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Neuroscience, Music Education and the Pre-service Primary (Elementary) Generalist Teacher

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Abstract

For three decades, research on training in music education for pre-service primary (elementary) generalist teachers has consistently highlighted four main issues that limit its effectiveness: 1) the influence of past experiences; 2) a lack of confidence 3) a lack of musical competence and 4) limited time to address these issues in teacher education courses. These issues have been addressed through different pedagogical approaches that have been largely based on the aesthetic (intrinsic) value of music education. The study reported in this paper aimed to advance this field of research through a pedagogical approach that combined both aesthetic (intrinsic) and utilitarian (instrumental) values of music education. Pre-service generalist primary teachers were exposed to the neuroscientific research findings during a teaching intervention to explore if a combination of aesthetic and scientific justifications affected the value they placed on music education and their confidence and competence in teaching music. The study found that exposure to the broader benefits of music education to brain development heightened levels of confidence, commitment and responsibility for the delivery of effective music education.

Introduction

Primary generalist teachers, also known as elementary classroom teachers, are a specialised group of educators. Typically, they spend the majority of their professional life catering to a class of students for a school year, teaching them across multiple subject disciplines. They are required to have a solid basis of knowledge in multiple areas as well as an extensive knowledge of educational pedagogy and psychology. Concerning music education specifically, although requirements vary across school systems, primary generalist teachers may be required to deliver the music education curriculum to their class, or to assist the music specialist in the delivery and reinforcement. Pre-service teacher training in Australia includes music education in a variety of ways, as discrete areas of study or through integrated arts education courses. Music education comprises only a small part of the pre-service primary generalist teacher training, both in terms of time and the probability that they will be solely responsible for the delivery of music education for their students.

The assumption that arts disciplines can be taught at the primary level by generalist teachers continues to cause division amongst music teacher educators, university administrations and government policy makers (Stevens-Ballenger, Jeanneret & Forrest, 2010). Generalist teachers are required to enter their teacher training with a high level of literacy and numeracy, but this is not true in any of the arts disciplines, yet they are expected to deliver arts education of the same quality as their literacy and numeracy education. Furthermore this shortfall is not acknowledged or addressed in degree structures and with only restricted time available within a university degree to teach music education (Hocking, 2009) in comparison to other subject areas such as Mathematics. After 30 years of research into the content, pedagogy and focus of primary generalist teacher education courses in music and arts education, three main issues have come to the fore: 'lack of time given to arts teacher education; lack of confidence of pre-service teachers engaging with the Arts; and the influence of past experience on pre-service teacher engagement with Arts education' (Garvis & Riek, 2010).

However, the study reported on in this paper indicates a fourth, and overarching, issue: a theoretical grounding in the role and impact of music in child development. This study proposes that an additional issue should be added to this list, that of the value that pre-service teachers hold towards music education, both before they enter any teaching degree and after any type of music education course. These values can be influenced by all of the areas mentioned above: if the students do not feel confident in their own musical abilities, they may tend to value music education less for their students. This situation can be compounded by limited contact time in their undergraduate degrees in which to gain that confidence. Finally, past experiences may influence the values that they bring into their undergraduate degrees and consequently the lack of time and confidence feeds into the already low value that pre-service

teachers place on music education (Austin & Reinhardt, 1999). Consequently, tertiary music educators are faced with students entering their courses with a negative value towards music education, possibly formed through negative past experiences, compounded by a lack of consistent and sequential music education, which leads to a lack of basic music understanding (competence), which feeds a lack of confidence and finally reinforces a perceived lack of importance of music education for their future students. This is just one combination for these complex and interconnected issues, and their inter-dependent nature creates challenges for any tertiary educator.

In the first half of the 20th century, the value of music education was largely based on utilitarian or instrumental benefits such as the benefits to children's physical health, mental alertness and self-discipline (Henry, 1958). However the paradigm shifted to an aesthetic or intrinsic basis in the latter part of the 20th century, most notably in Reimer's *A Philosophy of Music Education* (1970) where he proposed that music education should be primarily valued for its own sake as an art form (Reimer, 1989b). As we advance into the 21st century the aesthetic paradigm remains the leading basis for the value of music education.

The use of this paradigm as the sole theoretical grounding for the value of music education with pre-service generalist primary teachers is a problem. A deep and effective understanding of the aesthetic benefits of music, or any arts, education, needs to be based on both personally experience and deliberate study of the aesthetic benefits. Due to the decrease in the emphasis, time, resources and training put towards music education over the past three decades, fewer and fewer of the pre-service teachers enter their degrees with a personal experience of the aesthetic benefits of music education. Consequently all that is left is the learned understanding of the benefits, which will always be weakened by a lack of personal reference and connection. This context restricts the effectiveness of any music education program and as such, a new and innovative approach to improving pre-service teacher education in music education is timely and necessary. The study reported in this paper explores the research project that used utilitarian (instrumental) benefits of music education, in the form of neuroscientific research, to improve the value that pre-service generalist teachers held towards music education. This approach, coupled with a teaching intervention focused on developing musical and aesthetic skills, saw a notable improvement in the confidence, competence and responsibility displayed by pre-service generalist teachers towards music education.

Pre-service primary (elementary) generalist teachers

With moves recently in Australia, the UK and the US for generalist teachers, rather than specialists, to deliver the majority of music education to children, research into effective training is crucial. In this environment, the effectiveness of music education courses for pre-

service primary generalist teacher will have a direct impact on the levels of musicianship and aesthetic understanding of future generations.

Confidence in the ability to teach music has been found to be a significant factor in the field of pre-service generalist teacher music education (Jeanneret, 1995; 1997; Hennessy, 2000; Holden & Button, 2006; Russell, 1996). Confidence can be affected by many factors, and researchers have worked to examine how these factors contribute to the overarching achievement of confidence in teaching music. Several researchers in the early 1990s explored the relationship between musical skill and confidence (Bresler, 1993; Gifford, 1991; 1993; Russell-Bowie, 1993). Musical skill, or a pre-service teacher's judgement of their musical skill can affect confidence (Shuter-Dyson, 1999) and negative perceptions can arise from their past experiences in music education. Ruddock and Leong's (2005) study found that such negative perceptions can be related to an unsuccessful attempt to make music in their past or a lack of understanding of music or ability to play an instrument.

Underlying beliefs can influence confidence. Hennessy (2000) found that pre-service primary generalist teachers held the belief that the ability to teach music required 'gifts' in instrumental performance and music reading, which led to low expectations for their future 'non-gifted' students. This is linked with Mills' (1989) earlier work exploring the perceptions of music as a specialist discipline and Jeanneret's (1997) survey of 222 pre-service teachers in both Australia and the US, which revealed the belief by many of the subjects that music was inherited and not learnt. In Kritzmire's (1991) study, pre-service teachers' attitudes were traced back to their own primary school experiences, and the attitudes that were formed during this period were highly resistant to change. In particular, negative self-perceptions of musical abilities based on experiences in primary school influenced beliefs in the ability to teach music effectively (Bresler, 1993; Krehbiel, 1990; Saunders & Baker, 1991).

Levels of confidence have been linked with a student's concepts of competence and self-efficacy in the field of music education. Bartel, Cameron, Wiggins and Wiggins (2008) make the point that 'confidence is meaningless if it is not accompanied by competence' (p. 3). Mills' (1991) study of 50 generalist teachers in the UK found that they rated their teaching competence lowest in music. Within pre-service generalist teacher training, pedagogical strategies and approaches to the acquisition of musical knowledge have been examined. This area of research has aimed to develop an understanding of the balance of learning about music while also learning about teaching music. Achieving competency in a subject area is made far more difficult if the student enters a course with a low level of subject knowledge and then receives minimum instruction in music education. In her report to the Music Council of Australia, Hocking (2009) surveyed 28 universities and found that on average only 16.99 hours were given to the study of music education in teacher-training programs. She found that

‘there is a general expectation that teachers need to know their content’ (Hocking, 2009, p. 4). Low levels of competence may come from pre-service teachers’ backgrounds in music. Russell-Bowie (2002) gathered information in multiple countries and found that students in Ireland were twice as likely to play an instrument as those in Australia, Namibia and South Africa. The impact of the lack of instrumental experience was understood further in Kane’s (2008) study in Australia’s largest state, New South Wales, where even many of those pre-service teachers who had learnt a musical instrument confessed they were no longer musically active and had forgotten much of what they had learnt. The implications of this context for music education for pre-service teachers are many. Bartel et al. (2004) described this inconsistency within teacher training well:

When prospective teachers study the art of teaching language, science, or mathematics, they receive comprehensive methods instruction at the post-secondary level that builds on approximately twelve years of progressive study in each discipline. We would not allow someone who had stopped studying mathematics at the fifth grade level to teach mathematics. We would be appalled at the idea that someone could teach language arts if he or she had not read a book or written a word since the age of eleven. Yet we expect that generalist teachers can teach music when their last formal musical instruction, if any, may have occurred at that age or earlier. (pp. 3–4)

Various pedagogical and systemic approaches have been researched with the concepts of confidence, competence, past experience and self-efficacy in mind. Austin (1991) along with fellow researcher Reinhardt (Austin & Reinhardt 1994; 1996; 1999) conducted several consecutive studies to improve the attitudes of pre-service teachers towards music education and accompanied this approach with the inclusion of more time in the music classroom for these students during their professional experience component of the course. In a literature review, Jeanneret et al. (2006) found that the content of music education courses for pre-service generalist teachers was largely based on the professional judgement of lecturers. Furthermore, that judgement was based on what these professionals believe the teacher should know, rather than what they need to know (DeGraffenreid, Kretchmar, Jeanneret & Morita, 2004). This is an important distinction and may contribute to the findings in Gifford’s (1993) study where participants’ confidence lessened after a 12-week music course due to a perceived lack of relevance. Seddon and Biasutti (2008) explored the use of music technology, the remote facilitator and the 12-bar blues and found that it improved participant’s perceptions of their own musicality. Heyworth (2011) explored the use of loops and moving from acoustic to digital music with a view to ‘encourage and empower pre-service teachers to facilitate musical activities in their classrooms’ (p. 42). Heyworth (2011) found that while this teaching strategy did break down many attitudinal barriers for the students, it may be more effective when coupled with tradition music making experiences.

Researchers have also examined the impact of all of these factors on generalist teacher approaches to music education in schools, as teachers' perceived beliefs, attitudes and self-perceptions can be seen to have a direct influence on how much and how well particular subjects or activities are taught by teachers (Guskey, 1988). Barnes and Shinn-Taylor (1988) found that almost half of the teachers they surveyed wanted to be relieved of all responsibility for teaching music. In Krehbiel's (1990) study, classroom teachers ranked the arts, including music, as the least important subject in the range of subjects they taught. In Bresler's (1993) three-year study of music instruction in three US elementary schools, she found that music activities were scant, occurred sporadically, and that the majority of teachers did not teach any music. The barriers Bresler (1993) identified to the greater inclusion of music activities included 'teachers' lack of knowledge, resources, and appropriate structures within an overall climate of pressure for academics' (p. 1). This suggests music education is devalued relative to subjects that are considered more 'academic' in nature. Garvis and Pendergast (2010b) examined the relationship between self-efficacy and arts education and found that:

There is a significant relationship between teacher self-efficacy [in the arts] and perceived support for subjects. . . . respondents in this study perceived a general lack of support for the teaching of the arts in their classroom, compared to English and maths. Many beginning teachers stated that schools provided greater financial support, assistance and professional development for the teaching of literacy and numeracy (typically described as English and maths), to increase school performance in national testing. (p. 18)

Currently, the research within the field of music education and the pre-service generalists is moving into the field in a number of directions. Wiggins and Wiggins (2008) completed a study investigating 'what actually goes on in the classroom when generalist teach music' (p. 4). One finding from this study was that generalist pedagogical knowledge contributed to some of the more effective learning experiences that the researchers observed. Garvis and Pendergast (2010a, 2010b) have continued to examine the issues of generalist teacher's concepts of self-efficacy in music education and the relationship between their initial teacher training and the provision and support for music education in their initial years of teaching. The mix of learning experiences within a pre-service generalist teacher-training course continues to be refined. In Siebenaler's (2006) study of a music fundamentals course in the US, he evaluated a number of strategies using singing activities to increase confidence levels, reporting that:

While 96% of the students enjoyed singing along with the radio and 51% had some type of choral experience, only 25% considered themselves 'good singers' at the beginning of the semester. Although the percentage of students rating themselves as 'good singers' had increased to 39% by the end of the semester, the majority still lacked self-assurance in regard to a skill they had practiced

consistently over the 15 weeks of the course. (p. 17)

Stevens-Ballenger et al. (2010) completed a study to put forward concrete recommendations about the knowledge and skills needed to teach music in the primary school. This study was in response to a series of reports and national reviews in Australia that highlighted ‘the need for the improvement of pre-service education in primary music but there is little in the way of concrete recommendations for this improvement’ (Jeanneret & Forrest, 2009, p. 85). In this environment it falls to the tertiary music educators to continue to develop models and methods to effectively train pre-service primary generalist teachers in music education.

Neuroscience and Music

Recent neuroscience studies have indicated that formal music training has measurable positive effects on multiple aspects of brain development. Put simply, musicians have been found to have bigger, better brains; bigger in terms of denser grey matter and highly developed structures such as the corpus callosum, better in terms of faster facilities for processing and systems for memory storage and retrieval. This field of research was born when neuroscientists, using fMRI machines to observe brain structures and function in real time, discovered that using music as a stimulus revealed new and unique understandings about the brain. As participants listened and processed the music their brains used many different areas concurrently, rather than one predominant area. The previous theories of a language or movement centre of the brain did not hold with the brain activity they were observing. The processing of musical sound and information happened across multiple areas and more interesting, was occurring simultaneously. This led neuroscientists to compare brain structures and functions in participants who had formal music training, in many cases in the form of learning a musical instrument, with those who had not. What they found, and continue to discover, were notable differences between the brains of musicians and non-musicians. These differences pointed towards the benefits of formal music training to many aspects of human behaviour and learning. Musical training has been found to enhance visual and verbal memory with superior abilities in both immediate recall and delayed recall of visual and verbal materials (Degé, Wehrum, Stark and Schwarzer’s, 2011; George and Coch’s, 2011; Jakobson et al., 2008). Jäncke’s (2008) research proposed that music and memory are connected through the way the brain responds to and processes emotion. The study indicated that emotion is a memory enhancer, and therefore the ability of music to illicit emotional responses acts to improve the many memory types that the brain creates, such as sensory and working memory. Jäncke explored the possibilities that ‘if music has such a strong influence on emotions and our cognitive system, this raises the question of whether the memory-enhancing effect of emotional music can be used to enhance cognitive performance in general’ (p. 4).

Gruzelier and Egner (2004) found that music training positively influences neural signals associated with attention and relaxation. Posner, Rothbart, Sheese and Kieras (2008) found that conflict resolution training and musical training both led to improvement in intellectual tests. Berkowitz and Ansari (2008) found that the continuous process involved in musical improvisation causes brain activity to overlap a number of regions. Bialystok and DePape (2009) found that musicians' brains perform in a similar manner to those of bilingual speakers when it comes to non-verbal spatial awareness tasks that measure levels of executive function. Among a myriad of other tests, Hanna-Pladdy and MacKay (2011) found that musicians perform better in executive processing than non-musicians. This particular study, as well as a previous study by Wan and Schlaug (2009), linked musical training to the preservation of cognitive function in advanced age.

The link between language and music has been investigated widely. The complexity of the relationship has prompted a large number of studies that have identified subtle, overlapping processes in shared, parallel and distinct brain regions (Hodges, 2009, p. 73). Patel (2008) highlighted the possibilities for music to help us better understand various brain mechanisms, particularly those related to speech. A significant area of research is the connection between musical syntax and speech syntax. Dammann (2009) suggested that music could help children decode the syntax of ordinary language. Jentschke and Koelsch (2009) went further to suggest that the improved levels of language acquisition in children with more than two years and nine months of musical training proves far transfer in the area of formal music training and language learning. Wandell et al. (2009) reported on the strong functional connections between musicians' brains and their heightened phonological (speech, voice and sound) awareness. The brain's message transport system, the axons, are more diffused in musicians' brains and therefore send messages to the temporal lobes, which are in charge of recognition and categorisation, more quickly. This allows musicians to process and assimilate some new information faster than non-musicians do, especially in the area of speech recognition and development. Recently this connection has been investigated with newborn babies and found that 'music and language are intimately connected in early life sharing part of the same neural pathways' (Perani, 2012, p. 1).

These are only a small number of the findings that have been made in the field of neuroscience and music, collectively known as neuromusical research. As the field is relative new, with findings beginning to be published in the mid 1990s, neuroscientists continue to work to clarify and replicate the findings and in turn, publish research findings that have a strong research basis. Many of these findings are yet to be widely disseminated and considered by those who deliver music training, music educators. This may be due to the youth of the field and the nature of the findings, which are primarily scientific, and their impact may not be immediately applicable to the field of education and the arts.

This may have a significant impact on the perceptions and value that teachers, policy makers and educational leaders have towards the purpose and place of music education in a child's educational development. It is this impact that was examined in a research project to determine if exposure to neuromusical research findings had an impact on the perceived value of music education in pre-service generalist primary (elementary) teachers.

Method

The study measured changes in the value that pre-service generalist teachers held towards music education when they were exposed to both the aesthetic and neuroscientific benefits of music education. The study took the form of a ten-week teaching intervention with a 78-question pre and posttest survey. The teaching intervention was based on research and models specific to the needs of pre-service generalist teachers in music education.

The participants were enrolled in a four-year undergraduate Bachelor of Education (Early Childhood and Primary) course and were undertaking their first unit in arts education, which included the disciplines of music and dance. Each student attended a 90-minute music tutorial and 90-minute dance tutorial per week for ten weeks, totally 15 hours of contact time for each arts discipline. Four class groups were included in the study, all of who were taught by the researcher, and 52-paired surveys were included in the SPSS analysis. Two of the classes were designated as control groups ($n=27$) and received the traditional curriculum based on the aesthetic benefits of music education only. Two of the classes were designated as the experiment group ($n=25$) and they undertook the same curriculum as the control group but were also exposed to the neuromusical research findings as well as the aesthetic benefits of music education to human development. Exposure to the neuromusical research findings was done in two ways; through focused discussions in class and explicit connections made between practical music making activities and brain development, which was then reinforced through purpose designed information sheets which were disseminated at the end of the tutorial.

The pre and posttest quantitative survey was based on the instrument developed by Austin and Reinhardt (1994; 1996; 1999) and Hash (2010). The Austin and Reinhardt (1994; 1996; 1999) instrument measured levels of agreement with validity and advocacy statements about music education. These statements were grouped in themes such as aesthetic benefits, social-emotional benefits and quality of life benefits. For the purposes of this study an additional group of statements were added with the theme of neuroscientific benefits. The Hash (2010) instrument examined numerous issues relating to importance, confidence, competence and past experiences and selected questions were used in this study to measure if exposure to the neuroscientific research changed the pre-service teachers beliefs on their responsibility and

delivery of music education. The measurement scales used in both the Austin and Reinhardt (1994; 1996; 1999) and Hash (2010) surveys were retained for continuity.

Basic demographic information was collected as well as information on the participants' musical background. The type and amount of musical training the participants had experienced was thought to influence the value they held towards music education. Consequently a criterion was developed to divide the group into musicians and non-musicians (Collins, 2014) with analysis carried out on the differences in their responses.

The teaching intervention was based on the education philosophies of Dewey (1910; 1934), Eisner (2002) and Vygotsky (1978), Swanwick (1988) and Elliot (1995), the teaching strategies of Rubin (1985), Gardner (2004) and Rogers (1979). The teaching model designed by Jeanneret(1995; 1997) served as the basis for the curriculum. The teaching intervention worked on a trajectory of learning for the participants to move them from a dependent state of learning to an independent state where they have the skills, knowledge and confidence to teaching music education as well as recognise the need to continued professional development in the field.

The teaching intervention was divided into two parts. In the first five weeks participants took on the role of primary students, physically involved in musical games, rhythm exercises, singing and melodic activities and using musical instruments typically found in a primary classroom. Before attending the class participants would complete chapters from a purpose-designed workbook on reading and writing music. The first part of the teaching intervention provided participants with competence in the musical language, practical learning experiences of that language to build confidence and challenged past personal music learning experiences. The second five weeks of the teaching intervention gradually reversed the participants role as student and put them in the role as teacher. Students were given a musical topic, such as the difference between a crotchet and quaver, and were asked to design and teach a three-minute activity to the class on that topic. Modelling of simple and effective teaching strategies was included in the first five weeks and participants based their activities on this modelling initially. Participants delivered two more teaching activities across the five weeks and gradually became more confident about their use of musical language, musical instruments, activity design and adjusting their teaching to the responses from the class. The second part of the teaching intervention reinforced confidence in both music and teaching and served as a practical experience to challenge the participants past experiences in music education.

Findings

An analysis of the results for the quantitative survey found that all groups showed a statistically significant increase in the value they placed on music education after the teaching intervention, and the experiment group held a higher value than the control group in the

majority of measures. The experiment group indicated a higher level of confidence to teach music when compared with 15 key learning areas and against other arts disciplines. The experiment group placed a higher level of importance on music education after the teaching intervention and the value of learning a musical instrument was heavily based on the benefit to brain development. Unexpectedly, the level of critical thought and philosophical justifications for the value of music education was far higher in the experiment group in the final qualitative question. Similarly, although assessment for the unit of learning was common across the control and experiment groups and not included in the study, those participants exposed to the neuromusical research findings submitted work of a noticeably higher academic standard. The following section will outline some of the significant findings in four areas; value (benefits) of music education, importance of music education, confidence to teach music and value of learning a musical instrument.

Some notable results were that the participants indicted at the start of the intervention that the value of music education was largely in the Aesthetic and Social-Emotional benefits it provides. Using the six-point scale developed by Austin and Reinhardt (1994), the majority of responses at the pre-test were in the “true” range and only rose slightly after the teaching intervention. However the Quality of Life and Neuroscience statement groups both showed a statistically significant increase, moving higher within the “more true than false” range and into the “true” range in the experiment groups’ responses (Table 1). It could be concluded that the participants retained their belief that the benefits of music education is to the aesthetic and social-emotional development of children, but that the teaching intervention changed their beliefs in the effects on the quality of life and brain development that music education can provide. The increase in the belief in the neuroscience statements is not surprising for the experiment group but does show that the manner in which they were included in the teaching intervention was effective.

Table 1
Difference in Quality of Life and Neuroscience statement groups

	Quality of Life benefits			Neuroscience benefits		
	Control	Experiment	All Groups	Control	Experiment	All Groups
	<i>n</i> =27	<i>n</i> =25	N=52	<i>n</i> =27	<i>n</i> =25	N=52
Pre	4.36	4.42	4.39	4.42	4.46	4.44
Post	4.79	4.99	4.89	4.44	5.10	4.96

The importance of music education increased by two rankings across all groups, but this was significantly different when comparing the control and experiment group (Figure 1). The

control group felt music education was more important by just over one ranking while the experiment group raised their importance of music education by close to three rankings.

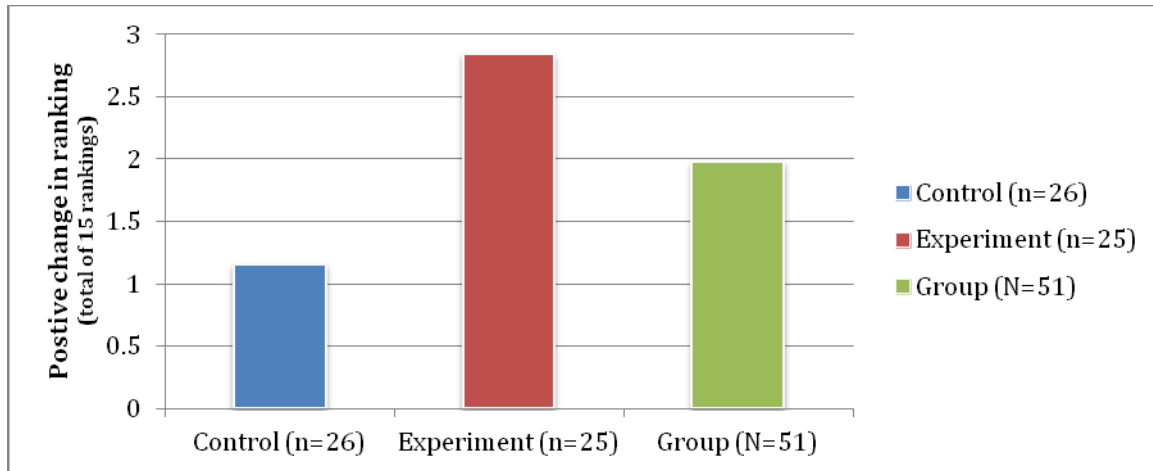


Figure 1. Importance of music education (ranked within 15 subject areas)

Similarly the confidence to teach music increased by over four rankings across all groups and was again higher for the experiment group (Figure 2). These findings show that the teaching intervention increased the confidence levels within the group and exposure to the neuromusical research findings may have positively affected those confidence levels.

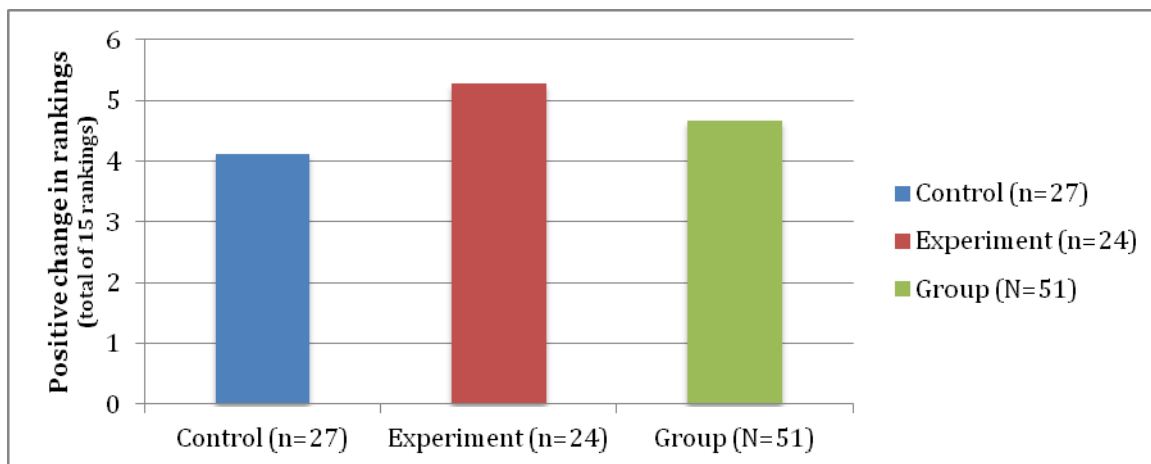


Figure 2. Confidence to teach music education (ranked within 15 subject areas)

Participant's open text responses to the value of learning a musical instrument showed a change in focus after the teaching intervention between the control and experiment group. The control group responses revealed the stronger focus to be on the social-emotional benefits of music education, however their comments were spread across the other benefits, even

neuroscience. Apart from the addition of the neuroscience benefits, their values towards learning a musical instrument did not change notably as a result of the teaching intervention. This indicates that the intervention may have reinforced their established beliefs. The experiment group responses shifted significantly after the pretest. Before the teaching intervention the experiment group indicated a higher value towards the social-emotional benefits of music education than any other group of values. However after the teaching intervention their comments were based strongly in the neuroscience benefits, with all but two participants highlighting these benefits above all others. These findings show that the neuroscience benefits had a significant impact on the experiment group participants and that they informed their value of music education very strongly. This showed again that the material and the manner in which it was incorporated in the teaching intervention had a significant impact on the values the pre-service primary generalist teachers ascribed to music education.

One final, and unexpected, result emerged at the end of the analysis phase of this study. The final question in the survey was an open text question asking for the learning that participant's found most valuable during the teaching intervention. The responses were markedly different from each group. The control group (C) focused on understanding the teaching process and their personal development as musicians. Their answers were short and often in a list format.

Everyone has a singing voice. Music allows for all students to participate. All in class activities can incorporate music. (C-Participant 2)

How to teach students through simple activities & how to extend on a basic activity (C- Participant 6)

The experiment group (E) responses focused on brain development, philosophical considerations concerning curriculum design and broader issues of educational achievement.

I have learnt about the academic reasoning behind including arts education in the curriculum and that music helps improve students' well-being, memory and attitude towards learning in general. (E-Participant 9)

Music is more than just learning an instrument. It is a fundamental part of a well-rounded education and has increasing benefits to brain growth and self-confidence that may not be gained if not for music education. Participation in music education can benefit all other areas of social and educational life. (E- Participant 34)

Furthermore responses from the experiment group were longer, focusing on issues of equity, sustainability and educational ideals, and with a note of advocacy. To further understand the differences in the responses a text analytics program was used and verified conceptual focus, themes and quality of writing. It was also noted, although not part of the study itself that

participants exposed to the neuromusical research findings submitted assessment items of a noticeably higher standard.

Conclusions

This study revealed two key findings. The first finding was that a tailored curriculum and teaching approach for pre-service primary generalist teachers can increase the value, confidence and importance they place towards music education. The complex issues that face this group of students in the field of music education requires a research-led approach in order to be effective. It is a delicate combination of teaching strategies and curriculum design that cater to personal and professional aspects of the student simultaneously and deliberately. The teaching intervention took the participants on a journey from being a student to being a teacher within a unit of learning, not across multiple units within a teacher-training course. This approach modelled the trajectory from pre-service teacher to in-service teacher and showed the participants in an irrefutable way that they were capable, physically, emotionally and intellectually, of teaching music successfully.

The second finding is that exposure to the neuromusical research findings within this tailored curriculum heightened the values and levels of confidence, importance and intellectual rigour expressed by the participants towards music education. The inclusion of the aesthetic rationales as well as utilitarian rationales, in the form of improved brain development as seen in areas such as memory formation and language acquisition, appears to have greater impact on the pre-service generalist teachers than just their value of music education. Exposure to this scientific research, in the field of arts education that has not traditionally included them in curriculum, has been shown to have a wide-ranging impact on the pre-service generalist teacher values. With a change in values comes the potential for a change in actions and the improvement of learning outcomes in music education for future students. Yet we must be mindful of when and how this research is presented, examined and used by generalist and specialist educators, policy makers and educational leaders. Too easily these neuromusical research findings can be misunderstood or simplified down so that the important nuances are lost, or worse still, corrupted.

With the potential for the majority of primary school music education to be delivered by primary generalist teachers, effective training for both pre-service and in-service teachers is vital. In the case of music education this training needs to be based on a clear understanding of what drives a large proportion of generalist teachers to marginalise music education, either through perceived lack of skill, resources, confidence or importance. The inclusion of neuromusical research in one pre-service generalist teacher program is not the magic ingredient to fix this complex problem, but the findings of this study suggest that it is a concept worth exploring further. It will be important to examine if and in what ways this type of program impacts on practice when these teachers enter the profession. Similarly the impact of

the neuromusical research findings on practicing teachers' values may be very different. It must also be acknowledged that parental support and encouragement in the area of music education is pivotal to a student's continued involvement, and this neuromusical research may alter the perceived value of music education for parents as well. Ultimately the economic pressures and political agendas that are at play on education systems globally require policy makers, educational leaders, practicing teachers, teacher educators and specialist music educators to constantly re-examine the tools we have available to maintain an understanding of the vital benefits of music education in every child's development.

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