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European Music Portfolio – Maths: Theoretical and Practical Contributions in the Catalan and Spanish Context

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ABSTRACT | Music and mathematics have a very close relationship and over the years many professionals from these and other scientific fields have underscored the numerous connections between the two disciplines. Nonetheless, few contributions have been made as yet on a scientific and educational level with the aim of promoting a more integrated approach to learning music and mathematics, especially in the Spanish context. In order to cover this shortfall and, ultimately, to contribute to a more integrated and holistic kind of education, the implementation of the European Music Portfolio: Sounding Ways into Mathematics (EMP-M) project began in Spain and the other European countries involved in 2013. This paper is intended to summarise some of the most important contributions made by the EMP-M in the Catalan and Spanish panorama. To this end, we present the state of affairs of the current relationship between music and mathematics in education, first referring to the international perspective, then focusing on the Spanish context and later describing training strategies and transfer activities that have been carried out to enhance integrated work in both subjects among Catalan primary school teachers. This paper concludes with a reflection on how the EMP-M is helping to address the challenges of the Spanish educational landscape, not only with respect to music and mathematics education but also the process of change and educational improvement needed overall.

Keywords: music education, mathematics education, primary school, teacher training, interdisciplinarity.

1. THE EMP-M PROJECT AND THE STATE OF MATHEMATICS AND MUSIC EDUCATION IN THE CATALAN AND SPANISH CONTEXT

Since the first contributions made by Pythagoras no one has questioned the close relationship between music and mathematics. Over time, musicians, scientists and scholars have studied and highlighted the many aspects that unite both disciplines. With this relationship providing a starting point, the implementation of the *European Music Portfolio: Sounding Ways into Mathematics (EMP-M)* began in the 2013-14 year, a Comenius European project lasting three years and part of the *Lifelong Learning Programme*, which involves nine institutions from seven different countries including Spain and Greece. The EMP-M examines the relationship between music and mathematics and explores the educational possibilities of an integrated teaching and learning approach with the goal of contributing to a more holistic type of education, as proposed by Viladot and Cslovjecsek (2014). This project therefore seeks to explore new ways of breaking down the barriers between the disciplines in order to design activities, materials and strategies that favour an interdependent relationship between them (Mall et al., 2016). It is intended to provide primary school music and mathematics teachers with resources that not only influence the pupils' results in both subjects but accompany their development in the broadest sense.

In Spain, the introduction of this project in 2013 coincided with the implementation of the Organic Law for the Improvement of Educational Quality (LOMCE), a new education bill that made music an optional subject at school and therefore introduced the possibility of students completing compulsory education without having undergone any musical training. Paradoxically, almost at the same time as the approval of the LOMCE and also in Spain, numerous educational research papers were published that highlighted the importance of the role of music and art for learning and for the overall development of the person (e.g. Andreu & Godall, 2012; Reyes, 2011). Although this idea is not new, and less so in the international panorama, it is undeniably useful for learning about the place of music education on the Spanish educational agenda, the same agenda in which mathematics appears as a priority. It is common knowledge that mathematics has historically always been one of the most highly valued subjects on the school curriculum; on the other hand, poor results in the PISA tests have only made the Spanish educational authorities more concerned about this subject (Ministerio de Educación, Cultura y Deporte [Spanish Ministry of Education, Culture and Sport], 2014).

Under these circumstances, the EMP-M project is envisaged as an opportunity to contribute to a process of change and educational improvement that is considered inevitable. With this hypothesis this article aims to describe the state of affairs concerning the relationship between music and mathematics, both internationally and, more specifically, in Spain, in order to later present the contributions being made by the EMP-M in the Spanish context, to offset – in part – existing deficits, and propose solutions to some of the problems present in the Spanish educational panorama.

2. THE RELATIONSHIP BETWEEN MUSIC, MATHEMATICS AND EDUCATION

2.1. THE INTERNATIONAL CONTEXT

When looking for literature that links music and mathematics, the enormous interest aroused by this issue in the international arena becomes clear. Anderson (2014), Vaughn (2000) and Xenakis (1992) are examples, though the list should also include the biographies and works of musicians with significant mathematical concerns – Bach, Bartok, Schillinger, Schoenberg and Stockhausen, among others – and, conversely, mathematicians with obvious musical interests, Pythagoras Descartes, Galileo, Mersenne, Leibniz, Euler and Alember for example.

In the sphere of the education, there are also many studies that explore this relationship, especially coming from the United States (An, Capraro & Tillman, 2013; Boyd, 2013; Cheek & Smith, 1999; Gardiner et al., 1996), and also from the UK (Sanders, 2012; Hallam & Price, 1998) and Australia (Geoghegan & Mitchelmore, 1996). In general, these studies agree on the positive impact made by musical instruction on mathematics learning and the results obtained by students in tests on this subject.

As regards practical resources, applicable in the classroom, the three volumes of *Mathemacht Musik*, published by the Swiss lecturer Cslovjecsek (2001/2004), deserve special mention. These books propose structured activities based on key mathematical content, through which pupils can work on the main aspects of mathematics. More recently, the same Cslovjecsek and Linneweber-Lammerskitten (2011) proposed activities for working on maths concepts through music.

In the USA again, An and Capraro (2011) propose, by way of a complementary approach, musical activities as a basis for working on different mathematical concepts. Johnson and Edelson (2003) and Shilling (2002) have carried out similar work too, although emphasizing the role of music as a resource – for obtaining a mathematical education – and not as an end in itself. And, in general, the approach that prevails in this type of work is unidirectional because it is posed as a way of fostering learning in one of the disciplines involved, usually mathematics, and rarely as an opportunity to learn in a more integrated, holistic way. This conclusion is applicable in the cases of both research from the academic world and other more practical resources contained in books, websites, blogs and suchlike.

2.2. THE SPANISH CONTEXT

In the Spanish context, the bibliography relating music and mathematics in education is rather limited, as shown by the analysis of the literature carried out by Casals, Carrillo and Gonzalez-Martín (2014) and summarized below.

Initial evidence, approaching the theme from a scientific and academic perspective, was collected by means of an analysis of publications in leading Spanish journals dealing with music education (LEEME, Música y Educación, Eufonía, RECIEM) and mathematics education (UNO, Suma, Números). This analysis showed that about twenty articles have been published over the last fifteen years, most of them in the same journal – Suma – and written by the same author, Vicente Liern (University of

Valencia). In general, these articles have an informative character and are mostly focused on secondary or higher education. It was also found that most of the publications linking music and mathematics education have been published in mathematics education journals and adopt a mathematical perspective. This re-confirms the above-mentioned point about the directionality that has generally typified this kind of article. It may well be that scientific nature of mathematics – as opposed to the artistic character of music – and also the greater value that has historically been placed on mathematics in the school curriculum have contributed decisively to this reality.

In a second step the analysis of the literature on the subject brought to light the existence of two types of publications, described in greater detail below:

- Theoretical publications: This first group contains those publications whose main purpose usually bypasses practical experiences and any kind of didactic contribution. They include informative studies dealing with specific aspects (e.g. Liern, 2008), others that take a more analytical approach (e.g. Lopez & Gustems, 2007) and educational research papers (e.g. Venegas et al., 2013). In general, these publications make contributions of a varying nature to demonstrate the connection between music and mathematics, often as a starting point for interdisciplinary approaches in the classroom. Sometimes, however, they also suggest activities for maths and music teachers working in secondary or higher education, though the study made by Venegas et al. (2013) refers to primary education.
- Publications with a didactic approach: This second group comprises those papers that offer strategies, materials and other activities that can be applied in the classroom. In general, most of these publications focus on early childhood (e.g. Lárazo & Riano, 2009; and Ayala et al, 2003), probably owing to the integrative, interdisciplinary perspective usually adopted by teaching during this educational stage. But there are also studies focussed on secondary education (Arenzana & Arenzana, 1998), perhaps because the content relating music and mathematics in the educational context is more typical of this stage, something that favours greater practical applicability. On the other hand, the contributions aimed at primary education are even scarcer and less substantial (e.g. Segarra, 2008; Liern, 2011).

The references provided so far highlight the lack of contributions and the low impact of the papers that deal with the relationship between music and mathematics education in Spain. However, from constant contact with teachers and student teachers, these authors can safely say that teaching practices promoting the integration of both disciplines do exist, although very few of them have been disseminated through channels open to the public. Examples include the *Matemusicant* and *Sumado* programmes, organised by primary and secondary school teachers respectively, with the aim of collecting together educational activities, resources and other materials that connect music with mathematics; platforms such as ConCIENCIA Musical, which present experiences, books and curiosities about music and mathematics and the relationship between the two disciplines; and final year dissertations at undergraduate and master's levels, from different Spanish universities, which indicate the growing interest in this subject in the educational community, perhaps because of the need to find new educational approaches which respond to some of the today's challenges in the Spanish educational landscape.

In short, the discussion in this section highlights the current interest in the pedagogical relationship between music and mathematics but at the same time brings to light a significant lack of proposals and teaching materials, especially in primary education in the Catalan context. From now, we'll refer to Catalonia instead of Spain, because this autonomous community holds delegated powers in the field of education (for further information about this topic see Ferrer, 2000) and this is the reality where the authors work and live.

Let's look at what actions are being taken to resolve these shortcomings under the EMP-M project.

3. CONTINUOUS TRAINING ACTIVITIES UNDER THE EMP-M

Within the EMP-M project, the Autonomous University of Barcelona (UAB) is ultimately responsible for knowledge transfer in the form of teacher training, which needs to be suitable for the whole of Europe. As the reader may well imagine, this is a major challenge given the disparity of contexts and training opportunities around Europe.

Given the above-mentioned challenge, it was decided to develop and experiment with different types of continuous training activities considered suitable for the immediate educational landscape, Catalonia. The goal was to validate these activities and ensure they could be subsequently adapted to the rest of the Spain and other EMP-M member countries, and, ultimately, to anywhere in Europe.

The development of a variety of training activities was considered necessary given the flexibility required to deal with the different training demands that usually emerge. In line with the philosophy of the project, this deliverable also had to be adaptable to the particular circumstances of different contexts and foster cooperation by building bridges between educational sectors, countries and trainers.

In addition, the potential of these activities to promote work and research on the training and materials under development was also assessed. The various activities being undertaken are described below:

a) Training and advice at preschools and primary schools

This strategy consists of meeting and supporting the demands of a school by working directly with the teaching staff (all the teachers in the school). This training is tailored to the needs of each centre and promotes progress in both individuals and the group. These are often schools with a prior interest or some previous training in the use of music as the core of the educational project, which seek to deepen the music-maths relationship but lack references or materials.

The trainers come from the Catalan/Spanish EMP-M partner's team (Musicomàtics) and usually form a tandem made up of an expert in music education and another in maths education. They plan, supervise and jointly evaluate sessions with teachers. Apart from the sessions with all teaching staff, they sometimes divide the teachers into subgroups to develop activities and reflect on specific educational stages (3-6 years, 6-8 years, 8-10 years; 10-12 years).

This training lasts from fifteen to thirty hours a year and is approved and funded by the Catalan Department of Education. The programme lasts the whole school year so that teachers have time to create and experiment with activities in their classes and share their experiences with colleagues and trainers.

Specifically, we have worked closely with nearly 100 teachers from three schools since the beginning of the 2013-14 school year. In two of them, given the interest at the schools, the training programme has been extended for two years in a row.

b) Teachers' working group

This type of continuing education activity is designed for a small group of teachers from different preschools and primary schools. Participants in the working group are offered training through workshops in the music and maths activities on the project. This training is used to develop spaces for deeper reflection, involvement and work among professionals. Thanks to the resultant networking, the ideas explored, developed and discussed by just a few teachers end up spreading to the different schools where they work, with which the training ends up having much greater impact and – given the participants' commitment – becoming really effective.

Each school participating in the working group is represented by two teachers (a music specialist and a generalist who teaches mathematics). On the same lines, the working group is coordinated by one expert in music education and one in mathematics education in order to favour more careful and effective work.

Training in this format is planned for a minimum of two school years, since the main object is to foster teachers' creativity so that they are able to develop combined music and maths activities from a truly interdisciplinary perspective. Thus, during the first year the participating teachers receive initial training in the project subject matter and experiment with and implement different music and maths activities in their classes, which are then analysed, evaluated and modified by the whole group. These teachers' experiences serve to specify the basic characteristics of good practices in the field of combined music and maths activities (see an example in the article *Maths & Music in search of the lowest common multiple* by González-Martín, Pérez-Moreno i Prat in this same monograph). This is followed by a second year where teachers think up and develop activities that take these features into account. These activities are presented, discussed and jointly reformulated by the working group, and once they have been approved, put into practice. Subsequently, they are re-appraised and further discussion ensues about each activity as applied in the classroom. Difficulties and possibilities are identified and those activities considered valid are saved for dissemination in other schools.

Teachers participating in the working group receive training certification recognized by the Catalan Department of Education.

There are currently two working groups receiving training under the EMP-M project:

- The first, which is in its second year of training, counts on the participation of eight pilot schools and a total of 20 teachers, who will receive forty-five hours' training in total.
- The second, being organised at the moment, counts on five schools and 12 teachers.

In general terms, training in a working group format permits, on the one hand, further exploration of the possibilities of combined music and mathematics activities in Catalan schools, and on the other hand, generates valid materials useful to the educational community.

c) Workshops and continuous training courses

Another approach consists of intensive training activities aimed at a broad spectrum of teachers (from very different educational institutions, stages and contexts). These activities can last from four hours (workshops) to thirty hours (courses). In the former case, the goal is to provide a very practical, focused session in just one day. These workshops focus on actively explaining some of the EMP-M core activities, and they are complemented by a brief presentation of this project. They are aimed at teachers who may be both music specialists and class tutors and mathematics teachers at different levels (preschool, primary and secondary). They normally involve groups of 25 to 30 teachers and the final goal is to present the possibilities and benefits of EMP-M and ultimately awaken their interest in going deeper into music and maths integration. Apart from the positive feedback provided by participants, it should be noted that this is also an effective way of spreading the project ideas further afield. So far four workshops have been held in different cities within 170km of Barcelona.

Continuing professional development (CPD) courses are the second intensive training option. They usually last from fifteen to thirty hours and may be organised locally or at European level. The proposed training is similar to that of the workshops but with the possibility of deeper study. In the case of the thirty-hour courses, the aim is that teachers learn how to use tools to create new activities on their own. These courses, which also take a practical, interactive, applied approach, can provide teachers with resources that give them confidence when using interdisciplinary practices in the classroom. Lastly, it should be noted that the possibility of working together and exchanging experiences with colleagues from other centres is one of the most valuable aspects of this type of training.

Specifically, a first fifteen-hour course was held in Barcelona in autumn 2015, aimed at Catalan teachers but with the participation of trainers from different parts of Europe. In September 2016 a thirty-hour course addressed to teachers from all over Europe will be held in Barcelona.

d) Activities in the university context

The project has also had an impact on training and research carried out at universities. With regard to initial teacher training, it has played a role both at the Autonomous University of Barcelona (UAB) and at the University of Vic (UVic). In the case of the UAB, some of the project members are lecturers at this university and have used the activities in their classes. And at the UVic two team members were expressly invited to present the project.

Furthermore, over the last few years six related final-degree projects have been completed at UAB. These were obligatory professionalizing or research projects carried out in the final year of a master's degree. Thus, this is a current, consolidated line of work within the framework of primary education teacher training at the UAB.

Finally, in respect of content taught at master's level, sessions have been included in a master's degree course at the UVic and three master's research projects are currently being supervised, leading to a more detailed, scientific reflection on the various possibilities of the project. A benefit of research is that it entails deeper examination of some aspects and their impact, which ends up having an impact on the design of the training programme.

4. BY WAY OF A CONCLUSION

As the reader will have realized, the article starts with the theory and the need to advance in the integrated use of music and maths in order to explain how the EMP-M project proposals can help provide solutions in the Spanish and Catalan context. One way or another, the training activities and research promoted by the EMP-M local team come full circle, because they corroborate the importance of the relationship between music and mathematics as already described in the theoretical framework, and demonstrate the interest generated among teachers and future teachers by the proposals being developed and promoted in the Catalan educational context.

The key to success undoubtedly lies in the variety and flexibility of the different training activities, thus enabling them to reach different educational contexts and making them adaptable to the needs and demands of each context. All told, these activities are gradually achieving acceptance in schools, thereby encouraging interdisciplinary content. Professional relations and joint reflection among teachers are clearly being promoted and pupils find this educational approach truly meaningful. It lets a chink of light into schools because it is a more holistic way of understanding the teaching-learning process, counting on involved, creative teachers, motivated by active, experiential teaching methods.

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