Qualitative research** - A method of inquiry employed in many different academic disciplines. Qualitative researchers aim to gather an in-depth understanding of human behaviour and the reasons that govern such behaviour.

**Quantitative research** - A method of research used that asks a specific, narrow question and collects a sample of numerical data from participants to answer the questions. The researcher analyses the data with the help of statistics. The

researcher was hoping the numbers would yield an unbiased result that can be generalised to some larger population.

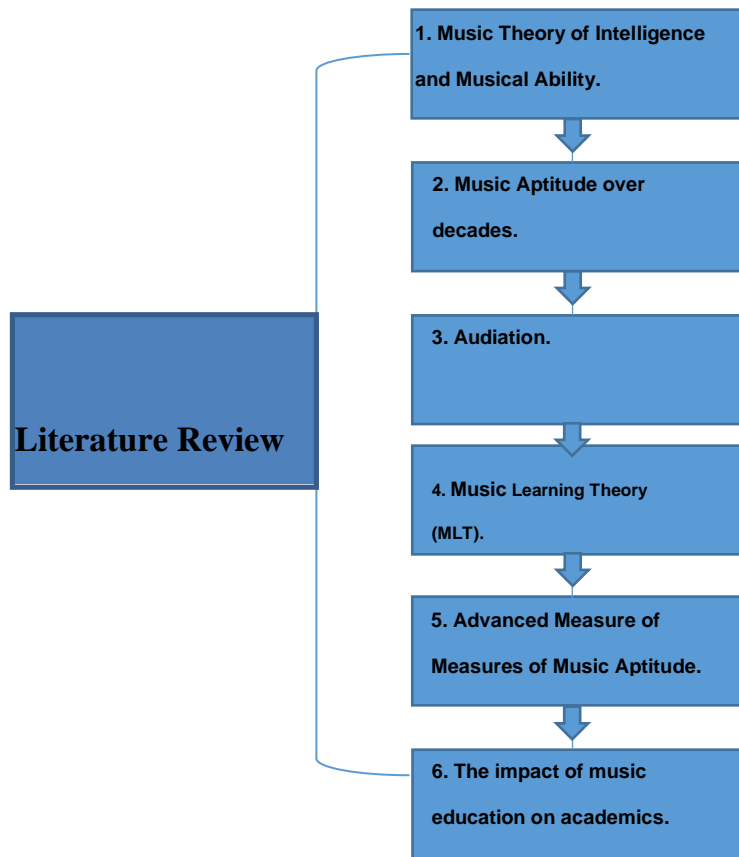
**Questionnaire** - A research instrument consisting of a series of questions and other prompts to gather information from respondents.

**Sample** - In statistics, a sample is a subset of a population.

**Texture** - The way the melodic, rhythmic, and harmonic materials are combined in a composition.

## 2.3 LITERATURE REVIEW

The literature review consisted of various sources being consulted to create an in-depth study around intelligence, music aptitude and mathematics with its connection and relationship using primary and secondary sources including previous thesis, dissertations, journals, various articles, books and articles written by and about Gardner (1999a, 1999b, 2003) and Gordon (1965, 1967a, 1967b, 1979, 1982, 1988, 1989a, 1989b, 1989c, 1990, 1991, 1997, 2003, 2004, 2011) In aid of this study the following figure 1 illustrates the process of development to support this literature review.



*Figure 1: Literature Review for this study (literature consulted)*

This Chapter is divided into six subsections as follows: the first section covers all the areas of intelligence measurement; the second section: discusses, the History of Music Aptitude over the decades; the third section: defines Audiation with its relevance and importance within musical aptitude tests; and the fourth section discusses the Music Learning Theory focusing on the Advanced Measures of Music Audiation designed by Gordon and its previous research and relevance to various elements of music used within aptitude tests: the fifth section focusses on the test

used for this project, and the final section outlines the impact of music education and academic achievement and how these influence the musical and mathematical aptitude of learners. Everyone was inspired to complete their music qualifications through primary and secondary schools, and then completed their external examinations with either RSL, ABRSM, TCL or even UNISA in their specific instruments of instruction. To obtain excellent results in any of these institutions one must have a degree of intelligence and musical ability.

### **2.3.1 INTELLIGENCE AND MUSICAL ABILITY**

In most music classrooms and schools around the globe, class teachers encourage students to work on their music skills. To develop one's skill, one has to understand what that particular skill involved, and required; hence there is a difference between intelligence and musical ability. When one refers to the word "intelligence" one evaluates the perceptions, and interpretations of the theories presented. There are several prominent researchers but Gardner (1999a:180-181, as cited in Müller, 2012) is probably the foremost music educator, that explores the multiple intelligences, and how these impacted on the thinking and practices in education, especially within the context of the United States of America. He suggested:

I want my children to understand the world, but not just because the world is fascinating and the human mind is curious. I want them to understand it so that they will be positioned to make it a better place (Gardner, 1999a).

Therefore, one could argue that without the possibility of displaying and developing your musical abilities, one cannot master the craft of performance, by being competent instrumentalists when playing a piece of music, or composing, when creating your own music. The framework of Gardner's (1999b:41-43) theory of multiple intelligences included linguistic intelligence, logical-mathematical intelligence, musical intelligence, bodily–kinaesthetic intelligence, spatial intelligence, interpersonal intelligence and finally intrapersonal intelligence.

Gardner (1999b:44) argued: “The theory is an account of human cognition in its fullness. The intelligence provided ‘a new definition of human nature, cognitively speaking. Human beings are organisms who possess a basic set of intelligence”.

It can be concluded that humans have a unique blend of intelligence, whichever category you considered. Gardner (1999b) argued that the big challenge facing the deployment of human resources “is how to best take advantage of the uniqueness conferred on us as a species exhibiting several bits of intelligence” (ibid:45).

The following is a definition of the different levels of intelligence as designed by Gardner (1999b:41-43).

**Spatial Intelligence** - This intelligence involves the potential to recognise and use the patterns of wide space and more confined areas. Professions in terms of careers would explore becoming chemists, pharmacists, architects, scientists, and engineers (Cherry, 2019).

**Linguistic Intelligence** - This intelligence involves sensitivity to spoken and written language, the ability to learn languages quickly, and the capacity to use language to accomplish certain goals. This included the ability to effectively use language to express oneself rhetorically or poetically; and language was used to remember information. Gardner associated writers, poets, journalists, teachers, lawyers and speakers as professions that displayed high levels of linguistic intelligence (Cherry, 2019).

**Logical-mathematical Intelligence** - This intelligence consists of the capacity to critically analyse problems logically, carry out mathematical operations, and investigate issues scientifically. Professions, and careers would include mathematicians, accountants, bankers, and financial analysts (ibid).

**Bodily–kinaesthetic intelligence** – This intelligence involves the potential of using one’s whole body or even parts of the body to solve problems systematically. It focused on using mental abilities to coordinate bodily movements. Gardner related this level of intelligence to mental and physical activity in most of his studies.

Professions would include gym instructors, gymnasts, health educators, physiotherapists, and physical educators (Cherry, 2019).

**Musical Intelligence** - This intelligence involves skill in performance, composition, and an appreciation of musical patterns. It encompassed the capacity to recognise and compose musical pitches, tones, and rhythms. Professions would include musicologists, music teachers, music educators, music researchers, music writers, composers, and performers. According to Gardner's theory musical intelligence runs in an almost structural parallel to linguistic intelligence (ibid).

**Interpersonal intelligence** - This intelligence is more concerned with understanding the intentions, motivations, and desires of other people. It allowed individuals to work effectively with others with a strong emphasis on personality traits. This was relevant to educators, salespeople, religious and political leaders, and counsellors (Cherry, 2019).

**Intrapersonal intelligence** - This intelligence involves the capacity to understand oneself, and to appreciate one's feelings, fears, and motivation. Professions included psychologists, sociologists, anthropologists, philosophers, and engineers (ibid).

Gardner's multiple theory of intelligence was very important to scholars, and has been researched in depths by various researchers (Cherry, 2019, 2020; Edutopia, 2009, 2016; Marenus, 2020). The following illustration (see Figure 2) demonstrates the eight multiple intelligences human beings experienced in their lifetime.



*Figure 2: Gardner's Multiple Intelligence Theory (Cherry, 2019)*

In any school setting whether primary or secondary, a learner would display a sense of intelligence to be able to demonstrate their musical aptitude. The theory of Gardner (1999) can be applied to students in both schools, especially those who have been identified as “gifted” and “talented”, and who display various characteristics, as outlined by Gardner's Theory of Multiple Intelligence. What is important, is to allow learners to express themselves through music, and to be able to differentiate between all the concepts being taught in their music classes and

juxtapose the brain patterns and the processes involved in a student applying mathematical skills.

Reynolds and Hyun (2004:18, cited in Müller, 2012) have researched and examined teachers' understanding of musical aptitudes for decades. The data provided educators with the necessary information to use to conclude new developments in terms of research with several findings related to how to measure the understanding of aptitude, and the overall skills required to become a confident performer, composer, music scholar, or even musician. They examined how teachers selected, suspended, checked, regrouped, and transformed their understanding when measuring the overall musical aptitude tests of their students with a pure focus on how to obtain standardised musical aptitude test scores from their participants. The study involved ten classroom teachers from South Korea and the USA, who elaborated on their experiences with a final individual interview.

Boyle (1992:247) suggested:

Those teachers differ in their understanding of music constructs such as talent, ability, musicality, and aptitude is not surprising. Researchers and teachers would do well to achieve consensus about music constructs, their measurement, and the use of results because testing offers objective bases for instructional, curriculum, and program changes that take into account students' differences.

The research of Reynolds and Hyun (2004:18 cited in Müller, 2012) confirmed that objective measurements of innate music potential were relevant to promoting optimal music learning for learners in the developmental stages of musical aptitude, agreeing

with Gordon's definition of musical aptitude, focusing on the potential to achievement overall in music (Gordon, 2003:372). It was imperative to understand how these music aptitude tests worked, what advantages and disadvantages of using each was readily available for learners in both primary and secondary schools. The way the brain works, would be similar for those completing calculations for mathematics, adding, and subtracting, whilst multiplying, and coming up with logical answers. In music, we use lines, and spaces, and in mathematics numbers; how the brain functioned was similar. Maths helped learners read music; for example, when we use measures, and we count how many bars were required, we used the numbers or measures as allocated in the scores. According to Reynolds and Hyun (2004:19) who concurs with most researchers (Auh, 1992; Brown, 1928; Cain, 1960; Christy, 1956; Culver, 1965; Doxey and Wright, 1990; Drake, 1949; Forsythe, 1984; Gaston, 1957) concurred that there was a direct relationship between a teacher's judgement, and the test scores of a student's abilities or aptitudes, due to the evidence of their (learners) test's validity.

Furthermore, researchers (Boyle, 1992; Boyle and Radocy, 1987; Gaw, 1995; Gordon, 1967b; Young, 1976) have confirmed that teachers were influenced by non-musical factors such as students' temperaments, attitudes, personalities or interests, or their evaluations of students' music achievement when making decisions about musical aptitude, even though researchers have suggested various guidelines to be

followed. In this regard, the researcher disagreed with his colleagues who were predisposed by musical factors when assessing their students.

Working through previous research conducted on the topic of languages, music, and mathematics, it was important to highlight that evaluating the research of Buttall (2007, cited in Müller, 2012) one can conclude that in many cases musical precocity co-existed with their abilities in mathematics, or languages through investigating the biographies of major composers. Buttall (2007:3) argued that there is a relationship between music and intellectual ability. A student with musical ability should somehow display some level of intellectual ability, considering the theories presented by Gardner (Cherry, 2019). Furthermore, Wing (1948: 78) confirmed that a good agreement existed between low intelligence and students' low scores in their tests of musical ability whereas a high score, or their musical aptitude always accompanied a high level of IQ. Your IQ levels determined your ability to achieve better results in music, using your musical aptitude. Edmunds (1960:40, cited in Müller, 2012) also discovered that low intelligences and low musical abilities appeared to be closely related. He confirmed the theory of such students with an IQ of 90 where intelligence no longer played a significant part and verified when a student was musical or unmusical? Considering the subject of composition, where one must be creative through experimenting and understanding the rules of the figured bass, and bass lines. Could this relate to why imminent composers from the

classical period, who were able to compose with ease, having the ability to write symphonies, and concertos, without access to the digital forms and notational programs that are globally available to date including Muse Score, Finale, Sibelius, and Cake Walk? it was believed that Bach's IQ ranged was between 125 and 140, Beethoven's between 135 and 140 and Mozart's between 150 and 155. However, as a group, the musicians possessed the lowest IQs of the most eminent men studied as outlined by Müller (2012). This would confirm why Mozart was able to compose several symphonies highlighting the structure of the Exposition, Development and Recapitulation as part of Sonata Form. Most musicians remembered Symphony No 41; being the most famous Symphony Mozart composed for orchestras, which is enjoyed even today, with numerous performances from brilliant orchestras performing all three movements across the globe.

White (1931:75, as cited in Müller, 2012) furthermore argued that these composers were amongst the least versatile. This could be concluded due to the differences in their musical ability. It was also disputed that some aspects of musical ability were related to general intelligence. Further research developments have shown that this theory, too, was by no means consistent. Buttall's research confirmed that students with a musical background had an advantage overall when learning a foreign language. There was a connection between mathematical aptitude and musical abilities as Howes (1958:20) confirmed:

The analogy between mathematics and music has been recognised from antiquity, and though all attempts to press the analogy, or even to define it, soon break down, it is still recognised by musicians and mathematicians and the rest of us who are neither as a way of thinking in relationships (Howes, 1958).

Buttall concluded that the evidence so far suggested that musical ability on a larger scale could be more specific with a well-established connection between it, and general intelligence in the case of younger and less intelligent learners (Buttall, 2007:4). This correlated in terms of some common abilities, thanks to the powers of attending, concentrating, or even following instructions in the classroom.

The musical ability of students depends more on specific musical factors than it does on their intelligence. Positive correlations were found between measures of musical abilities, and other cognitive aptitudes. The study of musical cognition had long fascinated researchers (Gaab and Schlaug, 2003; Gaser and Schlaug, 2003; Zatorre et al., 1998, 2003).

One of the aims and findings of the research of Norton et al., and Schlaug (2005:124) were to determine whether children, who chose to participate in music training, performed at a higher level than those who did not seek training on any cognitive outcome previously found to be enhanced by, or associated with, music training.

The empirical research resulted in the model associated with Reynolds and Hyun (2004:18), which confirmed that objective measurement of innate music potential is

relevant to promoting optimal music learning for children in the developmental stages of musical aptitude, agreeing with Gordon's definition of musical aptitude focusing on the potential to achieve overall in music (Gordon, 2003:372). The researcher agrees with this statement, as Reynolds and Hyun (2004:19) revealed that most researchers (Auh, 1992; Brown, 1928; Cain, 1960; Christy, 1956; Culver, 1965; Doxey and Wright, 1990; Drake, 1949; Forsythe, 1984; and Gaston, 1957) concurred that there was a direct relationship between a teacher's judgement and their test scores of a student's abilities or aptitudes, due to the evidence of their (learners) test's validity. There was a connection between mathematical aptitude and musical abilities, as Frank Howes (1958) confirmed.

The researchers' opinion was that without intelligence and musical ability, no learner or student could ever pass the standard examination requirements for external institutions such as ABRSM and TCL, or even Rock School in the United Kingdom. There were rigid criteria that readily needed to be met whether performing as a soloist or completing a music theory paper or performing as part of an ensemble. Ear training tests assessed whether you understood all the elements of music as outlined with the specific criteria for each grades obtained, and levels of competency expected. Achieving excellent results in the music curriculum involved years of perfecting their performance skills and applying their theoretical knowledge through means of music analysis.

### 2.3.2 THE MUSIC APTITUDE OVER DECADES

It was important to understand the various music aptitude tests that were available for teachers on the market, and how they all developed through the years. The first test that was released was “The Seashore Measures of Musical Talents” in 1919. The Advanced Measures of Music Audiation Test (AMMA; Gordon, 1989), the Bentley Test (BT; 1966), the Montreal Battery of Evaluation of Amusia (MBEA; Peretz et al., 2003), the Karma musical aptitude test (KMAT; 1993) and the Distorted Tunes Test (DTT; Drayna et al., 2001), all had their specific criteria and ways of defining musical aptitude.

The test developed by Bentley examined pitch discrimination ability, tonal memory, chord analysis and rhythmic memory (Milovanov, 2009:8). The Seashore test considered musicality to be an entity emerging from relatively independent sub-skills organised according to the different sound parameters, and cognitive demands (for example pitch-discrimination accuracy/temporal accuracy versus memory for pitch/rhythm). The research of Karma (1993) developed a test that considers musicality to be more a general ability to structure sounds cognitively (Milovanov, 2009:8-9).

Milovanov (2009:7, cited in Müller, 2012) further stated:

Terminological uncertainty can be sometimes confusing or even misleading in the field of musicality research. Terms, such as musical capacity, musical talent, musical aptitude and musical ability are often discussed and used synonymously with the term musicality, which they are not. Boyle (1992) takes the position that musical capacity is the result of genotype and maturation. The high level of musical performance, on the other hand, recognizes musical talent. The achievements of musical ability are the results of capacity, surroundings and musical education. It is justified to say that there is no exact and unequivocal definition of the term musicality and there are as many definitions for the term as there are researchers.

Milovanov (2009:14, cited in Müller, 2012) concluded that:

Musical aptitude and music skills have often been connected to other cognitive skills, such as linguistic skills, cognitive development, motor abilities, social skills, and the ability to express oneself. Several correlative studies have shown that, on average, participants with musical aptitude perform better in many fields.

Seashore (1919) was the forerunner of the music aptitude test focusing on musical ability in 1919. The objective was to concentrate on the belief that musical aptitude was innate and was developing up to the age of nine years, after which age it was confirmed that music aptitude stabilises (Law, 2018:18). A strong emphasis on his test was designed for primary school students being tested on the various elements of music. Law (2018) suggested that the tests of Bentley (1966), Gordon (1965), Seashore (1919a), Drake (1954) and Wing (1948) were designed for children aged eight or nine years and above. *Seashore Measure of Musical Talent* (1919) was the first standardised test of music aptitude (1919), later renamed the Seashore

Measures of Musical Talent (1939). The battery of subtests included: (a) sense of pitch, (b) sense of loudness, (c) sense of rhythm, (d) sense of time, (e) sense of timbre, and (d) tonal memory. This test was designed to measure students from the fourth grade through college seniors. The focus of these music aptitude tests was on the various elements of music, which included pitch, dynamics, timbre, rhythm and tonality. Seashore (1919) designed music aptitude tests, which catered for both primary and secondary school students.

Midway between Seashore's first and second editions, *Kwalwasser and Dykema* published the *Kwalwasser-Dykema Music Tests* (1930). Six of the ten subtests in the battery were developed to measure the same dimensions in the Seashore battery, although designed and titled differently. The difference was that Kwalwasser used orchestral instruments and the Duo-Art Reproducing Piano as stimuli for some of the subtests. Another music aptitude test, known as the Kwalwasser Music Talent Test (1953), was developed with only four discrimination factors measured. Unlike his earlier test, this test excluded preference measures.

The emphasis of Seashore (1919) study focussed on the elements of music, which became the basis for most of the musical aptitude tests available. It was therefore important for educators to familiarise learners with all the elements of music, as a foundation for them to be able to become competent and skilled musicians with the necessary information to differentiate between tempo, melody, harmony, rhythm,

form, timbre, dynamics, and pitch. It was important to test the students at Liverpool secondary school on the elements of music as suggested above, which impacted the study objectives for the researcher, focussing on the tonal and rhythm aspect only, and linking these with which appropriate instruments measured their musical talents, whilst juxtaposing them with mathematical achievement.

The next major development in music aptitude testing was *Wing's Standardised Tests of Musical Intelligence* (1948). This test was also revised and labelled *Tests of Musical Ability and Appreciation* (1970). Gordon (1987) noted that Wing's test was an attempt to apply Gestalt principles to study music aptitude including the performance of traditional musical instruments. There are seven subtests with three non-preference tests requiring students to count notes in a chord and detect slight alterations of one note in a chord or melody. The four preference subtests asked the students to choose better rhythmic accents, harmonisation, phrasing, and dynamic expression in two performances presented. These tests were designed for students eight years of age, focussing predominantly on primary school learners. Although this test was geared towards primary school learners, much emphasis was placed on the importance of harmony and phrasing, which will fall into articulation as part of the elements of music. Teachers usually taught learners the difference between staccato, and legato, and expected students to identify them with ease. Some instruments' articulations differed; for example, on a string instrument, students

would use the pizzicato technique to pluck on a string, whilst using the bow for arco where symbols indicated on scores, most articulations on strings could even include tremolos. These tests were all created focussing on the different music instrumentations suggested, which was highlighted in the researcher's study objectives, links could be made of what instruments used enhanced their music abilities and reiterated their music aptitude. These also connected with the research questions that posed by choosing the most suitable instrumentations to have measured their musical aptitude.

Drake (1957) published the *Drake Musical Aptitude Tests* with only two subtests, rhythm and musical memory. In the rhythm subtest, participants must determine the number of beats that would have occurred during a period of silence. The musical memory subtest required students to compare two melodies and detect slight changes in melody, rhythm, and key, or to determine if the two melodies are similar. The test was designed for learners in primary school through adulthood. Links to the elements of music connected with the study objectives here focussing on their musical abilities and understanding tonal and rhythm changes by identifying the melodies, and using their musical memory.

The *Bentley Measure of Musical Abilities* (1966) published with four subtests in the battery, was designed for children as young as seven years of age and who were in grade two, academically. This aptitude test was designed for primary school learners

and was hardly used for learners in secondary school. Subtest categories included pitch discrimination, rhythmic memory, tonal memory, and chord analysis. The last two parts were constructed similarly to Wing's memory and chord Analysis. Gordon (1998) believed that Bentley was of the opinion that there was a difference between the description of music aptitude of younger and older children in Gordon's Developmental and Stabilised Music Aptitude Tests. Gordon obviously considered the previous tests that were available and used and emphasised several for both primary and secondary school learners, focussing on the various elements of music and making it available nationwide for every music teacher to use. These music aptitude tests linked with the researcher's study objectives by focussing on using the appropriate instruments to have measured musical talents, the elements of music, in the case of the researcher's (Müller) study, which related to tonal and rhythm aspects of the Advanced Measures of Music Audiation (AMMA) test.

Gordon (1998) developed several music aptitude tests. Developmental music aptitude tests are designed specifically to assess the music aptitudes of children from three to nine years of age. Examples of developmental music aptitude tests are *Audie* for children three and four years old, the *Primary Measures of Music Audiation* [PMMA] for children in kindergarten through third grade, and the *Intermediate Measures of Music Audiation* [IMMA] for learners in first through the sixth grade. Each of these tests consists of a tonal subtest and a rhythm subtest.

Audie required learners to answer “yes” or “no” concerning the tests that are concluded on different days. Each test consisted of ten questions, how the programme worked was when a special song was played the child responded “yes” and if a different song was played the child responded “no”.

According to Gordon (1998:7):

During the Tonal subtests, if *Audie*’s special song is not played, it is because a pitch is changed in the melodic pattern even though the rhythmic patterns remain the same. During the Rhythm subtest, if *Audie*’s Special song is not played, it is because the duration is changed in the melodic pattern while the tonal pattern remains the same. A parent or teacher marks the answer sheet according to the child's response.

The tonal subtest was without rhythm and the rhythm subtest is without variable pitch (Gordon, 1998). Although the IMMA was designed to be a test of developmental music aptitude, it functions as a test of stabilised music aptitude when administered to persons nine or older Gordon (1989). Gordon hypothesised that developmental, and stabilised music aptitudes were more a matter of attributes of the mind rather than the properties of the test. In the researcher’s study, it was important to elaborate how the AMMA test impacted the mathematical achievement of students, by focussing on the tonal and rhythm tests of Gordon (1965).

## **The Primary Measure of Music Audiation (PMMA)**

This test was designed for children in kindergarten through three, including children with special educational needs. The test was designed to be used either individually or within a group setting. The test consists of 40 questions and practice examples.

According to Gordon (1998:8) who suggested:

The purpose of the test is to measure a child's ability to give syntactical meaning to music. To do well, the child must organise isolated pitches into tonal patterns, which are then audiated about a pitch centre in a reality and/ or tonality. Similarly, the child must organise isolated durations into rhythm patterns, which are audited about macro beats, in a consistent tempo and/ or metre... Children simply answer questions by drawing circles around pictures of faces on an answer sheet. In name of an object is announced on the recording before a set of patterns is heard. The children look at that object and find the pairs of faces underneath it. If the two tonal patterns or rhythm patterns heard on the recording sound the same, the child draws a circle around the pair of faces that look the same. If the two patterns sound different, the child draws a circle around the pair of faces that look different... The recording for each subtest includes approximately 12 minutes of listening time, and each subtest requires approximately 20 minutes to administer. Each question on the Tonal subtest includes two tonal patterns, and each question on the Rhythm subtest includes two-rhythm patterns. The pitches in the tonal patterns are performed on the same pitch. All of the tonal patterns, which are from two to five pitches long, are performed at the same tempo. At least one tonal pattern in every pair includes the tonic. Through the audiation of the tonic, the child is guided by the syntax for each tonal pattern (Gordon, 1998:8).

Gordon (1998:8-10) confirmed that: “the design of a developmental music aptitude test for very young children, three and four years old, must have characteristics in common with stabilised music aptitude tests that were designed specifically for both

young adults and adults in order for test results to yield satisfactory reliability and validity”.

A stabilised music aptitude test was designed to assess the music aptitudes of students nine years and older. Examples of stabilised music aptitude tests include *Musical Aptitude Profile* [MAP] (Gordon, 1965) for learners in the fourth through twelfth grades, and the *Advanced Measures of Music Audiation* [AMMA] (Gordon, 1989) for learners in the seventh grade through adulthood. The dimensions measured by the MAP battery are: (a) tonal imagery, (b) rhythm imagery, and (c) musical sensitivity. There are seven subtests in the battery. Two subtests are provided for each of the two non- preference total tests: (a) melody and harmony for the tonal imagery and (b) tempo and metre for the rhythm imagery. The preference total test, musical sensitivity, contains: (a) balance, (b) phrasing, and (c) style sections. The word imagery was used in the original edition of the MAP test battery and has continued to be used in subsequent editions because of its familiarity with the use of the test. Gordon (1995) stated that the word imagery is vague and has come into question in recent years. The verb audiate was not coined until 1976, more than ten years after the first printing of the MAP. The complete battery requires approximately one- hour and fifty minutes to administer. The foregoing literature (Seashore, 1919; Wing, 1948; Drake, 1957; Bentley, 1966; Gordon, 1987) related to the researcher’s study by supporting the problem statement, objectives, and

research questions presented of the study concluded. The importance of testing the elements of music was highlighted here by evaluating the music aptitude tests available for educators to use in secondary schools, in this case, the researcher investigated the benefits of the AMMA test used within a South African context.

### **2.3.3 AUDIATION**

This part of the literature review was essential to establish how the students differentiate between the tonal and rhythm changes and whether it was due to merely a change in tonal, tempo and even rhythm. For students to be able to conduct these, one must outline the process of audiation, which plays an imminent role.

Gordon (1989:12) validated that “Audiation is the basis of music aptitude”. Reading the Manual of the AMMA test he concluded the following:

Audiation is to music what thinking is to language. Because the ability to imitate represents only the readiness to learn how to audiate, audiation is [thus] different from imitation. To imitate is simply to perform vocally or on an instrument without musically understanding what was heard just a few moments ago (Gordon, 1989:12).

Investigating further and exploring the concept of the idea of audiation; one wonders whether this was the main process associated with music aptitude. Gordon (1989, 2004:9) suggested: “Audiation is fundamental to both music aptitude and music achievement, but audiation functions differently in each”. Gordon admitted that

students hardly shared the same innate capacities. The main reason why the concept of audiation cannot be taught to students is that it happened naturally. Through appropriate knowledge and experiences, audiation can be developed further, which in all determines their music aptitude. He explored sound, which he believed was not music.

Gordon (2004:10) explained: “Sound becomes music only through audiation, when, as with language, you translate the sounds in your mind and give them meaning”. Audiation thus can be defined as the process of assimilating and comprehending in our minds the music we hear or heard performed in the past. To explain and understand his theory this researcher designed this flow diagram below (see Figure 3). There is a specific cycle known as the “Audition process cycle” for students to explore when they experience audiation using their sensory skills.

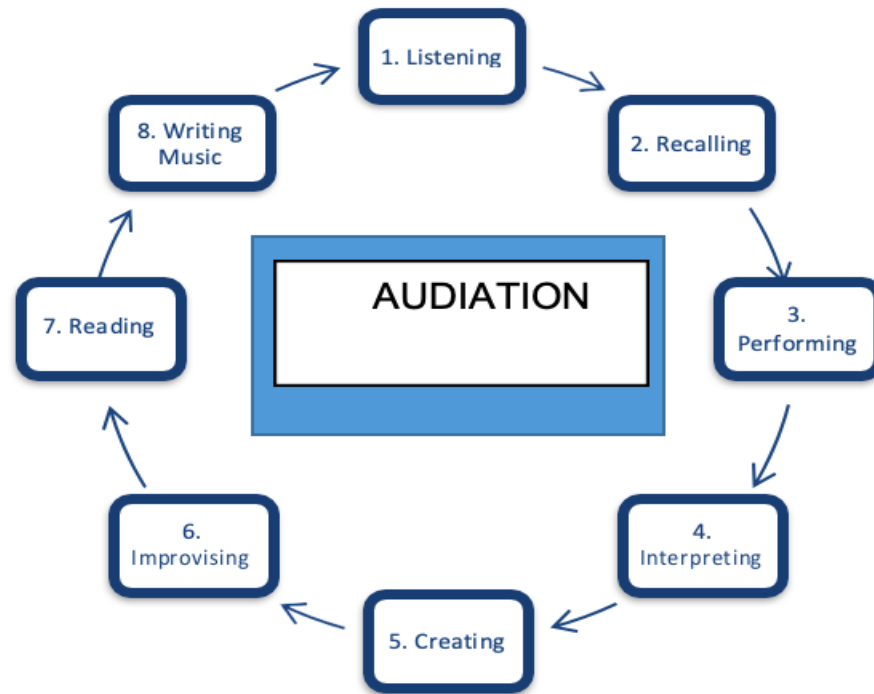


Figure 3: Audiation Process Cycle (Gordon, 1989, 2004)

According to the Manual written by Gordon (1989, 2004:10-13) students could differentiate between the eight types of audiation stages as indicated in the cycle above (see Figure 3).

- When students listened to music for its syntactical tonal and rhythmic patterns, they *audiated*.
- When you recalled music from the past, you *audiated* – this could also be when your brain recalled musical notation from melodies heard from the past,

and the concept of aural dictation that took place; these processes automatically therefore *audiated*.

- When students performed various melodies and pieces from memory they have studied in the past, they *audiated*.
- When we interpreted various melodies, and played them back, we *audiated*.
- When we created composition by using notation and aural perception, we *audiated*.
- When you improvised a section of music completely unexpectedly, you *audiated*.
- When you read something in your mind without actually making the sound (this could include a passage during silent reading), you *audiated*.
- When you wrote down several tonal and rhythmic patterns through means of aural dictation, you *audiated* (Anderson, 1993; Gordon, 1989, 1990, 1991, 2004; O'Donnell, 2011).

It may seem contradictory that whilst listening to music one could also *audiate* that music. This researcher agreed with the above-mentioned statement. Gordon's (2004:10) research elaborated, when he said: "that when you automatically think about what has been said whilst at the same time you are listening to or participating in conversation". You can thus, have compared it to comprehension, listening to

speech; thus, in the case with comprehension, which constituted similar operations, to have been experienced.

Further, let us consider language or speech, and the thought processes involved? Language was the result of the need to have communicated; speech was considered to be the manner in which we communicated. Thought was what we communicated eventually. The same principle applied regarding music, performances, and audiation, which had parallel meanings. Music was the result of the need to communicate and performances which was how these forms of communication took place, and audiation was therefore what essentially was communicated (Gordon, 2004).

The theory of audiation was important when you listened to music from different genres. Today, teenagers listen to music from different styles including Rap, R and B, House music, African Jazz, and especially Techno Music. The principle remained the same; if they listened to these kinds of music, they were still audiating.

#### **2.3.4 MUSIC LEARNING THEORY (MLT)**

Music theory played an important role in any musician's life, and hence it was important to have introduced and integrated it as part of the music education programmes in most schools, especially within a South African context.

Gordon (2011:7) stated:

Among other uses, a well-constructed music aptitude test battery provides teachers with the necessary information for improving music instruction by assisting them in teaching students' individual musical differences in terms of musical strengths and weaknesses. In the initial development of MAP, decisions had to be made about the content of the test battery, how many subtests might be included in the battery to cover the broad spectrum of music aptitude, what content of the subtests might be, and how content might best be measured.

He continued in his academic studies with many discoveries and findings; even within his own research concluded, and that of his colleagues, which involved the topic of Music Theory Learning (Gordon, 2011:8-10). There were several factors to be included into the curriculum, such as Tonal, Rhythmic, and Expressive considerations, and the implications of each as presented.

### **Tonal Considerations:**

The ability to have established tonalities before pitches were heard, performing patterns in a musical context, providing students with the ability to audiate; thus allowing them the capabilities to have musically responded to the given test questions. These substantially raised validity coefficients.

- By discriminating pitches heard in isolation of the established tonality (major/minor). Border reliability (only minimal concurrent) validity occurred

when the resultant scores correlated with outside criteria due to the relationship with the school music achievement.

- Formal (previous) instruction in music, knowledge of music theory and the ability to have read music notation, did not particularly aid with achieving high scores for the music aptitude tests.
- Students achieved significantly high scores on their tonal aptitude tests by using their singing voice quality. Most students imitated these without an intrinsic understanding of the music. In comparison to others, those who could not sing but still scored high scores on their tests, confirmed that their singing ability was not a prerequisite to attaining the high scores achieved.
- Previous and formal instruction in music experienced or knowledge of music theory and the ability to read music notation, had no direct impact, as it steadfasted students to attain high scores for their music aptitude tests overall.
- An increase in test validity existed when short melodies of original music were administered as content for the test questions.
- Grouping of three or more pictures as part of tonal patterns instead of only one or two isolated pitches, enhanced students' audiation overall, and had the effect of increasing the test validity.

- The importance of the two types of tonal tests, foremost melody and harmony was significant. A low inter-correlation was demonstrated with each other, but a high correlation was obtained with the outside validity criteria. Overall scores on tests of harmony predicted success in school music were better than scores on tests based on melodies.
- The students' composite tonal scores of either being high or low had no effects on them identifying three successive chords (chord patterns), and normal chord progressions (usually four or more successive chords) due to their baffled responses, notwithstanding, and
- Making sense of contrapuntal melodies than harmonic progressions was much easier for students to have identified (Gordon, 2011).

### **Tonal Implications:**

- The established guidelines for developing tonal aptitude tests presented indirectly findings for understanding how we learned when we were taught music.
- Through conceptualising tonal learning sequence activities, a sequential tonal music curriculum based on music learning theory led to the derivation of the concept, of audiation.

- Content and context co-existed within the music. Context represented tonality (and metre) where content represented the tonal patterns (including rhythm patterns). Through teaching and learning music, students acquired a sense of tonality (and metre) and readiness for learning content focusing on tonal patterns (Gordon, 2011).

### **Rhythm Considerations:**

- Previous instruction and knowledge of notation and music theory were irrelevant when distinguishing rhythm aptitude. A distinction was made between 'note' and 'duration'. A note referred to notation in comparison to the duration heard in an audition.
- The ability for students to audiate by established metre before durations were heard, or even performing patterns within a musical context.
- The ability to have discriminated duration heard separated from the metre (usual duple and usual triple) projected the best marginal reliability, and only minimal concurrent (criterion-related) validity when resultant scores was correlated with the validity criteria associated with various types of music achievement. Those who displayed high scores on rhythm aptitude tests were able to chant and move comfortably in flowing continuous movement in directed spaces.

- The rhythm aptitude test consisting of the two metres and rhythm was identified as being fundamental. These displayed low to moderate inter-correlations with each other but contributed substantially to the validity of the composite test scores.
- The metre and tempo aptitudes were more imminent than melody and harmony together for predicting success in school music, and of the two aptitudes metre had higher predictive validity than tempo. This reinforced the idea that rhythm aptitude was basic in comparison to tonal aptitude (Gordon, 2011:12).

### **Rhythm Implications:**

- The results for the rhythm aptitude tests including those for tonal aptitude established indirect evidence and offered implications for the further development of MLT.
- The two most important parts of rhythm are metre and tempo both of which represent the context. Regarding content again it was surely patterned, specifically rhythm patterns, not the individual notes or duration. No relation was demonstrated to content or context. High scores obtained by students were merely due to metres.

- The placement of macro beats, the ability to maintain a steady tempo, by which discriminated meter and comprehension of precision in rhythm patterns, insights in rhythm, however, was lacking.
- Perception of rhythm was crucial for understanding the tonal dimensions of music (Gordon, 2011:13).

### **Expressive Considerations:**

- Phrasing, Balance and Style became the subtest for the Musical Aptitude Profile that was designed.
- Focusing on phrasing, students decided which of the two excerpts of the same melody was played with more expression.
- The variables highlighted are the interaction of phrasings, tempo, volume, dynamics, tone quality and intonation.
- Considering Balance, students had to decide, which tempo was more suitable for the same melody (Gordon, 2011:13-14).

### **Expressive Implications:**

- The learners who scored the highest on the preference measure were the successful learners in school music.

- Due to the physical actions of students being not rigid, students scored high on preference measures.
- Learners, who obtained high scores on their tests, rendered the most interpretive vocals and instrumental music performances.
- The scores on preference measures correlated with learner's potential to learn; create and improvise music.
- Males and females exhibited similar high expressive music aptitudes.
- Tone quality was outlined as the biggest determining factor in preference regardless of a learner's aptitude (Gordon, 2011:14).

Gordon's Music Learning Theory (MLT) according to O'Donnell (2011: 34) was described as "an analysis and synthesis of the sequential manner in which music can be learned". One could therefore have categorised Music Learning Theory into three areas:

- The first category involved skill learning sequence – these were divided into two major parts namely discrimination and inference learning. Others knew discrimination learning as rote learning. Whereas inference learning had hierarchical levels and subparts. Discrimination learning always included oral/aural, verbal association, symbolic association, and partial and composite synthesis. Inferential learning would always include generalisation,

creative/improvisation, and theoretical understanding (Gordon, 2003; O'Donnell, 2011: 34).

- The second category involved tonal content learning sequences. These tonality classifications include Major, Harmonic-minor, Dorian, Phrygian, Lydian, Mixolydian, Aeolian and Locrian modes. These pattern functions included tonic, subdominant, dominant, cadential, multiple, modulatory, chromatic, expanded, characteristic tone and median functions (Gordon, 2003; Gordon, 2011; O'Donnell, 2011).
- The third category included rhythmic content learning sequences. Metre classifications included duple, triple, usual combined, unusual paired, unusual unpaired, unusual paired intact and unusual unpaired intact. The pattern functions were always included macro/micro beats, division, elongation, rests, ties and even upbeats (Gordon, 2003; Gordon, 2011; O'Donnell, 2011).

Gordon's Music Learning Theory (MLT) was analysed, and synthesised of the sequential manner in which music was to be learned. MLT could be categorised into three separate areas. The first area, skill learning sequence, was divided into two major parts that were categorised into discrimination learning and inference learning. This sequence was based on skill learning theory (Gordon, 2003). Discrimination learning was also known as rote learning. Inference learning was conceptual learning. Both discrimination learning, and inference learning had hierarchical levels,

and subparts. Discrimination learning included aural/oral, verbal association, partial synthesis, symbolic association, and composite synthesis. Inference learning included generalisation, creative/improvisation, and theoretical understanding (O'Donnell, 2011).

By using this tonal system over others, Gordon (2003) wanted to maximise audiation. By using this system, only the audiation of patterns as they related to the syllable associated with the resting tone, which was necessary to become aware of the tonality. Another advantage of the “do” based major and “la” based minor system was that it provided for chromatics with logical independent syllables. Typical modulations were in multi-tonal and multikey music could be performed without difficulty, there was no consonant syllable endings, and verbal associations, that remained logically consistent within a tonality regardless of its reality (O'Donnell, 2011).

Gordon's relations among rhythm syllable names were derived from the metre, the underlying macro and micro beats, and the melodic rhythm of the rhythm patterns. The syllables, much like the McHose and Tibbs (1957) syllables, were based on beat function rather than counting. The McHose and Tibbs syllables used a system of counting based on the visual representation of time signatures, and traditional theory. When students utilised Gordon's rhythm syllables based on beat function,

their audiation skills were enhanced and the need for traditional music theory or counting were to be explained, where rhythm was unnecessary (Gordon, 2003).

This review of literature examined the use of audiation and musical achievement, the different types of music audiation, the different stages, and the various levels of Gordon's music learning theory. Several studies had identified difficulty levels of tonal patterns (Jones, 1979; Lai, 1999; Sinor, 1984) and rhythm patterns (Bradford, 1995; Lai, 1999). Studies have suggested that students who were taught via tonal pattern instruction (Azzara, 1993; Gamble, 1989; Grutzmacher, 1985) scored significantly higher on tests of music achievement, and tonal audiation. Students who received instruction, with an emphasis on rhythmic pattern instruction (Azzara, 1993; Coley, 1987; Gouzouasis, 1990; Kitts, 1993; Palmer, 1976; Shehan, 1987) generally exhibited higher musical achievement than students without such an emphasis.

According to Gordon (2003), there were two distinct levels of music aptitude. Developmental music aptitude occurred from birth to the age of nine. Environmental factors and music instruction may have influenced developmental music aptitude. Tests that measured developmental music aptitude included Audie, the Primary Measure of Music Audiation (PMMA), and the Intermediate Measures of Music Audiation (IMMA). Stabilised music aptitude began at approximately nine years of age, and remained constant through adulthood, and was not affected by

environmental factors. Stabilised music aptitude tests included the Music Aptitude Profile (MAP) and the Advanced Measures of Music Audiation (AMMA). The AMMA was found to be a valid test of music aptitude for secondary school students (Fullen, 1993).

Research into developmental and stabilised music aptitude has led to some expected and some conflicting results. Flohr (1981) and Rutkowski (1986) discovered that developmental music aptitude was affected by music instruction. This appeared to be contrary to Gordon's (2003) assertion that musical environmental factors would not affect stabilised music aptitude. Additionally, Estrella (1992) found that treatment of tonal and rhythm patterns could have a significant improvement on the AMMA. Music aptitude was also founded to be a strong predictor of music achievement among grade school students (Kehrberg, 1984; Zdzinski, 1992).

Gordon's (2003) Music Learning Theory contained eight types and six stages of audiation. Although not hierarchical, some types of audiation served as readiness for others. The types of audiation include listening, reading, writing, recalling, writing familiar recalled patterns through audiation, creating, and improvising. The six stages of audiation were both hierarchical and cumulative. These stages included momentary retention, imitating, audiating patterns, and identifying a tonal centre with macro beats, establishing objective or subjective tonality, and metre, retaining in

audiation tonal, and rhythm patterns that has been organised, recalling tonal, and rhythm patterns organised, where were audiated in other pieces of music, by anticipating, and predicting tonal, and rhythmic patterns.

### **2.3.5 THE ADVANCED MEASURES OF MUSIC AUDIATION (AMMA)**

For this study the researcher used the Advanced Measures of Music Audiation (AMMA) to test (see Appendix G, figure 46 - 49) students in Grade 8 and 9 in Benoni Johannesburg. This research tool designed by Gordon (1965) was used to assist teachers in exploring a student's music aptitude. It was known that Gordon's research had enlightened, and made him known as the forerunner, creator, and developer of music aptitude tests in recent years (Gordon, 1965, 1979, 1982, 1988, 1989a, 1989b, 1995, 2011). Many other researchers (Anderson, 1993; Hang, 2011; Hart, 2011; Humphreys and Özeke, 2007; Lu, 2013; O'Donnell, 2011; Schneider, 2000; Stringham et al., 2011) have all used the AMMA test as a research tool to complete their academic studies.

The AMMA was first published in 1989. It was designed solely for the use of college and university students. The test functioned extremely well with adults who had no formal instruction on it was to be included, and trialled with middle-school students (Gordon, 2004:8).

There was a large volume of literature on the acceptable reliability and validity of the Advanced Measures of Music Audiation (AMMA), these studies of prominent researchers confirmed the validity (Estrella, 1992; Fullen, 1993; Gordon, 1989c, 1990, 1991; McCrystal, 1995; Stringham, 2009, 2010; Stringham et al., 2011). Previous studies have reported the predictive validity of music aptitude tests within college settings revealing promising results (Anderson, 1998; Gordon, 1989c, 1990, 1991; Schleuter et al., 1978). These tests are usually administered to students aged twelve and upwards including those at colleges and universities with either a music or non-music major's background.

### **DESCRIPTION, DESIGN AND CONTENT OF THE AMMA TEST**

The AMMA test consisted of 30 questions, which were programmed on a computer and performed on a synthesised keyboard. Directions for taking the test and three practice exercises were included at the beginning. The administration time of this test required only 20 minutes. It consisted of a short music statement, followed by a short musical answer, which then the students had to decide whether their answer to each statement was the same or different for each question presented. If a student decided that the musical answer was different from the original statement, they decided whether it involved a tonal or rhythm change. One or more tonal and rhythm changes may have occurred in each musical statement but never both changed at the same time (Anderson, 1993; Hang, 2011; Hart, 2011; Humphreys and Özeke,

2007; Gordon, 1989, 1990, 1991; Lu, 2013; O'Donnell, 2011; Schneider, 2000; Stringham et al., 2011).

Understanding how the AMMA test worked was imperative. If the musical answer and statement were the same, then the student filled in the blank in the same column on the answer sheet after the number for the question. If there was a difference between the musical answer and statement due to tonal changes, then the student filled in the blank space in the tonal column. If the musical answer was different from the musical statement due to rhythmic changes, then the student filled in the blank space in the rhythm column.

If a student was unsure of the answer, then the student left the blank space unfilled. For each question, the musical statement, and answer had the same number of musical notes. Therefore, students' were not able to answer correctly by simply counting and comparing the number of notes in the musical statement, and the musical answer. The musical answer could even be different from a musical statement as a result due to the tonal change of one or more pitches, tonality, or reality, or because of a result of a rhythm change of one or more durations, tempos and even metres. There were a variety of tonalities, keyalities, tempos, and metres as well as tonal and rhythm modulations represented in the questions of the tests. Concerning scoring, the tonal and rhythm score, and total scores that were derived

from the same 30 questions (Gordon, 1989:8-18; 1991:1-5; Stringham et al., 2011:10).

## **THE PURPOSE OF THE TEST**

Music aptitude was defined as a measure of a student's potential to have achieved in music. In most traditional schools, teachers decided whether a student had musical abilities without testing them properly. Hence why it was important to highlight to the Department of Education in South Africa, how to employ and introduce these musical aptitude tests within government schools throughout all the provinces, giving students the opportunity to excel and realise their potential and possible music abilities.

Gordon (1989:5) argued:

The words "talents" and "ability" are often used in a general way to describe musicianship that is demonstrated either formally or informally. Unfortunately, neither of those words has a specific meaning, both inclusive, and thereby confuse, aptitude and achievement.

The concealed music aptitudes of many students, regardless of formal or informal instruction in music, were quickly revealed through the process of valid music aptitude tests. Discoveries have soon led us to believe that 50 % of 4th – 12th Grade students' overall music aptitude was above the 80th percentile who did not receive any music instruction or wished to enrol for music performance activities in their

schools. The AMMA test was specifically designed for students in Grade 4 through Grade 12.

As Gordon (1989:7) verified and confirmed with the following statement: “It is recommended that the Advanced Measures of Music Audiation now be used with undergraduate and graduate students in colleges and universities because it is designed specifically for those students”.

**Gordon (1989) outlines the seven purposes:**

- To have served as part of the criteria for entrance to college or university departments or music schools.
- To identify college and university students, which were music majors or non-musicians.
- To have established objective and realistic expectations for music achievement for colleges and universities for non-musicians, and music majors.
- To efficiently and diagnostically adept music teaching in private instruction.
- To have assigned college and university students to specific classes including music ensembles, jazz clubs, or music technology clubs, etc.
- To have assisted students who were in colleges and universities in making the correct career decisions.

- To have adapted music teaching efficiently and diagnostically within a classroom environment and private instruction (Gordon, 1989:8-9, 1990:1-2).

**The general rationale of the Advanced Measure of Music Audiation was based on the following principles:**

- The audiation of music, memorization, not imitation or discrimination of musically isolated pitches or duration plays an integral element of the test.
- The design had to be administered to either an individual or a group of students.
- The time allocation for this test to be administered should be less than half an hour.
- The answer sheet should be designed for electronic and hand scoring.
- Students should not have had a background or previous experience in writing and reading music to have completed this test.
- No previous instrumental experiences were needed to complete this test.
- To have completed these tests students required no prior learning, or previous background in the history of music, and the theoretical aspect of music presented.
- The music performed in the tests included that from professional musicians.

- The technical quality should have been of the highest standards when reproducing the music in these tests.
- The tests should have been entertaining and enjoyable for students who completed these tests. Hence the inclusion of various tonalities metres, keyalities and tempos.
- The best aspects of Gestalt and atomistic theories should have been incorporated into these tests through their being eclectic.
- These tests should be suitable for assessing a variety of music aptitudes in the classroom setting.
- These types of responses to have answered the questions should not have been too complex.
- The students who completed these tests should never have been forced to answer a question, and if they were uncertain rather be encouraged not to have responded to a question (Gordon, 1989:16-17, 1990:1-2).

**Materials required for administering the AMMA test:**

- The manual, which explained the test.
- The CD clearly marked Music Audiation.
- One answer sheet for each individual student was required.

- A set of four scoring masks: two, T1 and T2, for deriving the Tonal score; and two, R1 and R2 for establishing the derived Rhythm score.
- A CD player that worked correctly.
- Spare No.2 pencils with erasers for students to be able to use if needed as a supplement.
- A clean and well-lit, and ventilated room for students to hear the recording.
- A writing desk, and ample workspace (Gordon, 1989:21).

#### **Scheduling the administration of the AMMA test:**

- Twenty minutes should be allowed to complete these tests.
- Approximately sixteen minutes were allowed for students to devote themselves to listening to the recording, and answering their questions.
- Four minutes were required for students to complete names, other information, and practice questions.
- The best time to have completed the test was to have it administered at the beginning of the regularly scheduled music class (Gordon, 1989:21).

#### **Directions for Administering the AMMA test:**

- Teachers, had to have tested the CD player well in advance before the students entered the room and ensured they were able to hear the recording.

- Have extra No.2 pencils in case some students needed some.
- When students were seated, ensure they printed their names clearly.
- Tell students they should complete the AMMA test for music aptitude.
- Explained the procedures to students including the practice exercises at the beginning before taking the test were administered.
- Start the CD recording and walk to the back to have ensured that they heard the sound.
- At the end the teacher collected the answer sheets after the 20 minutes, when the test was completed (Gordon, 1989:22).

**Direction for scoring the AMMA test - Scores provided with the AMMA tests:**

- Three types of scores were provided, and included the raw scores, adjusted scores and percentile ranks.
- A raw score involved the simple count of the questions answered correctly.
- Raw scores were transformed into standard scores to compare a student's relative standing on the different tests presented. For interpretive purposes, raw scores were therefore transformed into percentile ranks, the most widely used type of standard score (Gordon, 1989:24; Stringham et al., 2011).

**Norms provided for the AMMA test:**

- There were three test scores available for the AMMA test – Tonal, Rhythm and Total.
- Percentile norms included three groups – College and University music majors, College and University non – music majors and High Schools students (Gordon, 1989:24).

### **Scoring Procedure for AMMA test:**

The logic of the scoring procedure for the AMMA was based on the belief that in a test question, the two parts were the same. If there was a rhythm change in the second part, the student made an error by indicating there was a tonal change in the second part, one point should have been subtracted from his/her Tonal scores. The same applied to the Rhythm score; if a student made an error as a student indicated there was a rhythm change in the second part, one point should also have been subtracted from their Rhythm scores. If the students did not attempt to have answered a question due to being unsure, no credit was given, and nothing was subtracted from their score (Gordon, 1991).

As Gordon (1991:3) stated:

Concerning the Advanced Measures of Music Audiation, when a student believes that a musical answer is the same or different because of a rhythm change, one point

is subtracted from his score. Similarly, when a student believes[s] that [a] musical answer is different from a musical statement and the musical answer is the same or different because of a tonal change, one point is subtracted from his score.

### **Scoring the Answer sheets of the AMMA test by hand:**

- Three processes were involved – The first was counting the correctly answered questions to obtain the raw scores, the second was adjusting the raw scores and the final process was converting the raw scores to percentile ranks.
- There were two sets of scoring marks – one set for deriving the Tonal raw score and the other the Rhythm raw scores. Each set included two scoring marks. For the Tonal set if you had T1 and T2 and for the Rhythm set, you then had R1 and R2. The title of each score mark was printed on the answer sheet (see Annexure E).
- When using the T1 scoring mark, teacher had to count the number of blanks, which were filled correctly on the answer sheet. Avoid counting the same window more than once and looked carefully at the grid on the answer sheet titled “Scores”. These included four boxes in the grid. The top box was always to be labelled T1. Then the teacher wrote the number of the T1 score in that box.

- For the T2 scoring mark, the teacher did the same process, by counting the correctly answered questions. It was reiterated to have avoided skipping answers. Removed the scoring mark from that answered sheet and then found the box in that grid labelled T2. Now the person marking the score, completed this task by writing the score for T2 in that box.
- You had to add twenty points to the T1 score, and then afterwards subtracted the T2 score from the T1 score. For example, if a student's score for T1 = 14 and the other score for T2 = 2. The calculations involved  $20 + 14 - 2$  which equalled to 32, which was defined as the raw score of 32. Another example would be if the T1 = 16 and T2 = 4. You would calculate  $(20 + T1 - T2)$   $20 + 16 - 4 = 32$ . This meant the adjusted tonal raw score would be 32 then. The same principle and process would be used for working out the raw scores for the Rhythm section  $(20 + R - R2)$ . For the total raw score add both row scores for Tonal and Rhythm together. For example: If the highest Tonal Raw score was 40, and the highest Rhythm Raw score was 40; the Total Raw score would be 80 (Gordon 1989:26).

#### **Deriving Percentile Rank Norms for the AMMA test:**

- The percentile rank norms were provided in Table 1 (see Appendix H), Table 2 (see Appendix I), and Table 3 (see Appendix J).

- The tonal tests, Table 1 (see Appendix H) were divided into three groups: Music majors, Non-Music Majors, and High School students. For this research project, we only used the second column for non-Major music students. and the third column for High School students (depending on their age).
- For the Rhythm test, Table 2 (see Appendix I) the same applied.
- For the Total Test, Table 3 (see Appendix J) the three groups were the same. For using and determining the percentile ranks we only used the third column for each section of Appendix H - J.
- To find the exact percentile rank norm for each given raw score, the teacher focussed on the last column for each and either move upwards or downwards to establish the percentile. For example, if the raw score for a student's Tonal Test was 27, the Percentile would be 69. If a student obtained a raw score of 25 for the Rhythm test, then the Percentile Norm Rank would be 40. And finally, if a student obtained a Total raw score of  $(27+25) = 41$  the equivalent percentile would be 20.
- Once all of these procedures were completed on the answer sheets, they were then written down on the Tonal percentile rank norm on the answer sheet in the box in the second column labelled 'PR' after Tonal. The same procedure you would apply for the Rhythm percentile group. Once you have established the equivalent percentile rank norm for the Total, you would write

these details in the second column labelled 'PR' after 'Total' (Gordon, 1989:27).

Gordon (1989:10-11) explained how he developed his *Advanced Measures of Music Audiation* (AMMA) in the administrator's manual:

Regarding music aptitude, there are two general beliefs: The Gestalt and the atomistic. The Gestalt group believes that music aptitude is a unitary trait of which overall intelligence is a significant part. The atomistic group contends that music aptitude is multidimensional: it has various parts, none of which is significantly related to overall intelligence. Gestalt psychologists insist that a music aptitude test must yield only a total score without subtest scores, that the content of the test questions be in a music context, that each test question includes as many music dimensions (tonal and rhythmic) as possible, and that the stimulus for each question is a musical instrument. If the music aptitude test has many parts, as the atomists believe, subparts also must exist and need to be considered. Researchers have addressed this area, suggesting that pitch discrimination, pitch recognition, pitch memory, and "absolute pitch" are all subparts of the tonal dimension and that there is a difference between melodic aptitude and harmonic-contrapuntal aptitude. As to the rhythm dimension, they suggest that rhythm recognition, rhythm memory, and time discrimination are all parts of the rhythm dimension and that there are differences between aptitudes for melodic rhythm, meter, and tempo. For the aesthetic-expressive-interpretive dimension, differences in aptitudes for phrasing, balance, style, melody, harmony, rhythm, and intensity have been established. Recent findings suggest that although there are probably no separate aptitudes (but possibly personality traits and psychomotor abilities) for composition, improvisation, conducting, and instrumental and vocal performance, still there are separate parts and subparts of music aptitude, including preference as well as non-preference measures (Gordon, 1989).

Gordon's (1987) research indicated that music aptitude has a low correlation with general intelligence. According to Gordon, music aptitude cannot be accurately predicted by performance on a general intelligence test or an academic achievement test, nor can general intelligence be accurately predicted by performance on a music

aptitude test. There have been some studies that compared musical achievement, and academic achievement. McMahon (1979) studied music instruction and reading skills with the discrimination of major and minor triads. Students who received music instruction were able to discriminate phoneme changes more accurately than musically untrained children. Kehrberg (1984) found that music aptitude, music achievement, and attitude towards music were not related to frequency of listening to music. Further findings indicated that musical aptitude was a strong predictor of music achievement among grade school students. Music aptitude, home musical environment, “outside-of-school” instrumental playing activities, and the degree of partaking in school musical activities were strong predictors of general music achievement among high school students.

The AMMA was a stabilised music aptitude test that measures two separate dimensions (tonal and rhythm) and takes 20 minutes to administer. The AMMA had no separate tonal and rhythm subtests. Students with stabilised music aptitude responded to the tonal aspects and rhythm aspects in the same question. The main differences between the MAP and the AMMA was that the MAP offered an extensive diagnosis with seven subtest scores, whereas the AMMA offered only two test scores. The AMMA offered a composite score, which Gordon (1998) considered the most valuable part of the AMMA because the information, which was gathered was in a shorter length of the test.

When choosing any music aptitude test, the test must be a valid and reliable instrument. The AMMA was found to be a valid and reliable measure of stabilised music aptitude (Gordon, 1989,1990; Miceli 1998). Fullen (1993) investigated whether the Advanced Measures of Music Audiation was a valid test of music aptitude for secondary school students. He also sought to determine the effect participation in choral ensembles had on the students' AMMA scores. The AMMA was administered to five junior highs and four senior high choirs. The results of the first administration were used to determine predictive validity. The results of the first and second administrations were used to estimate test-retest reliability. The first and third administrations were used to determine the effects of typical music instruction on students' AMMA scores.

During the last three weeks of music instruction, the students sang two melodies with their performances recorded and rated independently by two judges using the same three-dimensional rating scale. This meant for the combined judges' ratings on each dimension separately, and all dimensions for the junior high students, who scored in the top 20% on the AMMA were significantly higher than the means of students who scored in the lower 20%. Senior high students that scored in the upper 20% on the AMMA rated significantly higher than the lower 20% on the tonal dimension. The reliability coefficient for the test-retest total was .81 for the senior high students. The reliability coefficient for the test-retest total was .72 for the junior

high students. The mean difference for the total AMMA raw score gained between the first and third administrations was 1.15 for junior high students and 1.62 for senior high students. Neither of these differences was statistically significant. Fullen (1993) concluded that the AMMA accurately predicted musical achievement of secondary students who demonstrated high and low levels of music aptitude and predicted less accurately the music achievement of individual students. The AMMA also predicted less accurately the music achievement of students, who had similar levels of music aptitude. The AMMA scores were not sensitive to music instruction, achievement in music, or familiarity with taking the test itself (Bradford, 1995; Lai, 1999; O'Donnell, 2011).

Several studies have found that students, who are taught via tonal pattern instructions, score significantly higher on tests of tonal audiation and music achievement (Azzara, 1993; Gamble, 1989; Grutzmacher, 1985; O'Donnell, 2011). It would be valuable for the researcher (Müller) to know whether the students who completed the AMMA test impacted their mathematical achievement overall?

Zdzinski (1992) studied the relationships between parental involvement, music aptitude, and musical achievement in instrumental music studies. Results indicated that there was a significant relationship between parental involvement and both musical achievement and music aptitude as well as a strong relationship between music aptitude and both musical achievement and performance achievement. In this

case; Tonal and Rhythmic Pattern Instruction. Several studies have identified difficulty levels of rhythm patterns (Bradford, 1995; Lai, 1999) and tonal patterns (Jones, 1979; Lai, 1999; Sinor, 1984).

Grutzmacher (1985) emphasised tonal conceptual development using tonal patterns as content with harmonisation and vocalisation versus a traditional single-note identification approach involving music symbols, and pitches taught from notation. Studies have suggested that students who experienced tonal pattern instruction scored significantly higher on music achievement and tonal audiation tests than students, who did not receive such instruction (Azzara, 1993; Gamble, 1989; Grutzmacher, 1985). Further research has indicated that students who received an emphasis on rhythmic pattern instruction exhibited more musical achievement than students, who did not receive such instruction (Azzara, 1993; Coley, 1987; Gouzouasis, 1990; Kitts, 1993; Palmer, 1976; O'Donnell, 2011; Shehan, 1987).

For this study the researcher used the Advanced Measures of Music Audiation (AMMA) to test the students in Grade 8 and 9 at a Secondary (High) School in Benoni. This research tool designed by Prof Edwin Gordon could be used to assist teachers in exploring a student's music aptitude. It was known; that Gordon's research has enlightened, and made scholars aware that he was the forerunner, and developer of music aptitude tests in recent years (Gordon, 1965, 1979, 1982, 1988, 1989a, 1989b, 1995, 2011).

Other researchers (Anderson, 1993; Hang, 2004; Hart, 2011; Humphreys and Özeke, 2007; Lu, 2013; O'Donnell, 2011; Schneider, 2000; Stringham et al., 2011) have all used the AMMA test as a research tool to complete their studies. The AMMA was first published in 1989. It was designed solely for the use of college and university students. The test functioned extremely well with adults who had no formal instructions that it was, later, to be included and trailed with middle-school students (Gordon, 2004:8).

There was a large volume of literature that has been published on the acceptable reliability. and validity of the Advanced Measures of Music Audiation, which studies confirmed the validity (Estrella, 1992; Fullen, 1993; Gordon, 1989c, 1990, 1991; McCrystal, 1995; Stringham, 2009, 2010; Stringham et al., 2011). Previous studies have reported the predictive validity of music aptitude tests within college settings revealing promising results (Anderson, 1998; Gordon, 1989c, 1990, 1991; Schleuter et al., 1978). These tests were usually administered to students aged twelve and upwards including those at colleges and universities with either a music or non-music major's background.

The AMMA test should always be concluded within 20 minutes from the start to the end. There were 30 questions in total with some practice examples, and questions at the start (see Appendix H). Once they have completed the test the marking grid is used to ensure that all the questions have been answered. Once you had the

scores for Tonal Marks (T1 and T2), teachers worked out the raw marks by calculating them out by using the formula  $(20 + T1 - T2)$  to establish the raw mark. The same process applied to Rhythm Mark (R1 and R2). To establish their raw marks, apply the same principle by using the same formula  $(20 + R1 - R2)$ . Once you have the raw scores then you could work out the percentile norms (see Appendix H - J) according to the third column provided for each section Tonal, Rhythm and Total. (Gordon, 1989, 1991; Southworth, 2009: 65; Stringham et al., 2011:10).

### **2.3.6 THE IMPACT OF MUSIC EDUCATION ON ACADEMIC ACHIEVEMENT**

It was important to have acknowledged that without music aptitude, academic achievement was not always obtained. In most international schools, and prestigious private schools attaining the highest level of academic achievement students needed to be skilled, and talented in all disciplines including languages/literacy, numeracy/mathematics, sciences, music, and computer science (ICT) and other arts-related subjects.

Gordon (1990:1) with his one-year longitudinal predictive validity study of the AMMA stated:

First, the majority of college and university administrators and professors believe that they are more capable than any test recognizing “musical talent” and “musical

ability”. They typically are not aware of the difference between music aptitude and music achievement. Music aptitude is a measure of what a student can learn. Music achievement is a measure of what a student has learned.

This researcher completely agreed with these statements, as without music aptitude one could not possibly have any music achievement. Students who were brilliant in composition and music theory, would not be able to complete simple theoretical questions, and be totally creative by composing in different styles of several genres, without prior knowledge or music aptitude for that matter.

It can also be confusing, if you focused on the words – ‘talent’ and ‘ability’, which lacked specific meaning. Kehrberg (1984:69) outlined five musical characteristics, which he included in his studies as: music aptitude, music achievement, level of school participation, attitude towards music and the general music environments at schools. Music achievement was attained due to active participation within school activities and home musical environments (O’Donnell, 2011: 9-25).

Further research by Babo (2001), Cobb (1997), Huang (2004), Hodges et al. (2005), Miranda (2001), Schneider and Klotz (2000), and Underwood (2000) supported the argument that most students who participated in formal music education usually had higher achievement scores than students who did not participate at all. This confirmed why students achieved higher results in music and mathematics due to

their previous experience, and exposure to music. This clarified, why the researcher could not understand why the students at his school were achieving better results in music and mathematics? The link was most evident between music and mathematics, and hence the importance of proving the theory of correlation between music aptitude and mathematical achievement.

Supplementary research supported the idea that students who attended instrumental lessons, and who were being excused from non-music classes' academic performances was not affected (Cox, 2001; Engdahl, 1994; Kvet, 1982; Hodges et al., 2005). Schneider and Klotz (2000:21-23) examined the relationship between enrolment in music performance classes and athletic extracurricular activities on academic achievements.

The subjects (n=346) were divided into three groups: musicians, athletes and non-participants. The three groups were statistically equivalent in fifth and sixth grades. During seventh – ninth grades, the musicians achieved significant higher academic achievement scores than the athletes and never scored higher than non-participants. There was sufficient evidence that those who participated in music, had higher achievements than those who did not (Arneet-Gary, 1998; Shobo, 2001; Yoon, 2000). The research of Drydent (1992), Hodges et al. (2005) and Neuhart (2000) made a discovery that music participants had much higher achievement scores usually in reading but not maths. It was the research of Kluball (2000), that

confirmed that instrumental music was significantly related to mathematics and science tests.

It was the research of Gordon (1989:9), that suggested:

Early psychologists whose primary interest was in music disagreed about the difference between music aptitude and music achievement. But from the beginning to the middle of this century there was general agreement that music aptitude is hereditary and dichotomous: as a birthright, one is born either with music aptitude or without music aptitude.

One could clearly argue then that a child who showed a level of giftedness, and musicality would automatically be able to attain high scores, showing music achievement overall. Gordon shared a different view as he claimed: “There is a difference between music aptitude and music achievement”.

Further:

Aptitude is the potential to achieve, and musicians manifest the capacity when they intuitively understand what others consider inextricable connections in music that defy notation, and they are able to vocalise them or sing them through their instruments. When words such as ability, gifted, musical and talented are used, the difference between aptitude and achievement are obscured and the meaning of the two tends to become synonymous (Gordon, 2004:8).

Spatial reasoning played an imminent role when comparing the relationship between music participation and mathematics achievement as outlined in the research of Boyd 2013; Shaw 2003; others confirmed that the presence of music has always had a positive effect on the brain, which was likely to have affected students’

academic achievement (Boyd, 2013; Hall, 2007; Shaw, 2003; Stein, 2004; Strickland, 2002).

## **2.4. THEORETICAL FRAMEWORK**

For the Theoretical framework the following two theories formed the foundation and ground basis of this study. The first theory is "The Sound Theory" which played an important role on how students perceived the music they heard.

### **2.4.1 THE THEORY OF SOUND**

The Theory of Sound was very important as most of the students would listen to audio-recorded sounds as part of the Advanced Measures of Music Audiation (AMM) test designed by Gordon (1989), who was the forerunner in music aptitude tests. These tests were used at University and College (High School) levels especially at the freshman level to have assessed whether students entering college showed a level of aptitude.

The "Theory of Sound" was outlined by Strutt and Rayleigh (1877) as:

The sensation of sound as a result of vibrations in the air caused by pressure fluctuations, which can be measured with a sound level metre. ... The simplest type of vibration is a pure tone, which is a one-dimensional sinusoidal vibration with only one frequency component ([www.acoustics.no/sound\\_measurement/sound\\_theory](http://www.acoustics.no/sound_measurement/sound_theory)).

The sensation of sound may be the result of vibrations created by pressure fluctuations, which could be measured with the use of a sound level metre. Vibrations were commonly related to the mechanical framework, but air moreover had mass and solidness, and as sound travels within a vacuum or medium the air was compressed and extended. The best sort of vibration may be unaltered tones, which could be – dimensional sinusoidal vibrations as if they were one recurrent component. These sinusoidal vibrations were classed as basic consonant vibrations and were measured in Pascal (PA), with concentrated sound being measured in Watt/m<sup>2</sup>; the sound metre that was used consistently to measure the vibrations and give an overall overview to researchers ([www.acoustics.no/sound\\_measurement/sound\\_theory](http://www.acoustics.no/sound_measurement/sound_theory)).

#### **2.4.1.1 AMPLITUDE**

The amplitude of a periodic variable is defined as the maximum difference of the variable's extreme values over one single period, usually the distance between the top and the bottom of the curve. Large amplitude signified high sound levels (which became noise) and low amplitude signified, low sound levels (when it became quiet).

The sound wavelength was not altered when changing the amplitude, it only increased or decreased the loudness of the sound  
([www.acoustics.no/sound\\_measurement/sound\\_theory](http://www.acoustics.no/sound_measurement/sound_theory)).

#### **2.4.1.2 FREQUENCY**

The measurement unit of frequency was Hertz (Hz) and described as the number of cycles the period repeated per second (1 Hz = 1 cycle per second). The most often utilised frequencies in sound theory were 20Hz to 20 000 Hz (20kHz), which corresponded to the frequency range, to which the human ear could respond.

However, ultrasonic frequencies over 20kHz, and infrasonic frequencies below 20Hz were also included in the discipline of acoustics.

The length of the sound wave depended on the velocity and frequency of the phase. The period was defined as the time it took to repeat one cycle in seconds. In other words, the wavelength described the distance required to complete one cycle. Typical low-frequency sound had long wavelengths, and high energy levels, whereas high-frequency sound had short wavelengths and low energy levels. Bass levels often represent low-frequency sound, whereas high-frequency sound is often represented by high-pitched details.

([www.acoustics.no/sound\\_measurement/sound\\_theory](http://www.acoustics.no/sound_measurement/sound_theory)).

### 2.4.1.3 THE HUMAN EAR

The ear reacted to frequencies between 20Hz and 20kHz but had a sensitivity peak of about 3-4kHz. The resonance of the ear cavity, which amplified particular frequencies, was responsible. Many years of evolution have trained the ear to be more sensitive to the speech frequency spectrum because that was the principle, which caused human communication. So, the ear was not equally sensitive at all frequencies.

The sound unit was Decibel (dB) and was a measurement representing the logarithm of power or intensity. The human ear could hear between 0dB and 120dB, and the last was the pain threshold. The ear could be harmed at a level of 120dB or higher and lead to lifelong impaired hearing, in the worst circumstances.

In the acoustic sector, numerous "sound filters" were being introduced because of the reaction of the ear to different frequencies. The most prevalent was the A-weighted filter, which was based directly on the loudness the human ear perceives. The sound was filtered, as the ear is less sensitive at low audio frequencies, by dampening the low-frequency sound. There were further filters that had been weighted B, C, D and Z. The C-weighted and z-weighted filters were the most utilised. C weighting comprised more than A-weighting than the low-frequency

sound, whereas Z-weighting were merely a linear flat filter  
([www.acoustics.no/sound\\_measurement/sound\\_theory](http://www.acoustics.no/sound_measurement/sound_theory)).

#### **2.4.1.4. NOISE**

Another sound category was noise that was usually undesirable. The notion of noise was very subjective since people reacted to what noise was differently. Noise could be characterised by incidental health disturbance. Exposure to high amounts of noise every day could possibly impair your hearing. If the ear had been severely wounded, it was not likely to heal, to its previous form. Although the notion of noise was very individual, acoustic engineers used sound levels to characterise them more objectively. ([www.acoustics.no/sound\\_measurement/sound\\_theory](http://www.acoustics.no/sound_measurement/sound_theory)).

#### **Examples**

#### **Wavelength:**

The equation for the wavelength was defined as  $\lambda = c/f$ .

Where  $c$  is the phase speed (dependent on temperature and medium) and  $f$  is the frequency.

- At 20°C in air, with  $f=63\text{Hz}$ :  $\lambda = 5.4$  metres and
- At 20°C in air, with  $f=20\ 000\text{Hz}$ :  $\lambda = 17.2$  centimetres.

### **Decibel:**

Converting between sound pressure level and sound intensity levels were easy, given this equation:

Where SPL was the sound pressure level in dB and SIL was the sound intensity level, the reference values were  $P_{ref} = 20\mu \text{ Spa}$  and  $I_{ref} = 10^{-12} \text{ W/m}^2$

([www.acoustics.no/sound\\_measurement/sound\\_theory](http://www.acoustics.no/sound_measurement/sound_theory)).

## **2.5 THE CULTURAL DIFFERENCES IDENTIFIED IN LANGUAGES EXPLORED THROUGH MUSIC WITHIN A SOUTH AFRICAN CONTEXT**

This part was relevant in the study, as most of the students presented in the school spoke several languages as their mother tongue or first languages. Currently there are eleven official languages spoken in South Africa. You had people coming from the North and South, the West and East, where each culture represented a level of individuality. The eleven main languages spoken in South Africa are:

- English
- Afrikaans
- Zulu
- Xhosa

- Southern Sotho
- Tswana
- Northern Sotho
- Venda
- Tsonga
- Swati
- Ndebele

Traditionally when you greeted someone (see Table 1) in one of the eleven official languages you would hear the difference in dialect, and musical tones being used.

<b>Language:</b>	<b>Greetings:</b>
English	“Hello”
Afrikaans	“Hallo”
Zulu	“Sanibonani”
Xhosa	“Molo”
Southern Sotho	“Thobela”
Tswana	“Dumela”

Northern Sotho	“Dumela”
Venda	“Riya-visa”
Tsonga	“Abusheni”
Swati	“Dumela”
Ndebele	“Salibonani”

*Table 1: How to greet in eleven official languages of South Africa*

Music played an imminent role in the traditions of various religious customs where families gathered, and celebrated the following:

- Religious festivals.
- Weddings.
- Christenings.
- Funerals.
- Wakes.
- Revealing of tomb stones.
- Rite of Passage (Reaching adulthood within an African culture).
- Birthdays.
- Anniversary or any opportunity to celebrate something worthwhile.

Your culture predetermined your overall look at life, your religious beliefs especially, and the way you accepted people within your community. Culture had relevance to music as it inspired people to create what they were familiar with, have grown to love, and have endless memories they always cherish. Challenges arises when people try to maintain their own identities and protect their very own culture. This was why it was important to understand cultural awareness, through researching this phenomenon further. Pewa (2005) referred to music as a form of communication with the following statement as outlined from Bebey (1987:6):

.... a lullaby, like almost all. African music conveys a number of ideas simultaneously. Outwardly, it is intended to soothe the baby and lull him to sleep but at the same time, it expresses his mother's gratitude toward Nature or God for having given her a child, a privilege denied to so many other women.

A phenomenal feature of music in Zulu cultural was used to communicate between animals and human beings whereby the herd-boy used the technique of whistling to communicate with his animals producing certain tones to induce and encourage the animal to cooperate when milking (Pewa, 2005:129). These cultural practices are used even today, and imperative to understand, especially when you have students in your classroom from different cultural backgrounds.

### 2.5.1 CULTURAL IDENTITY WITHIN MUSIC

In her abstract in a Journal for proceedings in the IASPM conference with her paper titled: “The interplay of ethnic and other identities in Tsonga popular music” focussing on *cultural identify*, Madalene (2011:171) suggested:

Studies in Black South African popular music have often invoked the idea of identity performance: certain music genres are associated with particular ethnic identities, for example, Maskandi with Zuluness. This work shows various South African popular music construct ethnic identities. Although ethnic identities continue to be performed in contemporary black South African popular music, there is also, I argue in this paper, a performance of discourse on identities that exceed ethnicity. In this paper, I focus on the relationships between ethnic identity and other identities that elide the national South African identity as manifested in the stories and music of two Tsonga musicians from different generations (Madalene, 2011:171).

It was important to preserve your cultural identity and reaffirm what you believed in and have been exposed to all your life. Music played an imminent role in the development of your cultural Identity. There was a distinct difference between popular and rock music. Generally, people had a different preference for music genres ranging from Baroque, Classical, Romantic, Modern, Jazz, Pop and even Fusion. Just because one enjoyed Modern music did not mean that everyone you were familiar with shared the same likes or dislikes for Bartok, Berlioz or the music of Mahler.

One could then have debated, and argued that music that was considered to be desirable, promoted and allowed in previledged settings, emphasised the

importance of identifying and belonging to a particular culture. Trehub (2003:670) proposed that “It is reasonable to conclude, then, that the rudiments of music listening are gifts of nature rather than products of culture”. A connection co-existed between music and language, which was historically aroused with much interest and speculation (Gilleece, 2005:13). Hauser and McDermott (2003:667) concluded that “Some aspects of rhythm perception for music may be tapping domain-general auditory mechanisms”. Cultural diversity was prevalent, the importance of understanding your student’s cultural heritage within your music or mathematics classroom was always relevant, and imperative.

Assimilations between language and music were closely related to culture (Gilleece, 2005:15). Rousseau (1998:321) highlighted the difficulty in appreciating music, which was unfamiliar in a particular culture, and stated that “the most beautiful songs to our taste will always only indifferently touch an ear that is not at all accustomed to them”. Some theorists agreed with the view that musical meaning was widely determined by cultural convention (Blacking, 1973; Walker, 1996). The empirical study of Balkwill and Thompson (1999) revealed that emotions in music were communicated through an amalgamation of universal, and cultural cues.

Karma (2007) noted that definitions of musical aptitude were criticised for low ecological validity, as were definitions of music aptitude and consequently music aptitude tests. According to Choksy (2003:6), with reference to the criticism, tests

often had very low validity or did not measure musical aptitude at all. Psychological tests were devised to measure psychological constructs such as intelligence, personality or musical aptitude. Gembris (1997) discussed three phases in the definition of musicality. The first phase was the phenomenological approach, the main trend in the 20th century, with traces in the 21st century. There was a close relationship between music and the aesthetics of its time; understanding of musical beauty was the most important ingredient in the concept of musicality (Karma, 2007:80). The second phase of the psychometric approach was most dominant during the 20th century. The main interests were objective definitions of musicality and standardised tests to measure it. According to Gembris, the third phase referred to the musical meaning approach, this being the most important one practiced today. According to Karma (2007:80) success in music studies was obviously affected by several variables (Harrison, Asmus and Serpe, 1994). Every teacher knew the overall importance of motivation, with motor abilities and intelligence playing pivotal roles. It was also not uncommon to find that academic abilities explained success in music studies better than musical abilities (Harrison, 1990; Hedden, 1982; Klinedinst, 1991). If this was true, even a comprehensive measure of musical aptitude would not reach a complete correlation with success in music studies (Karma, 1982).

The literature here clearly related to the objectives of this study, by evaluating, identifying, and establishing a connection between musical acumen and mathematical achievement in selected learners by using the most appropriate instruments available for measuring musical talents, and by juxtaposing them with mathematical achievement.

## 2.6 SUMMARY

The framework of Howard Gardner (1999b:41-43) included linguistic intelligence, logical-mathematical intelligence, musical intelligence, bodily–kinaesthetic intelligence, spatial intelligence, interpersonal intelligence and intrapersonal intelligence.

Music aptitude tests had a history of over 85 years of refinement and development and the majority measured discrimination skills. Evaluating the history of musical aptitude tests one could conclude the following timelines, showing progression over the years:

- a) 1919 – *Seashore developed “The Seashore Measures of Musical Talents”;*
- b) 1966 – *Bentley created “The Bentley Test”;*

- c) 1989 – Edwin Gordon produced “*The Advanced Measure of Music Audiation Test*”;
- d) 1993 – Kai Karma made “*The Karma Musical Aptitude test*”;
- e) 2000 - Ki-Boem Jang invented “*The Korean Music Aptitude Profile*”;
- f) 2001 – Drayna, et al. (2001) created “*The Distorted Tunes Test*” and
- g) 2003 – Peretz, et al. (2003) produced “*The Montreal Battery of Evaluation of Amusia*”.

There were seven stages of audiation, which were hierarchical and cumulative. In the first stage of audiation, we could retain short series of pitches and durations that we heard just a moment earlier in familiar or unfamiliar music, which we were listening to. We could retain short series of pitches and durations of immediate impressions without giving them any musical meaning. In the second stage, we silently imitated the series of pitches, and durations that we retained from the previous stage of audiation. Then we usually organised them through audiation, the short series of pitches and duration into one or more tonal and rhythm patterns based on pitch and placement of macro beats. In the third stage of audiation we established the results of the interactions of the tonal patterns with one another, and the rhythm patterns without one another, focusing on the tonality, metrical and modulation that we heard within the music. Concluding with the fourth stage, we retained audiation

in the tonal and rhythm patterns presented. In the relationship to the tonality and metre that we have established, this was done through the process of organising the music, to which we were listening to. In the fifth stage, we recalled the tonal and rhythm patterns that we audited and organised according to the pieces of music. In the sixth stage, we predicted the tonal and rhythm patterns that we hear.

When one wrote down several tonal and rhythmic patterns through means of aural dictation, one audiated (Anderson, 1993; Gordon, 1989, 1990, 1991, 2004; O'Donnell, 2011). Music Learning Theory (MLT) could be defined according to Gordon (2003) as the “knowledge of sequential music learning combined with music audiation, and aptitude”. Through MLT students would have a greater understanding of music through the development of their audiation skills. Developmental music aptitude stage involved learning a new piece of music (Gordon, 1998; O'Donnell, 2011).

The Music Learning Theory has been developed progressively through the years by Gordon (2003, 2011) and known as Gordon's Music Learning Theory (MLT). The research of others (Jones, 1979; Lai, 1999; O'Donnell, 2011; Sinor, 1984) identified difficulties in tonal and rhythm patterns (Bradford, 1995; Lai, 1999; O'Donnell, 2011). Several studies found that students who were taught via tonal pattern instructions,

scored significantly higher on tests of tonal audiation and music achievement (Azzara, 1993; Gamble, 1989; Grutzmacher, 1985; O'Donnell, 2011).

The AMMA was a music aptitude test designed by Gordon (1989). According to Gordon (1991:2) "It differs from the Primary Measures of Music Audiation and Intermediate Measures of Music Audiation". The AMMA test included both Tonal and Rhythm dimensions, which inevitably included Tonal and Rhythm scores. A melody overall incorporated both tonal and rhythm dimensions. Each question included the same short melody, performed twice or included two different melodies being played (Gordon, 1991:3). When using the AMMA test, the teacher always ensured that you administered the test correctly by ensuring that the rooms, and environment for the students were always suitable. In advance, the teacher tested the CD player beforehand, to ensure that the audio was easily heard from the back before the participants started the test. The teacher ensured that there were extra pencils, and erasers for the students to use in case of an emergency. The test would always be concluded within 20 minutes. There would only be 30 questions in total with some practice examples and questions at the beginning. Once they had completed the test; teachers used the marking grid to ensure that all the questions had been answered. Once you had the scores for Tonal Marks (T1 and T2) teachers worked out the raw marks using the formula  $20 + T1 - T2$  had to be used consistently to

establish the raw mark. The same process applied to Rhythm Mark (R1 and R2). To establish their raw marks, applying the same principles by using the same formula  $(20+R1 - R2)$ . Once you had the raw scores, then you could work out the percentile norms according to the third column provided for each section Tonal, Rhythm and Total. Due to the test being used for grade 8 and 9 students, it was advised to only use the last column to establish the precise percentile (as these were used for High School students). The teacher wrote all the information on the answer sheets in the spaces provided for T1 – T2, Tonal Raw Score, R1, R2, Rhythm Raw Score, Tonal Percentile (PT), Rhythm Percentile (PR) and Total.

According to Kehrburg (1984) the following five musical characteristics were included:

- a) music aptitude,
- b) music achievement,
- c) level of school participation,
- d) attitude towards music classes, and
- e) overall school music achievements obtained and are important to pre-determine your academic achievements within the music.

A stimulating environment for a student to have explored their music aptitude involvement and performances of instrumental music programmes was imperative as outlined by researchers (Kehrberg, 1984; O'Donnell, 2011). Teachers concluded that without the correct attitude that it was impossible to achieve excellent results in the music programme; fostering a high level towards music achievements by regular external examinations presented for students to have reached their full potential in the music classroom.

Achievement has been misunderstood for many years reflecting the music aptitude of others; one could only confirm that a correlation existed between obtaining achievement through means of aptitude overall. This confirmed why students achieved better results in music and mathematics due to their previous experience, and exposure to music. Did this explain why the researcher could not understand that the students at his school were achieving better results in music and mathematics? The link was most evident between music and mathematics.

For the Theoretical Framework the "Theory of Sound" was discussed and outlined in detail by differentiating between "frequency and decibels". Another objective was to have created opportunities, and a platform for musicians to have engaged with one another, and shared ideas, and ideologies, giving importance to their own

culture and focus foremost on individuality. For music scholars generally, this was an ample opportunity to create blogs and websites, where students from any background within Africa could share music and interpretations of the ideology of culture.

This literature reviewed was directly relevant to this study, as it assessed, recognised, and established a correlation between musical skill, and mathematics performance in pre-selected students. It also evaluated the most suitable techniques for measuring musical ability, and juxtaposed them with the math results obtained linking these directly with the mathematical achievement from the sample of high school learners in Johannesburg.

## CHAPTER 3

### RESEARCH APPROACH, DESIGN AND METHODOLOGY

*“A man should hear a little music, read a little poetry, and see a fine picture every day of his life, in order that worldly cares may not obliterate the sense of the beautiful which God has implanted in the human soul.”* — Johann Wolfgang von Goethe

#### 3.1 GENERAL INTRODUCTION

This study is primarily empirical and relies on the responses from participants of the one test conducted (AMMA, seen as an evaluation) at a High School in Benoni in Johannesburg answering the research questions presented as an individual case study. The second part involves conclusion of observations and direct interviews with the one music teacher, who was based at Liverpool Secondary School. Regular communication between the respondent and the researcher coexisted through means of different platforms including Skype calls and electronic documents that were communicated online. The last part of this research involved a detailed questionnaire, which all the respondents had to complete online using the survey monkey research tool. Another 30 respondents from within South Africa and around

the globe were included in this study. These findings were presented as a report and a survey. The study consisted of mixed research methods, as the researcher used both quantitative<sup>1</sup> and qualitative<sup>2</sup> methods in answering the research questions as described by Mouton (2001:149 –152).

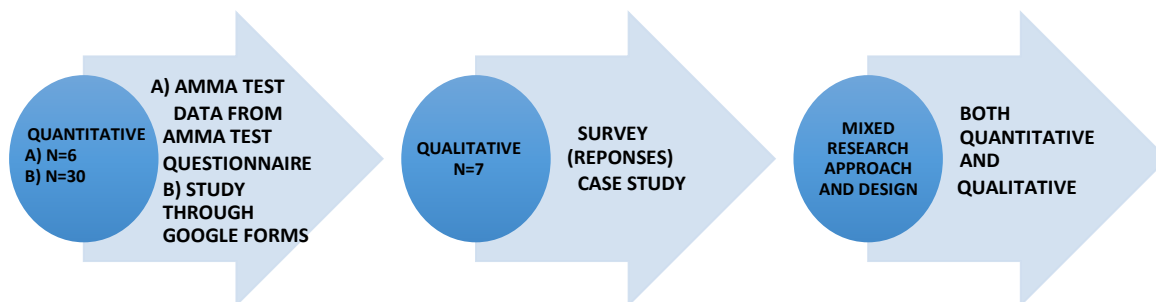
### **3.2 RESEARCH APPROACH**

The project was highlighted as an evaluation, based on utilising the quantitative and qualitative mixed research methods. Using mixed research methods would complement new theoretical findings and improved existing teaching practices, and formulate attributed around the conceptualisation of music aptitude, and mathematical achievement (see figure 4).

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<sup>1</sup> A method of research used that asked a specific, narrow question and collected a sample of numerical data from participants to answer the questions. The researcher analysed the data with the guidance, and supports of statisticians. The researcher hoped that the numbers used would yield an unbiased result that could be generalised to some larger population.

<sup>2</sup> A method of inquiry employed in many different academic disciplines. Qualitative researchers aimed to gather an in-depth understanding of human behaviour, and the reasons that governed such behaviour.



*Figure 4: Mixed research approach used for this study (Mouton, 2002; Creswell, 2003, 2009)*

The reason for using the mixed research methods was to collect, analyse, interpret and report data as suggested by Creswell (2009: 53).

Creswell recommended:

Mixed methods designs may be fixed and/or emergent, and researchers need to be cognizant of the approach that they are using ... Fixed mixed methods designs are mixed methods studies where the use of quantitative and qualitative methods studies is predetermined and planned at the start of the research process (Creswell, 2009: 54).

Creswell (2009:61) justified the mixing of quantitative and qualitative research methods within your own research study. As outlined by Bryman (2006, cited by Creswell, 2009:62) there were several reasons to mix your research methods in order to validate triangulation.

Triangulation or greater validity, which refers to the traditional view that quantitative and qualitative methods were used to combine and triangulated your findings. Completeness referred to the notion where the research could bring together a more comprehensive account of the inquiry through use of both quantitative and qualitative research. A different research question referred to the argument that quantitative and qualitative research could answer different research questions. The use of quantitative and qualitative strands within mixed methods concluded with an overall interpretation of your study. Priority referred to the relative importance of weighting the quantitative and qualitative methods for answering your research questions.

The implementation of the three -weighting option:

- **Equal Priority** – Where both research methods play an equally important role in addressing the research problem presented.
- **Quantitative Priority** – where greater emphasis is placed on quantitative methods than qualitative methods and,
- **Qualitative Priority** – where greater emphasis is placed on qualitative methods than quantitative methods (Creswell, 2009:65).

According to Johnson and Christensen (2014:108):

The researcher uses a mixture or combination of quantitative and qualitative methods, approaches, or concepts in a single research study or in a set of related studies. The qualitative and quantitative parts of a research study might be

conducted concurrently (conducting both parts at roughly the same time) or sequentially the other second to address a research question or a set of related questions.

The test design involved four phases. The first phase gathered data from a total sample of students as per the quantitative method ( $n=6$ ) of research conducted through the AMMA aural tests (the listening tests), as part of the extended study the research used 30 music educators as part of respondents ( $n=30$ ) to answer a detailed questionnaire as part of google forms, then analysed to answer the research questions and presented as one individual case study making it also qualitative ( $n=6$ ). The second phase of the design involved both quantitative and qualitative research to answer the research questions; focusing on observations and direct interviews, with one music teacher, who was were teaching at Liverpool Secondary School in Benoni, in Johannesburg with the addition of the respondent ( $n=7$ ) that was included in this project. The third phase involved a follow-up questionnaire (which was qualitative), which all the participants had completed online with statistics presented in the form of a report and a survey ( $n=7$ ). The fourth phase involved an electronic questionnaire being presented as a survey ( $n=30$ ) through means of google forms.

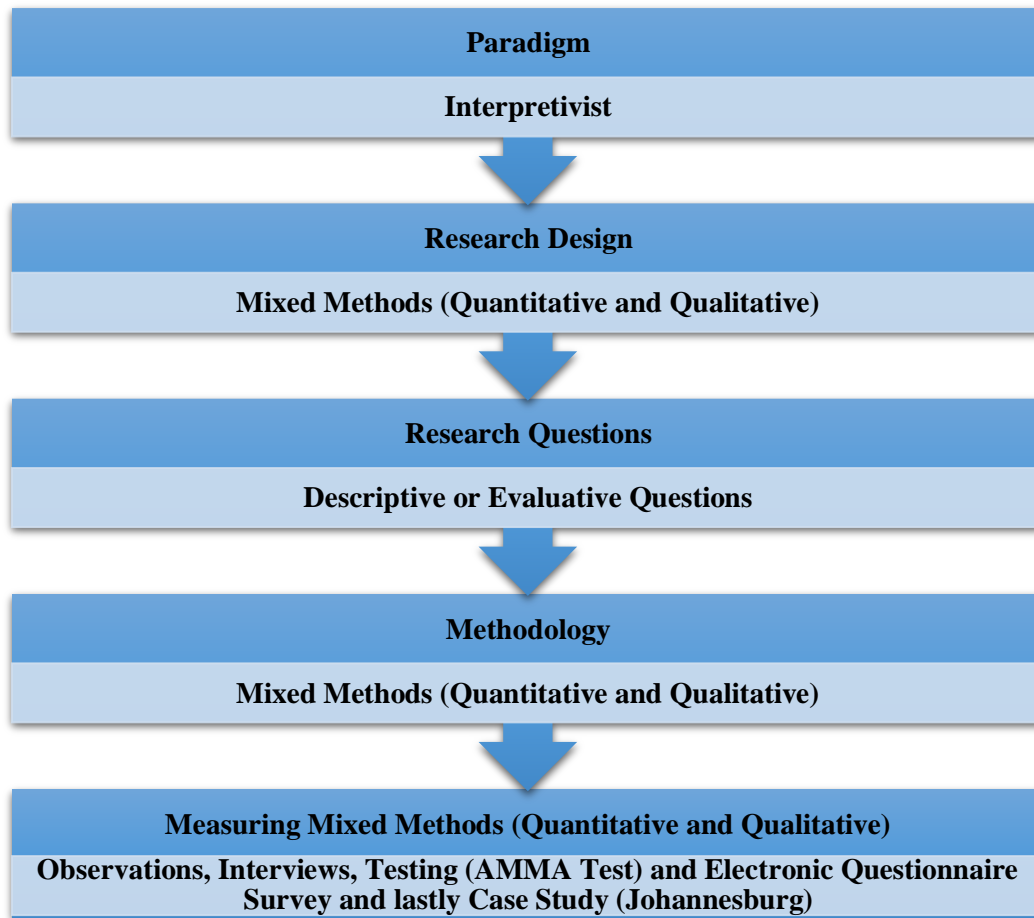
The study targeted students that were in Grade 8 and 9 in Benoni; aged between twelve and fourteen<sup>3</sup>. The data collection was completed with several music listening tests completed based on the elements of music. The data was analysed<sup>4</sup> under the sections age, gender, Tonal scores (T1 - T2), and Tonal Raw scores, Converted Tonal Percentile, Rhythm scores (R1 - R2), Rhythmic Raw Scores, Converted Rhythmic Percentile, Total Percentile and music experience (aptitude).

The research instruments and data collection strategies involved qualitative processes namely interviews, observations, video recordings, documents (letters) and quantitative processes, which included questionnaires (AMMA and detailed follow-up interview questionnaires (completed online) which involved mixed methods (see figure 5).

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<sup>3</sup> Most pupils were placed into the mainstream despite their age and learning capabilities.

<sup>4</sup> The data was interpreted after results had been discussed in consultation with a resident university statistician. The sampling strategy involved students in two classes per year, each in Grade 8 and 9, aged 12 – 14 years of age in Benoni in Johannesburg. Each year group per year/grade at the school comprised of a total of 6 participants.



*Figure 5: Data collection strategies for this study*

### **3.3 CONSIDERATIONS FOR USING MIXED RESEARCH METHODS**

Johnson and Christensen (2014:158) identified a mixed research problem:

- It could be like a quantitative research problem (mixed research could add perspectives to a quantitative study),

- It could be like a qualitative research problem (mixed research could add perspectives to a qualitative study),
- It could be a hybrid of the quantitative and qualitative research, which were included in a single problem statement and,
- Mixed research method applied to the statements of purpose, and the main research question.

### **3.3 DEFINING AND CONCEPTUALISING THE RESEARCH QUESTIONS**

The study was based on the following main research question:

***Does the AMMA music aptitude test corroborate the mathematical achievement of students?***

The inquiry into the relationship between the AMMA music aptitude test and students' mathematical achievements seeks to establish a correlation between the two domains. By systematically analyzing the test results alongside corresponding mathematical performance, this study aims to determine whether a significant alignment exists. The findings derived from this investigation could provide empirical evidence to either validate or challenge the potential correlation between musical aptitude and mathematical achievement, contributing to a deeper understanding of the cognitive connections between these skill sets. Such insights have the potential

to influence educational practices and curriculum development. As McLeod (2007:1) acknowledged, students from different cultural backgrounds and different IQ levels with various abilities had the ability to learn at a different pace. To pass their musical tests successfully every student needed to have had a concrete background in music education focusing on the elements of music. The research concluded that the AMMA can impacted the mathematical achievements of students overall. The students completed a detailed questionnaire where they answered a survey based on questions related to music aptitude and mathematical achievement. Here different responses were collated to answer the research questions outlining the mixed-method approach.

The following sub-questions were posed:

***What are the predominant attitudes and perceptions concerning the potential relationship between music aptitude and mathematical achievement?***

The study delves into uncovering the prevailing attitudes and perceptions regarding the potential interplay between music aptitude and mathematical achievement. Through qualitative analysis of participant responses and in-depth interviews, this research aims to discern common perspectives and nuanced viewpoints that shed light on how individuals perceive the possible connection between these two cognitive domains. By elucidating these predominant attitudes, the study contributes

valuable insights to the broader discourse on the intersections of music and mathematics in education.

***Can the hypothesis, stemming from the survey, be substantiated, indicating a potential correlation between music aptitude and mathematical achievement?***

Indeed, the hypothesis derived from the survey can be substantiated, as the collected data reveals a clear and meaningful correlation between music aptitude and mathematical achievement. The analysis demonstrates a statistically significant relationship, highlighting the potential impact of musical engagement on enhancing students' performance in mathematics. These findings underscore the importance of further exploration into the cross-disciplinary benefits of music education.

***How effective are the currently available music aptitude testing programs in accurately gauging individuals' musical potential?***

The evaluation of the existing music aptitude testing programs focuses on assessing their efficacy in accurately gauging individuals' musical potential. Through a comprehensive analysis of the methodologies, validity, and reliability of these programs, this study seeks to determine the extent to which they provide a reliable measure of musical aptitude. The findings from this investigation contribute to a

deeper understanding of the strengths and limitations of current assessment tools and their relevance in identifying individuals' inherent musical capabilities.

**How can an appropriate music aptitude test be formulated to provide educational advantages for students within the specific context of South Africa, enhancing their learning outcomes?**

Addressing the context of South Africa, the study endeavors to devise a tailored music aptitude test that strategically enhances students' learning outcomes with relation to mathematics. By amalgamating culturally relevant musical elements and pedagogical approaches, this research seeks to create an assessment tool that aligns with the unique educational landscape of South Africa. Through meticulous design and validation, the proposed aptitude test aims to not only measure musical potential but also contribute to a more effective and culturally sensitive educational experience, fostering improved learning outcomes for students.

### **3.4 SAMPLE DESIGN AND METHODS**

This study consisted of mixed research methods approach as outlined by Creswell (2007, 2009). These involved qualitative and quantitative methods. According to Johnson and Onwuegbuzie (2004), mixed research methods were an attempt to legitimise multiple approaches in answering several research questions; it was

expansive, and creative a new form of research (Johnson and Onwuegbuzie, 2004:17).

The strength of mixed research methods employed included:

- Words, pictures, and narrative that could be used to add meaning to the numbers;
- The researcher could generate and test a grounded theory or hypothesis;
- It could answer a broader, and more completed range of research questions because the researcher was not confined to a single approach;
- It could provide stronger evidence in conclusion through convergence, and corroboration and
- Qualitative and quantitative research used together could produce a more completed knowledge necessary to inform theory and practice (Johnson and Onwuegbuzie, 2004:21).

**Weaknesses of mixed research methods:**

- It could be difficult for a single researcher to carry out both qualitative and quantitative research,
- It could be time-consuming and,
- It could be more expensive financially (Johnson and Onwuegbuzie, 2004:21).

<b>Mixed Methods Design Classification used from 1989 – Present</b>		
<b>Author/Researchers</b>	<b>Discipline</b>	<b>Mixed Methods Design</b>
Greene, Caracelli and Graham (1989)	Evaluation	Initiation, Expansion, Development, Complementarity, Triangulation
Patton (1990)	Evaluation	Experimental design, qualitative data and content analysis. Experimental design, qualitative data and statistical analysis etc.
More (1991)	Nursing	Simultaneous triangulation, Sequential triangulation.
Steckler et al. (1992)	Public health and education	Model 1 – Qualitative methods to develop quantitative measures. Model 2 – Qualitative methods to explain quantitative findings etc.
Greene and Caracelli (1997)	Evaluation	Component designs, Triangulation,

		Complementarity, Expansion, Integrated design etc.
Morgan (1998)	Health Research	Complementary designs, Qualitative preliminary, Quantitative preliminary, Qualitative follow up etc.
Tashakkori and Teddlie (1998)	Educational Research	Mixed Research design, Equivalent status (sequential or parallel), Dominant-less dominant (sequential or parallel), Multilevel use, Mixed model design etc.
Creswell (1999)	Educational policy	Convergence model, Sequential model, Instrumental-building model

Sandelowski (2000)	Nursing	Sequential, concurrent etc.
Creswell, Plano Clark et al. (2003)	Educational Research	Sequential explanatory, Sequential exploratory, Sequential transformative, Concurrent triangulation, etc.
Creswell et al. (2004)	Primary medical care	Instrument design model etc.
Tashakkori and Teddlie (2003)	Social and behavioural Research	Multi-Strand design, Concurrent mixed designs etc.
Greene (2007)	Evaluation	Component designs, Convergence, Extensions etc.
Teddlie Tashakkori (2009)	Educational Research	Mixed methods multistrand designs etc.
Morse and Neihaus (2009)	Nursing	Mixed method simultaneous Designs

*Table 2: Mixed method design adapted from Creswell et al. (2003:216-217)*

Mixed research methods had a long history of utilisation. Table 2 outlined, and highlighted the other disciplines where it has been successfully used.

In music education, several researchers used mixed research methods incorporated in their research studies (Cushinery, 2011; Fitzpatrick, 2011; West, 2011).

### **3.4.1 MIXED METHODS APPROACH EMPLOYED**

- Pragmatic, knows, claims.
- Sequential, concurrent, and transformative.
- Both open and closed-ended questions. Both emerging and predetermined approaches and both quantitative and qualitative data and analysis.
- Collected both quantitative and qualitative data.
- Developed a rationale for mixing approaches/methods.
- Integrated the data of different stages of inquiry.
- Presented visual pictures of the procedures in the study.
- Employed the practices of both qualitative and quantitative research (Creswell, 2005).

### **3.4.2 DEFINITION OF MIXED METHODS RESEARCH**

Researchers (Rashakkori and Teddie, 2003; Creswell, 2005; Ivankova et al., 2005) defined “Mixed methods” as a procedure to collect, analyse and “mixing” or integrating both qualitative and quantitative data, within a single study for the main purpose of gaining a better understanding of the research problem. Two phases could be established:

### **3.4.2.1 QUANTITATIVE PHASE**

Can be viewed in this regard as the web-based survey involved concluding a questionnaire. In this study, everyone completed a music aptitude, and the data related to mathematical achievement. As part of the study the researcher included 30 educators from South Africa and different provinces and globally, internationally. Prominent researchers included these phases in their own studies (McMillan, 2000; Creswell, 2005; Ivankova et al., 2005).

### **3.4.2.2 QUALITATIVE PHASE**

Using the case study approach within this High School context, and specifically putting an emphasis on the six students studied interviewed. This was used to obtain a detailed, in-depth data collection process through presenting one collective case study using the following:

- In-depth semi-structured interview,
- Researchers' reflections,
- Electronic follow-ups and interviews, and
- Participants' responses to the open-ended and multiple-choice questions on the survey in the first, quantitative phase.

In conclusion, this phase was in alignment with other researcher's work that used the mixed-method approach in their design (Merriam, 1998; Stake, 1995; Ivankova et al., 2005; Yin, 2003).

### **3.5 RESEARCH DESIGN**

The nature of mixed research methods and popularity could be easily documented through the journals, articles, conference proceedings, books, and formation of special interest groups (Creswell and Plano Clark, 2010). It was known as the "third methodological movement" incorporating quantitative and qualitative research (Tashakkori and Teddlie, 2003:5).

Johnson and Obwuegbuzie (2004:15) described it as the "third research paradigm". Mayring (2007:1) described it as "a new star in the social science sky". A mixed research method was an intuitive way of doing research that is constantly displayed in our everyday lives. Greene (2007:20) viewed these methods as "multiple ways of seeing and learning". This meant using multiple ways, which were significantly visible in everyday life; thus employing emerging mixed-methods, which became a natural outlet, for research.

This was an accessible approach to addressing a particular inquiry. The history of mixed methods existed from 1989 until today in the 21<sup>st</sup> century, with the following

authors defining its usage, with a mixture of at least one quantitative method - designed to collect numbers, and one qualitative method - designed to collect words (Green et al., 1989:256; Tashakkori and Teddlie, 1989:6; Johnson et al., 2007:123; Green, 2007:20; Creswell and Plano Clark, 2007:5; Creswell and Wood, 2010).

30% of this research project (see figure 6) included the sample of the first phase AMMA aural tests and collected a more in-depth data according to the qualitative method of research (which included age, gender, Tonal scores (T1 + T2), Tonal Raw scores, Converted Tonal Percentile, Rhythm scores (R1 + R2), Rhythmic Raw Scores, Converted Rhythmic Percentile, Total Percentile, and music experience. 40% of the second phase included the written report of the observations, and interviews conducted with the one teacher, who was a music teacher at Liverpool Secondary School in Benoni, in Johannesburg with the candidate, Müller. The third phase included 20% of the sample which concluded a follow-up interview, and a detailed questionnaire completed online by all respondents; constituting a survey as per the suggested qualitative process as outlined by Mouton (2001:152), which made this project predominantly an empirical nature. The fourth phase included 10% of the sample, which included 30 music teachers concluding detailed electronic questionnaires electronically through google forms online.

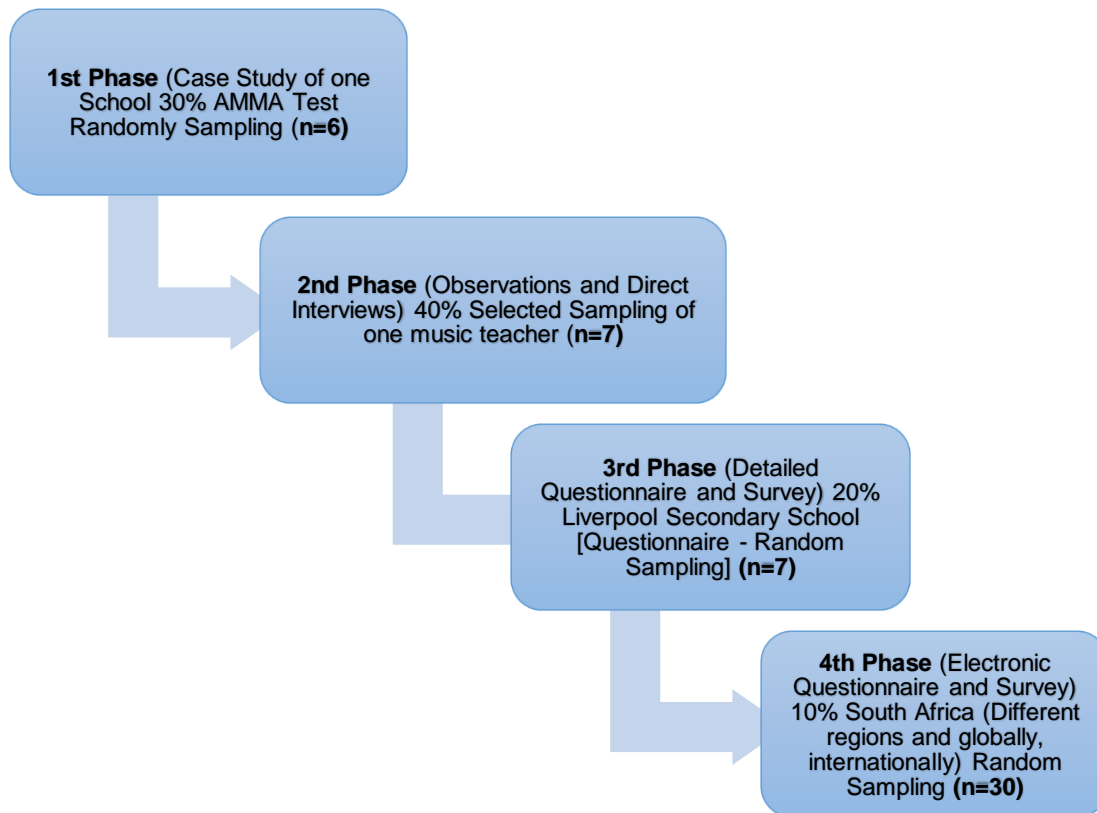


Figure 6: Research Design for this study

### 3.6 RESEARCH METHOD

This study used mixed research methods as outlined by Creswell (2003, 2009). The researcher used the *Sequential Explanatory Design*, where the researcher wanted to generalise, assess, or test quantitative explanatory results to see if they could be

generalised to a sample, and a population. This was applicable when the researcher had time to conduct the research in two phases (quantitative and qualitative). The researcher identified a new emergent research question based on the quantitative results that could not be answered with quantitative data alone (Creswell, 2009).

The researcher used the following steps as suggested by Creswell (2009):

### **Step 1 - Design and Implement the Quantitative Strand**

- Stated quantitative research questions, and determined the quantitative approach.
- Obtained permissions.
- Identified the quantitative sample.
- Collected open-ended data with protocols.

### **Step 2 - Use Strategies to build on Quantitative Results**

- Refined quantitative research questions, and the mixed methods questions, and
- Determined how participants would be selected for the quantitative sample.

### **Step 3 - Design and Implement the Qualitative Strand**

- Stated the qualitative research question, and built on the quantitative results, to determine the qualitative approach.

- Obtained permission.

#### **Step 4 - Interpret the Connected Results**

- Summarised and interpreted the quantitative results.
- Summarised and interpreted the qualitative results.

According to Creswell et al. (2003) “The mixed methods explanatory design consisted of two distinct phases: quantitative followed by qualitative”. The researcher used the same steps in this study to answer the research question of whether a correlation existed between music aptitude and mathematical achievement. The findings were presented as one collective case study. Stake (1995) and Yin (2003) based their case study approach on a constructivist paradigm.

The following should be considered when using case studies:

- The focus of the study is to answer “how” and “why” questions.
- One should not manipulate the behaviour of those involved in the study.
- You want to cover contextual conditions because you believe they are relevant to the phenomenon under study.
- The boundaries between the phenomenon, and context are not clear (Yin, 2003, 2009).

Baxter et al. (2008:548) and Yin (2003, 2009) suggested that: “multiple case studies enable the researcher to explore the differences within and between cases. The goal is to replicate findings across cases because comparison will be drawn”.

This study encompassed the four phases – the first phase collected data through the test completed (one listening - AMMA test). It took the researcher twenty minutes to conduct the AMMA test. These findings were presented in a report format in terms of gender, results as individual case studies for the one secondary school being researched. The second phase included personal interviews and observations, with all the respondents including the one teacher at Liverpool Secondary School. The third phase concluded with the online questionnaire, which the 7 respondents completed through the help of technology and the internet. The music teacher completed most of his interviews, and questionnaire online. The last (fourth) phase included 30 respondents (music teachers locally in South Africa and globally abroad) concluding an online electronic questionnaire in a google form. The findings were presented then as a report form of a survey. The study used the following timelines to obtain, collect data, and conduct interviews with observations (see Table 3).

Studies that were usually qualitative in nature and aimed to provide an in-depth description of a small number were considered case studies, which were empirical, exploratory with descriptive questions, with observations as sources of data

including, participant observation; semi-structured interviewing, and use of documentary sources (Mouton, 2002:149).

Surveys were usually quantitative in nature and aimed to provide a broad overview of a representative sample, empirical in nature with Sequential Explanatory questions with observation sources of data which included structured questionnaires, structured telephone interview schedules, structured mail questionnaires and structured electronic questionnaires including a survey (Mouton, 2002:153).

<u>Data collection strategies employed with the High School in Benoni, Johannesburg</u>	
<b><u>Instruments Used and Dates</u></b>	<b>Liverpool Secondary (High) School, Benoni, Johannesburg</b>
<b><u>Testing:</u></b>  AMMA Test  Dates: November 2021	(n=6)
<b><u>Interview:</u></b>  Dates: December 2021	(n=7)
<b><u>Observations:</u></b>  Dates: October 2021	(n=7)

<p><b><u>Survey</u></b></p> <p>(Electronic Evaluation Questionnaire &amp; Google forms)</p> <p>Dates: Ongoing whenever the respondents were available.</p>	<p>(n=7)</p> <p>Six respondents, and music teacher.</p> <p>(n=30) Thirty music educators from within South Africa and globally, internationally.</p>
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*Table 3: Data collection instruments and timeline used for this study.*

### **3.7 DATA COLLECTION METHODS: SAMPLING STRATEGY**

All the students who participated in the research project were in Grades 8 and 9 at Liverpool Secondary School in Benoni, Johannesburg. Most participants were aged 12 – 14 years and mixed (boys and girls) gender. They only had to declare their age, gender, musical experience background, and school on their AMMA test. The music teacher involved in this research was contacted through regular email correspondence, and was a colleague, and music teacher at the school.

The researcher liaised with the music teacher on a regular basis via skype and documented his findings, and experiences by scribing the recorded conversations, whilst all participants including the music teacher completed an online detailed questionnaire (see Appendix A) considered as part of the survey monkey research instrument. As part of the extended study the researcher connected with 30 music

teachers within South Africa from different provinces and concluded a quantitative study locally and internationally.

### **3.8 COMPARING METHODOLOGIES OF PREVIOUS STUDIES**

In the previous studies conducted around the AMMA test; the following research methodologies, and techniques were applied. Rather (2012) used the AMMA test and the American College Test (AST) as part of her methodology assessment using four tests, namely English, Mathematics, reading and science reasoning. In her study, only the mathematics test was used, and students used their reasoning skills to solve practical problems in the areas: of pre-algebra, elementary algebra, intermediate algebra, coordinate geometry, Plano geometry and trigonometry. The instrumentation was the scores for the music aptitude through the AMMA test scores and the AST Assessment tests to determine the mathematical achievement. The data was then analysed using the Pearson Product Moment Correlation Coefficient ( $r$ ) to determine the degree of the relationship between the two variables (Rather, 2000:15-18).

O'Donnell (2011) used the methods of randomised pre-post-test design. Participants were catalogued using Microsoft Excel spreadsheets. He used an experimental and control group, after which the scores were then compared using statistical analysis.

The research instruments were the AMMA test, which was administered to both groups. A Multivariate Analysis of Covariance (MANCOVA) was used to determine whether the main effects or interactions occurred between the control and experimental group. Descriptive statistics were analysed to provide a demographic profile of the participants (O'Donnell, 2011:40-53).

Boyd's (2013) used the research design correlation research, as he sought to analyse the relationship between mathematics achievement (Georgia Criterion-Referenced Competency Test [CRCT]; Georgia Department of Education [GaDOE]; 2011) test scores and the 14 variables of music participation, as determined by the Music Participation Questionnaire (MPQ). The results were then analysed using the Pearson Product Moment Correlation Coefficient ( $r$ ). Through the analysis of the variance (ANOVA), which was used, the intensity and relationships between music participation and mathematics that changed over time were established (Boyd, 2013:57-67).

### **3.9 TRIANGULATION OR VALIDATION OF THE RESEARCH**

The study formed a level of triangulation, as the researcher used mixed research methods; both the quantitative and qualitative. In the view of Rowley (2002:23), one of the strengths of case studies was the availability of evidence from multiple sources

of data being presented. Triangulation used evidence from different sources to corroborate the same facts or findings. Guion et al. (2011) believed methodological triangulation involved the use of both quantitative and qualitative methods. These included results from surveys, focus groups, and interviews that were then compared to establish if similar results were found. If the conclusion for each of the methods was the same, then validity was established.

### **3.10 LITERATURE REVIEW, INTERVIEWS, QUESTIONNAIRES, OBSERVATIONS, CASE STUDIES AND SURVEYS**

In Chapter 2 the literature review was discussed in detail under the following six sections:

- Music Theory of Intelligence and Musical Ability.
- Music Aptitude over decades.
- Audiation.
- Music Learning Theory (MLT).
- Advanced Measures of Music Audiation (AMMA).
- The Impact of Music Education on Academic Achievement with a strong Theoretical Framework (Theory of Sound etc).

## (A) QUESTIONNAIRES

The researcher employed and applied a detailed questionnaire for the respondents to complete including the music teacher.

In qualitative research, questionnaires were used to collect information from a wider sample that could be reached through a personal interview. Woods (2006:22) explained:

Where certain clearly defined facts or opinions have been identified by more qualitative methods, a questionnaire can explore how generally these apply if that is a matter of interest. Ideally, there would be a qualitative 'check' on a sample of questionnaire replies to see if respondents were interpreting items in the way intended. Alternatively, a questionnaire might be used in the first instance, followed by qualitative techniques on a sample as a check and to fill out certain features of the questionnaire replies. Interaction among techniques in this way is typical of qualitative research.

He outlined the following to be considered with questions of:

- Access – The researcher needed to know that everyone was answering the questionnaire and that the respondents were giving full, and truthful responses.
- The need to have identified the context in which the replies on the questionnaire were given.

- The nature of the data required. The purpose of the questionnaire was to help discover new qualitative material; thus, it was important to have more open, unobtrusive and unstructured questions, and
- The need for checks, extensions, and modifications to be applied (Woods, 2006).

Hannan (2007) advised following the guidelines below when designing a good questionnaire:

- What were you trying to find out?
- Write your own rationale where their opinions in methods were not pre-selected by the research (Hannan, 2007), and
- The design of questionnaires was very important considering each strength and weakness as discussed by Koshy (2005:35).

#### **STRENGTHS:**

- To gather a large amount of data, quickly.
- The data could be expressed statistically through graphs, allowing comparisons with other studies.
- This may have enabled overall statements to be made concerning the sampled population and,

- Allows comparison of responses to specific questions listed (Koshy, 2005).

### **WEAKNESSES:**

- The researcher sets the agenda, not the respondents.
- The questions about complex issues were difficult to compose and responses could be difficult to categorise.
- The short responses often fail to reflect varying depth or complexity of feelings and,
- The questions asked could introduce subjectivity and be biased (ibid).

Koshy (2005:37) suggested that when designing and administering questionnaires to keep the make sure you have the approval to proceed from ethics/research committees, if appropriate, before you move too far with your preparation and that this could take some time”.

He advised the following:

- Know and list all items about which information was required for your research.
- Use word questions when using the questionnaire. These should be written separately on cards to help order them later in the questionnaire.
- In advance decide which question type to be used.

- The wording of each question should be correct.
- Only once you were satisfied with all the questions listed, then organise them into the correct order.
- The instructions given on the questionnaire should always be clear and direct.
- Layout and appearance of the document is important. Instructions must always be clearly presented.
- Check to see whether you needed a right-hand margin for coding.
- Decide on the sampling technique you intend to use.
- Always pilot your questionnaires in advance irrespective of limited time.
- Try out different methods of analysis with the pilot data that was collected.
- Make the necessary adjustments to the questionnaire considering pilot respondents' comments and with your preliminary analysis.
- Think of the distribution of your questionnaire in advance.
- Always check that you knew what you meant by anonymity and confidentiality – and that you made your definitions clear to all your participating respondents.
- Decide what you were going to do about non-respondents before you distributed the questionnaires so that they knew in advance what was to be expected with reference to data collection.

- Remember to mention when your questionnaire when needed to be returned; if possible, give the preferred date and day, which allowed respondents ample time to have completed the questionnaire.
- Always begin to record responses as soon as the completed questionnaires were received back from respondents.
- That researchers had to avoid complicated statistics unless you knew what you were doing and were familiar with the data (Koshy, 2005: 42).

## **(B) INTERVIEWS**

In this study, the researcher employed interviews with the respondents, and later with the music teacher.

Mcbride and Schostak (2006:9) commented that “most of your data will be collected at the interview” For this reason it is imperative to distinguish between the two different interview types: formal and informal interviews.

Mcbride and Schostak (2006:15) further suggested that:

Informal interviews try to engage the interviewee in 'conversations'. The intention is to allow the interviewees to address their own agenda of concerns and interests without imposition by the interviewer. The interviewer may begin with a simple "Can you tell me something about 'x'?" Typically, the interviewee then makes the points perceived as significant, tying them together in a way he or she sees as 'rational'. Informal interviewing may take place under formally agreed conditions; or, it may be

simply a passing conversation. In the latter case, the researcher has to consider the ethical questions associated with using this information.

## THE 'RULES' OF INFORMAL INTERVIEWING

Informal interviewing was more an art form than a 'science'. There were no hard and fast rules. However, there were possible problems that the interviewer needed to be aware of:

- Coming across as being threatening (e.g., adult versus the child; teacher versus the pupil); thus, considering the necessity of engaging in threat-reducing strategies.
- Always avoid situations when the interviewer spoke too much and came across as revealing one's interests in a way that the interviewee 'gives you what you want to hear' - thus leading questions and,
- Never used an audio recorder without consulting the interviewee as this created a level of distrust amongst the respondents – not many people appreciated an interview recording without permission ([www. enquiry learning.net](http://www.enquirylearning.net)).

## STRATEGIES FOR INFORMAL INTERVIEWING

Mcbride and Schostak (2006:15) advised that everyone developed their own style according to their personality. Acting out of character was easily detected. Thus, it

was best to have learned by trial and error, discussions and reflections on what worked, and what did not for the researcher.

Following are different interviewing styles:

- *The provocative style.* This meant some people had what may be called almost an 'attack'. One of the advantages was that it got to the central issues very quickly by provoking responses. It could, however, also set up a level of distrust towards the respondent, a nervousness, which inhibits the interviewee's final responses.
- *The 'I'm on your side' style.* In this case, the interviewer addressed and spoke to copy the image of the interviewee. An advantage was to have established an initial favourable response. However, an unconvincing interviewer may be founded out by the respondent.
- *The 'laid back style.* This style is casual, 'cool', almost clumsy, and clearly no threat to anyone. For this to have happened required a certain attitude of mind, which was foremost non-judgemental, did not indicate a level of anger or animosity or frustration but always indicated an interest in whatever was being said and discussed, no matter how boring or trivial or even shocking the information that was disclosed might be. The only danger about using this technique was that the interviewee did not treat the interviewer seriously at

all. But that, too, was its strength. It could lull the interviewee into revealing what otherwise would have remained hidden or undisclosed, and finally;

- *The social worker/encounter therapy style.* In this style, the interviewer indicating to the respondent 'that's interesting, tell me more' and sets an engaging conversation. This could lead the interviewee to simply give the interviewer what he or she wanted (i.e., what is interesting, I can relate to that, I know what you're saying, I feel the same). It could also be unnerving to some respondents - it may prompt a feeling of being secretly psycho-analysed by the interviewer. Nevertheless, it could build a level of trust where the respondent felt more comfortable disclosing information. It provided an 'ever listening ear' which is useful if that person likes to talk, especially about themselves and the interviewer listens attentively ([www.enquirylearning.net](http://www.enquirylearning.net)).

Another technique when interviewing a respondent/participant was encouraged by Key (1997:3) and involved:

- The researcher controlling his reactions as the purpose of the initial interview was to find out people's views and responses.
- The environment, which always was comfortable and secured for participants to feel at ease in an interview.
- Using questions which were "yes" or "no" as they stifled detail.

- The researcher who was always flexible in his/her approach to the participants and,
- That group interviews were usually useful, particularly within an initial interview.

Kvale (1996:88) recommended using the following seven stages of an interview investigation:

- Thematising – Through formulating the purpose of the investigation and describing the concepts of the topic that was investigated.
- Designing – To have planned the design of the study using all seven stages prior to the interview.
- Transcribing – To always in advance have prepared the interview material of analysis – this usually involved transcribing from an oral speech to the written text.
- Analysing – Prior to the investigation always decided the purpose of the research study to use the correct methods of analysis where appropriate, and which nature of interview material.
- Verifying – Make sure how consistent the results were through reliability and also to see whether the interview study investigated what was intended to be investigated through means of validity.

- Reporting – Always communicated your findings of the study and the methods applied.
- There were certain ethical issues the interviewer had to have in mind when conducting a research project and therefore ensured that the respondents were informed as to the purpose of the research and the level of confidentiality.

### **(C) OBSERVATIONS**

The researcher concluded observations with the respondents in this study, especially with the music teacher, McBride and Schostak (2006:7) suggested that:

The problem here is the issue of what is meant by valid and true. It is a truism that different people make different judgements upon what they see. Observation cannot be separated from the different meanings that actors place upon their actions, the actions of others, the 'stage' upon which they act and the 'props' they use. Thus, in making a representative description of observable characters, events, 'stages' and 'props', it is important to subject that description in some way to the interpretations of the actors involved.

They also advised the following for the researcher to consider:

- Seek occasions when one's understanding of the meaning of a situation could be tested by asking the respondents if the interpretation or understanding was 'correct'.

- Engage respondents in reflection upon a recording and later asking for their interpretations of it, e.g., re-playing a video recording to pupils.

By carrying out such 'tests' on a frequent basis, the researcher ensured that understanding of what was being observed did not differ significantly from those of the respondents. However, rather than one interpretation, the researcher collected many interpretations of a given observation, particularly when was being observed involved an 'us' or 'the' situation. Thus, the observation went hand in hand with interviewing ([www.enquiry learning.net](http://www.enquirylearning.net)).

The two most relevant observation techniques that were used in this research were participant observation and direct observation.

### **PARTICIPANT OBSERVATION:**

- Is the most common method used for qualitative data collection.
- Is one of the most demanding research techniques used today.
- The researcher becomes a participant within a culture or context being observed.
- Participant observation (literature) discusses how to enter the context; the role of the researcher as a participant; the collection and storage of field notes and the analysis of field data.

Participant observation often required months or years of intensive work because the researcher needed time to become accepted as a natural part of the culture in order to ensure that the observations were of the natural phenomenon – time and planning played an imperative role ([www.socialresearchmethods.net](http://www.socialresearchmethods.net)).

Five different types of participant observations were outlined by Key (1997:3):

1. **External Participation** – This entailed the lowest involvement of observations, and usually involved observing participants on television/ videotape.
2. **Passive Participation** – This meant that although the researcher was present at the scene of action, he/she never fully interacted or participated, and assumed the role of a spectator.
3. **Balanced Participation** – This meant that the researcher maintained a balance between being an insider and an outsider. The researcher participated and observed some activities, though did not participate fully in all the activities.
4. **Active Participation** – This meant that the researcher always completed the same tasks as everyone else, and actively engaged in all the activities and,
5. **Total Participation** – The researcher was always a natural participant. This encompassed activities which the researcher enjoyed, and fully engaged in; a

study the researcher particularly took an interest in and already was known as a natural participant (Key, 1997:3).

## **DIRECT OBSERVATIONS**

The differences between participant observations and direct observation were:

- The direct observer never attempted or even tried to become a participant in the context.
  - The direct observer always strived to be as unobtrusive as possible, and unbiased towards the observations.
  - Direct observation suggested more of a detached perspective.
  - The researcher observed instead of participating using technology, which formed part of direct observation. For example, when you videotaped a respondent, the researcher then observed from behind one-way mirrors.
  - A direct observation focussed more than participant observation.
  - The researcher observed certain sampled situations or people rather than tried to become immersed in the entire context.
  - Direct observation took less time than participant observation
- .([www.socialresearchmethods.net](http://www.socialresearchmethods.net) ).

## **(D) CASE STUDIES**

The researcher presented a case study of one High School in Benoni, Johannesburg.

Researchers including Merriam (1988), Stake (1978) and Yin (1981) delineated case study research as a specific type of research associated with qualitative research. To define a case study, you concluded “a form of qualitative research that was focused on giving a detailed account of one or more cases (Johnson and Christensen, 2014). Here references were made to a high school, organisation or even an individual.

A collective case study has been used in this study where one studied multiple cases in one research study according to Johnson and Christensen (2014:585).

### **Characteristics of case studies:**

The following various characteristics could be outlined in case studies:

- Phenomenon was examined in a natural setting.
- Data was collected by multiple means.
- One or few entities (person, group, or organisation) were examined.
- The complexity of the unit was studied intensively.

- Case studies were more suitable for the exploration, classification and hypothesis development stages of the knowledge building process; the investigator had a receptive attitude towards exploration.
- No experimental controls or manipulation were involved.
- The investigator never specified the set of independent, or dependent variables in advance.
- The results derived depended heavily on the integrative powers of the investigator.
- Changes in site selection and data collection methods took place as the investigator developed new hypotheses.
- Case research was useful in the study of "why" and "how" questions because these dealt with operational links traced over time rather than with frequency or incidence.
- The focus was on contemporary events (Benbasat et al., 1987).

### **Questions to consider when conducting a case study**

Following are questions that the researcher considered when concluding case study research:

- Was the phenomenon of interest to be studied outside its natural setting?
- Has the study focussed on contemporary events?

- Was control or manipulation of subjects or events necessary?
- Does the phenomenon of interests enjoy an established theoretical base?  
(Benbasat et al., 1987).

### **The data collection process using case studies**

The data collection process when using case studies differed in terms of:

- Documentation – written material ranging from memoranda or newspaper clippings to formal reports.
- Archival records – organisation charts, service, personnel or financial records.
- Interviews – these may be open-ended or focused.
- Direct observation – absorbing and noting details, actions, or subtleties of the field environment.
- Physical artefacts – devices, outputs, and tools. (Benbasat et al., 1987).

### **(E) SURVEYS**

The researcher employed a survey by completing a detailed questionnaire for all the respondents to answer including the music teacher. Furthermore, as part of the study another survey was concluded through google forms with 30 music teachers within South Africa and globally.

The survey was a process of gathering data that included a variety of data collection methods, which included a questionnaire. Every questionnaire was a survey, but not every survey was a questionnaire.

### **There were different types of surveys**

Here was a list of the various types of surveys the research could possibly have employed in a research project:

- Social media surveys.
- Email surveys.
- Online surveys
- Paper surveys.
- Mobile surveys.
- Phone surveys.
- Face-to-face interview surveys.

### **Benefits gained of using surveys**

The following benefits were notable when using surveys for research:

- Costing was inexpensive.
- Extensive and useful in describing large populations.

- Flexible, which can be administered in various modes. You have various types in a mixed mode where you can apply both, which could be online and on paper surveys to collect and compile results in one data set ready for analysis and,
- Dependable – Anonymity allowed a respondent to answer with candid and valid answers. Anonymous surveys allowed unambiguous responses ([www.snapsurveys.com](http://www.snapsurveys.com)).

### **Advantages of using surveys**

There were several advantages of using surveys within your research:

- High representativeness.
- Low costs.
- Convenient for collecting and gathering data.
- Good statistical significance.
- Little or no observer subjectivity and,
- Precise results ([www.explorable.com](http://www.explorable.com)).

### **Disadvantages of using surveys**

The following disadvantages to using surveys have been outlined:

- Inflexible Design – once you started administering a method you were not allowed to later change the data process later.
- Not ideal for controversial issues and,
- Possible inappropriateness of questions – most surveys were standardised.

The research created questions to have accommodated the general population ([www.explorable.com](http://www.explorable.com)).

### **3.11 SUMMARY**

This study was conducted using mixed methods which employed a mixture of both quantitative and qualitative research design, methods and data collection.

With reference to the research questions that was outlined by Creswell et al.

(2009), the study was predominately a *Sequential Explanatory Design* as illustrated in the following flowchart (see figure 7).

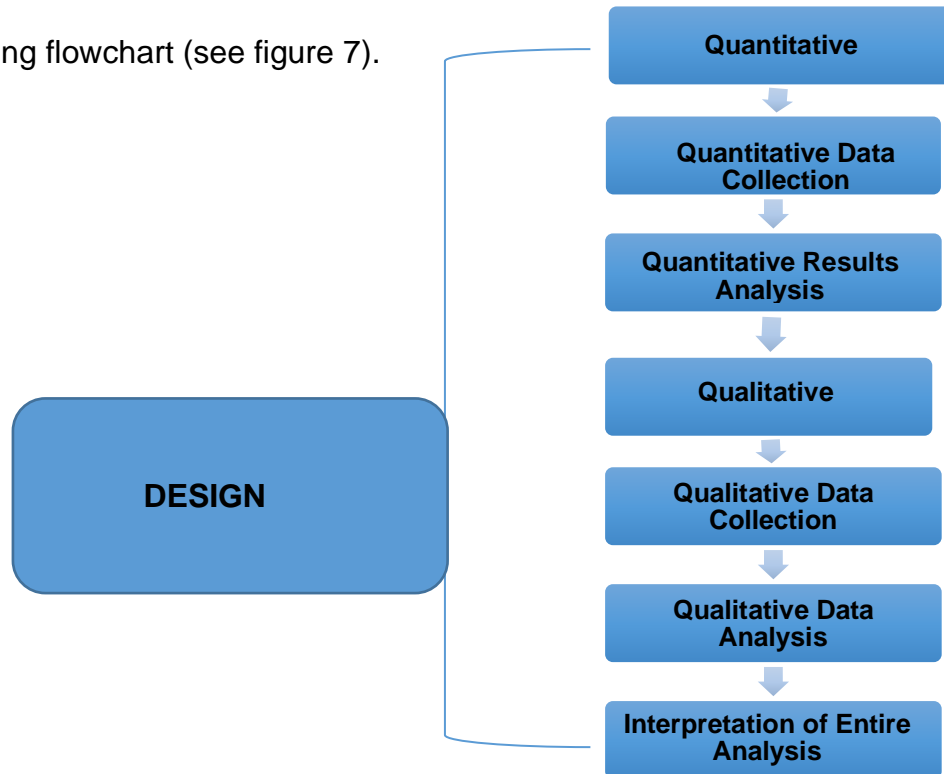


Figure 7: Research Design adapted from Creswell et al. (2009)

Using mixed-method design, obtained information confirmed the final interpretation as indicated in this study:

- a) Produced a justification for every question asked.
- b) Many questions could be close-ended.
- c) The use of open-ended questions was preferable allowing the respondents, to give more information, including feelings, attitudes and understanding of

the subject. This allowed researchers to better access the respondents' true feelings on an issue.

- d) It was concluded that the research questions posed allowed mixed methods to be applied to have answered the questions related to quantitative, with numeric data being obtained, collected and analysed. Having used qualitative research methods collected and analysed to have answered the research questions, which allowed responses of texts and information written down. The entire analysis answered the main research question, in this case whether a correlation was distinguished between music aptitude and mathematical achievement. The main form of data collection methods was questionnaires gathered from the listening tests, observations and interviews. The advantages and disadvantages of each method and technique has been discussed in much detail.

<b>Research questions:</b>	<b>Research method:</b>
Does the AMMA music aptitude test corroborate the mathematical achievement of students?	<i>Quantitative and Qualitative (Mixed Methods)</i>
What are the predominant attitudes and perceptions	<i>Quantitative</i>

concerning the potential relationship between music aptitude and mathematical achievement?	
Can the hypothesis, stemming from the survey, be substantiated, indicating a potential correlation between music aptitude and mathematical achievement?	<i>Quantitative and Qualitative (Mixed Methods)</i>
How effective are the currently available music aptitude testing programs in accurately gauging individuals' musical potential?	<i>Qualitative</i>
How can an appropriate music aptitude test be formulated to provide educational advantages for students within the specific context of South Africa, enhancing their learning outcomes?	<i>Quantitative and Qualitative (Mixed Methods)</i>

*Table 4: Research questions using the correct research methods*

The various techniques assimilated to achieve the data collection have been discussed in-depth, giving the reader an overview of the advantages and disadvantages of using mixed research methods.

The importance of using mixed research methods were discussed in detail with appropriate examples.

The following features were highlighted when using mixed methods research:

- a) The advantages of using this research method in your studies were addressed.
- b) The considerations to be considered when using mixed research methods was outlined.
- c) Defining and conceptualising the research question, and why we employed mixed research methods was justified.
- d) The sample design and methods used during this study was highlighted.
- e) The quantitative phase was discussed in great length with examples.
- f) The qualitative phase was summarised in detail with detailed examples.
- g) The research design used for the concluded study employed mixed research methods.
- h) The data collection methods with sampling strategies were discussed in detail and summarised, and
- i) A comparative study of comparing methodologies of previous research used was referenced and listed clearly.

## CHAPTER 4

### RESULTS: PRESENTATION AND DISCUSSION

*“I see my life in terms of music.” — Albert Einstein*

#### 4. INTRODUCTION

Part of testing and assessing a student was to confirm whether they understood a particular concept that was taught in the music classroom. We worked with children with different IQ levels, educational backgrounds, and learning capabilities. Every child had a right to education, and every child mattered. It was important to emphasize the value of assessments by being consistent and regular in assessing whether a student was on the right path within his/her educational journey, giving parents regular feedback on elaborating their overall progress achieved. The South African assessment policies played a pivotal and equally important role. The Government viewed assessments as an integral part of ensuring that students were tested regularly and feedback with the appropriate reports was shared with parents.

Comparing assessment policies with other countries the following conclusions can be drawn. In the United Kingdom, the assessment for learning reform group for the DfES (2008:3) stated:

Assessment for learning is the process of seeking and interpreting evidence for use by students and their teachers to decide where the students are in their learning, where they need to go and how best to get there. When one analyses the above statement one usually assimilates evidence with data or even results from what students achieved in a particular module or assessment task. One of the aims of assessment for learning as outlined in the DfES (2008:4) is to make an assessment for learning more widespread, systematic and consistent.

The DfES (2008:4) suggested that:

Every child knows how they are doing, and understands what they need to do to improve and how to get there. They get the well-founded judgements about pupils' attainment, understand the concepts and principles of progression, and know how to use their assessment judgements to forward plan, particularly for pupils who are not fulfilling their potential; every school has in place structured and systematic assessment systems for making regular, useful, manageable and accurate assessments of pupils, and for tracking their progress; every parent and carer knows how their child is doing, what they need to do to improve, and how they can support the child and their teachers.

Focusing on the statement mentioned above the following summarise can be concluded:

- That it was imperative for students to know how to have improved and achieved the targets set out by the concerned teachers.
- Teachers should be able to have demonstrated that students knew and were familiar with their target levels, and what they must do in order to have improved their target levels.
- This meant that teachers should be able to monitor students' achievement and what action plan was in place to support these students further.

- That parents, and carers were always informed about any developments regarding the progress of their children's education.

## **4.2 DATA CAPTURING AND ANALYSIS**

The data capturing and analysis using mixed research methods and use of a variety of strategies to collect data both quantitative and qualitative research methods, which was analysed in terms of their age groups, gender, musical abilities, and mathematical achievement. Here the statement of the problem, objectives of the study and research questions were addressed by the data that validated the correlation between music aptitude and mathematical achievement.

### **4.2.1 QUANTITATIVE DATA**

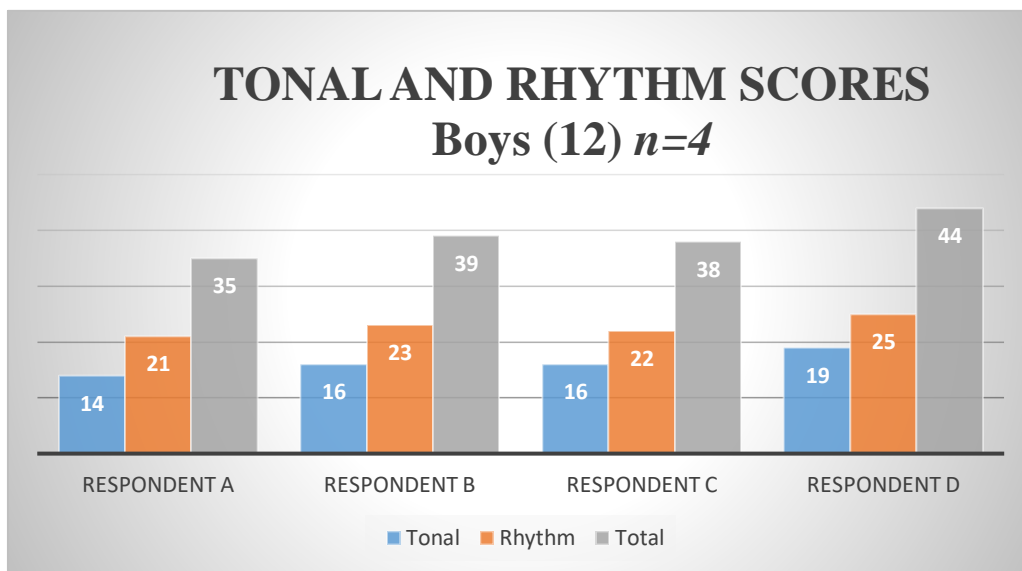
The research used mixed research methods through means of interviews, observations and music aptitude tests with a mathematical assessment as described in Mouton (2001:196). Permission letters (see Appendix B - D) were solicited from parents of students after which the process of data collection began. The data collection was conducted differently from the O'Donnell study. The main form of data collection was by means of group-administered tests (Music listening tests/questionnaires) to the sample of high school students completing the

questionnaires in the form of a test, which took 20 minutes, as part of the first phase of the study. Every student needed to state his or her age, gender, ethnicity, and years of musical tuition. The music listening tests/questionnaire included thirty questions, which ranged across the elements of music; focusing on melody where they heard a first statement being played. They had to compare the first statement with a second. They then had to choose whether the statement in the melody was the same even if there were changes; inevitably it could either be tonal or rhythmic, and they could only choose one.

The researcher tested several candidates from the school but focussed on the six respondents. Each candidate had to complete the AMMA test that was administered within 20 minutes with three sample questions posed at the beginning before starting the official test. The data was then collated by using the guidelines that were provided in the manual. The manual advised that you used all four scoring marks clearly marked Tonal 1 and 2 with Rhythm 1 and 2. Once you had the total for Tonal scores you added 20 marks automatically to column 1 then deducted that mark from Tonal 2. The same applied to Rhythm. When you had added both scores for Tonal and Rhythm you obtained a total mark. These was then compared according to the candidate's musical knowledge either being a non-music major, music major or amateur. These scores would automatically be first converted, and then a percentile score was allocated.

The first part and phase included quantitative data and responses. The second phase included the interview and observation with the respondents providing a detailed qualitative response from all the respondents. The third phase included a follow-up interview with the music teacher. The last phase (fourth) included 30 music teachers from within South Africa (different provinces) and globally, internationally was given a questionnaire to answer questions related to music aptitude and mathematical achievement.

**TONAL AND RHYTHM SCORES FOR LIVERPOOL SECONDARY SCHOOL, JOHANNESBURG BOYS (12) [n=4]**



*Figure 8: Tonal and Rhythm scores of boys aged 12 (n=4) - LSS*

The following data confirmed (which has been converted using Appendix H and I from raw scores) that the boys aged 12 from four samples (n=4), who completed the AMMA test with:

- Respondent A achieved **14** for the tonal score, and **21** for the rhythm scores with a Total of **35**.
- Respondent B achieved **16** for his tonal score, and **23** for his rhythm score with a Total of **39**.
- Respondent C achieved **16** for his tonal score, and **22** for his rhythm scores with a Total of **38**, whilst
- Respondent D achieved 19 for his tonal scores, and **25** for his rhythm scores with a Total of **44** overall.
- Comparing the data conclusion was drawn that the students were more proficient with rhythm instead of tonal.

#### **AVERAGE TONAL AND RHYTHM SCORES BOYS AGED 12 (n=9) - LSS**

The following examples was concluded using the accompanying data to verify the average scores of the students.

<b>Respondents</b>	<b>Age</b>	<b>Tonal</b>	<b>Rhythm</b>	<b>Total</b>

A	12	14	21	35
B	12	16	23	39
C	12	16	22	38
D	12	19	24	43
E	12	19	25	44
F	12	20	25	45
G	12	17	25	42
H	12	19	25	44
I	12	21	25	46
<b>TOTAL</b>		161	215	376
<b>AVERAGE</b>		18	24	42

*Table 5: Average Tonal and Rhythm scores boys aged 11 (n=9) - LSS*

When you compared this data with the Percentile according to the manual of the AMMA test it was concluded and confirmed accordingly with reference to the scores, obtained by the students.

According to the data provided conclusions were drawn that the average score for the (n=9) respondents who were aged 12 resulted of **18** for the Tonal score, and **24** for the Rhythm score respectively with an average of **42** for the Total score.

It was very important to note that the percentile <sup>5</sup>scores would automatically differ entirely as you had to convert your data accordingly. For this reason, the appendix J has been used to convert the total from the percentile score achieved and then given the required converted numbers.

The following percentiles were concluded using the data from the respondents at Liverpool Secondary School. All the boys were aged 12 and achieved higher results for rhythm instead of tonal scores.

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<sup>5</sup> Please note that the Percentile Scores differed mathematically due to converting the data according to the Manual for the Advanced Measures of Music Audiation by Gordon. See Appendix H – I to convert the Percentile scores accordingly.

## PERCENTILE FOR LIVERPOOL SECONDARY SCHOOL BOYS (12) [n=4]

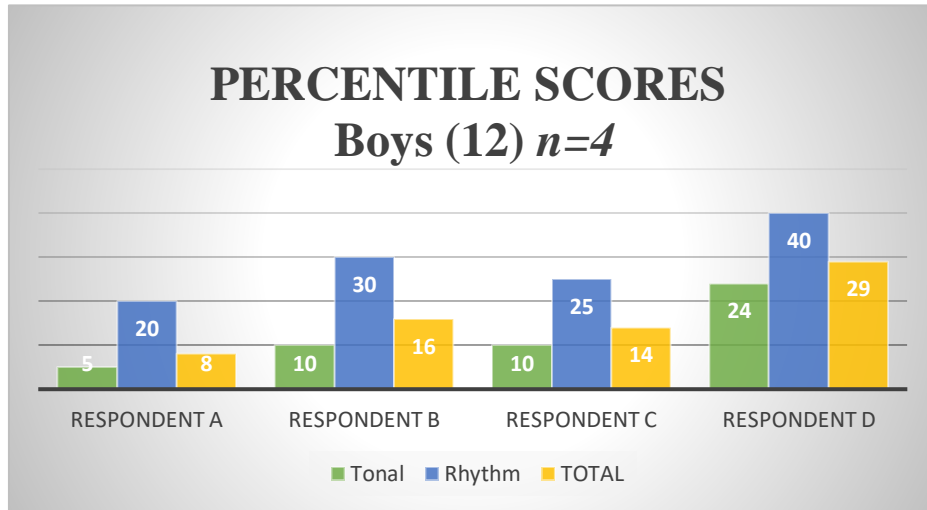


Figure 9: Percentile for Tonal and Rhythm scores boys aged 12 (n=4) - LSS

The following data was presented using the manual for AMMA and working out the Percentiles for four boys aged 12 years. They all achieved the following results:

- Respondent A achieved **5** for his Tonal score, and **20** for his Rhythm score whilst achieving a Total score of **8**.
- Respondent B achieved **10** for his Tonal score, **30** for his Rhythm score achieving an amazing **16** for his Total score.
- Respondent C achieved **10** for his Tonal score, **25** for his Rhythm score achieving **14** for his Total score in terms of Percentile.

- Respondent D achieved **24** for his Tonal score, **40** his Rhythm score, and a total of **29** overall according to the manual as all the students were non-music majors.

**AVERAGE SCORES FOR PERCENTILE FOR STUDENTS AGED 12 YEARS OLD AND BOYS (n=9)**

Respondents	Age	Tonal	Rhythm	Total
A	12	5	20	8
B	12	10	30	16
C	12	10	25	14
D	12	24	40	26
E	12	24	60	48
F	12	29	40	29
G	12	14	40	23
H	12	24	40	29
I	12	34	40	35
TOTAL		174	335	228
AVERAGE		19	37	25

*Table 6: Average Percentile for Tonal and Rhythm scores boys aged 11 (n=9) - LSS*

The following data showed an average score for the (n=9) respondents of 12 years old with the results of **19** for Tonal score, and **37** for Rhythm score respectively with an average of **25** for the Total score. When one compares this data with the Percentile according to the manual of the AMMA test one can conclude the following that the students showed remarkable progress in the Rhythm aspect of the test.

### TONAL AND RHYTHM SCORES FOR GIRLS (12) [n=8] LSS

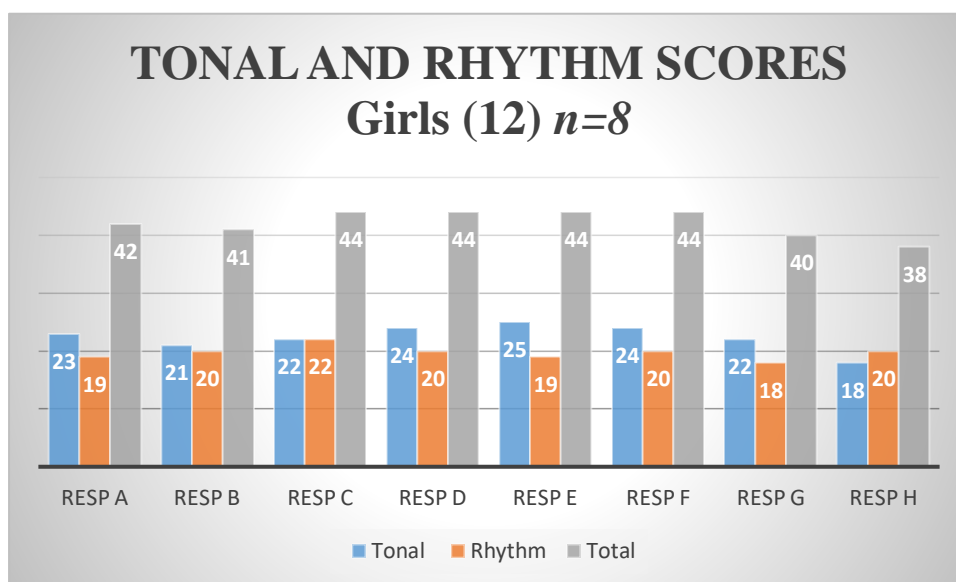


Figure 10: Tonal and Rhythm scores girls aged 12 (n=8) - LSS

From the eight respondents of the girls aged 12 the following conclusions can be made:

These were concluded converting raw scores using appendix H and I and converting the raw scores.

- Respondent A achieved **23** for her tonal score, **19** for her rhythm score and a Total score of **42**.
- Respondent B achieved **21** for her Tonal score, **20** for her Rhythm score and a Total score of **41**.
- Respondent C achieved **22** for her tonal score, **22** for her rhythm score and a Total score of **44**.
- Respondent D achieved **24** for her tonal Score, **20** for her rhythm score and a Total score of **44**.
- Respondent E achieved **25** for her tonal score, **10** for her rhythm score and a Total score of **44**.
- Respondent F achieved **24** for her tonal score, **20** for her rhythm score and a Total score of **44**.
- Respondent G achieved **22** for her tonal score, **18** for her rhythm score and a Total score of **40**.
- Respondent H achieved **18** for her tonal score, **20** for her rhythm score and a Total score of **38**.

## AVERAGE SCORES FOR TONAL AND RHYTHM SCORES FOR GIRLS AGED

12 (n=4) - LSS

Respondents	Age	Tonal	Rhythm	Total
A	12	23	19	42
B	12	21	20	41
C	12	22	22	44
D	12	24	20	44
<b>TOTAL</b>		90	81	171
<b>AVERAGE</b>		23	20	43

*Table 7: Average Scores for Tonal and Rhythm scores for girls aged 12 (n=4) - LSS*

When you compared their data with the Percentile according to the manual of the AMMA test the following conclusions can be drawn with reference to the scores the student obtained.

According to the data provided the following conclusions were drawn with an average score for the female (n=4) respondents, who were aged 12 with the result

of **23** for the Tonal score and **20** for Rhythm score respectively with an average of **43** for the Total score.

### PERCENTILE FOR GIRLS LIVERPOOL SECONDARY SCHOOL (12) [n=8]

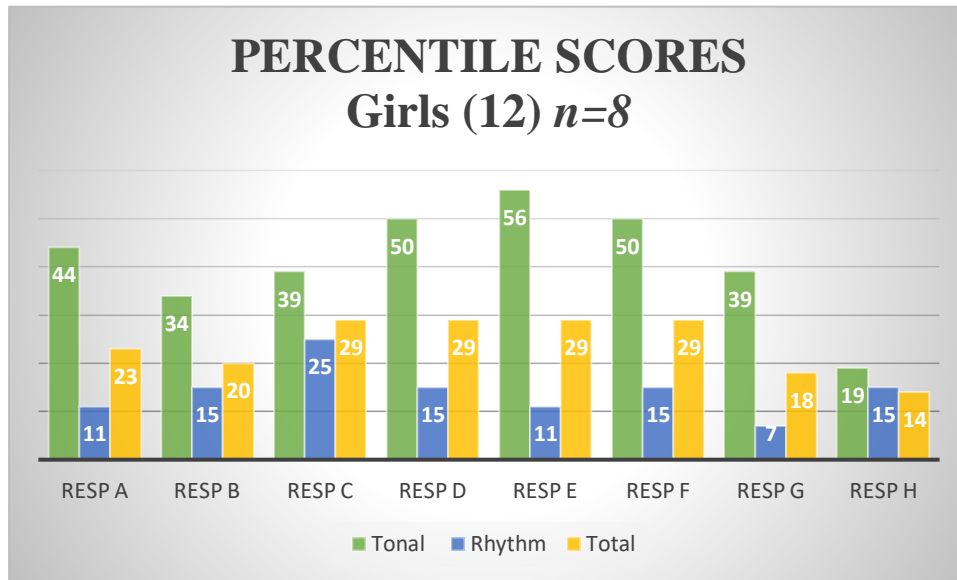


Figure 11: Percentile scores for Tonal and Rhythm girls aged 12 (n=8) - LSS

The following percentiles was concluded with the data from the respondents at Liverpool Secondary School. All the girls (n=8) were aged 12 and achieved higher results for Tonal instead of Rhythm scores. This conclusion was drawn by converting the raw scores and taking the totals and converting them further, using the required scores as indicated in the AMMA manual (see Appendix J):

- Respondent A achieved **44** for Tonal score, and **11** for his Rhythm score achieving a Total score of **23**.

- Respondent B achieved **34** for his Tonal score, and **15** for his Rhythm score achieving a remarkable **20** for his Total score.
- Respondent C achieved **39** for his Tonal score and **25** for his Rhythm score achieving **29** for his Total score in terms of Percentile.
- Respondent D achieved **39** for his Tonal score, and **25** for his Rhythm score achieving **29** for his Total score in terms of Percentile.
- Respondent E achieved **56** for his Tonal score achieving **11** for his Rhythm score, and with a total of **29** overall according to the manual as all the students were non-music majors according to the percentile calculations in the manual.
- Respondent F achieved **50** for his Tonal score, and **15** for his Rhythm score achieving a remarkable **29** for his Total score.
- Respondent G achieved **39** for his Tonal score, and **7** for his Rhythm score achieving **18** for his Total score in terms of Percentile.
- Respondent H achieved **19** for his Tonal score, and **15** for his Rhythm score achieving **14** for his Total score in terms of Percentile.

### AVERAGE FOR PERCENTILE FOR BOYS AND GIRLS AGED 12 (n=4)

Respondents	Age	Tonal	Rhythm	Total
A	12	44	11	23
B	12	34	15	20
C	12	39	25	29
D	12	50	15	29
<b>TOTAL</b>		167	66	101
<b>AVERAGE</b>		42	17	25

*Table 8: Average scores for Percentile for boys and girls aged 12 (n=4) - LSS*

The following data showed an average score for the female (n=4) respondents, who were aged 12 with the result of **42** for Tonal score, and **17** for Rhythm score respectively with an average of **25** for the Total score. When you compared the data with the Percentile according to the manual of the AMMA test the following conclusion was drawn that the students achieved excellent results in the Tonal section, which was by far superior.

## COMPARING BOYS WITH THE GIRLS' TONAL AND RHYTHM (LSS- 12) n=6

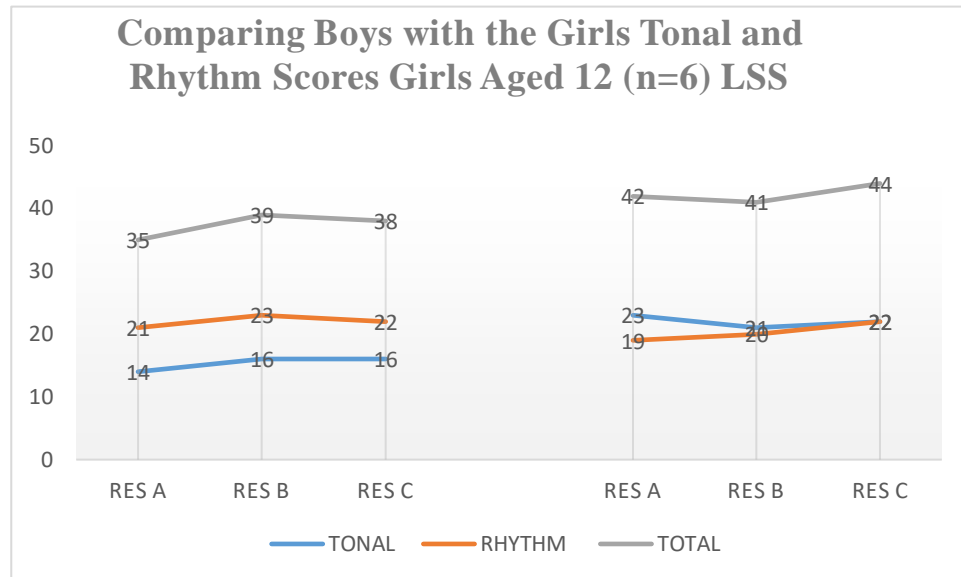


Figure 12: Comparing boys with the girls Tonal and Rhythm scores girls aged 12 (n=6)  
LSS

Comparing the data of both sexes of Liverpool Secondary in Johannesburg, the following conclusion was made:

- Data of the first three respondents of each gender, revealed after comparing their tonal and rhythm scores, and totals that the boys were more proficient in the Rhythm section compared to the girls. The boys achieved **23** for their rhythm scores (**Respondent B**).
- The girls were more proficient in the Tonal section of the AMMA test in comparison with the boys of the same ages. The girls achieved **23** for their Tonal scores (**Respondent A**).

- The totals of the girls were much higher than those of the boys comparing the data of the first three respondents of each gender. The boys achieved **39 (Respondent B)** whilst the girls achieved **44 (Respondent C)** with a difference of 5.

### COMPARING THE PERCENTILES OF THE BOYS AND GIRLS (12) [n=6], LSS

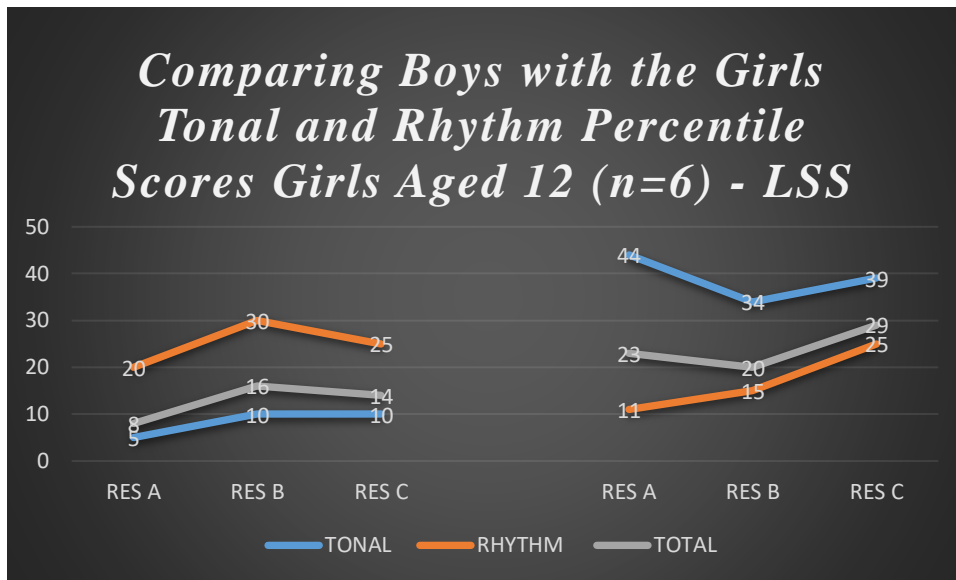


Figure 13: Comparing boys with the girls Tonal and Rhythm Percentile scores girls aged 12 (n=6) - LSS

Comparing the data of both sexes of Liverpool Secondary School the following confirmations were concluded:

Taking the first three respondents of each gender the data revealed after comparing their tonal and rhythm scores and totals that the girls were more proficient in the

Tonal section compared with the boys. The boys achieved **44** for their Tonal scores (*Respondent A*).

- The girls were more proficient in the Rhythm section of the AMMA test in comparison with the boys their age. The girls achieved **30** for their Rhythm scores (*Respondent B*).
- The totals of the girl's percentile was much higher than those of the boys comparing the data of the first three respondents of each gender. The boys achieved **16** whilst the girls achieved **29** with a difference of **13**.

#### TONAL AND RHYTHM SCORES FOR BOYS AGED (13) [n=4], LSS

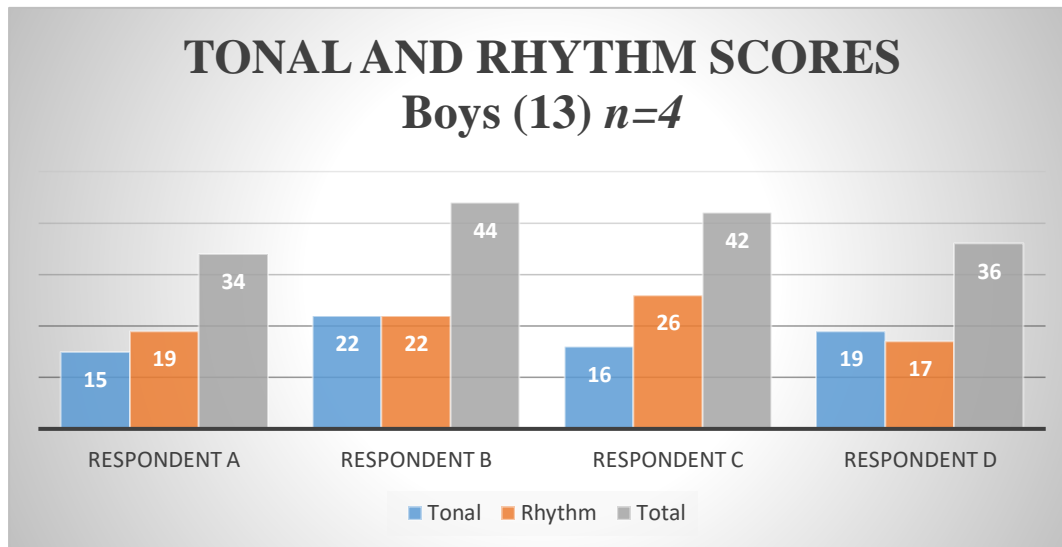


Figure 14: Tonal and Rhythm boys aged 13 (n=4) - LSS

The following data confirmed that the boys aged 13 from four samples (n=4), who completed the AMMA test (please check Appendix H – J as the raw scores were already converted and added up):

- Respondent A achieved **15** for the tonal score, and **19** for the rhythm score with a Total of **34**.
- Respondent B achieved **22** for his tonal score, and **22** for his rhythm score with a Total of **44**.
- Respondent C achieved **16** for his tonal score, and **26** for his rhythm score with a Total of **42** whilst Respondent D achieved **19** for his tonal score and **17** for his rhythm scores with a Total of **36** overall. Comparing the data one can conclude that the students were more proficient with rhythm than tonal.

**AVERAGE FOR TONAL AND RHYTHM FOR BOYS AGED 13 (n=5), LSS**

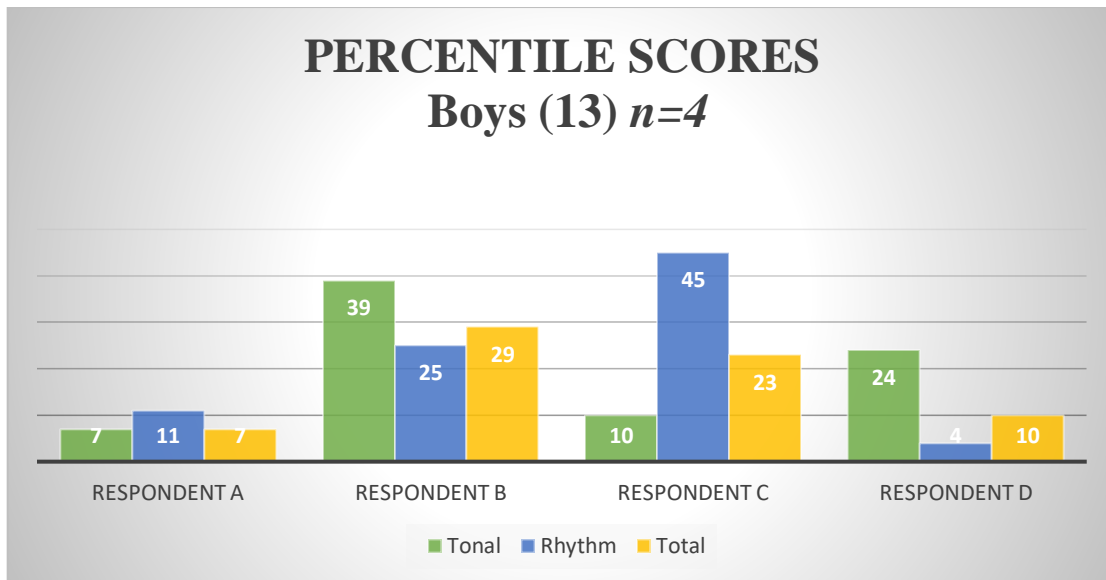
<b>Respondents</b>	<b>Age</b>	<b>Tonal</b>	<b>Rhythm</b>	<b>Total</b>
A	13	15	19	34
B	13	22	22	44

C	13	16	26	42
D	13	19	17	36
E	13	23	22	45
<b>TOTAL</b>		95	106	201
<b>AVERAGE</b>		19	22	41

*Table 9: Average scores for Tonal and Rhythm for boys aged 13 (n=5) - LSS*

The following data showed an average score for the (n=5) respondents, which were aged 13 with the result of **19** for Tonal score and **22** for Rhythm score respectively with an average of **41** for the Total score. When one compared this data with the Percentile according to the manual of the AMMA test the following conclusion were drawn.

## PERCENTILE SCORES FOR BOYS (13) [n=4], LSS



*Figure 15: Percentile scores of Tonal and Rhythm boys aged 13 (n=4) – LSS*

In this study the scores were converted taking the raw scores the students achieved and converting them using Appendix H and J finding the total and converting the data using Appendix I:

- Respondent A achieved **7** for his Tonal score, **11** for his Rhythm score whilst achieving a Total score of **7**.
- Respondent B achieved **39** for his Tonal score, and **25** for his Rhythm score whilst achieving a remarkable **29** for his Total score.
- Respondent C achieved **10** for his Tonal score, and **45** for his Rhythm score whilst achieving **23** for his Total score in terms of Percentile.

- Respondent D achieved **24** for his Tonal score whilst achieving **4** for his Rhythm score and with a Total of **10** overall according to the manual as all the students were non music majors according to the percentile calculations in the manual.

**AVERAGE SCORES FOR PERCENTILE FOR BOY STUDENTS AGED 13 (n=6),**

**LSS**

<b>Respondents</b>	<b>Age</b>	<b>Tonal</b>	<b>Rhythm</b>	<b>Total</b>
A	13	7	11	7
B	13	35	25	29
C	13	10	45	23
D	13	24	4	10
E	13	29	35	29
F	13	24	30	26
<b>TOTAL</b>		129	150	124

AVERAGE		22	25	21
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Table 10: Average scores for Tonal and Rhythm for boys aged 13 (n=6) - LSS

The following data showed an average score for the (n=6) respondents of 13 years old with the results of **22** for Tonal score, and **25** for Rhythm score respectively with an average of **21** for the Total score. When you compared this data with the Percentile according to the manual of the AMMA test one can conclude the following that the students showed immense progress in the Rhythm section of the test.

### TONAL AND RHYTHM SCORES GIRLS (13) [n=5], LSS

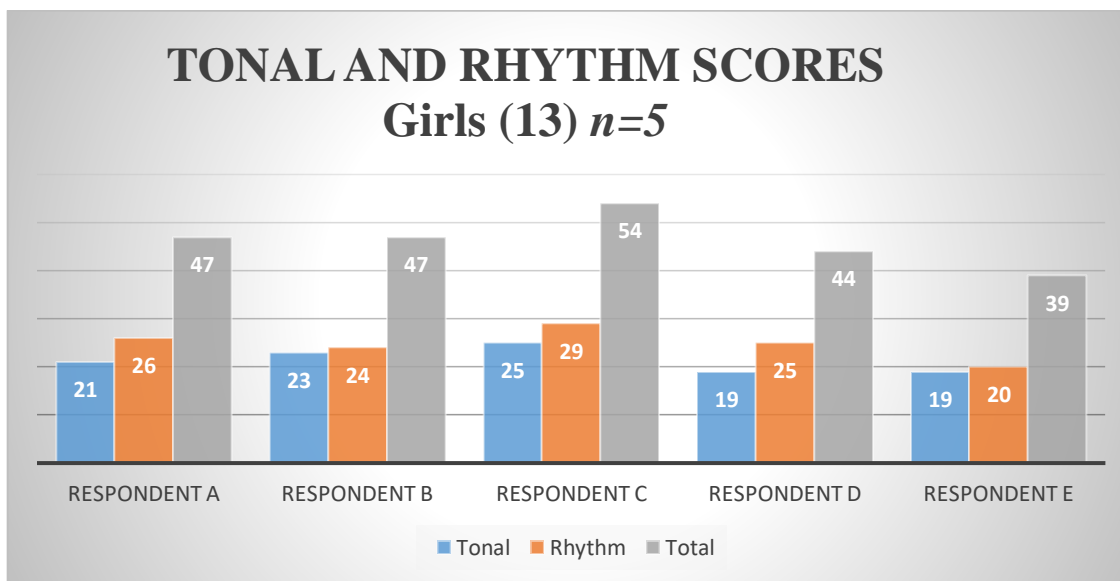


Figure 16: Tonal and Rhythm scores for girls aged 13 (n=5) - LSS

The following data confirmed that the girls aged 13 from five samples (n=5), who completed the AMMA test made:

- Respondent A achieved **21** for the tonal score, **26** for the rhythm scores with a Total of **47**.
- Respondent B achieved **23** for her tonal score, **24** for her rhythm scores with a Total of **47**.
- Respondent C achieved **25** for her tonal score, **29** for her rhythm scores with a Total of **54** whilst Respondent D achieved **19** for her tonal scores and **25** for his rhythm scores with a Total of **44** overall.
- Respondent E achieved **19** for her tonal scores, and **20** for her rhythm scores with a Total of **39** overall.
- Comparing the data one can conclude that the students were more proficient with rhythm instead of tonal.

#### **AVERAGE RHYTHM AND TONAL SCORES GIRLS AGED 13 (n=7), LSS**

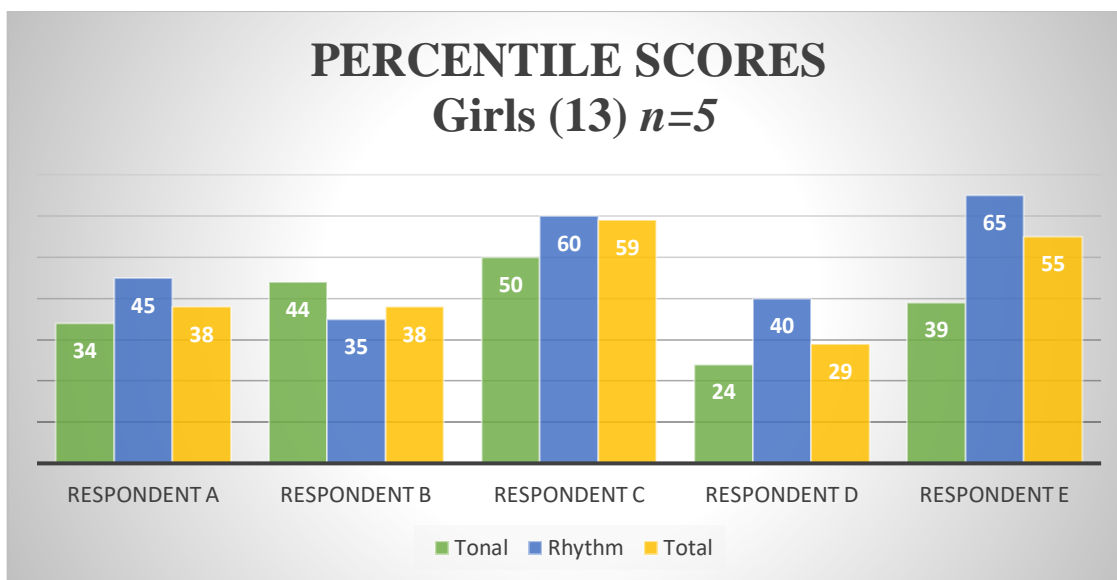
<b>Respondents</b>	<b>Age</b>	<b>Tonal</b>	<b>Rhythm</b>	<b>Total</b>
A	13	21	26	47
B	13	23	24	47

C	13	25	29	54
D	13	19	25	44
E	13	22	30	55
F	13	18	23	40
G	13	20	22	42
<b>TOTAL</b>		148	179	329
<b>AVERAGE</b>		21	26	47

*Table 11: Average scores for Tonal and Rhythm for girls aged 13 (n=7) - LSS*

The following data can show an average score for the female (n=7) respondents, who were aged 13 with the result of **21** for Tonal score and **26** for Rhythm score respectively with an average of **47** for the Total score. When one compares this data with the Percentile according to the manual of the AMMA test one can conclude the following:

## PERCENTILE SCORES FOR GIRLS (13) [n=5]



*Figure 17: Percentile scores of Tonal and Rhythm girls aged 13 (n=5) – LSS*

The following data presented using the manual for AMMA and working out the Percentiles for five girls aged 13 years. Here the raw scores were converted using the manual and Appendix H and I with the total being converted from Appendix J. They all achieved the following results:

- Respondent A achieved **34** for their Tonal score, **45** for her Rhythm score whilst achieving a Total score of **38**.
- Respondent B achieved **44** for her Tonal score, **35** for her Rhythm score whilst achieving an amazing **38** for his Total score.

- Respondent C achieved **50** for her Tonal score, **60** for her Rhythm score whilst achieving **59** for his Total score in terms of Percentile.
- Responded D achieved **24** for her Tonal score, **40** for her Rhythm score whilst achieving **29** for her Total score in terms of Percentile.
- Respondent E achieved **39** for her Tonal score whilst achieving **65** her Rhythm score and with a total of **55** overall according to the manual as all the students were non-music majors according to the percentile calculations in the manual.

**AVERAGE PERCENTILE FOR GIRLS AGED 13 (n=7), LIVERPOOL SECONDARY SCHOOL**

<b>Respondents</b>	<b>Age</b>	<b>Tonal</b>	<b>Rhythm</b>	<b>Total</b>
A	13	34	45	38
B	13	44	35	38
C	13	50	60	59
D	13	24	40	29

E	13	39	65	55
F	13	19	30	18
G	13	29	25	23
<b>TOTAL</b>		239	300	260
<b>AVERAGE</b>		34	43	37

*Table 12: Average Percentile for girls aged 13 (n=7), LSS*

The following data showed an average score for the (n=7) respondents 13 years old with the results of **34** for Tonal Score, and **43** for Rhythm score respectively with an average of **37** for the Total score. When you compared this data with the Percentile according to the manual of the AMMA test one can conclude that the students showed immense progress in the Rhythm section of the test.

## COMPARING BOYS WITH THE GIRLS' TONAL AND RHYTHM (LSS - 13) n=6

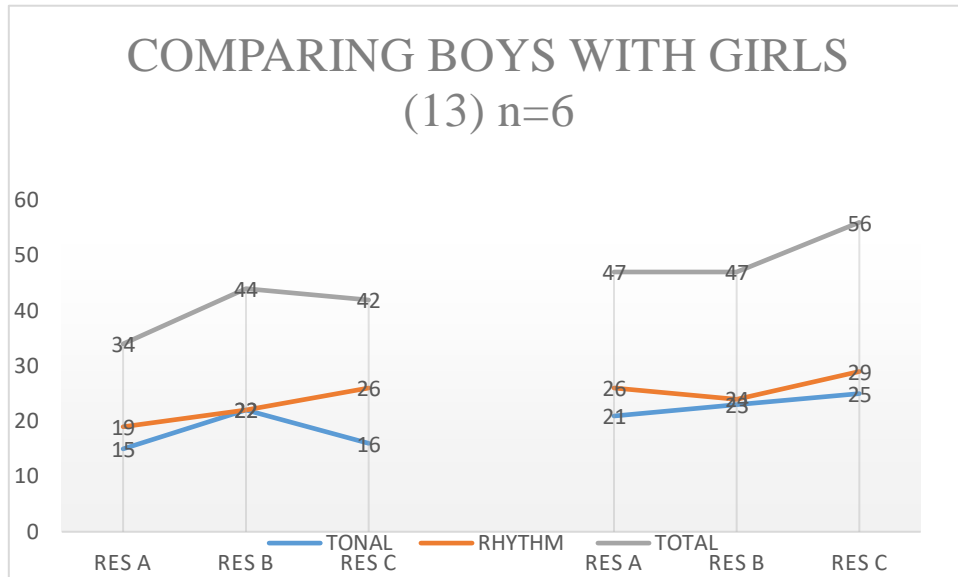


Figure 18: Comparing boys with the girls Tonal and Rhythm scores aged 13 (n=6) - LSS

Comparing the data of both sexes of Liverpool Secondary School in Benoni, the following confirmations can be made:

- Taking the first three respondents of each gender the data revealed after comparing their tonal and rhythm scores and totals that the girls were more proficient in the Rhythm section compared with the boys. The girls achieved **29** for their rhythm scores (**Respondent C**).
- The girls were more proficient in the Tonal section of the AMMA test in comparison with the boys their ages. The girls achieved **25** for their Tonal scores (**Respondent C**).

- The totals of the girls were much higher than those of the boys comparing the data of the first three respondents of each gender. The boys achieved **44 (Respondent B)** whilst the girls achieved **54 (Respondent C)** with a difference of 10.

### COMPARING THE PERCENTILES OF THE BOYS AND GIRLS (13) [n=6], LSS

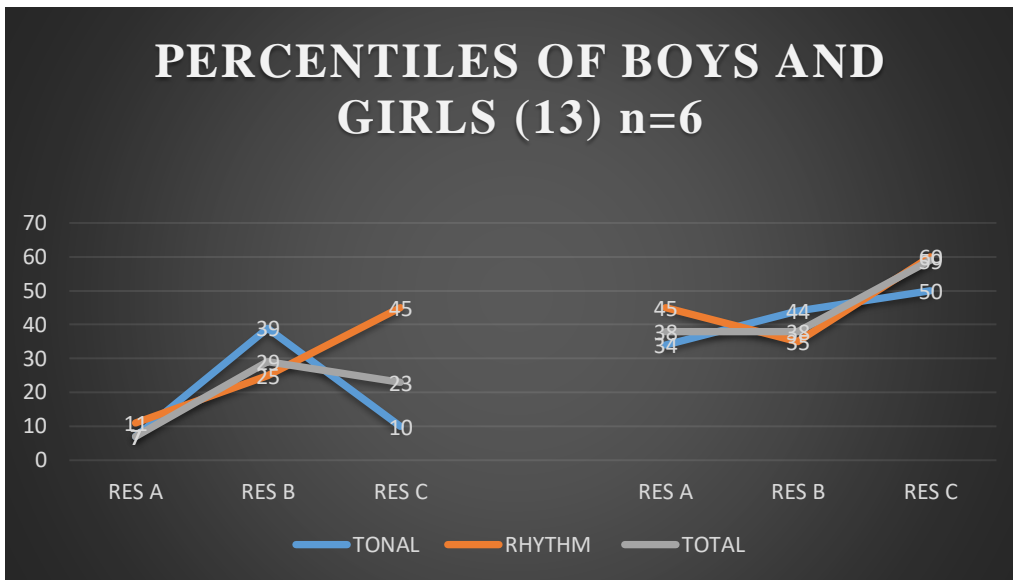


Figure 19: Comparing Percentile of boys with the girls Tonal and Rhythm scores aged 13 - LSS

Comparing the data of both sexes of Liverpool Secondary School, the following confirmations can be made:

- Taking the first three respondents of each gender the data revealed after comparing their tonal and rhythm scores, and totals that the girls were more

proficient in the Rhythm section compared with the boys. The boys achieved **39** for their Tonal scores (**Respondent B**).

- The girls were more proficient in the Rhythm section of the AMMA test in comparison with the boys their age. The girls achieved **60** for their Rhythm scores (**Respondent C**).
- The totals of the boys' percentile were much higher than those of the girls, comparing the data of the first three respondents of each gender. The girls achieved 59 whilst the boys achieved 29 with a difference of 30.

#### BOYS TONAL AND RHYTHM SCORES AGED (14) [n=3], LSS

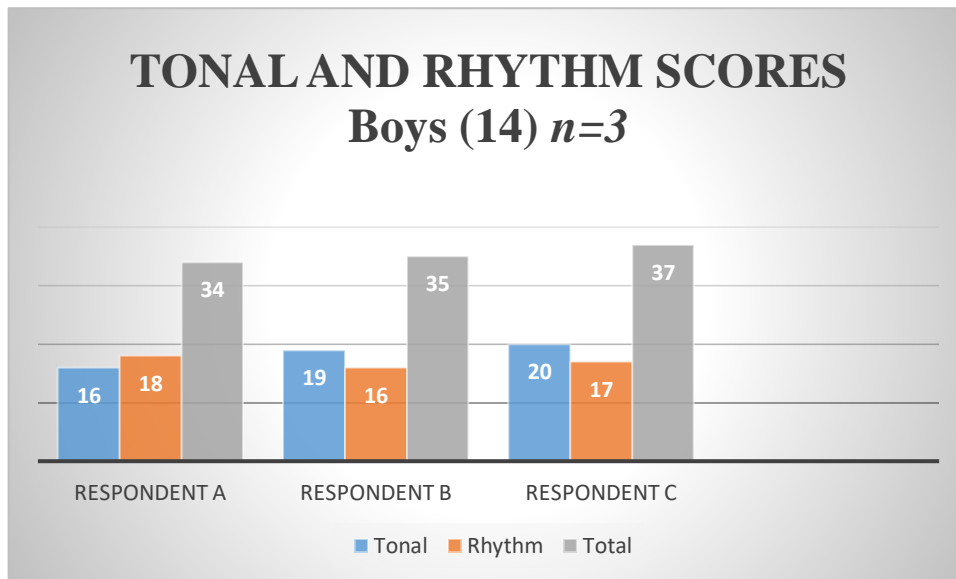


Figure 20: Tonal and Rhythm scores for boys aged 14 (n=3) – LSS

The following data confirmed that the girls aged 14 from four samples (n=3), who completed the AMMA test with Respondent A achieved **16** for the tonal score, and **18** for the rhythm scores with a Total of **34**. Respondent B achieved **19** for his tonal score, and **16** for his rhythm scores with a Total of **35**. Respondent C achieved **20** for his tonal score, and **17** for his rhythm scores with a Total of **37** overall. Comparing the data concluded that the students were more proficient with tonal instead of rhythm.

#### THE AVERAGE OF TONAL AND RHYTHM SCORES BOYS (14) [n=6], LSS

Respondents	Age	Tonal	Rhythm	Total
A	14	16	18	34
B	14	19	16	35
C	14	20	17	37
D	14	21	19	40
E	14	19	18	37
F	14	18	20	38

<b>TOTAL</b>		113	108	221
<b>AVERAGE</b>		19	18	37

Table 13: Average scores for Tonal and Rhythm for boys aged 14 (n=6) – LSS

The following data can show an average score for the (n=6) respondents of 14 years old boys with the results of **19** for Tonal score, and **18** for Rhythm score respectively with an average of **37** for the Total score. When you compared this data with the Percentile according to the manual of the AMMA test concluded that the students showed immense progress in both the Tonal and Rhythm aspect of the test.

#### PERCENTILES OF BOYS (14) [n=3], LIVERPOOL SECONDARY SCHOOL

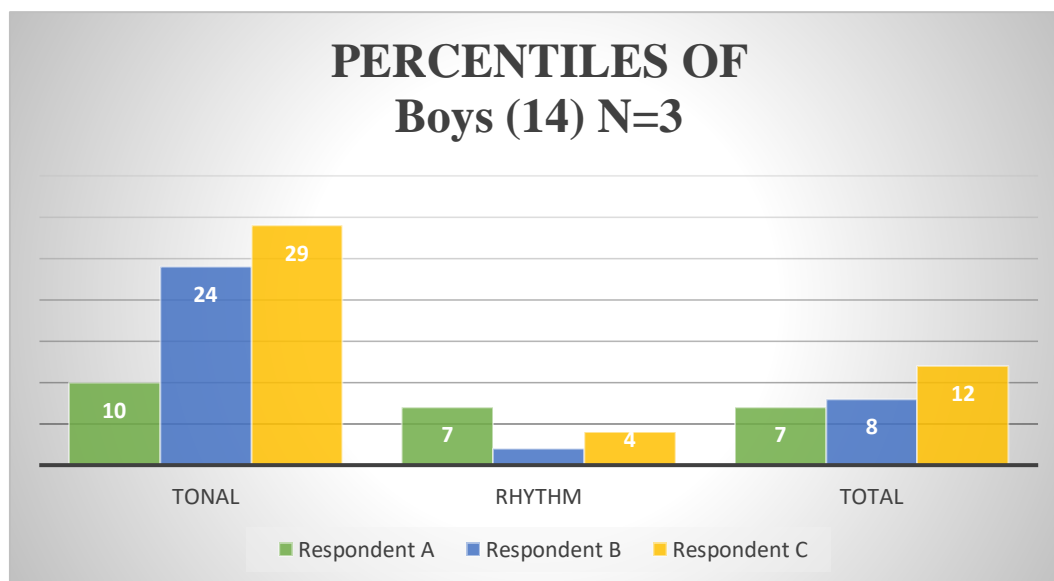


Figure 21: Percentile scores for Tonal and Rhythm boys aged 14 (n=3) – LSS

The following data presented using the manual for AMMA and working out the Percentiles for three boys aged 14 years. Here the data, and raw scores were converted using Appendix H and I, and getting the totals, which were transferred from using Appendix J. They all achieved the following results:

- Respondent A achieved **10** for their Tonal score, **7** for his Rhythm score whilst achieving a Total score of **7**.
- Respondent B achieved **24** for his Tonal score, **2** for his Rhythm score achieving an amazing **8** for his Total score.
- Respondent C achieved **29** for his Tonal score whilst achieving **4** for his Rhythm score, and with a total of **12** overall according to the manual as all the students were high school students according to the percentile calculations in the manual, and achieved higher results overall for the Tonal section in comparison with the Rhythm section.

**AVERAGE PERCENTILES OF TONAL AND RHYTHM SCORES BOYS (14) [n=6],  
LSS**

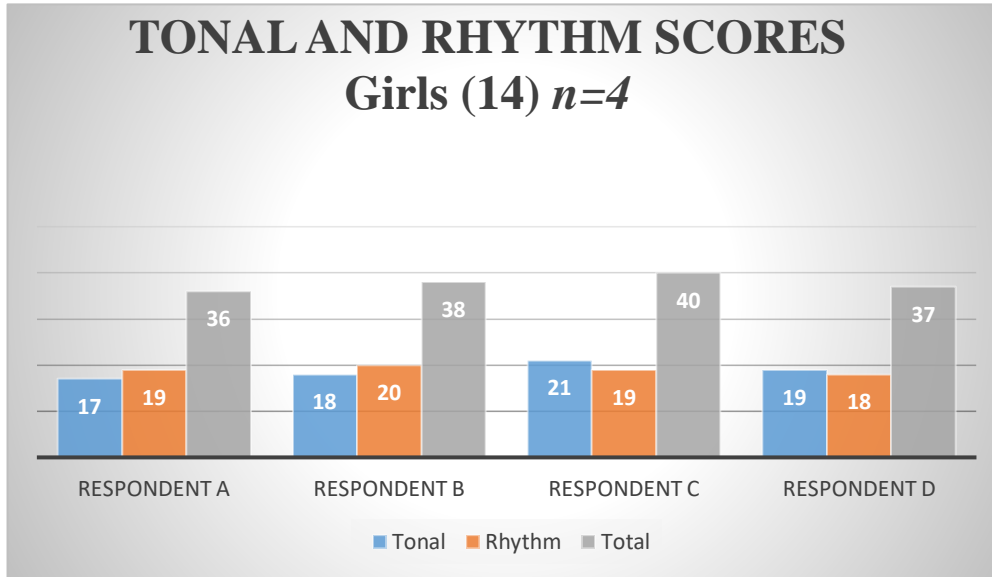
<b>Respondents</b>	<b>Age</b>	<b>Tonal</b>	<b>Rhythm</b>	<b>Total</b>
A	14	10	7	7

B	14	24	2	8
C	14	29	4	12
D	14	34	11	18
E	14	24	7	12
F	14	19	15	14
<b>TOTAL</b>		140	46	71
<b>AVERAGE</b>		25	8	12

*Table 14: Average Percentile scores for Tonal and Rhythm for boys aged 14 (n=6)*

The following data showed an average score for the (n=6) respondents of 14 years old with the results of **25** for Tonal score, and **8** for Rhythm score respectively with an average of **12** for the Total score. When you compared this data with the Percentile according to the manual of the AMMA test the following concluded that the students showed remarkable progress in the Tonal section of the test.

## GIRLS TONAL AND RHYTHM SCORES AGED (14) [n=4], LIVERPOOL SECONDARY SCHOOL



*Figure 22: Tonal and Rhythm scores for girls aged 14 (n=4) – LSS*

The following data confirmed that the girls aged 14 from four samples (n=4), who completed the AMMA test with Respondent A achieved **17** for the tonal score, and **19** for the rhythm scores with a Total of **36**. Respondent B achieved **18** for his tonal score, and **20** for his rhythm scores with a Total of **38**. Respondent C achieved **21** for his tonal score, and **19** for his rhythm scores with a Total of **40**. Respondent D achieved **19** for his tonal Score, and **18** for his rhythm Scores with a Total of **37** overall. Comparing the data, the conclusion was that the students were more proficient with tonal instead of rhythm.

**AVERAGE OF TONAL AND RHYTHM SCORES GIRLS (13) [n=6], LIVERPOOL  
SECONDARY SCHOOL**

<b>Respondents</b>	<b>Age</b>	<b>Tonal</b>	<b>Rhythm</b>	<b>Total</b>
A	14	17	19	36
B	14	18	20	38
C	14	21	19	40
D	14	19	18	37
E	14	20	20	40
F	14	19	20	39
<b>TOTAL</b>		114	116	230
<b>AVERAGE</b>		19	19	38

*Table 15: Average scores for Tonal and Rhythm for boys aged 14 (n=6) – LSS*

The following data showed an average score for the (n=6) respondents of 14 years with the results of **19** for Tonal score, and **19** for Rhythm score respectively with an average of **38** for the Total score. When you compared this data with the Percentile

according to the manual of the AMMA test, data concluded that the students showed remarkable progress in both the Tonal and Rhythm aspects of the test.

### PERCENTILES OF Girls (13) [n=4], LIVERPOOL SECONDARY SCHOOL

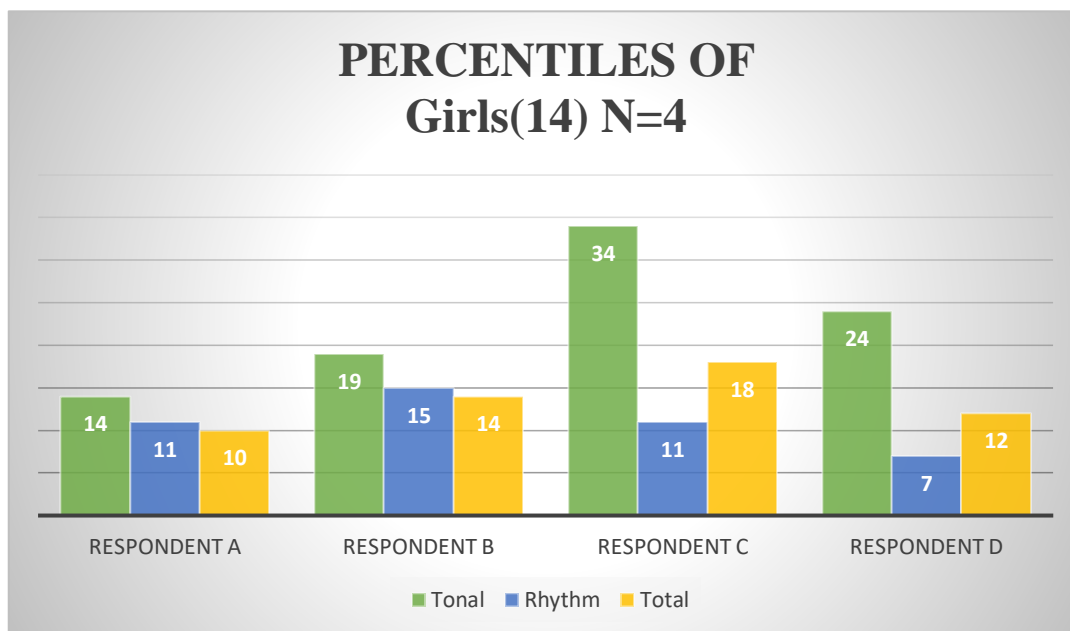


Figure 23: Percentile scores for Tonal and Rhythm girls aged 14 (n=4) – LSS

The following data presented using the manual for AMMA and working out the Percentiles for four girls aged 14 years. The data was converted using raw scores as outlined in Appendix H – J. They all achieved the following results:

- Respondent A achieved **14** for their Tonal score, **11** for his Rhythm score achieving a Total score of **10**.

- Respondent B achieved **19** for his Tonal score, **15** for his Rhythm score achieving a remarkable **14** for his Total score.
- Respondent C achieved **34** for his Tonal score, **11** for his Rhythm score whilst achieving an amazing **18** for his Total score.
- Respondent D achieved **24** for his Tonal score whilst achieving **7** for his Rhythm score and with a total of **12** overall according to the manual as all the students were high school students according to the percentile calculations in the manual and achieved higher results overall for the Tonal section in comparison with Rhythm section.

#### **AVERAGE PERCENTILES OF TONAL AND RHYTHM SCORES GIRLS (14)**

**[n=6], LIVERPOOL SECONDARY SCHOOL**

<b>Respondents</b>	<b>Age</b>	<b>Tonal</b>	<b>Rhythm</b>	<b>Total</b>
A	14	14	11	10
B	14	19	15	14
C	14	34	11	18
D	14	24	7	12

E	14	29	15	18
F	14	24	15	16
<b>TOTAL</b>		144	74	88
<b>AVERAGE</b>		24	12	15

Table 16: Average Percentile scores for Tonal and Rhythm for girls aged 14 (n=6) –

LSS

The following data showed an average score for the (n=6) respondents of 14 years old with the results of **24** for Tonal score, **12** for Rhythm score respectively with an average of **15** for the Total score. When you compared this data with the Percentile according to the manual of the AMMA test, you concluded that the students showed remarkable progress in the Tonal section of the test.

## COMPARING BOYS WITH THE GIRLS' TONAL AND RHYTHM (LSS- 14) N=6

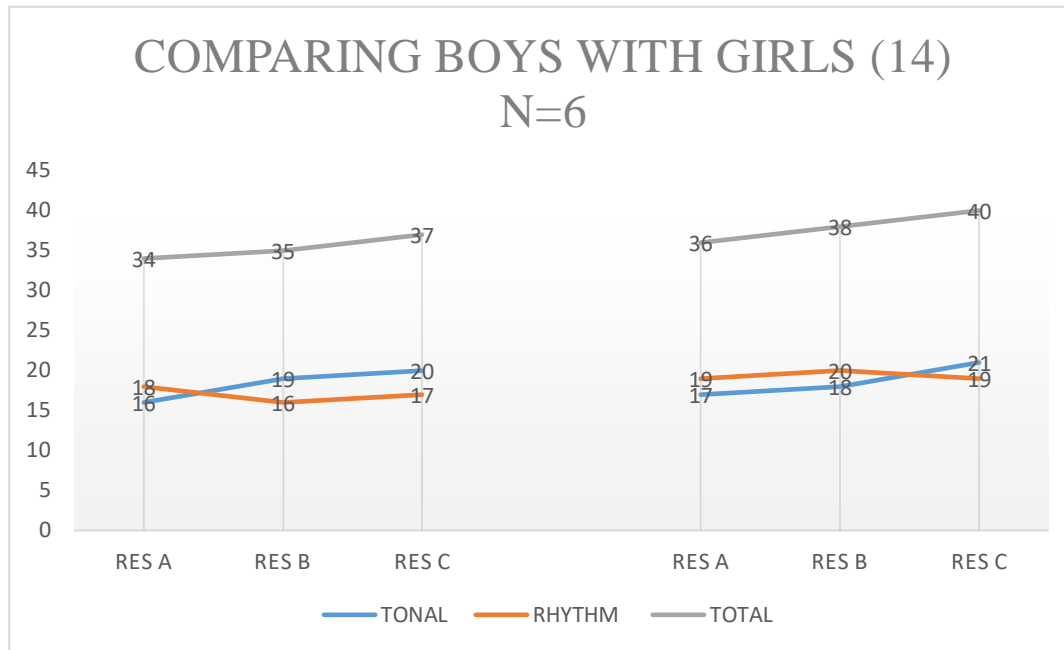


Figure 24: Comparing boys with girls Tonal and Rhythm scores aged 14 (n=6) – LS

Comparing the data of both sexes of Liverpool Secondary School in Johannesburg, the following conclusions can be made:

- The first three respondents of each gender, the data revealed after comparing their tonal and rhythm scores, and totals that the girls were more proficient in the Tonal section compared to the boys. The girls achieved **21** for their Tonal scores (**Respondent C**).

- The girls were more proficient in the Rhythm section of the AMMA in comparison with the boys. The girls achieved **20** for their Tonal scores (**Respondent B**).
- The totals of the girls were much higher than those of the boys comparing the data of the first three respondents of each gender. The girls achieved **40** (**Respondent C**) whilst the boys achieved **37** (**Respondents C**) with a difference of 3.

### COMPARING THE PERCENTILES OF THE BOYS AND GIRLS (14) [n=6], LSS

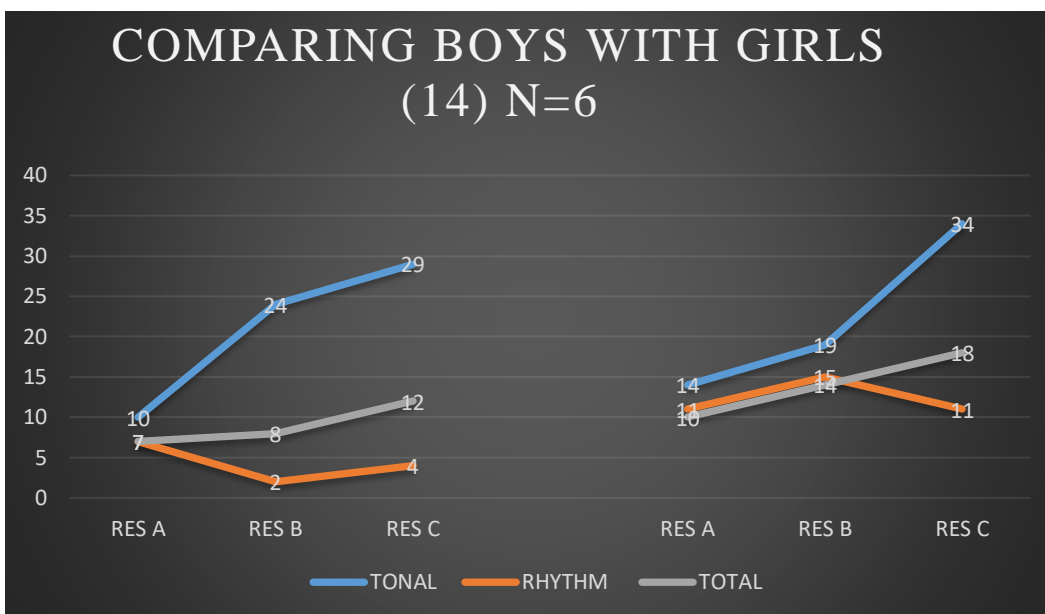


Figure 25: Comparing boys with girls Tonal and Rhythm scores aged 14 (n=6) - LSS

Comparing the data of both sexes of Liverpool Secondary School in South Africa, the following conclusions can be made:

- Taking the first three respondents of each gender the data revealed after comparing their tonal and rhythm scores, and totals, that the girls were more proficient in the Tonal section compared to the boys. The girls achieved **34** for their Tonal scores (**Respondent C**).
- The girls were more proficient in the Rhythm section of the AMMA test in comparison with the boys their age. The girls achieved **15** for their Rhythm scores (**Respondent B**).
- The totals of the girls were higher compared to the data of the boys for the first three respondents of each gender. The girls achieved **18** whilst the boys achieved **12** with a difference of **6**.

## 4.2.2 COMPARING THE FINAL DATA OF THE BOYS AND GIRLS AGED 12 (n=2), LSS

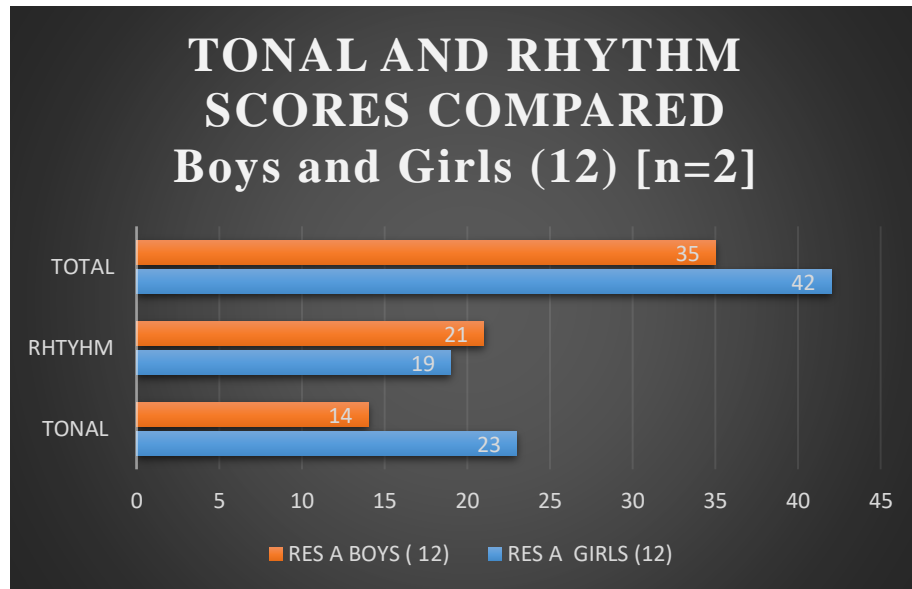


Figure 26: Boys and girls Tonal and Rhythm scores compared (12) n=2

The following graphs compared the data of the Tonal and Rhythm scores of the boys and girls aged 12. When you compared the data of the boys and girls Tonal and Rhythm scores for those students aged 12, using the Respondent A who completed the AMMA test the following conclusions can be made:

- In the Tonal section the girls were superior as they achieved **23** in comparison with the boys who achieved **14** with a difference of **9**.
- In the Rhythm section the boys were superior as they achieved **21** in comparison with the girls who achieved **19** with a difference of 2.

### 4.2.3 COMPARING THE FINAL DATA OF THE BOYS AND GIRLS AGED 13 (n=2), LSS

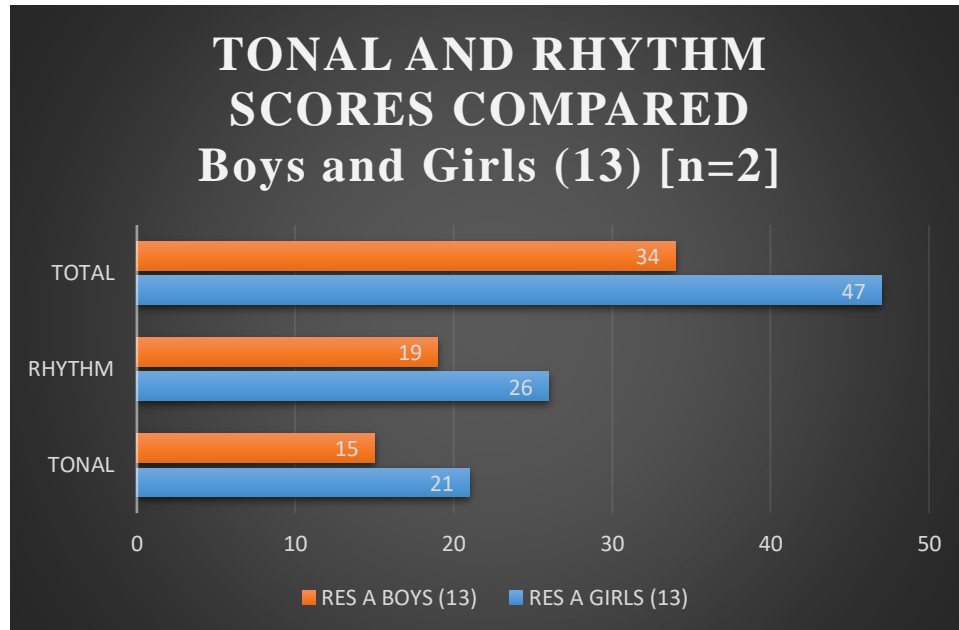
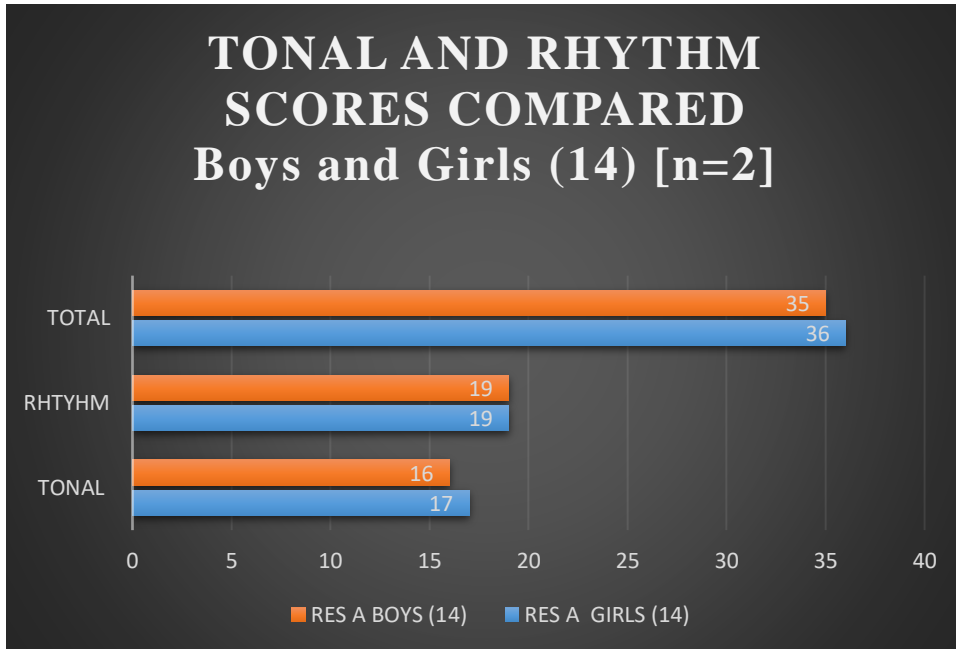


Figure 27: Boys and girls Tonal and Rhythm scores compared (13) n=2

When you compared the data of the boys and girls Tonal and Rhythm scores for those students aged 13 using the Respondent A, who completed the AMMA test the following conclusions can be made:

- In the Tonal section the girls were superior as they achieved **21** in comparison with the boys who achieved **15** with a difference of **6**.
- In the Rhythm section the girls were superior as they achieved **26** in comparison with the boys who achieved **19** with a difference of 7.

#### 4.2.4 COMPARING THE FINAL DATA OF THE BOYS AND GIRLS AGED 14 (n=2), LSS



*Figure 28: Boys and girls Tonal and Rhythms scores compared (14) n=2*

When you compared the data of the boys and girls Tonal and Rhythm scores for those students aged 14, using the Respondent A who completed the AMMA test the following conclusions can be made:

- In the Tonal section the girls were superior as they achieved **17** in comparison with the boys who achieved **16** with a difference of **1**.
- In the Rhythm section the boys and girls were equal as they both achieved **19** in their scores.

#### 4.2.5 COMPARING THE FINAL DATA OF THE BOYS AND GIRLS AGED 12 -14 (n=6), LSS

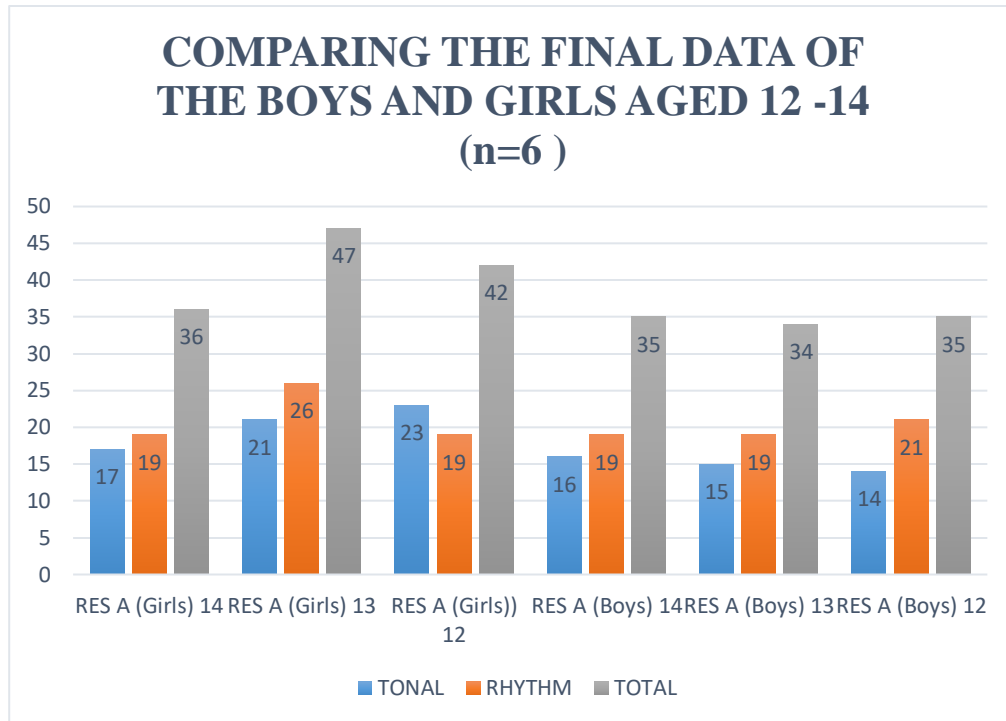


Figure 29: Comparing the final data of the boys and girls aged 12 - 14 (n=6)

The final stage of comparing the data of the Tonal and Rhythm scores of all the students from the boys and girls aged 12 – 14 the following conclusion was made:

- In the Tonal section the girls aged 12, obtained the highest mark, which was 23 in comparison with the boys aged 14 obtained, who obtained 16 with a difference of 7.

- In the Rhythm section the girls aged 14 obtained the highest mark, which was 26 in comparison with the boys aged 12, who obtained 21 with a difference of **5**.
- The final data established that the **median** was  $(36+47+42+35+34+35 / 6) =$  **38**.

### **PART OF THE STUDY (QUANTITATIVE)**

As part of the study the researcher presented another quantitative questionnaire by focussing on educators in South Africa and abroad to make new information available for future researchers to use with reference to music aptitude and mathematics achievements. Getting all the respondents to be involved who were teaching music in the Secondary Schools to be part of the following quantitative study. The study was concluded by using a questionnaire that was presented in terms of survey.

Over a period of one week the candidate presented 13 questions to educators around the world and in particular South Africa, especially the seven provinces to get their input, perspectives, experiences and expertise enhancing the topic of “music and mathematics”.

This was a quantitative study where the respondents concluded 10 questions based on their experiences within music education. Analysis of the Qualitative research then presented in both pie charts and written comments with responses to questions posed with one subjective written sentence to substantiate their choices for saying either “yes” or “no”.

Most of the questions were open-ended with a yes or no response whilst questions 3 and 7 focussed on particular answers related to the factors influencing and benefiting the mathematical achievement of the students they were teaching.

The participants were randomly selected through presenting a google questionnaire document available and shared platforms including Facebook and various other music education sites and groups available worldwide on the internet. The responses were varied from participants in South Africa and around the globe, especially in countries including the United Kingdom, Europe (France), Malaysia, China, Thailand, Mexico, and the United States of America.

Participants were given the opportunity to engage actively sharing their information and responses to the questions presented. For the first section, participants only had to state whether they were teaching a private school (PS) or Government School (GS) with the city or country they were teaching. Some participants included their cities including Wales, and London. Participants answered all the questions

focussing on the correlation between music and mathematics and the way it has impacted their students in the classroom.

On Monday, 17 July 2023, the questionnaire was compiled under the guidance of the supervisor, Mapaya and shared with respondents. On Sunday, 23 July 2023 the responses were stopped, and a data collection process took place. The data was collated using the questionnaire that took place in terms of a survey presented through google forms.

The data was interpreted in the following two ways, pie charts that involved the demographics of the study, the gender, age and teaching experiences. These were then divided into sections where data were analysed in pie charts and tables with written responses to the 10 questions that were posed.

## **QUESTIONNAIRE**

The first four questions were based on the respondent's area of expertise as educators, ages, gender, age, and years of teaching experience. For this section respondents outlined the country or region they were teaching and whether it was a private or government sector.

Question presented on the google forms focussed on the following:

- Where are you teaching at the moment?

- Gender (Male or Female),
- Teaching experiences, and
- Age.

Afterwards, the following 10 questions were presented where respondents had to write one sentence accompanying a yes or no answer.

1. Do you think music and mathematics are closely linked together? If you say yes or no could you, please justify your answer in one sentence.
2. Do you think music can enhance the ability of students doing mathematics in Secondary Grades 7 - 9 in schools in your district? If you stated yes or no, could you please justify your answer in one sentence.
3. What actions do you think we can take as educators to promote opportunities for these two subjects to collaborate? Could you write a short sentence to justify your reasons?
4. Do you have opportunities for Science, Technology, Engineering, Arts and Mathematics (STEM) in your school setting and curriculum? You can state yes or no and the reason for justifying your answer in one sentence.
5. Do you think that both music and mathematics requires a level of aptitude? You can state yes or no in one sentence to justify your reason.
6. Why do you think that music and mathematics are related somehow? You can state yes or no, and write down one reason, one sentence.

7. Are you familiar with the available music aptitude tests and mathematical aptitude tests available to promote in your classroom setting? Please state yes or no, and write down one sentence to justify your answer?
8. What factors do you think affect the academic achievements of students doing music and mathematics? Please write down one sentence to justify your answer.
9. If you had the opportunity to promote music together with mathematics, what activities or events would you arrange to promote in your school setting? Please state yes or no, and write down one sentence to justify your answer?
10. Do you feel competent that your music influenced your mathematical achievement whilst concluding your secondary education in school? Please state yes or no, and write down one sentence to justify your answer?

## **DATA ANALYSIS OF FURTHER QUANTITATIVE STUDY**

After the questionnaire were concluded by the 30 respondents the researcher sorted, analysed and interpreted the data in terms of:

- Demographics
- Gender

- Teaching Experiences, and
- Age

**Where are you teaching at the moment? (n=30)**

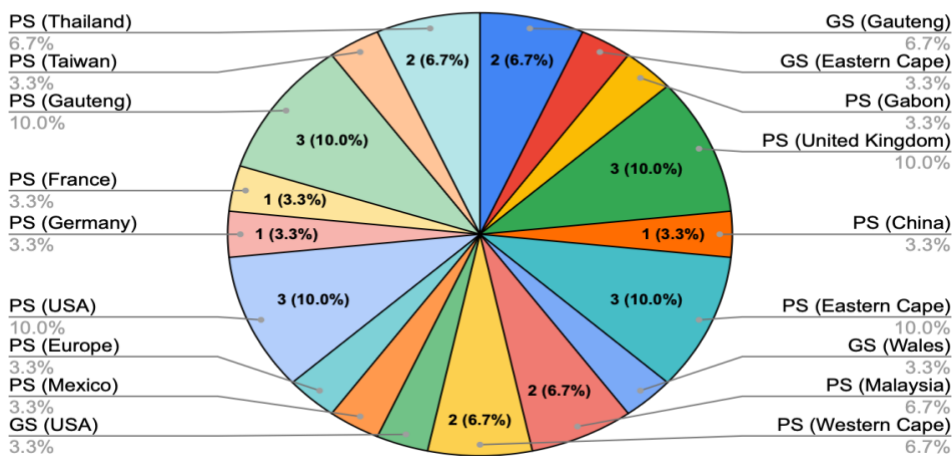


Figure 30: Demographics of study concluded, and participants involved (n=30)

Interpreting the following data, the following table summarises the findings as outlined by Mouton (2009).

Demographics of this quantitative study	
Sector (Private or Government)/Country/City/Province	Number of Participants and percentages
PS Eastern Cape	3 (10%)

PS Western Cape	2 (6.7%)
PS Gauteng	3 (10%)
PS Gabon	1 (3.3%)
PS United Kingdom	3 (10%)
PS Europe	1 (3.3%)
PS France	1 (3.3%)
PS Germany	1 (3.3%)
PS China	1 (3.3%)
PS Thailand	2 (6.7%)
PS Taiwan	1 (3.3%)
PS United States of America (USA)	3 (10%)
GS Gauteng	2 (6.7%)
GS Eastern Cape	1 (3.3%)

GS Wales	1 (3.3%)
GS United States of America (USA)	1 (3.3%)

*Table 17: Demographics of respondents (n=30)*

In the Private Schools (PS) the following number of respondents answered the questionnaire.

From the data collected the three respondents who identified with a ratio of 10% included:

- PS Eastern Cape
- PS Gauteng
- PS United Kingdom
- PS United States of America

From the data collected the two respondents who identified with a ratio of 6.7% included:

- PS Western Cape
- PS Thailand

From the following data collected the one respondent who identified with a ratio 3:3% included:

- PS Gabon
- PS Europe
- PS France
- PS Germany
- PS China
- PS Taiwan

In the government sector the following respondents concluded the questionnaire.

From the following data collected two respondents who identified with a ratio of 6.7% included:

- GS Gauteng

From the following data collected the one respondents who identified with a ratio of 3.3% included:

- GS Eastern Cape
- GS Wales
- GS United States of America (USA)

### **Gender**

In this study most of the participants came from countries in South Africa and abroad and included the following genders:

- 11 Females with a ratio of 36.7%
- 19 Males with a ratio of 63.3%

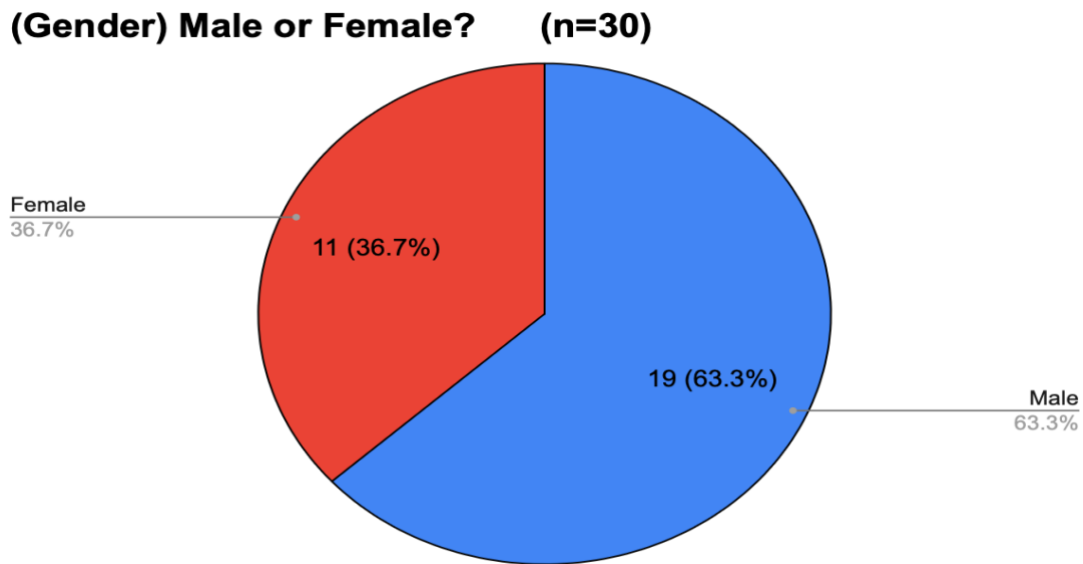


Figure 31: Gender of Males and Females concluding this study (n=30)

## YEARS OF TEACHING EXPERIENCES

Most of the 28 respondents that participated in this study were working either in a Government or Private School setting in South Africa or abroad. Their teaching experiences have been highlighted below (see figure 32).

How long have you been teaching for?

28 responses

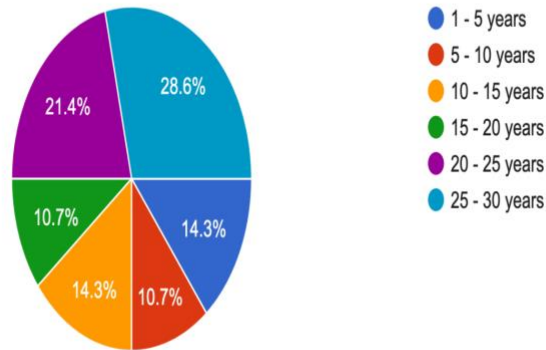


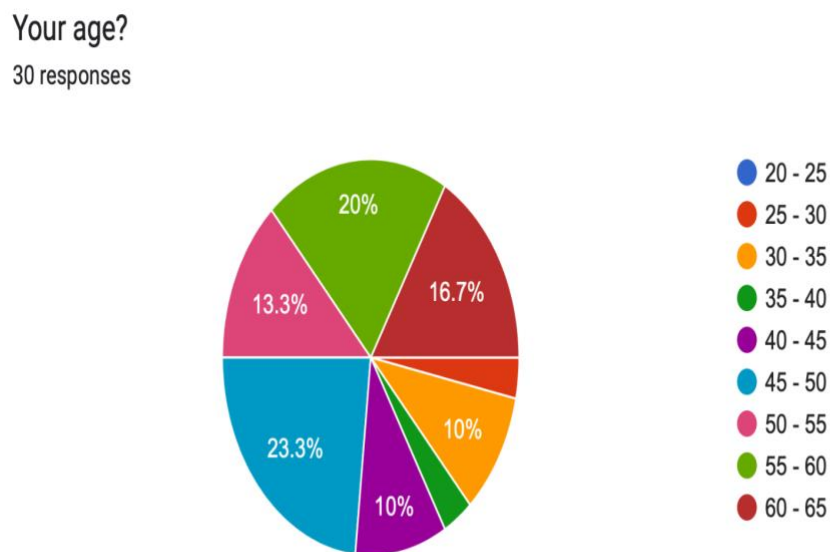
Figure 32: Years of Teaching Experiences (n=28)

The following data interpretation can be taken from the 28 respondents who answered the questionnaire as 2 respondents did not answer this part of the questionnaire with regards to their teaching experiences presented.

- 1 - 5 Years (n=4, with a ratio of 14.3%)
- 5 - 10 Years (n=3, with a ratio of 10.7%)
- 10 - 15 Years (n=4, with a ratio of 14.3%)
- 15 - 20 Years (n=3, with a ratio of 10.7%)
- 20 - 25 Years (n=6, with a ratio of 21.4%)
- 25 - 30 Years (n= 8, with a ratio of 28.65%)

## AGES

As part of the questionnaire the respondents had to provide their ages who all participated in the study with the following data being presented (see figure 33).



*Figure 33: Age brackets of the respondents who participated in the study (n=30)*

In terms of different age groups, the 30 respondents in South Africa and abroad who participated in this study were:

- 20 - 25 years of age (zero respondents answered from this age group)
- 25 - 30 years of age (n=1, with a ratio of 3.3%)

- 30 - 35 years of age (n=3, with a ratio of 10%)
- 35 - 40 years of age (n=1, with a ratio of 3.3%)
- 40 - 45 years of age (n=7, with a ratio of 23.3%)
- 45 - 50 years of age (n=7, with a ratio of 23.3%)
- 50 - 55 years of age (n=4, with a ratio of 13.3%)
- 55 - 60 years of age (n=6, with a ratio of 20%)
- 50 - 65 years of age (n=5, with a ratio of 16.7%)

## QUANTITATIVE RESPONSES

### RESPONDENT A

#### Responses to the Questionnaire about the AMMA test and Mathematical Achievement overall

The following questionnaire was completed and answered as outlined in the following table.

Questions	Responses
1.1	

<p><b>Having completed the AMMA (Advanced Measures of Music Audiation) test can you please answer the following questions? How would you describe your overall experience of the test you completed?</b></p>	<p>3 – Comfortable</p>
<p>1.2</p> <p><b>When you completed the Tonal test can you rate your overall impression and experience using the scale above from 1 – 5 when you completed the AMMA test?</b></p>	<p>3 – Comfortable</p>
<p>1.3</p> <p><b>When you completed the Rhythm test can you rate your experience using the scale above from 1 – 5 to answer your overall</b></p>	<p>3 – Comfortable</p>

<p><b>impression and experience of the AMMA test?</b></p>	
<p>1.4 <b>Your overall impression of the AMMA test would be? Using the scale above from 1 – 5?</b></p>	<p>3 – Comfortable</p>
<p>2. <b>Which one of the two areas of the AMMA test did you find difficult?</b></p>	<p>Rhythm</p>
<p>3. <b>Which one of the two areas of the AMMA test did you find easy?</b></p>	<p>Tonal</p>
<p>4.</p>	<p>3 – Average</p>

<p><b>Your results will not be revealed but using the following scale below from 1 – 5. How would you grade your overall music aptitude?</b></p>	
<p><b>5. Using the scale 1-5 below answer the following question:</b></p> <p><b>Do you think these tests will be useful to establish your overall music aptitude?</b></p>	<p>4 - Do you want to improve your music aptitude overall</p>
<p><b>6.</b></p> <p><b>Using the scale (1- 5) below how would you describe your experience completing the mathematical test this year overall?</b></p>	<p>3 – Comfortable</p>
<p><b>7.</b></p> <p><b>Using the scale below from (1-5) how would you best describe your results for the mathematical tests overall this year?</b></p>	<p>5 – Above 75 %</p>

<p><b>You are allowed to give an answer to what you predict!</b></p>	
<p>8.</p> <p><b>Using the scale below from (1-5) which mathematical area is your favourite when completing mathematics?</b></p>	<p>3 - Algebra Equations</p>
<p>9.</p> <p><b>Using the scale below from (1-5). We are hoping to prove that a correlation between music and mathematics exists. Which one do you think fits best after you have completed both tests?</b></p>	<p>5 - I am highly convinced and totally agree with this statement</p>

*Table 18: Quantitative responses from Respondent A of the questionnaire*

## RESPONDENT B

### Responses to the Questionnaire about the AMMA test and Mathematical Achievement overall

The following questionnaire was completed, and answered in terms of the following as outlined in the following table.

Questions	Responses
<p>1.1</p> <p><b>Having completed the AMMA (Advanced Measures of Music Audiation) test can you please answer the following questions? How would you describe your overall experience of the test you completed?</b></p>	<p>2 – Difficult</p>
<p>1.2</p> <p><b>When you completed the Tonal test can you rate your overall impression and experience using the scale above from 1 – 5 when you completed the AMMA test?</b></p>	<p>2 – Difficult</p>
<p>1.3</p>	<p>2 – Difficult</p>

<p><b>When you completed the Rhythm test can you rate your experience using the scale above from 1 – 5 to answer your overall impression and experience of the AMMA test?</b></p>	
<p>1.4 <b>Your overall impression of the AMMA test would be? Using the scale above from 1 – 5?</b></p>	<p>2 – Difficult</p>
<p>2. <b>Which one of the two areas of the AMMA test did you find difficult?</b></p>	<p>Tonal</p>
<p>3.</p>	<p>Rhythm</p>

<p><b>Which one of the two areas of the AMMA test did you really find easy?</b></p>	
<p>4.</p> <p><b>Your results will not be revealed but using the following scale below from 1 – 5. How would you grade your overall music aptitude?</b></p>	<p>2 - Normal</p>
<p>5.</p> <p><b>Using the scale 1-5 below answer the following question:</b></p> <p><b>Do you think these tests will be useful to establish your overall music aptitude?</b></p>	<p>3 - You are satisfied with your current music aptitude</p>
<p>6.</p>	<p>3 – Comfortable</p>

<p><b>Using the scale (1- 5) below how would you describe your experience completing the mathematical test this year overall?</b></p>	
<p>7.</p> <p><b>Using the scale below from (1-5) how would you best describe your results for the mathematical tests overall this year? You are allowed to give an answer to what you predict!</b></p>	<p>4 – Between 65% and 75%</p>
<p>8.</p> <p><b>Using the scale below from (1-5) which mathematical area is your favourite when completing mathematics?</b></p>	<p>5 - Fractions</p>

<p>9.</p> <p><b>Using the scale below from (1-5). We are hoping to prove that a correlation between music and mathematics co-exists. Which one do you think fits best after you have completed both tests?</b></p>	<p>4 - I completely agree with this statement and could experience the connection between mathematical and musical skills – Using the same reasoning techniques</p>
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*Table 19: Quantitative responses from Respondent B of the questionnaire*

### RESPONDENT C

#### **Responses to the Questionnaire about the AMMA test and Mathematical Achievement overall**

The following questionnaire was completed and answered in terms of the following as outlined in the following table.

Questions	Responses
1.1	

<p><b>Having completed the AMMA (Advanced Measures of Music Audiation) test can you please answer the following questions?</b></p> <p><b>How would you describe your overall experience of the test you completed?</b></p>	<p>3 – Comfortable</p>
<p>1.2</p> <p><b>When you completed the Tonal test can you rate your overall impression and experience using the scale above from 1 – 5 when you completed the AMMA test?</b></p>	<p>3 – Comfortable</p>
<p>1.3</p> <p><b>When you completed the Rhythm test can you rate your experience using the scale above from 1 – 5 to answer your overall</b></p>	<p>3 – Comfortable</p>

<p><b>impression and experience of the AMMA test?</b></p>	
<p>1.4 <b>Your overall impression of the AMMA test would be? Using the scale above from 1 – 5?</b></p>	<p>3 – Comfortable</p>
<p>2. <b>Which one of the two areas of the AMMA test did you find difficult?</b></p>	<p>Tonal</p>
<p>3. <b>Which one of the two areas of the AMMA test did you find easy?</b></p>	<p>Rhythm</p>
<p>4. <b>Your results will not be revealed but using the following scale below from 1 – 5. How</b></p>	<p>3 – Average</p>

<p>would you grade your overall music aptitude?</p>	
<p>5.</p> <p>Using the scale 1-5 below answer the following question:</p> <p>Do you think these tests will be useful to establish your overall music aptitude?</p>	<p>3 - You are satisfied with your current music aptitude</p>
<p>6.</p> <p>Using the scale (1- 5) below how would you describe your experience completing the mathematical test this year overall?</p>	<p>3 – Comfortable</p>
<p>7.</p> <p>Using the scale below from (1-5) how would you best describe your results for</p>	<p>5 – Above 75 %</p>

<p><b>the mathematical tests overall this year?</b></p> <p><b>You are allowed to give an answer to what you predict!</b></p>	
<p>8.</p> <p><b>Using the scale below from (1-5) which mathematical area is your favourite when completing mathematics?</b></p>	<p>3 - Algebra Equations</p>
<p>9.</p> <p><b>Using the scale below from (1-5). We are hoping to prove that a correlation between music and mathematics co-exists. Which one do you think fits best after you have completed both tests?</b></p>	<p>5 - I am highly convinced and totally agree with this statement</p>

*Table 20: Quantitative responses from Respondent C of the questionnaire*

## RESPONDENT D

### Responses to the Questionnaire about the AMMA test and Mathematical Achievement overall

The following questionnaire was completed and answered in terms of the following as outlined in the following table.

Questions	Responses
<p>1.1</p> <p><b>Having completed the AMMA (Advanced Measures of Music Audiation) test can you please answer the following questions? How would you describe your overall experience of the test you completed?</b></p>	<p>3 – Comfortable</p>
<p>1.2</p> <p><b>When you completed the Tonal test can you rate your overall impression and experience using the scale above from 1 – 5 when you completed the AMMA test?</b></p>	<p>3 – Comfortable</p>
<p>1.3</p>	<p>3 – Comfortable</p>

<p><b>When you completed the Rhythm test can you rate your experience using the scale above from 1 – 5 to answer your overall impression and experience of the AMMA test?</b></p>	
<p>1.4</p> <p><b>Your overall impression of the AMMA test would be? Using the scale above from 1 – 5?</b></p>	<p>3 – Comfortable</p>
<p>2.</p> <p><b>Which one of the two areas of the AMMA test did you find difficult?</b></p>	<p>Rhythm</p>
<p>3.</p> <p><b>Which one of the two areas of the AMMA test did you find easy?</b></p>	<p>Tonal</p>

<p>4.</p> <p><b>Your results will not be revealed but using the following scale below from 1 – 5. How would you grade your overall music aptitude?</b></p>	<p>4 - Above Average</p>
<p>5.</p> <p><b>Using the scale 1-5 below answer the following question:</b></p> <p><b>Do you think these tests will be useful to establish your overall music aptitude?</b></p>	<p>3 - You are satisfied with your current music aptitude</p>
<p>6.</p> <p><b>Using the scale (1- 5) below how would you describe your experience completing the mathematical test this year overall?</b></p>	<p>4 – Easy</p>
<p>7.</p> <p><b>Using the scale below from (1-5) how would you best describe your results for</b></p>	<p>5 – Above 75%</p>

<p><b>the mathematical tests overall this year?</b></p> <p><b>You are allowed to give an answer to what you predict!</b></p>	
<p>8.</p> <p><b>Using the scale below from (1-5) which mathematical area is your favourite when completing mathematics?</b></p>	<p>2 - Geometry</p>

<p>9.</p> <p><b>Using the scale below from (1-5). We are hoping to prove that a correlation between music and mathematics co-exists. Which one do you think fits best after you have completed both tests?</b></p>	<p>4 - I completely agree with this statement and could experience the connection between mathematical and musical skills – Using the same reasoning techniques</p>
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*Table 21: Quantitative responses from Respondent D of the questionnaire*

## RESPONDENT E

### Responses to the Questionnaire about the AMMA test and Mathematical Achievement overall

The following questionnaire was completed and answered in terms of the following as outlined in the following table.

Questions	Responses
1.1	

<p><b>Having completed the AMMA (Advanced Measures of Music Audiation) test can you please answer the following questions? How would you describe your overall experience of the test you completed?</b></p>	<p>3 – Comfortable</p>
<p>1.2</p> <p><b>When you completed the Tonal test can you rate your overall impression and experience using the scale above from 1 – 5 when you completed the AMMA test?</b></p>	<p>3 – Comfortable</p>
<p>1.3</p> <p><b>When you completed the Rhythm test can you rate your experience using the scale above from 1 – 5 to answer your overall impression and experience of the AMMA test?</b></p>	<p>3 – Comfortable</p>

<p>1.4</p> <p><b>Your overall impression of the AMMA test would be? Using the scale above from 1 – 5?</b></p>	<p>3 – Comfortable</p>
<p>2.</p> <p><b>Which one of the two areas of the AMMA test did you find difficult?</b></p>	<p>Tonal</p>
<p>3.</p> <p><b>Which one of the two areas of the AMMA test did you find easy?</b></p>	<p>Rhythm</p>
<p>4.</p> <p><b>Your results will not be revealed but using the following scale below from 1 – 5. How would you grade your overall music aptitude?</b></p>	<p>4 - Above Average</p>
<p>5.</p>	

<p><b>Using the scale 1-5 below answer the following question:</b></p> <p><b>Do you think these tests will be useful to establish your overall music aptitude?</b></p>	<p>3 - You are satisfied with your current music aptitude</p>
<p>6.</p> <p><b>Using the scale (1- 5) below how would you describe your experience completing the mathematical test this year overall?</b></p>	<p>4 – Easy</p>
<p>7.</p> <p><b>Using the scale below from (1-5) how would you best describe your results for the mathematical tests overall this year?</b></p> <p><b>You are allowed to give an answer to what you predict!</b></p>	<p>5 – Above 75%</p>
<p>8.</p>	<p>1 - Trigonometry</p>

<p>Using the scale below from (1-5) which mathematical area is your favourite when completing mathematics?</p>	
<p>9.</p> <p>Using the scale below from (1-5). We are hoping to prove that a correlation between music and mathematics co-exists. Which one do you think fits best after you have completed both tests?</p>	<p>4 - I completely agree with this statement and could experience the connection between mathematical and musical skills – Using the same reasoning techniques</p>

*Table 22: Quantitative responses from Respondent E of the questionnaire*

## RESPONDENT F

### Responses to the Questionnaire about the AMMA test and Mathematical

#### Achievement overall

The following questionnaire was completed and answered in terms of the following as outlined in the following table.

Questions	Responses
<p>1.1</p> <p><b>Having completed the AMMA (Advanced Measures of Music Audiation) test can you please answer the following questions? How would you describe your overall experience of the test you completed?</b></p>	<p>3 – Comfortable</p>
<p>1.2</p> <p><b>When you completed the Tonal test can you rate your overall impression and experience using the scale above from 1 – 5 when you completed the AMMA test?</b></p>	<p>3 – Comfortable</p>
<p>1.3</p>	

<p><b>When you completed the Rhythm test can you rate your experience using the scale above from 1 – 5 to answer your overall impression and experience of the AMMA test?</b></p>	<p>3 – Comfortable</p>
<p>1.4</p> <p><b>Your overall impression of the AMMA test would be? Using the scale above from 1 – 5?</b></p>	<p>3 – Comfortable</p>
<p>2.</p> <p><b>Which one of the two areas of the AMMA test did you find difficult?</b></p>	<p>Rhythm</p>

<p>3.</p> <p><b>Which one of the two areas of the AMMA test did you find easy?</b></p>	<p>Tonal</p>
<p>4.</p> <p><b>Your results will not be revealed but using the following scale below from 1 – 5. How would you grade your overall music aptitude?</b></p>	<p>4 - Above Average</p>
<p>5.</p> <p><b>Using the scale 1-5 below answer the following question:</b></p> <p><b>Do you think these tests will be useful to establish your overall music aptitude)?</b></p>	<p>3 - You are satisfied with your current music aptitude</p>
<p>6.</p>	<p>4 – Easy</p>

<p><b>Using the scale (1- 5) below how would you describe your experience completing the mathematical test this year overall?</b></p>	
<p>7.</p> <p><b>Using the scale below from (1-5) how would you best describe your results for the mathematical tests overall this year? You are allowed to give an answer to what you predict!</b></p>	<p>5 – Above 75%</p>
<p>8.</p> <p><b>Using the scale below from (1-5) which mathematical area is your most favourite when completing mathematics?</b></p>	<p>3 - Algebra equations</p>
<p>9.</p> <p><b>Using the scale below from (1-5). We are hoping to prove that a correlation between music and mathematics co-</b></p>	<p>4 - I completely agree with this statement and could experience the connection</p>

<p><b>exists. Which one do you think fits best after you have completed both tests?</b></p>	<p>between mathematical and musical skills – Using the same reasoning techniques</p>
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*Table 23: Quantitative responses from Respondent F of the questionnaire*

## **MUSIC TEACHER RESPONSES TO QUESTIONNAIRE**

### **Responses to the Questionnaire about the AMMA test and Mathematical Achievement overall**

The following questionnaire was completed and answered in terms of the following as outlined in the following table.

<b>Questions</b>	<b>Responses</b>
<p>1.1</p> <p><b>Having completed the AMMA (Advanced Measures of Music Audiation) test can you please answer the following questions? How would you describe your</b></p>	<p>2 – Difficult</p>

<p><b>overall experience of the test you completed?</b></p>	
<p>1.2</p> <p><b>When you completed the Tonal test can you rate your overall impression and experience using the scale above from 1 – 5 when you completed the AMMA test?</b></p>	<p>3 – Comfortable</p>
<p>1.3</p> <p><b>When you completed the Rhythm test can you rate your experience using the scale above from 1 – 5 to answer your overall impression and experience of the AMMA test?</b></p>	<p>4 – Easy</p>
<p>1.4</p> <p><b>Your overall impression of the AMMA test would be? Using the scale above from 1 – 5?</b></p>	<p>3 – Comfortable</p>

<p>2.</p> <p><b>Which one of the two areas of the AMMA test did you find difficult?</b></p>	Tonal
<p>3.</p> <p><b>Which one of the two areas of the AMMA test did you find easy?</b></p>	Rhythm
<p>4. <b>Your results will not be revealed but using the following scale below from 1 – 5. How would you grade your overall music aptitude?</b></p>	3 - Average
<p>5.</p> <p><b>Using the scale 1-5 below answer the following question:</b></p>	3 - You are satisfied with your current music aptitude

<p><b>Do you think these tests will be useful to establish your overall music aptitude?</b></p>	
<p>6. <b>Using the scale (1- 5) below how would you describe your experience completing the mathematical test this year overall?</b></p>	<p>3 – Comfortable</p>
<p>7. <b>Using the scale below from (1-5) how would you best describe your results for the mathematical tests overall this year? You are allowed to give an answer to what you predict!</b></p>	<p>3 – Between 50% and 65%</p>
<p>8. <b>Using the scale below from (1-5) which mathematical area is your favourite when completing mathematics?</b></p>	<p>3 - Algebra equations</p>

<p>9.</p> <p><b>Using the scale below from (1-5). We are hoping to prove that a correlation between music and mathematics co-exists. Which one do you think fits best after you have completed both tests?</b></p>	<p>5 - I am highly convinced and totally agree with this statement</p>
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*Table 24: Quantitative responses from Respondent G (the music teacher) of the questionnaire*

## **FURTHER QUANTITATIVE STUDY RESPONSES OF 30 MUSIC TEACHERS**

For the questions 1 - 10 the following tables were concluded to interpret their comments with references to the questions posed.

<p><b><u>Question 1</u></b></p> <p>Do you think music and mathematics are closely linked together? If you say yes or no could you please justify your answer in one sentence.</p>		
<p><i>Respondent</i></p>	<p><i>Yes or No response</i></p>	<p><i>Justification for the answer</i></p>

1.	Yes	Music and mathematics are closely linked together as the way the brain performs systematically is similar.
2.	Yes.	Music and Mathematics have always closely been linked in the approach and understanding. Studies have shown the development of the brain when music and mathematics are combined.
3.	Yes	Music and mathematics are linked because music uses the metric system which is a mathematical notion
4.	Yes	No justification was given
5.	Yes	Music can be understood in mathematical terms and the language of western music theory certainly shows this.
6.	Yes	Mathematics and music require the practising of

		formulas to create results.
7.	Yes	Analysis of serialism best example
8.	Yes	Both subjects activate the mind.
9.	Yes	Both require problem-solving skills, recognizing patterns and analytical thinking.
10.	Yes	Rhythmic patterns are very mathematical.
11.	Yes	Music is maths and maths is music
12.	Yes	Music is mathematical because each note has a value of time and length.
13.	Yes	In the foundation phase it plays a big role in counting.
14.	Yes	There is a close link between Math and Music as you need to count beats, know fractions to interpret

		music bars and read music.
15.	Yes	They both work with the interaction between time and space which is the basis of vibration and logic.
16.	Yes	It is not only structurally linked (counting etc), but neurologically.
17.	Yes	Both require a systematic approach and follow distinct logic and laws.
18.	Yes	It deals with times, pattern, Algorithmus, between many other things
19.	Yes	Maths is at work in music notation e.g. parts of a note(s). 2 semiquavers = quaver; groupings of notes as set out in score have specific symmetry ( like a mathematical equation) to determine timing in performance.

20.	Yes	Music and mathematics share connections. Musical rhythm, scales, and intervals are based on mathematical ratios and patterns, there is a relationship between these two disciplines.
21.	Yes	Yes, from the aspect that notations are mathematical by their nature themselves even as such in the production of music is not something as mechanical as a mathematical formula. It is an amalgamation of things with the biggest aspect being the spiritual and emotional interpretation of the music.
22.	Yes	They both use patterns and sequences.
23.	Yes	I'm in the process of solving a problem. In music, it is the process during practice.
24.	Yes	where there is a counting of beats, $\frac{3}{4}$ and $\frac{4}{4}$ which are fractions.

25.	Yes	Music is based on mathematics and they're both universal languages.
26.	Yes	Rhythm is all about distribution of numbers and harmony is formulas for how notes interact.
27.	Yes	The most definitely with maths and chess.
28.	Yes	All in music is about time signatures.
29.	Yes	They both have formulas.
30.	Yes	Rhythms are quantized and all pitches have harmonic overtones that can be calculated mathematically - the individual amplitude of each overtone and the interplay between them determines timbre.

*Table 25: Responses to Question 1 from respondents (n=30)*

In this first question 100% agree that music and mathematics were closely related and this has been outlined in the PhD study of Muller (2021).

**Question 2**

Do you think music can enhance the ability of students doing mathematics in Secondary Grades 7 - 9 in schools in your district? If you stated yes or no could you please justify your answer in one sentence.

<i>Respondent</i>	<i>Yes or No response</i>	<i>Justification for the answer</i>
1.	Yes	I have noticed how well the students have concluded results wise in both music and mathematics.
2.	Yes	Concentration, patience, determination, 'practices makes perfect' are all aspects one can draw parallels from.
3.	Nothing stated	I will say that I do not know because it is a system that we have not yet experienced.

4.	Yes	No justification given.
5.	Yes	Perhaps there is a correlative relationship but I think that it would be difficult to actually prove causation as oftentimes students who take private music lessons have other correlatives .
6.	Nothing stated	Music can be used to remember sequences of numbers and algebraic equations to reach results as well as increasing the ability to remember numeric sequencing.
7.	Nothing stated	Not sure, mine certainly was not
8.	Yes	Not justification was given.
9.	Yes	It has been scientifically proven that music helps to strengthen academic skills, and therefore mathematics too.

10.	No	Secondary schools teach maths that is complicated
11.	Yes	Music makes maths easier to understand
12.	Yes	These age groups are technically advanced already and have access to both music and maths online, including those who only listen and don't play instruments.
13.	Yes	Music has a positive effect on the social and emotional being of students and brings about a calmness that enhances learning.
14.	Yes	Music has a positive effect on the social and emotional being of students and brings about a calmness that enhances learning.
15.	Yes	if they are taught logic before they are taught maths or music. I understood maths and music only after I did a course in logic at university.

16.	Yes	The structure and practice of music is as inherent in our DNA as counting is; the two are inextricably intertwined - rhythms and phrases are representation of the number set and is underscored by the culture, its rhythms and the scale (pentatonic, melodic, etc.) are defined in a close proximity to their advancement in basic mathematical concepts.
17.	Yes	Absolutely. It's no coincidence that many musicians have an exceptionally high IQ. Not all of it is genetic, I'd say. Both subjects are supplementing each other, I think.
18.	Yes	Both by creating more cerebral connections but Also needed skills as consistency, perseverance, hard Work with delayed reward
19.	Yes	With a comprehension of maths workings, these can be applied to the study of music.

20.	Yes	Don't know for certain, but I think is Music enhances certain cognitive abilities, including mathematical skills. Listening to music or learning to play an instrument may improve focus, spatial reasoning, and mathematical understanding for learners. However, the effectiveness may vary among each individual.
21.	No	It would only be beneficial to younger children with the teaching of addition and fractions.
22.	Yes	it will help to record and retain information
23.	Yes	if the emphasis is in the practice and patterns.
24.	Yes	Classical music played quietly in the background has proved to improve children's concentration and ability, leading to greater outcomes.
25.	Yes	Placing mathematics in a musical context could inspire creative ways of understanding both subjects.

26.	Yes	It activates the same areas of the brain needed to do maths.
27.	Yes	but they must start with music at an earlier stage like grade 3 or 4.
28.	Yes	Music has a strict mathematical order and with many many repeats, should enhance a student's ability.
29.	Yes	the logic of music knowledge will enhance students' maths skills
30.	Yes	by using fractions and multiplication when dealing with rhythm and pitch.

*Table 26: Responses to Question 2 from respondents (n=30)*

In the second question the majority of the respondents said “yes” (n=24), with a ratio of 82.8%, whilst “nothing stated” (n=3), with a ration of 10.3% and the rest agreed with “no” (n=3), with a ratio of 6.9% as seen in the pie chart (see figure 34).

Question 2 (n=30)

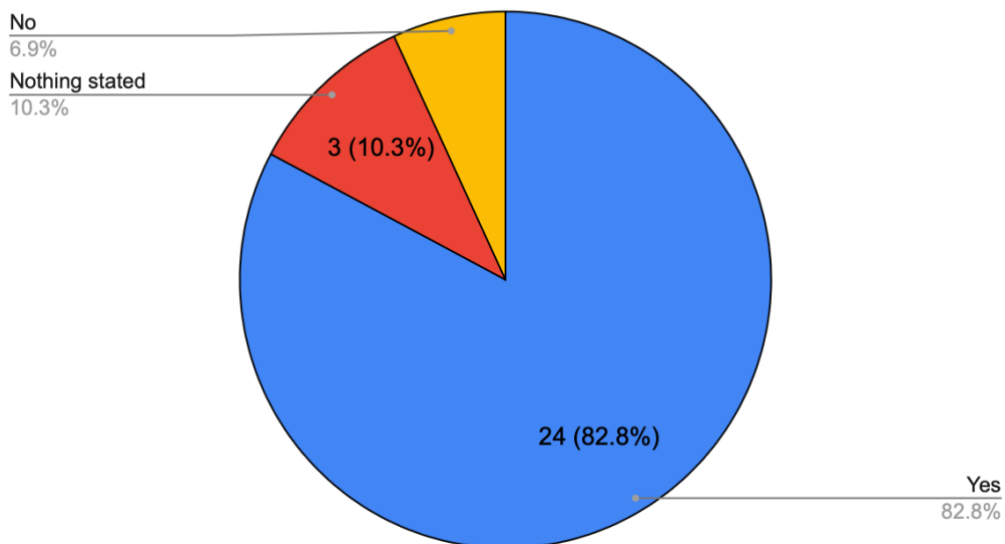


Figure 34: Responses to Question 2 (yes and no) from respondents (n=30)

**Question 3**

What actions do you think we can take as educators to promote opportunities for these two subjects to collaborate? Could you write a short sentence to justify your reasons?

<i>Respondent</i>	<i>Justification for the answer</i>

1	Through means of collaboration educators are able to share their skills and understanding.
2	<p>This is a difficult question as it is dependent on the music programme offered by the school and the amount of music staff.</p> <p>The more music staff, the more the workload can be spread and the more teachers can draw inspiration from each other.</p> <p>Beginning a recorder programme or a xylophone programme in each music class takes time and resources and will also require that the music educator is not burnt out. A true passion for music and the arts can die when not given the room to grow. The relationship amongst staff is also vital to ensure that all subjects are seen as equal.</p>
3.	we can incorporate in the mathematics course the addition of fractions in music so that the students are a little more interested and that they understand that these two subjects are very linked
4.	One example is teaching fractions and time signature + note values. Using different notes is basically fractions over time!

5.	There are infinite possibilities. The harmonic series can be explored through strobe lights and through links to physics.
6.	Being able to read music and understanding tempo, beat and pace can help to understand similar concepts in Mathematics.
7.	Aleatoric compositions or serialism
8.	Use rhythm to enhance calculations and body percussion to stimulate minds.
9.	Explore the physics/mathematics behind sound. Link up sequences and patterns in mathematics with music and vice versa.
10.	It is not our job to teach maths. I am not certified in maths.
11.	By actually listening to each other instead of ego fighting over what is more important
12.	We can create educational apps which link the two subjects.

	Children spend a vast amount of time on their mobile phones.
13.	Music promotes critical thinking.
14.	Planning cross-curriculum units where students transfer their "near and far" knowledge into their learning experiences in both subjects.
15.	Teach them musical notation. A course in rhythm, vibration and actually seeing it in musical notation will be very helpful.
16.	A bridging of music and maths, showing the beauty of numbers in the beauty of melody would at minimum expose the two disciplines in their harmony.
17.	Experimental, I guess. One could try to find similarities in the amount of certain notes, like proportionally or so, for example? Things like that.
18.	That's something I struggle to imagine besides a very theoretical

	approach.
19.	Through example and practise the similarities and differences can be explored.
20.	Promote STEAM more. Make Arts have prominence at schools.
21.	At a primary level, music teachers can incorporate Martha into the music lesson by then use of visual aids (e.g lego bricks to learn number bonds/bears in a bar)
22.	Case studies using control groups using music to improve a mathematical topic.
23.	Understanding patterns and processes in solving a task.
24.	Maths is compulsory, Music isn't but should be offered from a young age where all children should be taught to play a musical instrument which would give them the opportunity to shine or simply to use their voices to sing without criticism.

25.	Teach kids why it's important to know something, not just how to do it.
26.	Respondent did not answer.
27.	To start with an instrument at an early stage.
28.	Make the presentation attractive and exciting, also using live props. Bring in experienced tutors [at least two] for comparison and judgement by the students.
29.	Music to help students memorise maths knowledge, such as maths formulas.
30.	Mainly being open to changing teaching methods and content as needed to fit both subjects, and willing to work with colleagues.

*Table 27: Responses to Question 3 from respondents (n=30)*

In the third question of all the respondents (n=30), what actions can be taken to ensure collaboration between teachers in the maths and music departments.

**Question 4**

Do you have opportunities for Science, Technology, Engineering, Arts and Mathematics (STEM) in your school setting and curriculum? You can state yes or no and the reason for justifying your answer in one sentence.

<i>Respondent</i>	<i>Yes or No response</i>	<i>Justification for the answer</i>
1	Yes	We try to collaborate in IB education where educators collaborate regularly.
2	Yes	Within the school, yes. Within the greater community of Gqebera, yes. Within the CAPS curriculum, no. Most schools need to find partner schools or privately funded organisations that are willing to improve these areas.
3.	No	There are no opportunities yet because these are inexperienced areas

4.	Yes	No justification was given by the respondent.
5.	Yes	From the IB group 4 project to the MYP's mandate for interdisciplinary units of study.
6.	Yes	These broaden the opportunities for pupils' futures.
7.	Yes	STEM projects and Performing Arts collaborations
8.	No	My school is old school.
9.	Yes	My school recognizes the importance of all subjects.
10.	Yes	Sure, you could tie it in to anything, but again, not my job.
11.	Yes	All day everyday if the kids want.
12.	Yes	These are currently subjects for grades 7-12 where I live.
13.	No	We are purely an academic school.

14.	Yes	We are a school of the ARTS and academics, and the ARTS grows together, including STEM.
15.	No	Schools are more focused in South Africa at getting as many as possible students through the schools irrespective of quality of learning.
16.	No	I would love to but in my personal setting I could not achieve that.
17.	Yes	I find this not easy to answer. In my opinion there are always opportunities to incorporate one or another of these into your subject, if you want. This is solely dependent on the teacher, not the school setting. Well, of course some resources may help, notebooks or so, for example. But one can do without.
18.	Yes	Some but rare and depending 100 on student wish
19.	Yes	I principally work teaching one subject online.
20.	Yes	Using examples integrating the two subjects. Even for a non-music learner using such

		examples can assist in understanding certain concepts in the subject.
21.	Yes	Apart from engineering, as they are all subjects offered to our student body
22.	Yes	British National curriculum
23.	No	Currently not teaching in a school
24.	Yes	The world today's children are growing up relies on technology and it is our duty to encourage inquiry through kinaesthetic activities.
25.	Yes	The respondent did not justify the answer.
26.	No	There isn't a well-balanced curriculum here.
27.	Yes	We do technology and robotics at our school.
28.	Yes	There are always opportunities to integrate all the subjects together.
29.	Yes	The respondent did not justify the answer.

30.	Yes	I hope that my school will offer this - I will certainly work towards it.
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Table 28: Responses to Question 4 from respondents (n=30)

In the fourth question the majority of the respondents said “yes” (n=22), with a ratio of 76.7%, and the rest agreed with “no” (n=7), with a ratio of 23.3% as seen in the pie chart (see figure 35).

### Question 4 (n=30)

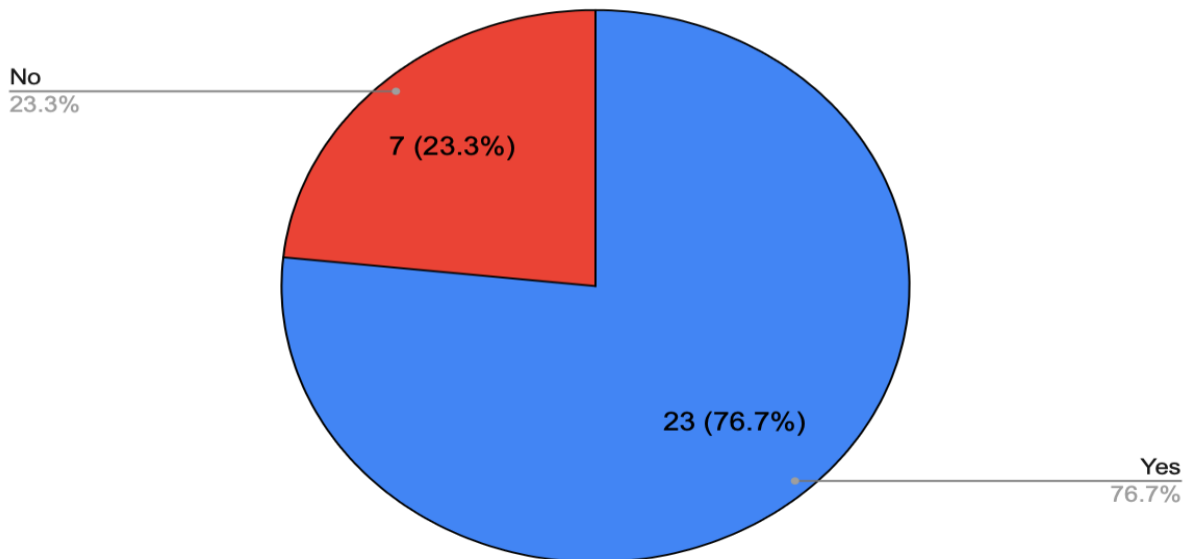


Figure 35: Responses to Question 4 (yes and no) from respondents (n=30)

**Question 5**

Do you think that both music and mathematics requires a level of aptitude?

You can state yes or no in one sentence to justify your reason?

<i>Respondent</i>	<i>Yes or No response</i>	<i>Justification for the answer</i>
1.	Yes	You have to practise both with skills where logical reasoning is involved.
2.	Yes	Most government schools have Grade 10 (FET) entrance exams and these exams should be set at the level for each phase of learning.
3.	Yes	Music and mathematics are exact sciences that require an average level to be applied and understood.

4.	Yes	Respondent has not justified a reason.
5.	Yes	I think there are observable aptitudes for both but that either can be treated as a skill which can be developed and nurtured
6.	Yes	There needs to be the necessary aptitude, as these are not easily developed in people who have no aptitude in these subjects.
7.	Yes	one has to be able to have a natural level of understanding.
8.	No	Every child is adaptable to new learning methods.
9.	No	It is not for everybody. However, I do believe that each child is capable, provided they had an excellent foundation for both in the early years.

		If this does not happen, students will struggle in the later years.
10.	Yes	Music is a skill.
11.	Yes	If in a formal conventional school setting yes, if not, no. Music and maths have existed for centuries without the necessity of testing aptitudes, skills were encouraged and allowed to flourish with guidance.
12.	Yes	When it comes to composing and writing due to increasing levels of difficulty.
13.	Yes	Music requires commitment and dedication.
14.	No	It requires a desire, strong foundations, consistent practice, feedback, and support.

15.	Yes	but once a child is taught logic, rhythm and experienced differences in combinations of time and space, they will automatically develop their aptitude for it. Teach a man to walk with crutches and he will very quickly develop strong arms, but if not taught to use crutches he will forever sit in his chair.
16.	Yes	Being fully unmusical, I think some people are born with a certain skill set. But nevertheless, I for example regret that we had such a bad music teacher and didn't even get the chance to play an instrument or try one, at least.
17.	Yes	Not sure how to understand... Everyone can do both, with work everyone can improve. Not everyone obviously can be a champ
18.	Yes	A basic- intermediate level of understanding in both disciplines is required to make effective

		progress.
19.	Yes	Both require skill and thinking. You need to love music, have dedication, and loads of practice and hard work
20.	Yes	One must be able to understand rudimentary mathematics when doing music theory.
21.	No	I feel they are accessible to all with the desire to learn.
22.	No	Command over the subject requires understanding and hard work. Artistic elements need a certain level of aptitude.
23.	Yes	It depends on how they're taught. They can inspire children to want to know more or completely switch them off. A child does not need to be able to read notes in order to

		compose music.
24.	Yes	Both are rather in-depth subjects that require both a sound theoretical and practical application.
25.	Yes	Once could learn both well to a degree but it takes natural aptitude to excel at either.
26.	Yes	Children who do music have a higher level of aptitude.
27.	Yes	The strict mathematics will also enhance one's ability away from music i.e. private life.
28.	Yes	The strict mathematics will also enhance one's ability away from music i.e. private life.
29.	Yes	Ability and skill for maths and music can be easily accessed

30.	No	Both can be done as a natural part of the human experience - however, both also need a certain skill set and knowledge base in order for someone to excel at it.
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Table 29: Responses to Question 5 from respondents (n=30)

In the fifth question the majority of the respondents said “yes” (n=24), with a ratio of 80.0%, and the rest agreed with “no” (n=6), with a ratio of 20.0% as seen in the pie chart (see figure 36).

**Question 5 (n=30)**

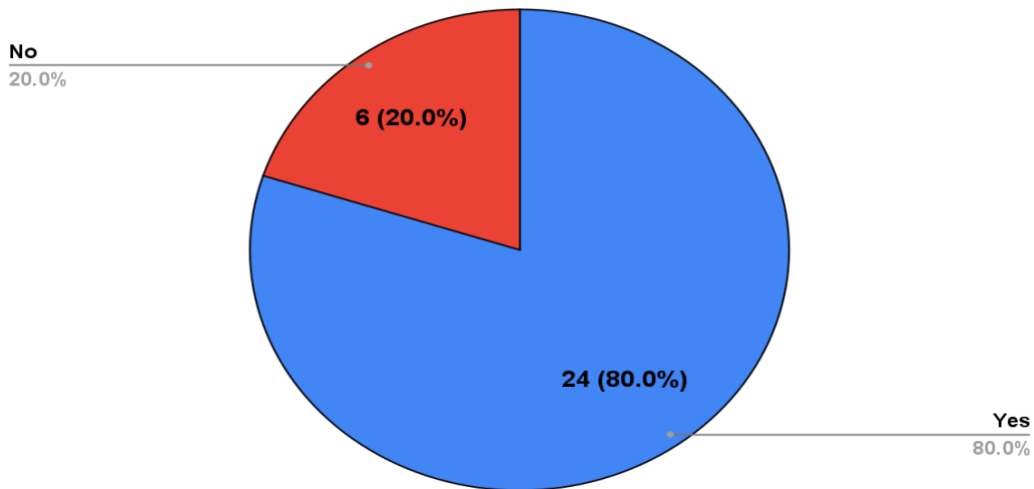


Figure 36: Responses to Question 2 (yes and no) from respondents (n=30)

**Question 6:**

Why do you think that music and mathematics are related somehow? You can state yes or no, and write down one reason, one sentence.

<i>Respondent</i>	<i>Yes or No response</i>	<i>Justification for the answer</i>
1.	Yes	A musician applies the same application and reasoning skills when concluding mathematics.
2.	Yes	Stated in Question 1 at the beginning of the questionnaire.
3.	Yes	music and mathematics are linked because both use the notion of numbers (counting for example)
4.	Yes	The very same reasoning and critical thinking skills are required for both.
5.	Yes	Music is the basic language through which most

		things are made scientific. Understanding music can be significantly enhanced in this way whether we are discussing rhythm or intervallic relationships or harmonic progression or structural elements.
6.	Yes	Mathematical equations can be used to find the ideal music for specific purposes through the development of algorithms.
7.	Yes	starts with beats, time signatures, etc.
8.	Yes	Both required a sense of calculation.
9.	Yes	Both require analytical thinking.
10.	Yes	They are related, due to rhythms and beats.
11.	Yes	Music has beats and rhythm as does maths, music has layers and is complex as is maths. They can be used organically and naturally to understand

		the other in a different way, making both accessible to a wider range of learners
12.	Yes	They both have a theoretical part which is then put into practice.
13.	Yes	Critical and logical thinking is required.
14.	Yes	It is related because you are able to transfer knowledge and skills between the two to enhance mastery of concepts and procedures.
15.	Yes	Already said that to me it is the interaction between time in space that is found in both.
16.	Yes	Without a concept of maths, it is virtually impossible to theoretically understand music, and like music maths is always reaching for the final resolution. Understanding that a piece of music is "not finished" is as soul-searching for the musician as it is for a mathematician not being able to find a

		final proof. Analogies maybe, but a mathematical structure is as important as musical structure - both are visceral and inherently part of our DNA.
17.	Yes	I think that relates to the first point in the questionnaire, no? I guess both are very logical, although I think that playing an instrument may also require a large degree of coordination skill (finger movement etc...).
18.	Yes	The same answer applies here as mentioned in question 1.
19.	Yes	As explained in question 1, notation and theory of music requires thinking in a mathematical way for group notation, timing & interpretation at practical level (score to performance)
20.	Yes	One reason why music and mathematics are related is that they both rely on patterns, ratios,

		and sequences to create structure and harmony. Both need precision, accuracy to be practised.
21.	Yes	See my answer as previously mentioned in question 1.
22.	Yes	Both have the ability to apply numeric formulae to create a specific outcome.
23.	Yes	If the process of learning and practice are similar.
24.	Yes	Each musical note has its own timing which must be counted and music has patterns as does Maths.
25.	Yes	Please refer to question 1.
26.	Yes	Rhythm is all about distribution of numbers and harmony is formulas for how notes interact.
27.	Yes	Music theory and maths are related.

28.	Yes	All music is divided into measures and beats. If you miss one, you have a problem.
29.	Yes	No subject is isolated.
30.	Yes	I would say that they are inter-related - in fact, the entire universe is based on predictable patterns of vibration and motion.

*Table 30: Responses to Question 6 from respondents (n=30)*

In the sixth question all the respondents (n=30) agreed “yes”, with a ratio of 100% that music and maths is closely related as outlined in Muller (2021) study as seen in the pie chart.

<b><u>Question 7:</u></b>		
Are you familiar with the available music aptitude tests and mathematical aptitude tests available to promote in your classroom setting? Please state yes or no, and write down one sentence to justify your answer?		
<i>Respondent</i>	<i>Yes or No</i>	<i>Justification for the answer</i>

	<i>response</i>	
1	Yes	We encourage both educators to work together in the school.
2	Yes	Answer stated in Question 5.
3.	No	I don't know of any because I haven't done any research yet, even though I suspect that there are some.
4.	Yes	I've used music aptitude tests for years.
5.	Yes	I am aware of this but have never taken one myself or used them as a teacher.
6.	No	I have not been exposed to them, but suppose they exist.

7.	Yes	have used examples of both preparing students for SATS, entrance exams.
8.	No	Never done one before.
9.	No	I have never had the need to access these.
10.	Yes	I've heard of it.
11.	No	I don't need them
12.	No	I haven't been introduced to these by the school.
13.	No	We don't offer music. We have external people coming in.
14.	No	The respondent did not justify the answer.
15.	No	I am not with a school and do not know what they use.

16.	No	Not used in my setting.
17.	No	I am not, unfortunately. Will inform myself, i.e. google it.
18.	No	The respondent did not justify the answer.
19.	No	Aptitude varies from person to person. Appreciation of music should be an organic process not contrived by aptitude tests and regimented training formats.
20.	No	The respondent did not justify the answer.
21.	No	I've never heard of them before.
22.	No	This is not my specialism.
23.	No	The respondent did not justify the answer.
24.	Yes	I don't actually teach music though I can play

		musical instruments, but I have used mathematical aptitude tests.
25.	Yes	I am now - kind of.
26.	No	I am not familiar with the aptitude tests.
27.	No	I am not familiar with music aptitude tests.
28.	No	We studied in the mid-sixties, and I cannot remember going through any of the above.
29.	No	The respondent did not justify the answer.
30.	No	Not at all, sorry.

*Table 31: Responses to Question 7 from respondents (n=30)*

For question 7, the majority of the respondents said “no” (n=22) with a ratio of 73.3% whilst the rest agreed with “yes” (26.7% with a ratio of 26.7% as seen in the pie chart (see figure 37) .

**Question 7 (n=30)**

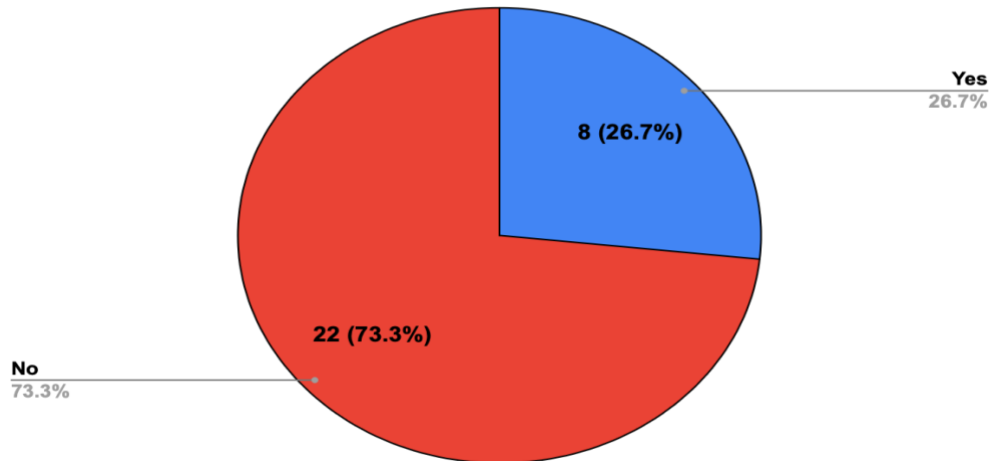


Figure 37: Responses to Question 7 (yes and no) from respondents (n=30)

**Question 8**

What factors do you think affect the academic achievements of students doing music and mathematics? Please write down one sentence to justify your answer?

<i>Respondent</i>	<i>Justification for the answer</i>
1	Transportation issues and mainly drug abuse.

2.	There are major benefits, similar to Question 2. And have seen first hand how 80% of our top achieving students are both academically and musically gifted.
3.	The lack of work and discipline are in my opinion the only factors.
4.	Students develop a better sense of logic and method as well as a higher ability to focus for longer periods. Their ability to process methodically is constantly developed!
5.	I think that success in any area of life begets success in others. Music teaches us to be patient, to work with pride and love, to express ourselves, and it also gives us a physical and practical way to observe the effects of consistent effort - I believe that this contributes to self confidence and a growth mindset.
6.	Musicians more likely have different attitudes towards

	<p>mathematics and have a greater aptitude for music than Mathematics whereas Mathematicians have a greater aptitude for Mathematics.</p>
7.	<p>School support for Music. Opportunities outside the classroom</p>
8.	<p>Besides hardwork and perseverance, an interest in the topics would be great. Class must be interesting enough to get students to engage.</p>
9.	<p>Good foundations. Good teachers in the early years.</p>
10.	<p>I don't know about maths, but a good teacher and curriculum geared toward student success and not a test.</p>
11.	<p>Fear of being wrong or not good enough or being embarrassed in front of their friends. As much as we would prefer otherwise students look to get on the good side of the teacher and if they can't, give up and</p>

	stop trying.
12.	Parental attitude towards their children and their achievements and the activities that boost their self-esteem and learning. Children should still be under the guidance of their parents while attending school.
13,	Music needs commitment and dedication which can affect academics.
14.	Foundational knowledge, low expectations, lack of practice and support and consistent feedback.
15.	Many... of which the enthusiasm of the teacher counts the most.
16.	It is a neuroscience fact that music and the cross-over of the hemispheres builds new neurological pathways. This new interconnectedness without a doubt would significantly increase academic performance all round.

17.	Able teachers, available instruments, opportunities to be creative (school bands or choirs, e.g.), learning maths hands on or project-related, I for example never understood why I have to learn integral calculation, while stochastic I found easy to relate to.
18.	Consistency, daily work
19.	Finding time to practise; the quality of tutoring; sufficient interest in the subject areas; perception of sound ie if someone's tone deaf then they may not get far musically in the traditional sense.
20.	cultural background, Mathematics perceived as a science and harder subjects and music as a softer subject with less credibility than mathematics.
21.	If one struggles with the basic concept of number, perhaps through having dyscalculia, then this would affect their understanding of the reading of music

	notation. It would not, however, if they learnt music solely by ear.
22.	Poor teaching, lack of motivation and enthusiasm
23.	Patterns and thinking skills.
24.	Instrumental music has a calming effect on children, improving their concentration and creativity.
25.	Intrinsic motivation, lack of context, an unsafe study environment at home (or at school for that matter), no time/place to practise.
26.	Intellect and reasoning skills.
27.	Plenty of doctors and highly educated persons usually took music in their younger years.
28.	Complete devotion and understanding of the genre - no two pairs of ears hear and experience the same

	work the same way.
29.	Syllabus, and teaching skills.
30.	Preconceived notions that students are either good or bad at it, rather than everyone can learn to do it - at least at their own level, because both subjects require a lot of abstraction to understand and analyse.

*Table 32: Responses to Question 8 from respondents (n=30)*

For questions 8 the different respondents shared the factors that they felt affected their achievement overall in terms of music and mathematics.

### **Question 9**

If you had the opportunity to promote music together with mathematics what activities or events would you arrange to promote in your school setting? Please state yes or no, and write down one sentence to justify your answer?

<i>Respondent</i>	<i>Yes or No response</i>	<i>Justification for the answer</i>
1	Yes	I would allow educators to meet regularly by having a joint project where both educators could work collaboratively together.
2.	No	I wouldn't arrange an event per say but ensuring that both subjects are featured in the others curriculum is more important. Our school arranges an annual career and subject choice evening where many benefits of each subject and subject combinations are spoken about and discussed.
3.	Yes	I will do the addition using the note figures as the value

4.	Yes	Cross curricular activities developing basic arithmetic skills through music
5.	Yes	I would if it were done in the name of creating something intrinsically amazing - I would not do so in the pure service of mathematics - i.e advocating for music's place in schools because of the positive correlative effect that it might have on student achievement in mathematics.
6.	Yes	Allow pupils to use computer algorithms to create music based on a chosen composer or musician.
7.	No	I find that Maths departments are not completely interested in such collaborations.
8.	Yes	I would create a drum circle activity,

		something for me to look into.
9.	Yes	Songwriting workshop: Students can write songs based on mathematical concepts.
10.	Yes	I would do rhythm activities.
11.	Yes	Recording music with the kids, editing music with the kids, layering music with them. A concert perhaps
12.	Yes	I would arrange a group outing to the Technical museum in the city.
13.	No	We do not offer music at our school.
14.	Yes	Using the opportunity during concerts, recitals, and performances to explain the connection between Math and Science to the audience.

15.	Yes	Dancing to different music and letting them count.
16.	No	Not appropriate for my setting.
17.	Yes	Maybe some playful activities like running from station to station where you have to solve musical questions like which band had this or that number one hit and another station where you have to solve maths problems?
18.	Yes	Why not try to give more sense to school?
19.	Yes	Live performances can often inspire young minds. Orchestras at work, brass bands, church music. Lunchtime concerts or free recitals.  Bring these experiences back to the classroom for discussion introducing

		music theory and application of maths and demonstrating how these all link up.
20.	Yes	Workshops
21.	Yes	I would host staff/student workshops with practical, fun activities/games.
22.	Yes	This is not my area, but I would design activities that are fun, engaging and relevant to current trends etc.
23.	Yes	Problem solving activities.
24.	Yes	This can be done through dance, which is highly mathematical and needs music for expression.
25.	Yes	Put on a musical about Pythagoras. Form connections between the different fields to

		create context for the students.
26.	Yes	Musical games that focus on the maths aspect.
27.	Yes	The relationship between music theory and maths.
28.	Yes	Students coming up and sharing the challenge or stage together in pairs of more persons with live props to demonstrate their abilities. Switch positions and see how a different approach affects the final sound.
29.	Yes	I have no idea about this question.
30.	Yes	Music composition challenges where students have to use certain formulae to create a piece of music or maths challenges to express popular songs

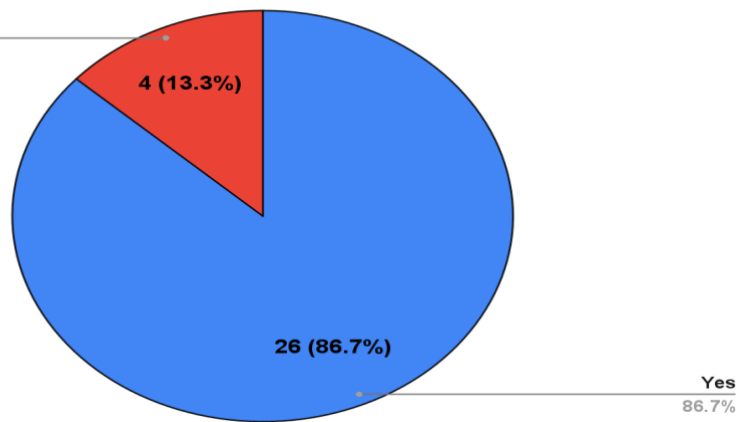
		through analysing them using percentages and graphs.
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Table 33: Responses to Question 9 from respondents (n=30)

For question 9 the majority of the respondents said “yes” (n=26) with a ratio of 86.7% whilst the rest agreed with “yes” (n=4) with a ratio of 13.3% as seen in the pie chart (see figure 38).

**Question 9 (n=30)**

No  
13.3%



Yes  
86.7%

Figure 38: Responses to Question 9 (yes and no) from respondents (n=30)

**Question 10**

Do you feel competent that your music influenced your mathematical achievement whilst concluding your secondary education in school? Please state yes or no, and write down one sentence to justify your answer?

<i>Respondent</i>	<i>Yes or No response</i>	<i>Justification for the answer</i>
1	Yes	I feel very comfortable and was very influenced in mathematics by being exposed to music from a young age.
2.	Yes	I was a top achiever in both subjects and obtained an A (80% and higher) for both.
3.	No	Music did not influence my success in mathematics in any way because no teacher taught me the link between music and mathematics. I learned it later through my

		research when I was at university.
4.	Yes	I qualified as both a music and mathematics teacher as a result thereof!
5.	No	At that stage of my life, I was not enthusiastic about mathematics and so I cannot say so with certainty.
6.	No	Although I took some music and sang in a choir, I was not able to perform well in Mathematics.
7.	No	I had a Maths tutor and I was grade 8 piano
8.	No	More can be ventured into this topic. It's difficult when music is not considered an important topic in my school.
9.	No	Whilst I was good at music, I was weak at mathematics due to poor levels of teaching.
10.	No	Music can't help me with algebra.

11.	No	Once I got to 15 years old I was n longer interested in maths and spent the following years frustrated and unmotivated in the subject
12.	Yes	These were both subjects that needed perseverance in trying to achieve results.
13.	Yes	Learning to read musicians and applying it, definitely helped with my mathematical achievement.
14.	No	We did not have a music program in HS.
15.	No	I did not take maths although I practised piano and listened to classical music a lot.
16.	Yes	I had two peers in my class who did music. All three of us were outstanding at mathematics and finding unusual solutions to problems.
17.	Yes	As said above, my music teachers were, honestly, but no offence, bad. I am not saying that this resulted in me being equally bad in maths, but I'd rather say that I didn't

		have the best setup / intellect / skill set in the first place for either maths or music. Having not the best teachers in those subjects didn't help me either.
18.	No	Not really... but I still do love maths and wish I were better.
19.	Yes	Music influenced my achievements in maths and vice versa!
20.	Yes	The respondent did not justify the answer.
21.	No	I had a natural affinity for music but struggled greatly with anything mathematical.
22.	No	music was not considered as a key part of the curriculum during my secondary education in the UK.
23.	No	It could be both ways and uncertain which affects which stronger
24.	Yes	Absolutely. I was raised on music and always had a song in my head, regardless of

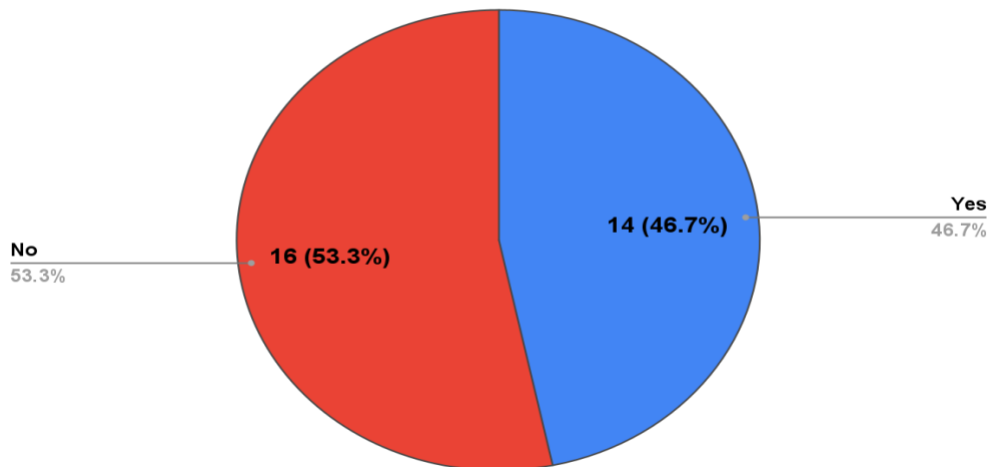
		what subject I was studying.
25.	Yes	We had such a bad music teacher turnover that I had to drop to maths literacy to try to pass music. I was also missing so much maths from teaching the music teacher that I was missing classes for him so I was going to have to drop down anyways. That's probably not what you meant but this is apparently confidential so I took the opportunity to vent a little.
26.	No	I started music after I dropped maths as a subject.
27.	Yes	Yes I took both music and mats as a subject in high school.
28.	Yes	When I was young, I was stupid, now I am older and wiser and will always compliment the music in me.
29.	No	The respondent did not justify the answer.
30.	Yes	Absolutely - my understanding of music helped me visually many different maths

		problems.
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*Table 34: Responses to Question 10 from respondents (n=30)*

For question 10 the majority of the respondents said “no” (n=16) with a ratio of 53.3% whilst the rest agreed with “yes” (n=14) with a ratio of 46.7% in the pie chart (see figure 39).

**Question 10 (n=30)**



*Figure 39: Responses to Question 10 (yes and no) from respondents (n=30)*

### 4.2.3 QUALITATIVE RESPONSES FROM RESPONDENTS A – F (N=6)

The following phase included the Qualitative responses from the students at Liverpool Secondary School. All students concluded a questionnaire based on their mathematical abilities. The following responses were concluded as per the Qualitative method of research.

For this sample, the researcher used students aged 12 – 14 to conclude the questionnaire, due to the confidentiality the researcher will refer to each six (n=6) respondents in terms of the following:

#### **RESPONDENT A:**

##### **Overall Observation:**

The results of a girl, who was aged 12, and who achieved exceptional results in mathematics overall, revealed that in the last six months she consistently worked well in most of the areas including Algebra, Geometry, Trigonometry and General applied mathematics.

##### **Challenges:**

The challenge the student had was attending a school where she had to travel one hour each way to obtain an excellent education. She was very happy with the

educational tuition offered by her secondary teachers. Apart from transportation problems, only one parent was working at home as her father had passed away. She came from a family of five children, and was extremely happy to be able to attend a school where all her educational needs were being met and attended. She worked cooperatively with most of her peers and had excellent attendance at school.

### **Music School**

At the music school she started playing the piano and achieved excellent results in both her AMMA test and music theory papers, and was currently enrolled to complete her Grade 1 Theory examinations with UNISA. She was highly proactive with attending concerts and performed regularly at the Music Eisteddfod, and piano recitals at the school. Her AMMA test revealed that she obtained better results in comparison with the boys of her age. Music was seen as a form of expressionism for her where no one judged her for creating and learning music. She regularly performed in her church and was a proactive person within her community where she engaged with other students her own age, and shared ideas and ideologies around music and her understanding of music theory. Although she had a particular interest in music technology the school did not have the facilities for her to explore composition further and had to indulge in several theory papers to understand the basic rudiments of music theory. She attended theory lessons regularly and made excellent progress with her music studies.

## **RESPONDENT B:**

### **Overall Observation:**

A boy, who was aged 12, and who achieved good results in mathematics overall. His results revealed that in the last six months he worked consistently in most of the areas including Geometry, Algebra, Trigonometry, and General applied mathematics.

### **Challenges:**

The challenge the student had was attending a school where he had to travel two hours each way to obtain an excellent education. He was very happy with the educational tuition offered by his secondary teachers. Apart from transportation problems, he could not afford extra tuition due to financial problems at home. He came from a family of three children and was extremely happy for the opportunities granted to him and to be able to learn new concepts taught in each lesson of the curriculum. He worked well independently and used every resource available to him and presented in the classroom. His attendance was good overall due to being able to attend only a few lessons due to financial problems at home.

### **Music School**

At the music school he started playing several instruments, and achieved excellent results in both his AMMA test and music theory papers and was currently enrolled to complete his Grade 2 Music Theory examinations with UNISA. He was highly proactive with attending concerts and performed regularly at the Music Eisteddfod and recitals at the school. He was part of a few ensembles and was happy with the opportunities given to him through the bursary that was offered by the school. His AMMA test revealed that he obtained good results overall in comparison with his peers and other boys in the class. Although the girls achieved the highest mark, his mark was positioned 2<sup>nd</sup> in the classroom. He was adamant to succeed in his music studies and take every challenge as a learning experience.

### **RESPONDENT C:**

#### **Overall Observation:**

A girl, who was aged 13, and who achieved good results in mathematics overall. Her results revealed that in the last six months she consistently worked well in most of the areas including Algebra, Trigonometry, Geometry and General applied mathematics.

#### **Challenges:**

The challenges that the student had was attending a school where she had encountered peer pressure. Being a teenager posed problems with some of her peers, which involved smoking at the school whilst she tried her best to be part of the different girl's groups at the school. Apart from their teenage problems she only had one parent that was interested in her academic work as her father worked mostly and was the financial supporter. She came from a family of three children and was ecstatic to be able to attend a school where she could obtain excellent academic results. She worked well cooperatively with other peers in her class and her attendance was excellent overall.

### **Music School**

At the music school she started playing the piano and achieved excellent results in both her AMMA test and music theory papers and was currently enrolled to complete her Pre-Grade 1 Theory examinations with UNISA. She was highly proactive and attended concerts and recitals regularly. Her AMMA test revealed that she obtained good results in comparison with the boys in her class; although the boys achieved better results overall.

### **RESPONDENT D:**

### **Overall Observation:**

A boy, who was aged 13, and who achieved excellent results in mathematics overall. His results revealed that in the last six months he worked consistently in most of the areas including Algebra, Trigonometry, General applied mathematics and Geometry.

### **Challenges:**

The challenge the student had overall was peer pressure from other students who were not as engaged as him in his education. Most students his age were already smoking and indulging in various substances including alcohol. Something that did not interest him due to his christian upbringing and fellowship within his local church within the community. He enjoyed being a student at the school, and excelling in all areas of the curriculum, especially music and mathematics. He came from a family of four children with a single mother working and making financial contributions to his household. He was honoured for achieving a bursary within the Music Department to sustain his music studies although he had no instrument to practise at home. He took advantage of every opportunity to practise at school when he had free time.

### **Music School**

At the music school he started playing the piano and obtained excellent results in both his AMMA test and music theory papers and was currently enrolled to complete his Grade 1 Music Theory examinations with UNISA. He was highly proactive with

attending concerts, and performed regularly at the Music Eisteddfod and recitals at the school. The most enjoyable experience was being able to play with the ensemble provided by the school. This was the highlight of his social interaction with other peers of both genders at the school. His AMMA test revealed that he obtained excellent results in comparison with the students of his age, and class setting.

### **RESPONDENT E:**

#### **Overall Observation:**

A girl, who was aged 14, and who achieved excellent results in mathematics overall. Her results revealed that in the last six months she worked consistently in most of the areas including Algebra, General applied mathematics, Trigonometry and Geometry.

#### **Challenges:**

The student had some challenges with peer pressure. She felt that some students in her classroom were not serious about their work, and were more concerned about interactions with the opposite sex. She took her academic work seriously and worked consistently although she was adamant to complete her matriculation and be the first in her family to graduate and be able to attend university. Her ambition was to study in the medical field and was determined to obtain excellent results. She was happy

at the opportunity given to her to attend a good school in the local area, which was near the school, which meant she had to travel short distances and be able to engage with other students in her class and review her homework with other girls living in the area.

### **Music School**

At the music school she started playing the violin, and obtained excellent results in both her AMMA test, and music theory papers, and was currently enrolled to complete her Grade 3 Music Theory examinations with UNISA. She was highly proactive with attending concerts and performed regularly at the Music Eisteddfod and recitals at the school. She enjoyed being part of the various ensembles available at the school and attended the Jazz Band. This was the highlight of her social interaction with other peers of both genders at the school. Her AMMA test revealed that she obtained excellent results in comparison with the girls of her age and class.

### **RESPONDENT F:**

#### **Overall Observation:**

A boy, who was aged 14, and who achieved good results in mathematics overall. His results revealed that in the last six months he worked consistently in most of the areas including Algebra, General applied mathematics, Geometry and Trigonometry.

### **Challenges:**

This student had many challenges ranging from transportation to attending classes regularly due to financial problems because he came from a family of five children and his mother was the breadwinner and made sure that all financial obligations were met. Although transportation was a major issue, he did not mind travelling long distances, which took him around two hours to get to school and back home. At home, he had to complete his regular home chores and play a proactive role within his family by looking after the rest of his siblings. He very much enjoyed attending the school, in which he was allowed to excel academically which made his mother extremely proud.

### **The Music School**

At the music school he started playing the piano, and obtained good results in both his AMMA test and music theory papers, and was currently enrolled to complete his Grade 1 Music Theory examinations with UNISA. He was highly proactive with attending concerts and performed regularly at the Music Eisteddfod, and recitals at the school. He enjoyed being part of the various ensembles available at the school and attended the Jazz Band. This was the highlight of his social interaction with other peers of both genders at the school. His AMMA test revealed that he obtained good results in comparison with the other boys of his age and class.

#### 4.2.4 QUALITATIVE - INTERVIEW AND OBSERVATIONS WITH MUSIC

##### TEACHER

The follow-up interview was held via Skype as the researcher faced Covid19 protocols due the situation in South Africa, where all means of direct communication were affected.

The researcher liaised regularly with the Music teacher to ensure that the data that was collected gave an in-depth account of the current situation, and challenges the teacher faced whilst working at Liverpool Secondary School.

One of the music teachers teaching at Liverpool Secondary School and was himself also a post-graduate candidate at the University of Venda (Univen). He completed his bachelor's in music Degree at the University of Cape Town and concluded his Master's Degree at Univen where he researched *Umaskandi* music. He was regularly performing as lead bassist with several ensembles and was solely responsible for teaching of Marimbas, Jazz Piano and acoustic ensembles at the school. He was employed at the school after several years in the corporate world. He was a passionate musician, and this was evident in his teachings and being responsible for the Jazz Band, who performed regularly. After 22 years of teaching, he believed it was important to allow students ample opportunities to showcase their

talents but foremost ensured that they became competent performers overcoming their nerves through displaying the natural gift for performance.

The Music Department was well resourced, and other teachers in the department were teaching piano, music history, and preparing the students for their annual music theory examinations. Amongst The music teacher duties was to ensure that students were well equipped with an understanding of improvisation and playing genres of different music ranging from Kwaito to Fusion and Jazz. He also ensured the students had a good understanding of *Umaskandi* music which he researched for his master's degree.

The music department was well resourced with the following:

- Practical books for ensembles including the jazz band.
- Tuition books available for several instruments ranging from strings, acoustic guitar, vocals, piano, keyboards, and recorders.
- Students had access to several recordings from different genres ranging from Baroque to *Umaskandi* Music.
- Several instruments including pianos, marimbas, drum set, bass guitar, acoustic guitars, recorders, trumpet and saxophones.
- Music Theory books covering grades from preliminary to advanced and Grade 7 UNISA, ABRSM, TCL and LCM.

- Music ear tests and sight-reading books for the several examination institutions (ABRSM, UNISA; TCL, ROCK SCHOOL, RSL and LCM).
- Past papers including books from TCL, Rock School, UNISA and LCM for students to revise in preparation for their music theory examinations.

The students met regularly for ensemble practice, which was scheduled according to his timetable. They were able to perform in front of their peers, and at Eisteddfods, which the school regularly organised in collaboration with several festivals the various ensembles attended.

### **Challenges:**

The only thing the department lacked was music technology with computers to allow students to compose regularly and familiarise themselves with Garage Band, Muse Score, Finale and Sibelius although Muse Score was freely available for students to download at home and use if they had access to a laptop. Notation programs were something they had to explore themselves.

According to the music teacher (2019) who suggested:

The students were enjoying music lessons, and this created opportunities for them to indulge in several ensembles where they could showcase their talents. Music was popular at the school and although the students were very academically driven despite their social-economic problems, they attended the jazz band regularly and always enjoyed the annual outings and regular music concerts. This was the highlight of their schooling as their peers got the opportunity to appreciate the music the students created.

For the students overall these opportunities helped them to engage on a social level with their peers, and show their progress, and an understanding of music overall. Their parents attended the music concerts that were hosted by the Music Department, and this allowed the students to express themselves through music. It was important for them to have a balance in their academic work but foremost most of the musicians were excellent mathematicians. And achieved excellent results in their mid-term examinations and cycle tests.

When the AMMA test was administered the students had the opportunity to explore a music aptitude test, which they were not familiar with. Although they were tested on their aural skills they had to listen attentively and differentiate between the various melodies being played with the first statement and compare with the second statement heard, which could either have a tonal or rhythmic change to be the same. They had to concentrate and use the skills that they were taught in the music class. This music aptitude test allowed students to realise their innate aural capabilities and test their skills. Little differentiation was required as all the students completed the same test and used the answer sheets that were supplied and provided.

When the music teacher completed this test, he found it comfortable as he studied music at university and was a proficient musician performing with several bands in his local community. He felt the Department of Education had to invest money to

ensure that all the magnet schools had access to one music aptitude test designed by Prof Gordon. This was a good experience for the students as well as for himself, as a music teacher who studied music in-depth and covering music analysis, form and structure, harmony and counterpoint and free jazz.

### **4.3 SAMPLE PROFILES**

Most of the students that featured in this study attended Liverpool Secondary school were in grades 8 and 9 were proficient in music and mathematics. Liverpool Secondary School, who studied music as part of the Arts and Culture module provided in school. Most of the students were of both sexes, and aged 12 – 14 years. Although a larger sample was tested, and outlined in the data sampling the emphasis was on focussing on the six individual students for this particular case study.

The statistics of the school overall:

- **LIVERPOOL SECONDARY SCHOOL SECONDARY/ HIGH SCHOOL – ACTONVILLE BENONI-Gauteng Province.**

Teachers: 58

Students: 1244

Phase: SECONDARY/ HIGH SCHOOL

Ownership: STATE

Build: Since 12/31/1899

Fees: NONE

Boarding: NONE

Specialisation: ORDINARY SCHOOL

- **LIVERPOOL SECONDARY SCHOOL LOCATION**

Physical Address: 1 BHATTAY STREET, ACTONVILLE, ACTONVILLE,  
1501

Township/Village: ACTONVILLE

Suburb: ACTONVILLE

Town/City: BENONI

Urban/Rural: URBAN

Local Municipality: EKURHULENI METROPOLITAN MUNICIPALITY

District: EKURHULENI NORTH

#### **4.4 SUMMARY (CONCLUDING INTERPRETATIONS)**

The summary of the data collection showed that both sexes achieved excellent results in both the Tonal and Rhythm aspects of the AMMA test.

It was important to conclude and study the material available in terms of their mathematical achievement, and both genders enjoyed completing the music

aptitude test. The following observations were made when concluding their results by comparing the data of the boys and girls from a sample of students taken:

- a) The boys aged 12 achieved better results in the rhythm section of the AMMA test.
- b) The girls aged 12 achieved better results in the tonal section of the AMMA test.
- c) Both the boys and girls aged 13 achieved better results in the Rhythm section of the AMMA test.
- d) The boys aged 14 achieved better results in the tonal section of the AMMA test and
- e) The girls aged 14 achieved better results in the rhythm section of the AMMA test.

Comparing the boys and the girls one could conclude the following:

- a) The girls achieved better results in the tonal section of the AMMA test in comparison with the boys aged 12.
- b) The boys achieved higher results than the girls in the Rhythm section of the AMMA test when one compared their ages.
- c) The girls achieved much higher results in both the Tonal and Rhythm sections of the AMMA test in comparison with the boys aged 13.

- d) The girls aged 14, achieved much higher results in comparison with boys in the Tonal aspect of the AMMA test, and,
- e) Both the boys and girls aged 14, achieved excellent results in the Rhythm section of the AMMA test.

### **Observations and Interviews**

- a) The researcher concluded observations and interviews with seven respondents including the music teacher.
- b) Most of the students faced several challenges which had financial implications on their education.
- c) Transportation was a big problem overall as students had to commute long distances to obtain a good education.
- d) Some students came from homes where one parent was working and the single financial contributor to the household.
- e) Most of the students enjoyed the opportunities given to them to study at Liverpool Secondary School.
- f) Reviewing their mathematical progress overall they all achieved remarkable results despite their socio-economic problems.
- g) They all confirmed possessing a music aptitude impacted their mathematical developments and achievements overall.

- h) The music teacher suggested that the Government invested money introducing the several music aptitude tests available to them.
- i) That differentiation could assist and help foster and reinforce positive learning environment for the music students, and
- j) Overall, most of the students that were examined in the study obtained excellent results in the mathematical scores, whether these involved tests, regular assignments, homework and end of year mid-term and final examinations.

### **SUMMARY OF QUANTITATIVE STUDY (30 RESPONDENTS)**

This extended study further delves into the captivating connection between music and mathematics, highlighting the underlying principles and shared concepts that unite these seemingly disparate disciplines. By examining the historical and contemporary perspectives, we uncover the mathematical foundations present in music, exploring topics such as rhythm, harmony, scales, and composition. Drawing upon renowned mathematicians and musicians, we shed light on the profound interplay between these two art forms. This investigation reveals how mathematics provides a framework for understanding and appreciating the beauty and complexity of music, while music, in turn, inspires mathematical exploration and innovation.

The bond between mathematics and music has long fascinated scholars and enthusiasts alike. This essay aims to explore the correlation between these two disciplines, revealing the mathematical underpinnings that shape musical composition, performance, and appreciation.

### **Historical Perspectives**

Throughout history, various cultures have recognized the mathematical nature of music. Ancient civilizations, such as the Greeks and Egyptians, acknowledged the numerical relationships that govern musical intervals and harmonies. Pythagoras, the renowned Greek mathematician, discovered the mathematical ratios that determine consonance and dissonance, laying the foundation for the concept of musical harmony.

### **Rhythm and Time Signatures**

Rhythm, a fundamental element of music, can be approached mathematically. The concept of metre and time signatures, such as  $4/4$  or  $3/4$ , involve counting beats and subdividing them, akin to mathematical fractions. Moreover, polyrhythms and syncopation demonstrate complex mathematical relationships and patterns that contribute to the rhythmic diversity found in various musical genres.

## **Harmony and Musical Scales**

Harmony, the combination of simultaneous sounds, exhibits mathematical principles. Western music theory, for instance, relies on the mathematical relationships within the chromatic scale and its subdivisions, such as the diatonic scale. The application of ratios and intervals in constructing chords and progressions further exemplifies the mathematical nature of harmony.

## **Composition and Mathematical Structures**

Mathematics plays a vital role in the composition of music. Composers employ mathematical concepts like symmetry, repetition, and mathematical transformations to create compelling musical structures. The use of Fibonacci sequences, golden ratios, and fractal patterns in composition showcases the intricate interplay between mathematics and musical creation.

## **Mathematical Innovations in Music**

Music has also inspired mathematical innovation. The field of music theory draws upon mathematical concepts to analyse and understand musical structures. From set theory and group theory to spectral analysis and digital signal processing, mathematics provides powerful tools for deciphering the complexities of music.

## Contemporary Applications

In the digital age, mathematics has revolutionised music production and synthesis. Digital audio processing, sampling, and algorithmic composition rely on intricate mathematical algorithms and formulas. Additionally, machine learning techniques have been employed to analyse musical patterns and generate novel compositions, further highlighting the symbiotic relationship between mathematics and music.

### Data Analysis:

Once the questionnaire was concluded by the 30 respondents the data was analysed

- Where are you teaching at the moment?
- Gender (Male or Female),
- Teaching experiences, and
- Age.
- 10 Questions were presented where candidates had to state “yes” or “no” with a short comment to justify their reasons/answers.

From the data collected the three respondents who identified with a ratio of 10% included:

- PS Eastern Cape
- PS Gauteng

- PS United Kingdom
- PS United States of America

From the data collected the two respondents who identified with a ratio of 6.7% included:

- PS Western Cape
- PS Thailand

From the following data collected the one respondent who identified with a ratio 3:3% included:

- PS Gabon
- PS Europe
- PS France
- PS Germany
- PS China
- PS Taiwan

In the government sector the following respondents concluded the questionnaire.

From the following data collected two respondents who identified with a ratio of 6.7% included:

- GS Gauteng

From the following data collected the one respondent who identified with a ratio of 3.3% included:

- GS Eastern Cape
- GS Wales
- GS United States of America (USA)

In this study most of the participants came from countries in South Africa and abroad and included the following genders:

- 11 Females with a ratio of 36.7%
- 19 Males with a ratio of 63.3%

In terms of different age groups, the 30 respondents in South Africa and abroad who participated in this study were:

- 20 - 25 years of age (zero respondents answered from this age group)
- 25 - 30 years of age (n=1, with a ratio of 3.3%)
- 30 - 35 years of age (n=3, with a ratio of 10%)
- 35 - 40 years of age (n=1, with a ratio of 3.3%)
- 40 - 45 years of age (n=7, with a ratio of 23.3%)
- 45 - 50 years of age (n=7, with a ratio of 23.3%)
- 50 - 55 years of age (n=4, with a ratio of 13.3%)
- 55 - 60 years of age (n=6, with a ratio of 20%)

- 50 - 65 years of age (n=5, with a ratio of 16.7%)

## **SUMMARY OF THE RESPONSES TO QUESTIONS 1 - 10 PRESENTED TO THE RESPONDENTS FROM AROUND THE GLOBE:**

- In this first question 100% agree that music and mathematics were closely related and this has been outlined in the PhD study of Muller (2021).
- In the second question the majority of the respondents said “yes” (n=24), with a ratio of 82.8%, whilst “nothing stated” (n=3), with a ration of 10.3% and the rest agreed with “no” (n=3), with a ratio of 6.9% as seen in the pie chart.
- In the third question of all the respondents (n=30), what actions can be taken to ensure collaboration between teachers in the maths and music departments.
- In the fourth question the majority of the respondents said “yes” (n=22), with a ratio of 76.7%, and the rest agreed with “no” (n=7), with a ratio of 23.3% as seen in the pie chart.
- In the fifth question the majority of the respondents said “yes” (n=24), with a ratio of 80.0%, and the rest agreed with “no” (n=6), with a ratio of 20.0% as seen in the pie chart.

- In the sixth question all the respondents (n=30) agreed “yes”, with a ratio of 100% that music and maths is closely related as outlined in Muller (2021) study as seen in the pie chart.
- In the seventh question, the majority of the respondents said “no” (n=22) with a ratio of 73.3% whilst the rest agreed with “yes” (n=8) with a ratio of 26.7% as seen in the pie chart.
- In the ninth question, the majority of the respondents said “yes” (n=26) with a ratio of 86.7% whilst the rest agreed with “no” (n=4) with a ratio of 13.3% as seen in the pie chart.
- In the tenth question, the majority of the respondents said “no” (n=16) with a ratio of 53.3% whilst the rest agreed with “yes” (n=14) with a ratio of 46.7%.

## **SUMMARY OF RESPONSES TO COMMENTS MADE BY ALL 30**

### **RESPONDENTS WHO PARTICIPATED IN THIS QUANTITATIVE STUDY**

#### **Question 1**

Music and mathematics share a strong connection, as they both involve systematic processes. Studies have shown that combining music and mathematics enhances brain development. Music uses the metric system, a mathematical notion, and can be understood in mathematical terms through western music theory. Both subjects

require problem-solving, pattern recognition, and analytical thinking. Rhythmic patterns in music have a mathematical basis, and musical notes have specific time values. Counting beats and understanding fractions play a role in music education. Music notation involves mathematical elements. Musical rhythm, scales, and intervals are based on mathematical ratios and patterns. Music and mathematics both utilise patterns, sequences, and formulas.

### **Question 2**

The correlation between music and mathematics is evident in students' improved results. Concentration, practice, and determination connect both disciplines. Music aids in remembering sequences and equations, strengthening academic skills, and promoting emotional well-being. While causation may be challenging to prove, music's positive impact on learning is clear. Music's structure and practice are inherent in human DNA, intertwined with mathematical concepts. It can enhance cognitive abilities, especially when introduced at a younger age. Music's mathematical order, rhythms, and patterns contribute to students' maths skills and understanding.

### **Question 3**

Educator collaboration facilitates skill-sharing and mutual inspiration. Integrating music and mathematics can be beneficial, such as teaching fractions through music

or exploring the physics of sound. Bridging music and maths highlights the beauty of numbers and melody. Educational apps can link the subjects, and music promotes critical thinking. Cross-curriculum units can transfer knowledge between the two subjects. Promoting STEAM and making arts prominent in schools can enhance the connection. Visual aids and case studies can aid comprehension. Early music education and the use of live props can make learning exciting. Openness to change and working with colleagues fosters successful integration.

#### **Question 4**

In the context of IB education, regular educator collaboration is emphasised, benefiting pupils' futures with interdisciplinary projects and partnerships. Opportunities to integrate STEM and Performing Arts into the curriculum vary, often requiring external support. Some schools focus on academic subjects, while others prioritise arts and academics together. The availability of incorporating these subjects may depend on the teacher's willingness and resources. While technology and robotics are present in some schools, a balanced curriculum is not always evident. Encouraging inquiry through kinesthetic activities is crucial in today's technology-dependent world. Personal preferences and school settings influence the possibility of integration.

### **Question 5**

Both music and mathematics involve logical reasoning and require an average level of aptitude to be understood and applied effectively. While every child can adapt to new learning methods, not everyone may possess a natural level of understanding in these subjects. A strong foundation and consistent practice are crucial for progress. Skill development depends on effective teaching and guidance. Both disciplines can be accessible to all with the desire to learn, but excelling may require natural aptitude and dedication. Music and maths complement each other and enhance cognitive abilities beyond the subject matter. Overall, both subjects can be learned and improved upon with effort and commitment.

### **Question 6**

Music and mathematics share a deep connection, using numbers and patterns in their respective structures. Both require critical thinking, calculation, and precision. Understanding music can enhance scientific concepts, while mathematical equations can optimise music through algorithms. They both involve theoretical understanding and practical application. Music's rhythm and beats align with mathematical distributions, creating harmony. Notation and theory in music require mathematical thinking. Both subjects require numeric formulae and countable timing. Musical notes are timed and structured, just like mathematical sequences. Overall,

music and mathematics intertwine with their common elements, making them interrelated aspects of our universe.

### **Question 7**

Educator collaboration is encouraged in the school, but some respondents are not familiar with music aptitude tests or have not used them. Some educators have used aptitude tests for maths but not for music. The awareness of these tests varies among respondents, and some do not find them necessary or relevant. Aptitude is seen as individualised, and organic appreciation of music is valued over standardised testing. Overall, music aptitude tests seem less familiar or commonly used compared to maths aptitude tests.

### **Question 8**

Various factors can impact success in music and mathematics. Good foundations, committed teachers, and support in the early years are essential. Enthusiasm, intrinsic motivation, and interest in the subjects play a crucial role. Parental attitudes, cultural backgrounds, and perceptions of the subjects can influence students' achievements. Consistency, daily practice, and a safe study environment are necessary for progress. Music's positive impact on focus and creativity can benefit academic performance. Neurological pathways created through music can enhance overall learning. Teachers' enthusiasm and the availability of instruments and

creative opportunities are significant. Patterns, thinking skills, and reasoning are vital in both disciplines. Music can instil patience, dedication, and self-confidence, contributing to a growth mindset.

### **Question 9**

Educators can collaborate by incorporating both subjects into each other's curricula. Joint projects, cross-curricular activities, and workshops can foster connections between music and mathematics. Creating fun and engaging activities, such as drum circles, songwriting based on mathematical concepts, and musical games with maths aspects, can make the learning experience enjoyable. Live performances, outings to museums, and concerts can inspire students and provide practical demonstrations of the connection between music and maths. Encouraging students to compose music using mathematical formulas or analysing songs using graphs adds an interactive element to the learning process. Contextualising subjects through activities and discussions enhances students' understanding and appreciation of both disciplines.

### **Question 10**

Exposure to music from a young age influenced some individuals' comfort and success in mathematics. For some, music and mathematics achievements were

closely linked, while others experienced challenges due to inadequate teaching or disinterest. Music's impact on mathematical understanding and problem-solving was evident to some, while others did not recognize the connection until later in life. The relationship between music and maths varies among individuals, with some feeling that music enhanced their mathematical abilities, while others did not observe a significant influence. Overall, experiences with music and maths were diverse, affecting different aspects of learning and performance.

In conclusion, the correlation between music and mathematics is a captivating exploration of the intertwined beauty and logic that underlie these disciplines. From the intricate rhythms to the harmonious melodies, music is inherently rooted in mathematical principles. Conversely, mathematics provides a framework for understanding, analysing, and creating music. As we continue to unravel the profound connections between music and mathematics, we gain a deeper appreciation for the symphony of numbers and sounds that shape our world. This confirmed the study that Muller concluded in, confirming a correlation exists between musical aptitude and mathematical achievement.

## CHAPTER 5

### CONCLUSIONS AND RECOMMENDATIONS

*“Those who educate children well are more to be honoured than parents, for these only gave life, those the art of living well” – Aristotle.*

#### 5.1 INTRODUCTION

Musical aptitude tests have a history of more than 85 years. For this research project, several respondents participated in the overall testing for stage 1 and a selection of 6 students were observed and interviewed as part of the process of the test for stage 2 including the resident music teacher. The last and final (third) stage was to conclude a survey and detailed questionnaire based on the AMMA test and mathematical achievement of students recorded over 6 months. The rationale was to see how students achieved in an AMMA musical aptitude test designed by Edwin Gordon with its relationship and impact on mathematical achievement. The students were tested based on their previous musical background regarding their extra-curricular music tuition and reinforcement of elements taught as part of the secondary and high school curriculum.

## 5.2 SUMMARY OF THE STUDY

Comparing the data and findings with that of other prominent music researchers which included Jang, 2000 et al. the analysis is categorised as follows:

- a) Elements of music used for research.
- b) Number of students who participated.
- c) Type of students used.
- d) Main research findings.
- e) Overall mean scores for the AMMA tests.
- f) Both genders were involved in the AMMA testing and the challenges involved proving that the AMMA music test impacted the general mathematical achievement of students aged 12 – 14 years of age.

In April 2012 the researcher concluded a master's degree with the University of Pretoria where he designed his music aptitude test in consultation with his colleagues in the Music Department at a North London School in the United Kingdom. This data is inserted in the centre to compare it with the current study and that of prominent other researchers.

### 5.2.1 JANG'S (2000) VERSUS THE RESEARCHER'S (2021) RESEARCH

The statistics which were compared (see table 35) can demonstrate that there is a difference in the mean of both tests. The students who participated in Jang's research had a higher mean of **65**; those who participated in the author's research achieved a mean of **38**. This reveals a mean score difference of **27**.

	<b>Jang's Research (2000)</b>	<b>The author's research (2012)</b>	<b>The author's research (2021), using the AMMA test of Edwin Gordon</b>
Elements of Music	Rhythm, Melody, Dynamics, Timbre, and Tempo.	Pitch, Melody, Texture, and Rhythm.	Tonal and Rhythm.

Number of subjects/ Participants	n=155  Aged 10 - 11	n=160  Aged 10 – 13	n=6  Aged 12 - 14
What type of students were used	Primary School Students	Prospective Secondary Students	Secondary or High School Students
Main Research Findings	A positive relationship existed between a child's ability in music and what they scored in mathematics. Groups with high musical ability showed better behavioural traits.	There was a positive relationship between students who had previous musical tuition with an excellent musical background (musical ability)	There was a positive relationship between the students who attended music classes at Liverpool Secondary School. The AMMA music test impacted the mathematical

	The study revealed that there was a link between musical ability and mathematical ability of students who participated (Jang, 2000: 3).	and their scores in their musical aptitude. Students scored high for the elements of melody and pitch overall.	achievement of students in the Secondary (High) School in Benoni.
Overall Mean Score	65	57	38
Tests	Pre and Post- Test	Only Post-test	Only Post-test

*Table 35: Jang's research statistics compared to the author's (2021)*

### **5.2.2 KARMA'S (1993) VERSUS THE RESEARCHER'S (2021) RESEARCH**

Comparing the data of the author's research (see table 36) and that of Karma (auditory structuring test) one can conclude that there is a huge difference between the mean of both tests. All the students who participated in Karma's research

achieved a mean of **32.1**. The reason why these statistics were used to compare the data was that students belonged to group 1 and could play an instrument. It would be unfair to compare the author's data with professional musicians. A mean score difference of **-5.9** existed when comparing both sets of data.

	<b>Karma's Research (1993) [Auditory Structuring Test]</b>	<b>The author's research (2012)</b>	<b>The author's research (2021), using the AMMA test of Edwin Gordon</b>
Elements of Music	Melody.  The test consisted of tasks where similarities and differences between sound patterns were detected. The subjects first heard a sequence of sound and then	Pitch, Melody, Texture and Rhythm. The test consisted of questions including listening to five different notes of a melody being played. They then	Tonal and Rhythm.

	<p>were instructed to detect a pattern that was played unaltered three times. After a short pause, the theme was heard again with the same or structurally different form. The answers alternated with the response was “the same” or “different.</p>	<p>had to compare it with the second five notes of a melody being played as either the same or identifying the change marking it on the answer sheet as a change of a note in measures 1, 2, 3, 4 or 5. The students had to listen to 2, 3 or 4 melodies played together for the section on textures. This consisted of two patterns of notes; each pattern had</p>	
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		<p>four beats. Then they had to decide whether it was the same or different. Students had to circle which one on either the 1st, 2nd, 3rd or 4<sup>th</sup> beat, was different.</p>	
<p>The number of subjects/ Participants</p>	<p>n=202 Aged 10 - 13</p>	<p>n=160 Aged 10 – 13</p>	<p>n=6 Aged 12 – 14</p>
<p>What type of students were used</p>	<p>Primary School Students</p>	<p>Prospective Secondary Students</p>	<p>Secondary or High School Students</p>

<p>Main Research Findings</p>	<p>The research concluded that participants were divided into three groups. Group 0 had no musical training at all, Group 1 had taken music lessons without aiming at a musical profession, and group 2 consisted of professional musicians. The means were:</p> <p>Group 0 = 28.6</p> <p>Group 1 = 32.1, and</p> <p>Group 2 = 38.0</p> <p>(Karma 2007: 86-88).</p>	<p>There was a positive relationship between students who had previous musical tuition with an excellent musical background (musical ability) and their scores in their musical aptitude. Students obtained high scores for the elements of melody and pitch overall.</p>	<p>There was a positive relationship between the students who attended music classes at Liverpool Secondary School. The AMMA music test impacted the mathematical achievement of students in the Secondary (High) School in Benoni.</p>
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Overall Mean Score	32.1	57	38
Tests	Pre and Post- Test	Only Post-test	Only Post-test

*Table 36: Karma's (1993) research statistics compared to the author's (2021)*

### 5.2.3 MILOVANOV'S (2009) VERSUS THE RESEARCHER'S (2021) RESEARCH

From the statistics which were compared (see table 37) one can conclude that there is a difference in the mean of both tests. The students who participated in Milovanov's research had a higher mean of **70**. And those who participated in the author's research achieved a mean of **38**. This shows a mean score difference of **32**. The participants of Milovanov scored high percentages overall for the elements of music: rhythm and tonality, with a score of **80%**.

	<b>Milovanov's Research (2009)</b>	<b>The author's research (2012)</b>	<b>The author's research (2021), using the AMMA test of Edwin Gordon</b>
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Elements of Music	Pitch, Loudness, Rhythm, Time, Timbre, and Tonal memory tasks.	Pitch, Melody, Texture, and Rhythm.	Tonal and Rhythm.
Number of subjects/ Participants	n=40 Aged 10 – 12	n=160 Aged 10 – 13	n=6 Aged 12 – 14
What type of students were used	Primary School Students	Prospective Secondary Students	Secondary or High School Students

<p>Main Research Findings</p>	<p>The <i>Seashore</i> musicality tests were used for her research because it was a valid and functional musical aptitude test with the longest tradition and was commonly used. Most music pupils had excellent linguistic skills (72%) as measured by the <i>Seashore</i> musicality test in comparison with other students with less accurate linguistic skills (54%). There was a direct relationship between musical aptitude and</p>	<p>There was a positive relationship between students who had previous musical tuition with an excellent musical background (musical ability) and their scores in their musical aptitude. Students scored high scores for the elements of melody and pitch overall.</p>	<p>There was a positive relationship between the students who attended music classes at Liverpool Secondary School. The AMMA music test impacted the mathematical achievement of students in the Secondary (High) School in Benoni.</p>
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	linguistic abilities (Milovanov 2009: 339).		
Overall Mean Score	70	57	3
Tests	Pre and Post- Test	Only Post-test	Only Post-test

*Table 37: Milovanov's (2009) research statistics compared to the author's (2021)*

#### **5.2.4 GILLEECE'S (2006) VERSUS THE RESEARCHER'S (2021)**

##### **RESEARCH**

The results of the research (see table 38) conducted when compared concluded that a difference in mean for both tests existed. The students who participated in

Gilleece's research had a lower mean of **33.8**. Those who participated in the author's research achieved a mean of **38**. This meant a mean score difference of **-4.2** existed.

	<b>Gilleece Research (2006)</b>	<b>The author's research (2012)</b>	<b>The author's research (2021), using the AMMA test of Edwin Gordon</b>
Elements of Music	Pitch, Tunes, Chords and Rhythm	Pitch, Melody, Texture and Rhythm	Tonal and Rhythm
Number of subjects/ Participants	n=149 Aged 10 – 12	n=160 Aged 10 – 13	n=6 Aged 12 – 14
What type of students were used	Primary School Students	Prospective Secondary Students	Secondary or High School Students

<p>Main Research Findings</p>	<p>The <i>Bentley</i> musicality tests were used for her research. There is a direct correlation between tonal memory and chord analysis. Similarly, tonal memory correlated significantly with pitch and tonal memory. The study overall revealed that there is a correlation between music and language aptitude (Milovanov 2006: 162).</p>	<p>There was a positive relationship between students who had previous musical tuition with an excellent musical background (musical ability) and their scores in their musical aptitude. Students scored high scores for the elements of melody and pitch overall.</p>	<p>There was a positive relationship between the students who attended music classes at Liverpool Secondary School. The AMMA music test impacted the mathematical achievement of students in the Secondary (High) School in Benoni.</p>
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Overall Mean Score	33.8	57	38
Tests	Pre and Post- Test	Only Post-test	Only Post-test

*Table 38: Gilleece(2006) research statistics compared to the author's (2021)*

### 5.3 OVERALL CONCLUSION

The conclusions that can be made was that students had the ability to complete the Advanced Measures of Music Audiation (AMMA) designed by Edwin Gordon. Most students of both sexes achieved excellent results for the Tonal and Rhythm aspects of the test. When comparing the data with the mathematical achievement of students over a period of 6 months one could draw the following conclusions:

- a) The music aptitude test that was designed by Professor Edwin Gordon has impacted the mathematical achievement of students aged 12 – 14 years of age.
- b) The reason for this was because students, in general, had auditory skills that would steadfast them to be able to have differentiated between the Tonal and Rhythm changes within the AMMA test.
- c) Their memory recall helped them actively to have differentiated between Tonal and Rhythm Changes.

- d) These impacted their mathematical achievement as the brain functioned the same systematically.
- e) The process involved that differentiating reasoning skills within mathematics was the same for music aptitude.
- f) When one possesses music aptitude this would impact mathematical achievement overall over time.
- g) Girls are generally more mature than boys as this study has revealed by showing that girls in comparison to boys their same age usually achieve better results and were more superior in comparison to boys their same age.
- h) The socio- economic situation does not impact one's learning, it was imperative to set goals and targets for oneself, and to be able to achieve attainable targets through working consistently, and throughout the school academic year.
- i) Everyone had a right to education, and at the end of the day it is up to the individual to have taken that opportunity, and have worked by excelling in all areas of the curriculum.
- j) By being organised, and structured when completing their studies as these would have enabled them to achieve their long-time goals overall.

- k) By being consistent with your actions with reference to your academic work.  
When you were working on mathematics it was important to ensure that you revised your work constantly as practice makes perfect, and finally,
- l) Drill and practice situations would ensure you attained those excellent results in both disciplines.

The primary aim of this study project was to establish whether the AMMA music aptitude test impacted the mathematical achievement of students in grades 8 and 9 in a secondary (high) school in Johannesburg and whether it could be proven that when a student displayed a level of aptitude that it automatically impacted their mathematical achievements. To ensure that all students achieved excellent academic results the basis of this theory confirms the following as outlined in the following flow chart diagram (figure 40) which gives rise to a new educational theory:

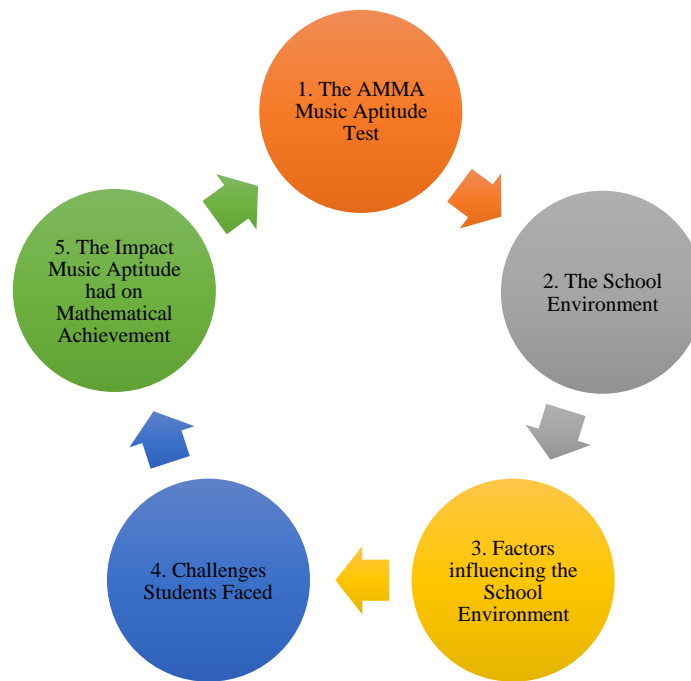


Figure 40: Müller's PhD Theory - Factors impacting mathematical achievement (2022)

1. The AMMA Music Aptitude test and the manner it is administered and introduced to the students in the High School.
2. Whether the school environment created a safe and stimulating environment for students to excel academically and achieve their targets set through exploring opportunities.
3. Issues that the students faced including health and safety issues, lack of Information Technology (Computer studies) and general reinforcement of positive attitudes, teenage pregnancies, HIV, drug abuse, financial insecurity, transportation and disruptions due to political unrest.

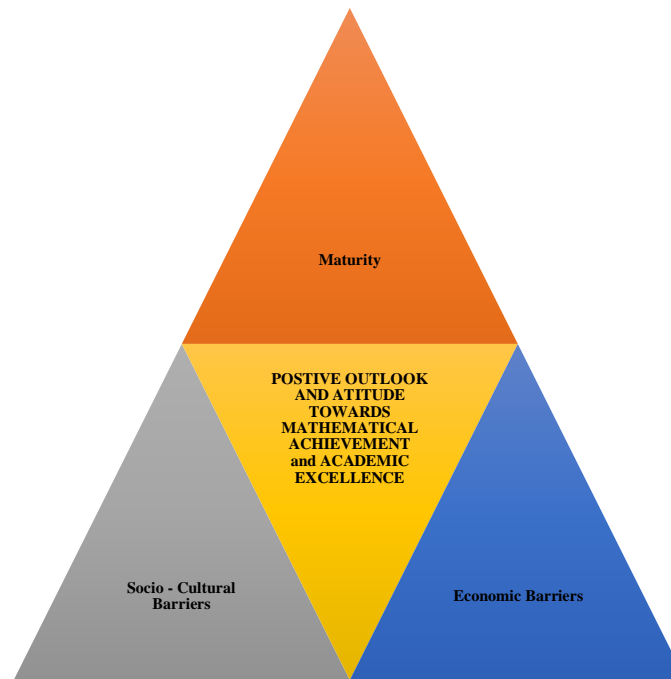
4. The impact that music aptitude had on the mathematical achievements of students. A close relationship was associated between music aptitude and mathematical achievement overall.

## **5.5 POSITIVE RELATIONSHIPS BETWEEN MUSIC APTITUDE AND MATHEMATICAL ACHIEVEMENT**

For both boys and girls, it was important to have outlined the following to ensure a positive relationship between music aptitude and mathematical achievement (see figure 41):

- Maturity and how one reinforced positive learning within the classroom setting. How the teachers dealt with issues, and adapted to situations ensuring that all students realised their potential and achieved excellent results academically?
- Economic barriers, which included financial insecurities, poverty within society and families had a direct and indirect effect on student's abilities.
- Social and cultural barriers, where students disrespected other cultures and lack of exposure to opportunities available to them influencing a sense of poor self-esteem and a sense of belonging, and

- How all these contributed to a positive outlook and attitude towards academic excellence and ensuring that each student reached their full potential?



*Figure 41: Gender Attributes for Boys and Girls (Aged 12 - 14) Müller's Theory (2022)*

Without a good and positive attitude towards life it was impossible to achieve excellent results and display a level of competence and excellence in mathematical achievement. These two entities (music aptitude and mathematical achievement) coincided as a direct relationship coexisted between music aptitude, and

mathematical achievement (see Figure 32). The processes of the brain involved the same systematic reasoning skills when compared to each other.

### **5.6.1 SIMILARITIES BETWEEN MUSIC APTITUDE AND MATHEMATICAL ACHIEVEMENT:**

- Reasoning (differentiating between different concepts).
- Memory (recall) how students remember things and how the brain functions and operates.
- High order of thinking (The processes involved and how it promotes and enables high order thinking).
- Music Aptitude involves notation, which involves reading lines and spaces, and
- In Mathematical Achievement one deals with notation, but references are made purely to numbers.

### **5.6.2 DIFFERENCES BETWEEN MUSIC APTITUDE AND MATHEMATICAL ACHIEVEMENT:**

- In Music Aptitude students are exposed to the Elements of Music (which include, Pitch, whether a sound being played is high or low and Tonal implications, Metre, which includes the various notes being used including semibreves, minims, crotchets, quavers, semiquavers, demisemiquavers and hemidemisemiquavers; Structure, whether something heard is in Binary form (AB), Ternary form (ABA) or Rondo form (ABACA); Dynamics, whether something heard is loud or soft; Tempo, (whether something heard is fast or slow?) and
- In Mathematical achievement students have to differentiate between the Rudiments of Mathematics, which involves factorization, multiplication, equations, algebra, trigonometry and geometry.

To show a clear progression towards music aptitude and mathematical achievement one must distinguish between the two and find the similarities and differences as outlined in this study. The following flow chart in the previous page (see Figure 42) shows the direct impact that each has on the other.

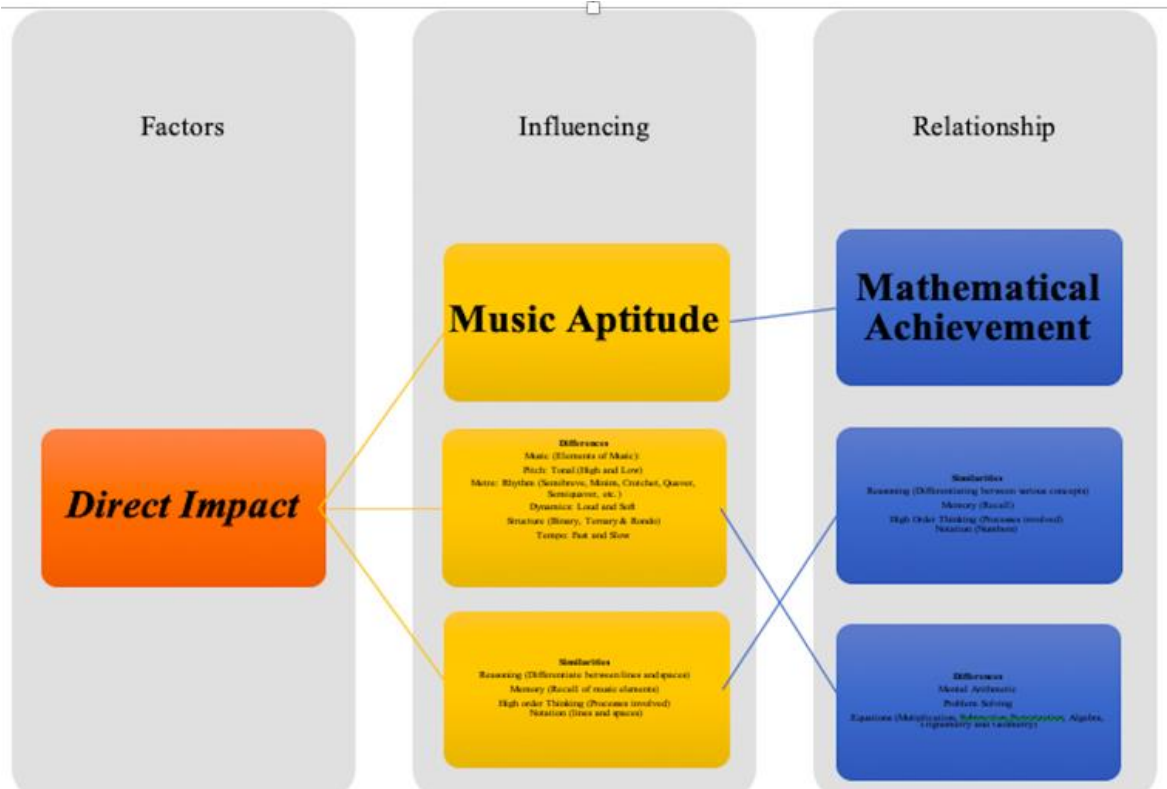


Figure 42: Factors Influencing - PhD Theory Müller (2022)

## 5.7 LIMITATIONS AND SHORTCOMINGS

The research focussed on the results of students who completed of the Advanced Measures of Music Audiation (AMMA) test designed by Gordon. The main reason for using these existing music aptitudes was because it was already researched and validated, and results assessed by prominent researchers. Several other music aptitude tests were available on the market including those of Seashore, Bentley, Wing and Gordon, which clarified, and expanded on some of their theories.

In terms of mathematics as a subject there was limited literature available that was relevant and recently conducted in the last decade with reference to music aptitude and mathematical achievement. The purpose of the benefits of mathematics and the importance in terms of education was available for research in comparison to the connection between music aptitude and mathematical achievement, where it was measured, compared, discussed, and correlated. The researcher demonstrated that music aptitude had a direct impact on mathematical achievements of students overall at a Secondary (high) school in Benoni, Johannesburg.

This gave rise to the recommendation for the need of government to invest money by ensuring that most of the magnet schools had access to the various music aptitude tests available to them. Without aptitude, the students would not have been able to achieve excellent results in both music, and mathematics. Although the focus

of this study highlighted the importance of music in comparison to mathematics, the connection to achievement was obtained and correlated. There was a need for more recent literature to be available in a South African context for future researchers to extend their understanding of particular the connection between music and mathematics. In comparison to other studies that have been concluded, this study confirmed the impact a students' music aptitude would have on mathematical achievement over a period of time.

## **5.8 RELEVANCE OF THE RESEARCH**

This study presented would be valuable for music educators, and schools, but especially the Department of Education in South Africa. The findings presented could be used to assist others in their research in similar or academic disciplines. The information gleaned should now provide an understanding of what provisions should be in place to cater for students with aptitude. The importance of the music aptitude test, and the direct impact it would have overall on mathematical achievements in any school setting it was important to make provision for the following:

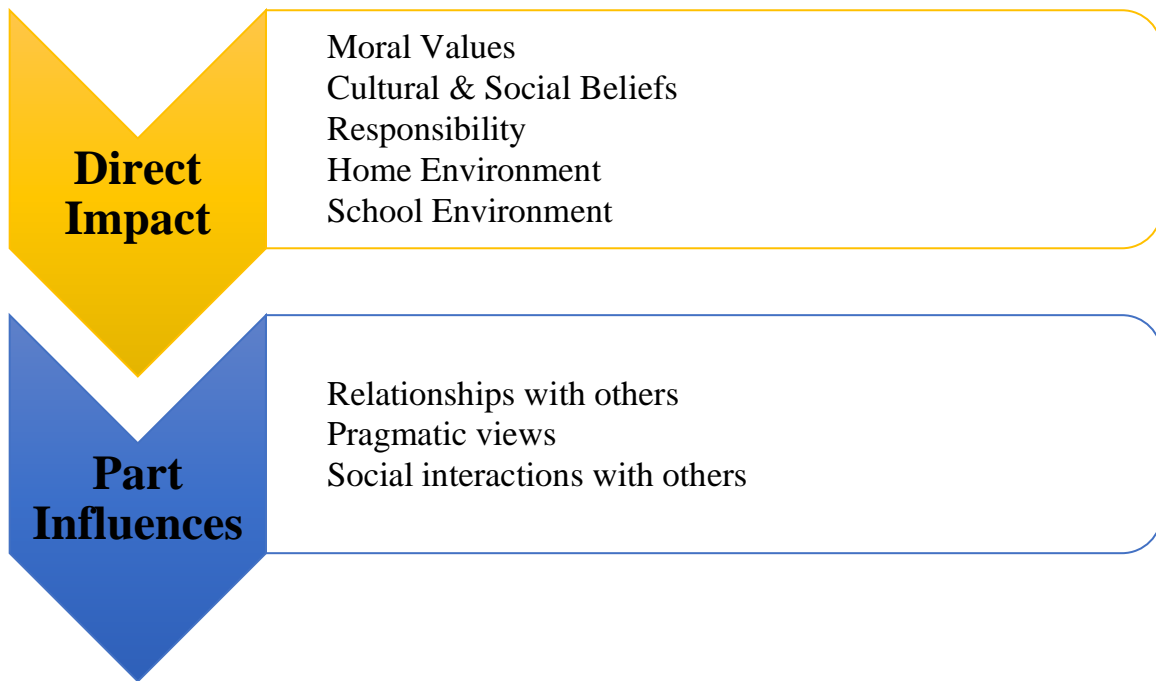
- The students who had shown an aptitude for music to be catered for.

- The regular use of music aptitude tests could have established whether students could be classified as “Gifted or Talented” and how to have made adequate provisions for them in the classroom.
- That music aptitude could have impacted the mathematical achievements of students’ overall.
- The Department of Arts and Culture should allow more opportunities for students to express themselves through music.
- The government has to invest more money in terms of making more magnet schools available for students to access music instruction.
- Music opportunities should be given to the students, which would improve the social, emotional skills and well-being of students in a secondary (high) school.
- To create opportunities for students to explore their natural music talents, and general mathematical skills.
- To create opportunities for students to share and showcase their talents within their own educational environments.
- To facilitate music technology to enhance their theoretical, and aural skills.
- To implement several music technology programmes where students had the opportunity to experiment with several notation programmes available including Muse score, Finale and Sibelius, and finally.

- To have allow students to explore creativity through creating their own original music and sharing them later on a greater platform, including sound cloud, band lab, etc.

## **5.9 DIRECT AND PARTIAL INFLUENCES FOR MUSIC APTITUDE AND MATHEMATICAL ACHIEVEMENT**

The following diagram illustrates (see Figure 43) the fundamentals of which directly and partially influences impacted music aptitude and mathematical achievement as underpinned in this study.



*Figure 43: Direct and Partial Influences– Müller Theory (2022)*

#### **DIRECT IMPACT:**

- Moral values – the way you differentiated between right and wrong through making decisive decisions related to your academic achievements.
- Cultural and social beliefs – your upbringing and things that you as an individual believed were of the utmost importance whether such as religious beliefs and social behaviour.
- Responsibilities – without being responsible you will not have the abilities to make concrete decisions related to your academic achievements.

- Home environment – the way you viewed life and made necessary adaptations ensuring a better way of living and what you have been exposed to since childhood, and
- School environment – the setting created for you to achieve obtainable goals and targets.

### **PARTIAL INFLUENCES:**

- Relationships with others – the way you formulated positive relationships with parents, peers, and fellow students.
- Pragmatic views – the way you conducted yourself in public sharing your opinions, views, and perceptions whether it included a perspective or not, and
- Social interaction with others – the way one behaved within a social environment either by contributing essentially by conversations or withdrawing from factors impacting on your own learning.

### **5.10 RECOMMENDATIONS**

Several factors can influence a student's progress in a school environment. The social environment plays an important role with reference to whether a student achieves the academic targets set by their school teachers. Liverpool Secondary

School is a school in a suburban area of Benoni, where most of the students come from different cultural backgrounds and are faced with many challenges. At most of the government schools in this area, teenagers are faced with several issues from teenage pregnancies to disruptions in their educational setting due to political unrest and several other problem including drugs and street gangs.

In 2009, Tasneem Ebrahim completed a Master of Arts in Educational Psychology with a thesis entitled: *Perceptions of factors affecting the pursuit of higher education among disadvantaged Grade 12 learners under the supervision of Tanya Swart at the University of Witwatersrand in Johannesburg.*

The aims of her study were the following:

This research aims to investigate the perceived barriers to accessing or pursuing higher education in a group of Grade 12 learners from disadvantaged backgrounds within the Greater Johannesburg area. In particular, the study focuses on exploring disadvantaged learners' perceptions of the factors that impact whether they choose to pursue some form of higher education following matriculation. The study focuses on possible financial, social, cultural and educational factors that could be impacting their ability to access higher learning. Through examining these perceptions, this research attempts to provide an in-depth understanding from the perspective of learners in low-income communities of the types of challenges experienced by young people in negotiating their future career options or academic development in the context of social inequality. This will assist in determining whether the perspectives of these learners are aligned with some of the structural barriers to higher education (Ebrahim, 2009:7).

Her findings (Ebrahim 2009) revealed that:

It was found that the economic, educational, socio-cultural and political factors interact with each other to promote inequality in accessing higher education.

Families, communities, schools, higher education institutions and government agencies are all structures that engage in processes and procedures that create and uphold inequalities in society by specifying the parameters in which decisions are made. It was found that although co-operative governance became the central principle underpinning the relationships within institutions, which has increased consultation, participation and transparency, and hence has led to the massification of education, the lack of economic and social upliftment of communities like Thembelihle has resulted in the manifestation of serious strains on this open and co-operative relationship as these communities are continuing to be excluded from higher education.

Although her study was geared towards grade 12 students, it has relevance to students in grades 8 and 9 as these challenges are pertinent to those in all grades in a high school environment. The following recommendations can be made to ensure that students achieve their full potential when using the AMMA test to enhance mathematical achievements:

- Be organised and make decisive decisions that will impact your learning.
- Be consistent in your behaviour concerning, time management and completion of assignments.
- Do your homework timeously and ask questions related to the concepts taught in class.
- Refrain from negativity and focus on the positive things that will steadfast your academic growth.
- See all projects through to a positive conclusion and ask for help when needed.

- Have a positive attitude towards your music and mathematics lessons by engaging fully in discussions, debates and presenting work of excellent standards.
- Set achievable and realistic targets for yourself and ensure you working cooperatively towards those goals.
- See every challenge as an opportunity to improve in all aspects of the curriculum whether it is music or mathematics.
- Surround yourself with people that will impact positively on your academic work.
- Perseverance was the keyword when related to your music and mathematical achievement.
- Don't allow peer pressure to get the best of you, and always see the good within people, and
- Trust your instincts and be responsible when it comes to your academic work.

The following suggestions are for teachers to ensure that their students are making excellent progress in all areas of both the music and mathematics curriculum.

- Always challenge your students.
- Exercise differentiation in the classroom and remember that each student learns at a different pace.

- Be consistent in your actions and give complimentary rewards and regular praise to your students.
- Try to see a situation through their eyes and avoid confrontation and making students feel insecure.
- Create opportunities for students to engage in the classroom and be a good listener by always treating your students without favour.
- Do not demand respect as respect is earned through years of experience and creating and fostering a positive learning environment for each student to develop their natural talents, and
- Finally, maintain a sense of humour and let the students see your creative, artistic but foremost loving and caring nature and attitude towards them.

### **5.11 CONCLUDING COMMENTS**

The most rewarding aspect of teaching was to unleash your student's creative energies. Teaching has its own demands and can be quite challenging but face those challenges as an opportunity for you to change the world and perceptions students might have of yourself. It is imperative to bring the best out of students and leave no child behind. Reflecting regularly on your own teaching methodologies, observing other teachers and being consistent in the manner you treat your students will impact the learning they have in your classroom.

Making connections with them will impact their direct learning as shown in this thesis and embarking on opportunities for your students to excel will lead them to become lifelong responsible members of society. One of my favourite quotes was by Nelson Mandela who stated: "*Education is the most powerful weapon which you can use to change the world. The power of education extends beyond the development of skills we need for economic success. It can contribute to nation-building and reconciliation*" (<https://borgenproject.org/nelson-mandela-quotes-about-education/>).

Music aptitude and mathematical achievement have a special relationship as outlined in the study. Using the AMMA test both the boys and girls could differentiate between the tonal and rhythm scores. I hope this AMMA test will be used in several high schools in South Africa and that the government would invest more money in keeping Arts and Culture alive and creating opportunities for South Africa to create the best musicians, mathematicians, engineers, medical doctors and probably future Nobel Prize winners. Everyone has a right to education and it is the way we impact the attitudes and perceptions of our students to excel either academically, emotionally, socially or mentally.

## 5.12 RECOMMENDATIONS FOR FUTURE RESEARCH

This study could become the basis for future research with the following recommendations for scholars:

- Look at the barriers to learning and how they impact music aptitude and mathematical achievement.
- Address the issues of music technology for students to excel and engage with other students to promote global thinking.
- Compare the available arts and culture programmes from Government in South Africa, and
- Compare with what other countries are offering in terms of music programmes, curricula to enable South Africa to become a leader producing best musicians, mathematicians, engineers, medical doctors and possibly Nobel Prize winners.

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## APPENDIX A: RESEARCH QUESTIONNAIRE

### RESEARCH QUESTIONNAIRE

#### Notes to the participants (Grade 8/9):

1. The following questionnaire needs to be completed online.
2. Your name will remain anonymous. Please fill in your country, name of your school and your age and gender.
3. **QUESTION 1 INCLUDES AN EXAMPLE!**
4. Answer the general questions and then the remainder of the questions will start at 1.1.
5. As these facts are important to support this research study.
6. Please answer all the questions as honestly as possible.
7. **QUESTION 1 – 5 will be based on the AMMA music aptitude test you completed.**
8. **QUESTION 6 – 9 will be based on the Mathematical tests overall this year and experience to date you completed.**
9. **THANK YOU FOR BEING HONEST AND RESPONDING TO, AND PARTICIPATING IN THIS RESEARCH PROJECT!**

**GRADE 8/9:**

COUNTRY: \_\_\_\_\_

SCHOOL: \_\_\_\_\_

**Name: (Anonymous)**

AGE: \_\_\_\_\_

GENDER: \_\_\_\_\_

**Question 1:**

*For the following questions posed below use the following scale to answer the questions to best of your ability. Select only one! The questions will follow this example. The homework in science is?*

1. Extremely difficult.
2. Difficult.
3. Comfortable.
4. Easy.
5. Very easy.

ANSWER: 4 - Easy

**Question 1.1:**

*Having completed the AMMA (Advanced Measures of Music Audiation) test can you please answer the following question? How would you describe your overall experience completing the test?*

1. Extremely difficult.
2. Difficult.
3. Comfortable.
4. Easy.
5. Very easy.

**Question 1.2:**

*When you completed the Tonal test can you rate your overall impression and experience using the scale above from 1 – 5 used when completing the AMMA test?*

1. Extremely difficult.
2. Difficult.
3. Comfortable.
4. Easy.
5. Very easy.

**Question 1.3:**

*When you completed the Rhythm test can you rate your experience using the scale above from 1 – 5 to answer your overall impression and experience of the AMMA test?*

1. Extremely difficult.
2. Difficult.
3. Comfortable.
4. Easy.
5. Very easy.

**Question 1.4:**

*Your overall impression of the AMMA test would be? Using the scale above from 1 – 5?*

1. Extremely difficult.
2. Difficult.
3. Comfortable.
4. Easy.
5. Very easy.

**Question 2:**

*Which one of the two areas of the AMMA test did you find difficult?*

TONAL

or

RHYTHM

**Question 4:**

*Your results will not be revealed but using the following scale below from 1 – 5. How would you grade your overall music aptitude?*

1. Unsatisfactory.
2. Normal.
3. Average.
4. Above Average.
5. Superior.

**Question 5:**

*Using the scale 1-5 below answer the following questions:*

1. Of no relevance to you.
2. It is of some relevance to you.
3. You are satisfied with your current music aptitude.
4. You want to improve your music aptitude overall.
5. You are now aware of your music aptitude and prepared to work to improve it in all areas.

**Question 6:**

*Using the scale (1- 5) below how would you describe your experience completing the mathematical tests this year overall?*

1. Extremely difficult.
2. Difficult.
3. Comfortable.
4. Easy.
5. Very easy.

**Question 7:**

*Using the scale below from (1-5) how would you best describe your results for the mathematical tests overall? You are allowed to give an answer as to what you predict!*

1. Below 20%.
2. Between 30% and 50%.
3. Between 50% and 65%.
4. Between 65% and 75%.
5. Above 75%.

**Question 8:**

*Using the scale below from (1-5) which mathematical area is your favourite when completing mathematics?*

1. Trigonometry.
2. Geometry.
3. Algebra equations.
4. Quadratic formulas and equations.
5. Fractions.

**Question 9:**

*Using the scale below from (1-5), we are hoping to prove that a correlation between music and mathematics exists. Which one do you think fits best after you have completed both tests?*

1. I disagree with this statement.
2. I somewhat agree with this statement.
3. I agree with this statement, but more research should be conducted.
4. I completely agree with this statement and could experience the connection between mathematical and musical skills using the same reasoning techniques.
5. I am highly convinced and totally agree with this statement.

**THANK YOU FOR YOUR TIME AND ANSWERING ALL THESE QUESTIONS**

## APPENDIX B: LETTER OF INFORMED CONSENT FOR PARENTS

Contact details of study leader:  
Professor Madimabe Geoff Mapaya  
Head of Department:  
Music University of  
Venda  
Tel: 015 962 8031  
email: [Geoff.Mapaya@univen.ac.za](mailto:Geoff.Mapaya@univen.ac.za)

Contact details of researcher Mr. Mario Maxwell Müller  
Tel: +27 081 \_\_\_\_\_  
Email: [headofmusicatstandrews@gmail.com](mailto:headofmusicatstandrews@gmail.com)



**University of Venda**  
*Creating Future Leaders*

**Department of Music**  
**Faculty of Humanities**  
**University of Venda**

\_\_\_\_\_ 2021

Dear \_\_\_\_\_

I am currently planning a post-graduate degree in music at the University of Venda, under the supervision of Prof Geoff Mapaya. The working title of my research is **“The correlation between music aptitude and the mathematical achievement of students in South Africa - a case study of six individual students from a high school in Johannesburg, South Africa”**.

The aim of this research project is to test the current Grade 8 and 9 students

at Liverpool Secondary School through means of a (20 minutes) music listening test (*Advanced Measures of Music Audiation* designed by Professor Edwin Gordon, USA) and a follow-up questionnaire (20 minutes) completed online during an ICT/computer lesson.

**I hereby ask for permission for**

1. your son/daughter to complete the music listening (AMMA) test and
2. your son, daughter to complete a detailed twenty-minute electronic questionnaire online.

**Please note that:**

1. Participation in this research is entirely voluntary.
2. Your child's name and identity will be kept confidential.
3. Your child may decide to withdraw from this study at any time by informing the interviewer at any point of his/her wish to withdraw.
4. Your child may be asked to participate in a follow-up interview after a few months. This is to enable me to compare information gathered during the research process.

Thank you for your participation.

Yours sincerely,

.....

Mario Maxwell Müller: **Researcher**

**REPLY SLIP:**

I, (student's name and surname) \_\_\_\_\_, a  
student at

Liverpool Secondary School currently in Grade 8/ 9 have read and understood the contents of this letter and agreed to participate in the abovementioned music test and online electronic questionnaire.

Signed: \_\_\_\_\_

## APPENDIX C: CONSENT LETTERS FOR STUDENTS PARTICIPATING

Contact details of study leader  
Professor Madimabe Geoff Mapaya  
Head of Department:  
Music University of  
Venda  
Tel: 015 962 8031  
email: [Geoff.Mapaya@univen.ac.za](mailto:Geoff.Mapaya@univen.ac.za)

Contact details of researcher Mr. Mario Maxwell Müller  
Tel: +27 081 \_\_\_\_\_  
Email: [headofmusicatstandrews@gmail.com](mailto:headofmusicatstandrews@gmail.com)



**University of Venda**  
*Creating Future Leaders*

**Department of Music**  
**Faculty of Humanities**  
**University of Venda**

\_\_\_\_\_ 2021

Dear \_\_\_\_\_

I am currently planning a post-graduate degree in music at the University of Venda, under the supervision of Prof Geoff Mapaya. The working title of my research is **“The correlation between music aptitude and the mathematical achievement of students in South Africa - a case study of six individual students from a High School in Johannesburg, South Africa”**.

The aim of this research project is to test the current grades 8 and 9 students at Liverpool Secondary School through means of a (20 minutes) music listening test (*Advanced Measures of Music Audiation* designed by Professor Edwin Gordon, USA) and a follow-up questionnaire (20 minutes) completed online during an ICT/computer lesson.

**I hereby ask for permission for**

1. your son/daughter to complete the music listening (AMMA) test and
2. complete a detailed twenty-minute electronic questionnaire online.

**Please note that:**

1. Participation in this research is entirely voluntary.
2. Your child's name and identity will be kept confidential.
3. Your child may decide to withdraw from this study at any time by informing the interviewer at any point of his/her wish to withdraw.
4. Your child may be asked to participate in a follow-up interview after a few months. This is to enable me to compare information gathered during the research process.

Thank you for your participation.

Yours sincerely,

.....  
Mario Maxwell Müller: **Researcher**

**REPLY SLIP:**

I, (student's name and surname) \_\_\_\_\_ a student at Liverpool Secondary School currently in Grade 8/ 9 have read and understood the contents of this letter and agree to participate in the abovementioned music and online electronic questionnaire.

Signed: \_\_\_\_\_



## APPENDIX D: PERMISSION FOR RESEARCH

Contact details of study leader Professor  
Madimabe Geoff Mapaya Head of  
Department: Music University of Venda  
Tel: 015 962 8031  
email: [Geoff.Mapaya@univen.ac.za](mailto:Geoff.Mapaya@univen.ac.za)

Contact details of researcher Mr. Mario Maxwell Müller  
Tel: +27 081 \_\_\_\_\_  
Email: [headofmusicatstandrews@gmail.com](mailto:headofmusicatstandrews@gmail.com)



Department of Music  
Faculty of Humanities  
University of Venda

\_\_\_\_\_ 2021

The head of the school/Principal

I am currently planning a post-graduate degree in music at the University of Venda, under the supervision of Prof Geoff Mapaya. The working title of my research is **“The correlation between music aptitude and the mathematical achievement of students in South Africa - a case study of six individual students from a High School in Johannesburg, South Africa”**.

The aim of this research project is to test the current Grades 8 and 9 students at Liverpool Secondary School through means of one (20 minutes) music listening test (*Advanced Measures of Music Audiation*) designed by Professor Edwin Gordon, USA) and a follow-up questionnaire (20 minutes) completed

online during an ICT/computer lesson.

**Please note that:**

1. Participation of all the students in the school in this research is entirely voluntary.
2. The students' names and identities will be kept confidential.
3. The students at your school may decide to withdraw from this study at any time by informing me at any point of your wish to withdraw.
4. The students at your school who are part of this research project may be asked to participate in a follow-up interview after a few months. This is to enable me to compare information gathered during the research process.

Thank you for your participation.

Yours sincerely,

.....  
Mario Maxwell Müller: **Researcher**

**REPLY SLIP:**

I, (Head of the school/Principal) \_\_\_\_\_, at Liverpool Secondary School will allow all the students currently in Grades 8 and 9 with selected teacher to participate in this post-graduate study and have read and understood the contents of this letter and agree to the students' and

selected teacher participation in the abovementioned AMMA (music) with interview(s) if they are selected.


Signed: \_\_\_\_\_

## APPENDIX E: AMMA TESTS EXAMPLES FOR TONAL AND RHYTHM CHANGE


### CHANGE

(a) AMMA test, example 12  
(tonal change) Edwin E. Gordon (1989)

first:



second:



The musical notation for Example 12 consists of two staves. The first staff is in treble clef with a key signature of one flat (Bb) and a common time signature (C). It contains a sequence of notes: G4, A4, Bb4, C5, Bb4, A4, G4, F4, E4, D4, C4. The second staff is also in treble clef with a key signature of one flat (Bb) and a common time signature (C). It contains the same sequence of notes: G4, A4, Bb4, C5, Bb4, A4, G4, F4, E4, D4, C4. Two arrows point from the first staff to the second staff, indicating the tonal change. The first arrow points to the first measure (G4, A4, Bb4, C5) and the second arrow points to the fifth measure (Bb4, A4, G4, F4). In the second staff, the notes in the first and fifth measures are circled with dotted lines.

(b) AMMA test, example 15  
(rhythm change) Edwin E. Gordon (1989)

first:



second:



The musical notation for Example 15 consists of two staves. The first staff is in treble clef with a key signature of two flats (Bb, Eb) and a 6/8 time signature. It contains a sequence of notes: G4, A4, Bb4, C5, Bb4, A4, G4, F4, E4, D4, C4. The second staff is also in treble clef with a key signature of two flats (Bb, Eb) and a 6/8 time signature. It contains the same sequence of notes: G4, A4, Bb4, C5, Bb4, A4, G4, F4, E4, D4, C4. An arrow points from the first staff to the second staff, indicating the rhythm change. In the second staff, the notes in the fifth measure (Bb4, A4, G4, F4) are circled with a dotted line.

Figure 44: The AMMA test (Example 12 and 15 – Tonal and rhythm change)

## APPENDIX F- AMMA TEST ANSWER SHEET

**Practice**

Same Tonal Rhythm

1 csa cta cfa

2 csa cta cfa

3 csa cta cfa

**Begin**

Same Tonal Rhythm

1 csa cta cfa

2 csa cta cfa

3 csa cta cfa

4 csa cta cfa

5 csa cta cfa

6 csa cta cfa

7 csa cta cfa

8 csa cta cfa

9 csa cta cfa

10 csa cta cfa

11 csa cta cfa

12 csa cta cfa

13 csa cta cfa

14 csa cta cfa

15 csa cta cfa

16 csa cta cfa

17 csa cta cfa

18 csa cta cfa

19 csa cta cfa

20 csa cta cfa

21 csa cta cfa

22 csa cta cfa

23 csa cta cfa

24 csa cta cfa

25 csa cta cfa

26 csa cta cfa

27 csa cta cfa

28 csa cta cfa

29 csa cta cfa

30 csa cta cfa

↑ FEED THIS DIRECTION

**KEY**

● EXAMPLE: csa cta cfa

● ERASE COMPLETELY TO CHANGE

**IMPORTANT:**

USE NO. 1 PENCIL ONLY

**ADVANCED MEASURES OF MUSIC AUDIATION - Edwin E. Gordon**

NAME \_\_\_\_\_

SCHOOL \_\_\_\_\_

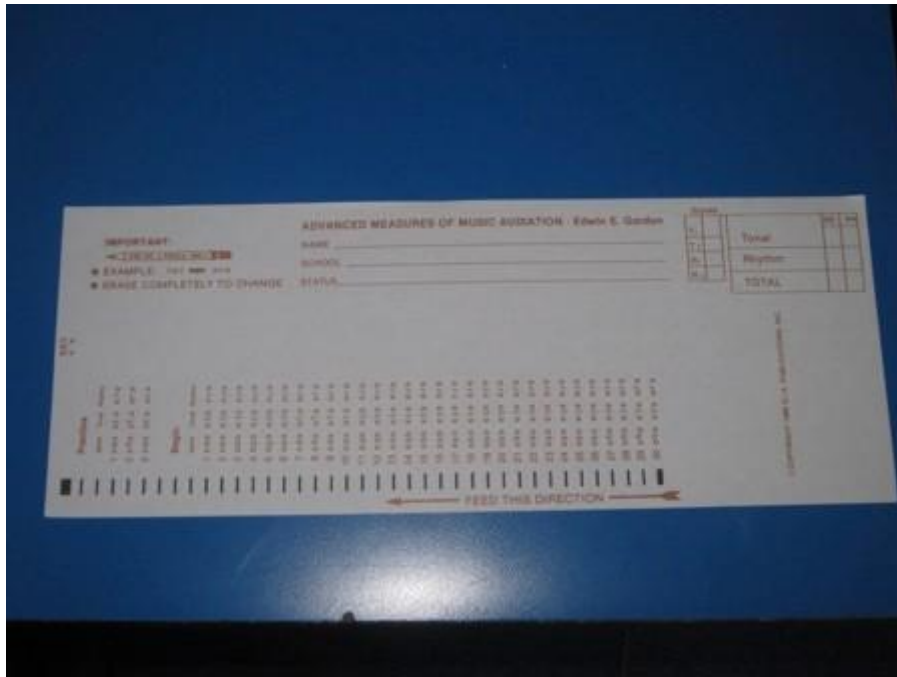
STATUS \_\_\_\_\_

Scores		T <sub>1</sub>	
		T <sub>2</sub>	
R <sub>1</sub>			
R <sub>2</sub>			
TOTAL			

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Figure 45: AMMA Answer Sheet

## APPENDIX G – AMMA TEST KIT



**REPORT BY:**  
 NAME: \_\_\_\_\_  
 SCHOOL: \_\_\_\_\_  
 DATE: \_\_\_\_\_

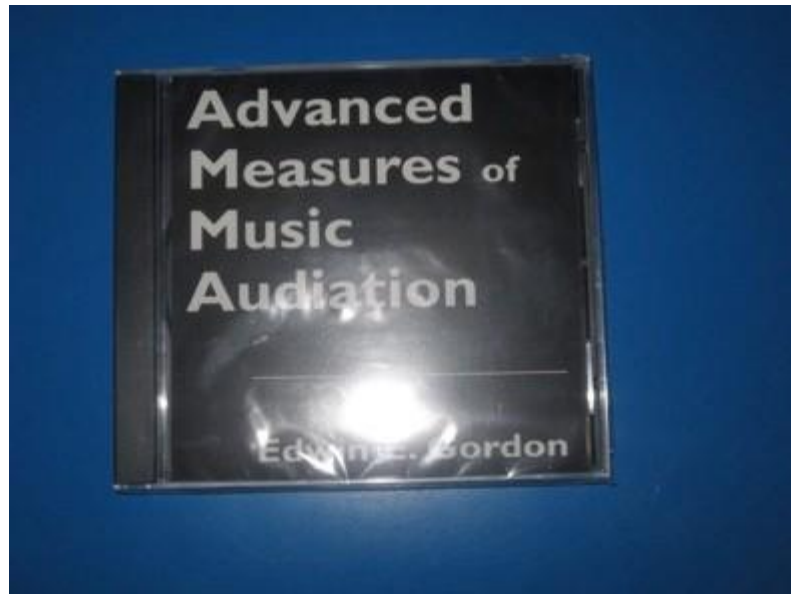
**ADVANCED MEASURES OF MUSIC APTITUDE - Edwin E. Gordon**

Item	Answer
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	

Section	Total
Tone	
Rhythm	
TOTAL	

FEED THIS DIRECTION →

Figure 46: The answer sheet for the music aptitude tests



*Figure 47: The accompanied CD used for the music aptitude tests.*



Figure 48: The AMMA testing kit



Figure 49: Literature books accompanied with AMMA test kit

## APPENDIX H – TONAL TEST (GORDON, 1989:28)

TABLE 1

### TONAL TEST

#### Percentile Rank Norms

Music Majors    Non-Music Majors    High School Students

Raw Score	Music Majors	Non-Music Majors	High School Students	Raw Score
40	99			40
39	98	99		39
38	97	98		38
37	96	97	99	37
36	94	96	98	36
35	91	95	97	35
34	87	93	96	34
33	82	90	94	33
32	76	87	91	32
31	70	83	88	31
30	64	79	84	30
29	57	75	79	29
28	50	71	74	28
27	44	66	69	27
26	38	61	63	26
25	32	56	57	25
24	27	50	50	24
23	22	44	44	23
22	17	39	39	22
21	12	34	34	21
20	8	29	29	20
19	5	24	24	19
18	3	19	19	18
17	2	14	14	17
16	1	10	10	16
15		7	7	15
14		5	5	14
13		4	4	13
12		3	3	12
11		2	2	11
10		1	1	10

## APPENDIX I – RHYTHM TEST (GORDON, 1989:29)

TABLE 2

### RHYTHM TEST

#### Percentile Rank Norms

Raw Score	Music Majors	Non-Music Majors	High School Students	Raw Score
40	99	99		40
39	96	98		39
38	93	97	99	38
37	90	95	98	37
36	87	92	96	36
35	83	89	93	35
34	78	85	89	34
33	72	80	85	33
32	65	75	80	32
31	58	70	74	31
30	50	65	68	30
29	42	60	62	29
28	35	55	56	28
27	28	50	50	27
26	22	45	45	26
25	16	40	40	25
24	11	35	35	24
23	7	30	30	23
22	4	25	25	22
21	2	20	20	21
20	1	15	15	20
19		11	11	19
18		7	7	18
17		4	4	17
16		2	2	16
15		1	1	15

## APPENDIX J- TOTAL TEST (GORDON, 1989:30)

TABLE 3

### TOTAL TEST

Percentile Rank Norms				
Raw Score	Music Majors	Non-Music Majors	High School Students	Raw Score
80	99			80
79	98	99		79
78	97	98		78
77	96	97		77
76	95	96		76
75	94	95	99	75
74	92	94	98	74
73	90	93	97	73
72	88	92	96	72
71	86	91	95	71
70	83	90	94	70
69	80	89	93	69
68	77	88	92	68
67	74	87	91	67
66	71	86	90	66
65	68	84	89	65
64	65	82	88	64
63	62	80	86	63
62	59	78	84	62
61	56	76	82	61
60	53	74	80	60
59	50	72	77	59
58	47	70	74	58
57	44	68	71	57
56	41	65	68	56
55	38	62	65	55
54	35	59	62	54
53	32	56	58	53
52	29	53	54	52
51	26	50	50	51
50	23	47	47	50
49	20	44	44	49
48	17	41	41	48
47	15	38	38	47
46	13	35	35	46
45	11	32	32	45
44	9	29	29	44
43	7	26	26	43
42	5	23	23	42
41	4	20	20	41

## APPENDIX K - QUESTIONNAIRE FOR FURTHER QUANTITATIVE STUDY



# Research study (Quantitative)

Dear Friend, colleague, educator,

I am busy compiling a research paper and would sincerely appreciate if you would conclude the following questionnaire.

## Instructions:

- Please conclude the following 10 questions.
- You simply have to answer yes or no and write down one sentence to justify your answer.
- The information would be treated with the utmost confidentiality.
- You will remain anonymous throughout this data collection.
- There is no right or wrong answers, please attempt to be as honest as possible when concluding the questionnaire.
- If you could please conclude these questions by **Sunday, 23 July 2023** it would be much appreciated.

Thank you in advance for participating in this study!

Researcher  
MM Muller

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\* Indicates required question

1. Email \*

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## Personal Details

The following details will be treated with the utmost confidentiality.

## 2. Where are you teaching at the moment? \*



Mark only one oval.

- Government School (Eastern Cape)
- Government School (Western Cape)
- Government School (Gauteng)
- Government School (Limpopo)
- Government School (Kwazulu Natal)
- Government School (North West)
- Government School (Northern Cape)
- Government School (Mpumalanga)
- Government School (Free State)
- Private School (Eastern Cape)
- Private School (Western Cape)
- Private School (Gauteng)
- Private School (Limpopo)
- Private School (Kwazulu Natal)
- Private School (North West)
- Private School (Northern Cape)
- Private School (Mpumalanga)
- Private School (Free State)
- Other: \_\_\_\_\_

## 3. (Gender) Male or Female? \*

Check all that apply.

- Male
- Female
- Prefer not to say
- Other: \_\_\_\_\_

4. How long have you been teaching for?



*Mark only one oval.*

- 1 - 5 years
- 5 - 10 years
- 10 - 15 years
- 15 - 20 years
- 20 - 25 years
- 25 - 30 years

5. Your age? \*

*Mark only one oval.*

- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65

6. 1. Do you think music and mathematics are closely linked together. If you say yes or no could you please justify your answer in one sentence. \*

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7. 2. Do you think music can enhance the ability of students doing mathematics in Secondary Grades 7 - 9 in schools in your district? If you stated yes or no could you please justify your answer in one sentence.



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8. 3. What actions do you think we can take as educators to promote opportunities for these two subjects to collaborate? Could you write a short sentence to justify your reasons? \*

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9. 4. Do you have opportunities for Science, Technology, Engineering, Arts and Mathematics (STEM) in your school setting and curriculum? You can state yes or no and the reason for justifying your answer in one sentence. \*

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10. 5. Do you think that both music and mathematics requires a level of aptitude? \*  
You can state yes or no in one sentence to justify your reason.



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11. 6. Why do you think that music and mathematics are related somehow? You \*  
can state yes or no, and write down one reason one one sentence.

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12. 7. Are you familiar with the available music aptitude tests and mathematical \*  
aptitude tests available to promote in your classroom setting? Please state  
yes or no, and write down one sentence to justify your answer?

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13. 8. What factors do you think affect the academic achievements of students doing music and mathematics? Please write down one sentence to justify your answer? \*



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14. 9. If you had the opportunity to promote music together with mathematics what activities or events would you arrange to promote in your school setting? Please state yes or no, and write down one sentence to justify your answer?

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15. 10. Do you feel competent that your music influenced your mathematical achievement whilst concluding your secondary education in school? Please state yes or no, and write down one sentence to justify your answer? \*

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