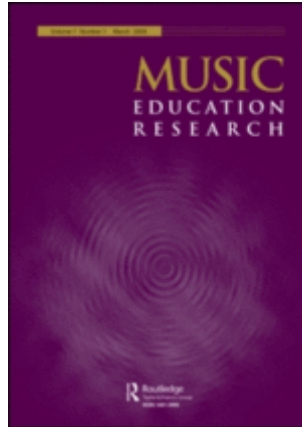




Digital didactic resources and music: mapping the last decade of research

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Digital didactic resources and music: mapping the last decade of research

Abstract

The main purpose of this paper was to carry out an analysis of the scientific production in the last decade on the creation and use of materials in the field of music related to digital technology. For this purpose, a bibliometric study was carried out on 773 articles available in Scopus, and a content analysis was done on 252 open access articles. Conceptual clarifications of concepts in the field and a brief contextualization of the study are also included. We go on to present the findings of the study showing a substantial advance in the use and consideration of digital media in music education. Nevertheless, no indication was found of improvement in learning, comprehensive student development, or competencies.

Key words: Music, technology/digitalization, resources/materials, bibliometrics, research.

Introduction

When carrying out their teaching practice, Music Education teachers currently have at their disposal digital resources to facilitate the process of curricular development. In particular,

digital resources have implied important derivations in terms of materials design as well as school organization and curricular practices (Gopal 2020).

Likewise, the role of technology and digital resources in the development of Music Education has been noted (Young 2020). With respect to recent lines of research, a number of studies have focused on the perception of primary school teachers regarding teaching materials and have reported that teachers express the need for quality digital resources (Vicente-Álvarez, Cores-Torres, and Rodríguez-Rodríguez 2019). In this line, some authors suggest that more initial training for music teachers is needed in topics involving Educational Technology for different levels of education (Vicente, Marín, and Cepeda 2018). These authors point out that digital tools offer a variety of opportunities for Music Education teachers and students to carry out diverse projects and foster musical initiatives across other subjects (Tejada and Morel 2019). Research also continues to demonstrate the role played by printed and digital textbooks in the transmission of values at different levels of education, as well as their relevant role in the context of digital schools (Rodríguez, Braga, and Bruillard 2019).

Recent national and international congresses have showcased extensive research on the role of teaching materials in the field of Music Education (Vicente-Álvarez et al. 2020). In line with the observations born out over the last decade in the field of educational resources and music

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education, a pressing need exists for an x-ray of recent research on digital educational resources and music education to complement previous literature reviews on other research topics (Morales et al. 2017; Calderón and Gustems 2018). Due to this need, we aimed to carry out a bibliographic and bibliometric study to highlight the research being carried out in the field of Music Education and Digital Educational Resources. Specifically, the aims of our study were as follows: a) to analyze the impact, collaboration, dispersion, and scientific productivity in this field of study, and b) to describe the research on the study of digital educational resources and Music Education.

The first aim was approached from a bibliometric perspective and the second using content analysis of the included papers.

In order to establish terms with specificity and concreteness in mind, the classification of digital teaching materials by Area (2017) and Rodríguez and Álvarez (2017) were taken as a reference for contextualizing the performed searches. The following resources were considered: sound-producing digital didactic materials, digital materials to support music learning, digital didactic materials for the development of school curricular projects and audio-visual digital didactic materials.

Methodology

We used a dual design combining the quantitative and qualitative methodologies of bibliometric and content analysis. This approach has proven to provide great advantages (Anguera et al., 2020), since it allows identification of quantifiable features of scientific production – here the use of music resources and technology – and deeper analysis into content for extracting evidence to design interventions and proposals with a greater degree of confidence.

The Scopus database was used to carry out this study due to its recognized prestige and the number of documents available in several languages (Martínez and Bedmar 2019). Based on the classification of digital didactic materials, the following keywords were used for the search: music AND education OR school AND digital OR material OR resource OR media technology OR video game OR educational software OR cd OR DVD OR textbook OR application (App); in English and Spanish.

Following the Prisma method, four phases were completed for the selection of documents to be analyzed in this study, as shown in in the first figure. The screening process was performed by two researchers with a high level of agreement ($k = 0.94$).

Figure 1. Flow chart showing the phases of the procedure. Source: own elaboration.

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The SPSS25 software program was used for data analysis and an *ad hoc* matrix was developed for content analysis. The three analysis categories that arose from reading the selected documents were participants, subject matter, and technological devices and resources. Finally, Vos Viewer and Excel software was used to visualize results.

Results

Our findings are presented complementarily in terms of the quantification of scientific production in this field as well as content analysis.

Bibliometric study

This section deals with issues involving dissemination, productivity, collaboration, and impact of the scientific publications analyzed.

Dissemination of knowledge: evolution over time and level of internationalization

With regard to evolution over time, it should be noted that quantity of publications on this subject has increased over the last decade, with the greatest production in 2020, representing 17.7% of the total number of papers. As shown in second figure, there is an upward trend.

Figure 2. Evolution in quantity of publications over the last decade. Source: Own elaboration based on Scopus data.

The level of internationalization of this area of study can be described as high for two reasons.

Firstly, because of the language chosen by researchers for disseminating their findings. English predominates (94%) among the 16 languages used, despite papers being published in 62 countries, among which the USA, Spain, the United Kingdom, and Australia stand out.

Secondly, the countries of origin are as distant and diverse as the USA, Norway, Chile, Japan, Botswana, Luxembourg, or Tanzania.

Specialization: producers and sources

Insofar as individual production, a total of 1402 authors have published papers on this topic, but the vast majority (99.5%) are considered low-productivity authors, seeing as 91.9% of them only have one publication focusing on DDM (digital didactic materials) in Music Education and 7.6% have between two and four publications. The remainder are middle-productivity authors and there is no high-productivity authors in this field. Therefore, Lotka's productivity

law is confirmed by the existence of an inverse linear relationship, and a Pearson correlation coefficient of $r = -0.56$.

The researcher with the greatest number of papers is Renée Crawford (Melbourne, Australia), with seven publications between 2011 and 2019.

With respect to high-output journals –those which have been published more than 20 articles on this topic– most are specifically Music journal, such as *Journal Of Music Technology And Education* (9.4%), *International Journal Of Music Education* (6.3%), *Music Education Research* (4.9%), and *Journal Of Research In Music Education* (0.13%). Nevertheless, there was also a generalist journal in the field of educational technology: *Turkish Online Journal Of Educational Technology* (3%).

Bradford's law relates the number of journals to the number of articles published on a subject.

It was found that a small number of journals, constituting the core, had published a large proportion of the articles. Thus, there are two differentiated areas having greater dispersion as they move away from the core, as can be seen in following figure.

Figure 3. Areas according to Bradford's Law. Source: Own elaboration.

Level of collaboration: number of signatories and origin

With respect to the number of authors listed on each article, the modest level of collaboration in this area is noteworthy, since almost half of the papers are single authored (46.1%). This contrasts with articles having eight or more authors, such as Erickson et al. (2020) which aimed to reduce the number of child deaths from snake bites by transmitting information about risks using the Iculo Ngenyoka song as a digital resource, demonstrating that music is a culturally appropriate and attractive method for achieving learning in vulnerable African communities. Also with a high number of authors was Viladot et al. (2018), which analyzed the results of a European project integrating the teaching of music and mathematics. These authors found that better outcomes were obtained using a transversal approach and observed the need for teacher training in the creation of DDM to allow further progress in schools. Kritsis et al. (2020) studied the effects of using the innovative iMuSciCa web environment with secondary school students in the subjects of Science, Technology, Engineering, Arts and Mathematics (STEAM). They found this environment to foster the development of creativity and learning through participation in musical activities.

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A detailed analysis of author affiliation reveals notable collaboration between researchers from different countries, although it is more common to find papers listing authors from the same institution or neighbouring institutions within the same country.

As the following Figure shows, some papers were written by researchers in several countries.

As a sample of recent work written by collaborators from different countries, Tejada and Morel (2019), from Spain and Chile, presented the design and evaluation of a course on music technologies in initial training for Music Education teachers and found that students rated the course positively, expressed confidence in their skills as well as the desire to use technologies in their future teaching practice because these technologies are important for their subject.

Figure 4. Collaboration among countries. Source: VosViewer.

Citation and impact level

The analysis took into consideration the journals with the greatest number of articles on the subject, the most cited articles, and the most cited authors.

Table 1 shows the impact index of journals with more than 20 published articles.

Table 1. Impact data by journal

As can be seen, two journals are in the first SJR quartile in both Music and Education, namely, *Music Education Research* and *Journal Of Research In Music Education*. The journal with the highest number of articles is *Journal Of Music Technology And Education*, which focuses on the analysis of technology use in Music Education and music technology in education. However, the highest impact pertains to *Journal Of Research In Music Education*, which explores music teaching/learning processes. Neither of these journals is restricted to a single educational stage, thus, they part from a broad view of music's possibilities for people of different ages and for lifelong learning.

Regarding citations, only six articles have more than 50 citations (Table 2).

Table 2. Impact of articles

Lastly, it shows the most cited authors, with lines indicating co-citations (Figure 5).

Figure 5. Most cited authors. Source: VosViewer.

Content analysis

Three analysis categories emerged from the text analysis: firstly, the analysis is presented according to research participants (students and teachers). Subsequently, the results are

presented according to research theme, which focused on training and rehabilitation. And lastly, an especially interesting core emerged from the investigation reflecting the considerable number of studies focusing on educational hardware and software.

Participants in the research focus

The content analysis began by way of participants, which consisted of recipients in some studies and study objects in others. Articles focusing on students stood out, especially those involving Primary Education and Higher Education, both representing 37% of publications. With respect to Primary Education, we found studies such as Laato, Laine and Sutinen (2019) involving music composition software for learning mathematics in primary schools and which concluded that this type of educational technology encouraged the learning of mathematical concepts, notation and calculation skills, and Romero and Vela (2014) analyzing how students and teachers assessed the use of musical Edublogs. There were also studies pointing out the psychological benefits of using multimedia materials such as Hanrahan et al. (2019), which analyzed joint music creation; and Fasano et al. (2019) on the use of multimedia content with Italian children aged 8 to 10 years and its effects on improving attention and reducing impulsiveness.

Insofar as Higher Education, we found research involving technological resources such as Tong (2016) on the use of mobile phones as a tool in university music teaching; and Liu (2015) on the development and application of audio-activated teaching materials in remote music teaching. We also found other research not directly related to music or teaching such as Harris and Flynn (2017), which found that technological resources for listening and auditory training through music improved sensory awareness skills among medical students.

The Secondary Education stage was addressed by 13% of publications. The study conducted by Albert (2020) analyzed the impact of technology on the co-creation of a classroom atmosphere, concluding that students did not attribute importance to either digital resources or teaching materials, but instead concentrated on the role of the teacher. We found studies on augmented reality in music education such as Cote and Santoyo (2017); evaluations of platforms such as Moodle by Espigares-Pinazo, Bautista-Vallejo and García-Carmona, (2020); and a study by de Marqués de Andrade et al., (2018) on the development of a musical keyboard linking robotics, programming, and physics.

The Early Childhood Education stage and Non-Formal Education (e.g., conservatories, music schools, and extracurricular activities) were only addressed by 10% and 8% of publications, respectively. This may be due to their non-compulsory nature and, thus, to having fewer participants in general. Articles such as Anzini, Baratè and Ludovico (2019) on 3D printing in preschool music education and Tomlinson (2013) on the design of digital tools for literacy through music as multimodal learning in early childhood addressed the Early Childhood stage. Regarding non-formal education, we found research on digital and virtual adaptation of teaching-learning processes during covid-19 lockdown in conservatories by Martín, Mogas and Ucar (2020), and articles on specific musical instruments such as Bolis and Scarduelli (2020) on a digital tool for transcribing expressiveness on the guitar. Finally, teachers (here understood as a professional group active at different educational stages) were the focus of 11% of the studies analyzed. Bautista and Fernández-Morante (2018) analyzed teachers' perceptions of using technological tools in the music classroom. Insofar as teacher training, Blanco and Peñalba (2020) analyzed the presence of technology and music as specific content within different educational stages.

Research focus: training and rehabilitation

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3 This section analyzes findings in terms of subject matter and pursued research aims.
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7 Student training stood out as the main theme in the analyzed research. We found studies such
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10 as Chao, Mato and López (2015) on the interdisciplinary nature of music and mathematics
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13 which analyzed resources, materials, and educational technologies; Magán-Hervás and
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17 Gértudix-Barrio (2017) studied digital and audio-musical resources for literacy acquisition in
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20 early childhood education; and Southcott and Crawford (2011) focused on ICTs and music
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30 Teacher training was also analyzed in studies such as Russel-Bowie (2009) on the technological
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33 challenges for music teaching in primary schools; and Merzero, Laucirica and Ordoñana (2018)
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37 on digital resources as a teaching tool for singing class.
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43 The next most common theme involved music for rehabilitation and/or treatment. A greater
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47 presence has become evident in recent years of studies focusing on the specific diversities of
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Current production and research continues to mention terms such as *music therapy* in Talavera and Gértrudix (2016) on students with Autism Spectrum Disorder (ASD) and the use of technologies and digital resources in open classrooms; Erina et al. (2019) referred to *special educational needs* (SEN) and analyzed the development of educational technologies in students with Attention Deficit Hyperactivity Disorder (ADHD); while Sallat and Jentschke (2015) referred to *specific speech difficulties* when evaluating musical skills through music software and digital media in students with Specific Language Impairment (SLI).

Also discussed were the benefits of music, though to a lesser extent. We found studies such as Sušić (2019) on the impact of music through digital tools on speech development in children; Epelde-Larrañaga, Onederra and Estrada-Vidal (2020) on music as a resource against cyberbullying and Gooding et al. (2014) which used multimedia technologies for musical training and found cognitive improvements in older adults.

Finally, in terms of research aims, we observed that curricular learning predominated, as initially expected. Educational system improvements also stood out. Examples of this were Hoffmann et al. (2016) on academic, technological, and creative challenges in secondary

education, as well as Marner and Örtengren (2013) involving different approaches for implementing digital media in arts education.

Hardware and software

The present extensive literature review showed that the incorporation of technological resources and software into the music classrooms at all educational stages favours the creation of new spaces for music learning.

Román (2017) carried out an exhaustive analysis of technological resources and software that have been incorporated into schools. and which facilitate self-creation by music professionals, teachers, and students themselves. In particular, free software was found to greatly reduced product costs. Also notable were contributions by audio sequencers or Midi, as well as apps and online resources such as Audacity, Ardour, Denemo, Muse score, Hydrogen, LMMS (Linux Multi Media Studio), GNU Solfege, and Phonascus, which can be used on generic electronic devices.

This proliferation of apps and other online tools has gone hand in hand with the integration of technological resources in schools (computers). This set of circumstances could explain why a

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4 large part of research focused on tools and internet-enabled devices. In general, this involved
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7 software and apps, but also platforms, such as YouTube (Wallerstedt & Pramling, 2015) and
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17 The pedagogical possibilities provided by devices, apps and digital materials have generated a
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20 wide variety of uses, ranging from production and use to the creation of repositories. In many
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23 cases, these spaces help to concentrate as well as preserve certain musical styles, such as the
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26 Russian ethnic musical heritage in Alieva et al (2019), and the earlier Wirlomin Noongar Stories
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29 and Languages Project carried out in Australia by Bracknell (2013).
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37 This diachronic study reflects the development of school incorporation of technological
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40 resources. Andrews (2013) used CDs along with other didactic materials in primary school to
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43 carry out music education proposals based on cooperative learning, student participation and
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46 autonomy. Based on students' opinions, this author concluded that the truly important aspect
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49 was the pedagogical model used in the classroom. Years later, Avanzini et al (2019) conducted
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52 research with preschool students and found that using 3D printers in the classroom facilitated
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55 access to musical instruments that would otherwise be unavailable. This study highlighted the
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richness provided to the acquisition of STEM skills. A recent publication by Zimmerman and Holmberg (2017) presented the results of an observational study involving early childhood education students working with cyborgs (robots), guitars and guitarists. These authors described a wide variety of activities and interactions of students with these resources.

In recent years, applications designed ad hoc for the purpose of music instruction in its various forms have emerged as another useful tool, due to their specificity. Music composition has come onto the scene with numerous devices produced to work with schools and families; for example, the ML2 app (Bresson et al., 2013).

In general, we could say that technological resources used in music played two basic roles within the teaching-learning process: on the one hand, the promotion of users as producers and creators, giving them an active and creative role as seen in Anthony (2018) on contributions of composition at different levels of education and Bolden & Nahachewsky (2015), which found student participation in the production of podcasts to promote individual personal development, improve expression, facilitate cooperation, communication and exchange and enhance intellectual development; while on the other hand, users were seen as more or less passive or

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active consumers of products made by external agents, depending on the methodology used in the pedagogical project or whether the target audience was early childhood students (Brooks, 2015).

Differences in pedagogical model and/or purpose may underlie this distinction in the use of technological devices for music teaching. An interesting example is Alpiste et al (2013), which analyzed the implementation of a compendium of electronic devices and specific software within the Opera eLearning project, whose success lie in the contextualization of eLearning possibilities. Even the customization of teaching-learning processes is facilitated. Yu et al (2013) analyzed the contributions of computers, ICT, and internet to facilitating music access for groups with traditionally limited participation, such as people with autism and diverse sensory or motor function.

Another interesting group of publications analyzed the suitability of a software used for music education: Brunt & Johnson (2013) evaluated the use of IGamelan in Indonesia; and Young (2012) analyzed the motivational potential of Karaoke and Videogames with British children aged 6 to 11 years.

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4 The use of musical devices and software was generally found to improve teaching-learning
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7 processes. The reasons for this include, for example, the increased motivation and positive
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10 attitude associated with education 4.0 tools used to train future primary school teachers (Yin et
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13 al. 2019) as well as the ease with which videoconferencing facilitates exposure to other cultures
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16 and musical practices (West & Clauhs, 2019). Tuuri & Koskela (2020) reported the three major
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19 contributions of apps to music education to be as follows: contributing to the conceptual
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22 construction of musical activities, the fusion of instruments, and reinforcing the epistemological
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25 continuum between abstract to concrete.
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34 However, drawbacks also exist and there may still be a deficit in the pedagogical use of
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37 technology in schools. In this sense, Albert (2020) reached the interesting conclusion that
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40 impact on learning was related to pedagogical model based on critical and careful inclusion of
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43 technology used by students for composition.
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51 Several studies have shown that the complementary use of several devices (radio, television)
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54 and internet could directly or indirectly foster the acquisition of musical skills (Terrazas et al,
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57 2015; Baratè et al, 2019; Barate & Ludovico, 2020).
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The use of devices and apps is also useful in the assessment process such as the one conducted by Asztalos & Csapó (2017), where the listening skills of 1st to 11th grade students in Hungarian schools were assessed using *eDia* (Electronic Diagnostic Assessment). The authors concluded that this assessment tool provided a contextualized analysis of each student's results.

The following figure shows the key terms that appeared most frequently in the analyzed articles and their tendency to appear together, which clustered into four groups.

Figure 6. Keyword co-occurrence map with fractional count. Source: VosViewer.

Conclusions

This study was carried out with a mixed quantitative-qualitative methodology, allowing for in-depth analysis of the state of the art as well as mapping of the research carried out in different contexts.

The data reveals that the laws of Lotka, Price and Bradford are fulfilled in this field of research.

The degree of collaboration among professionals was found to be modest, which is in line with

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7 work was apparent, and when there was collaboration among researchers, the signatories tended
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17 Content analysis revealed the quantity of resources available in this field, but the proper use of
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20 digital teaching resources to foster inclusion was lacking. Democratization can be fostered by
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23 using open and free resources and research has addressed motivational aspects. Nevertheless,
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29 development or competencies. Much of the research analyzed was repetitious in terms of aim,
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32 while paying little attention to resources themselves. Many publications were merely
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35 descriptive, without a critical or pedagogical outlook. They lacked focus on classroom
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38 methodology and the new practices that could be promoted by using digital teaching resources
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41 in Music Education. The number of innovative experiences focusing on intercultural social
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44 aspects and promoting active student engagement in musical creation was anecdotal; however,
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A decade of research on the incorporation of technology into primary school Music Education presents a very uneven landscape. As in other knowledge areas, the research showed that primary music education around the world is not alien to the incorporation of resources and DDM. However, although there have been some attempts to understand the impact of using these resources to improve teaching-learning processes, there is still a need to delve deeper into how technologies can contribute to music teaching in schools. We found hardly any research into technology contributions for dealing with student diversity, with the exception cultural diversity, where the use of certain Internet platforms in some schools makes it possible to experience music from a more intercultural perspective. The research reflected an understanding of technology in the field of music that is associated to therapeutic use for people with personal conditions requiring non- traditional school practices, particularly functional diversity. This leads to the conclusion that classroom practices and/or research itself have not yet taken full advantage of the potential of these resources and DDM as tools for enriching cooperative and participatory learning by all students. This wealth of possibilities is especially reflected by publications highlighting the success of pedagogical proposals involving musical creation by students of all ages.

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3 The use of technology has fostered access to knowledge and new ways of teaching and learning.
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6 Recent research in the field of music education has identified the use of apps, web, YouTube
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8 channels, and platforms like Spotify that allow teachers to carry out specific music programs in
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10 ordinary classrooms with all students. There has been a qualitative change in the type of
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12 technological resources and materials available in music classrooms. We have gone from only
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14 using music-centered resources to taking advantage of the vast potential provided by Internet
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16 and technological devices generally used in schools. 
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30 As for limitations, we can mention three. Firstly, there is the exclusion of other databases for
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32 the identification of articles. The reasoning for this was that the prestige of Scopus was
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34 considered to guarantee a representative sample of recent research. The second limitation is
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36 related to journal access policies, which in many cases restrict full reading of texts and,
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38 therefore, restrain research dissemination hinder citation compared to other areas such as
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40 Medicine. And finally, our broad approach provides an overview of recent developments in the
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42 field, but this perspective must still be complemented by micro studies focusing on much more
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44 specific issues such as the implications of music in attention to diversity.
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The limitations encountered in the process may be helpful for orienting future lines of research.

Prospectively, a need has been identified for further research on teacher competence in the creation of technological resources for Music Education, the evaluation of different types of material, publisher policies regarding the production of DDM and the potential of technology for inclusion or gender equality. These issues emerged from the lack of related publications.

Similarly, there was a lack of research on music as a leisure tool as well as studies on attention to diversity in terms of inclusive education.

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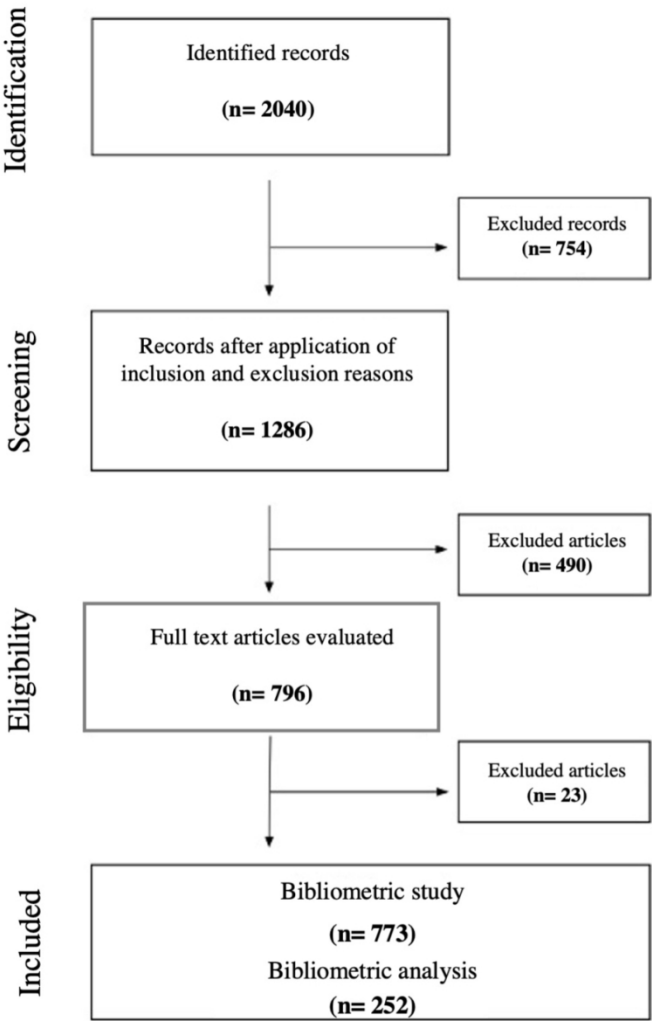
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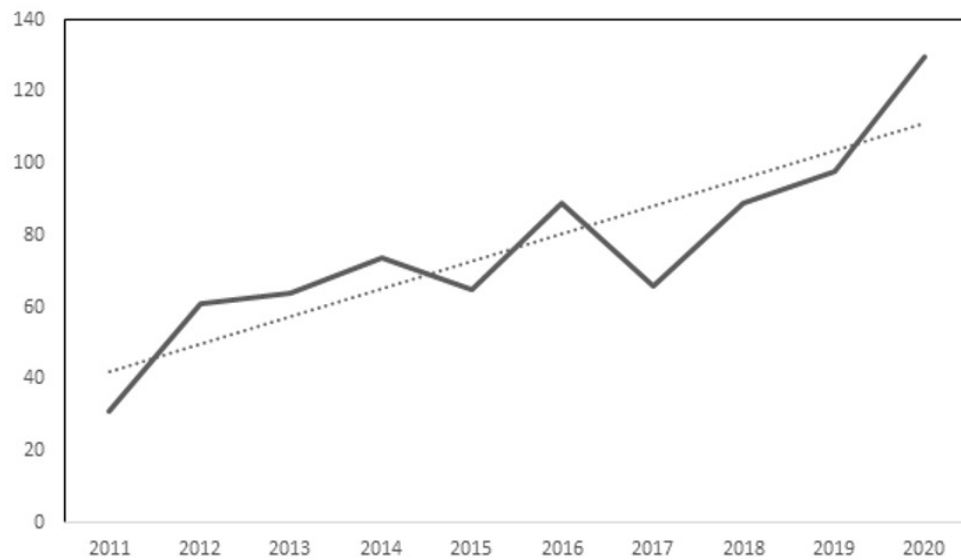
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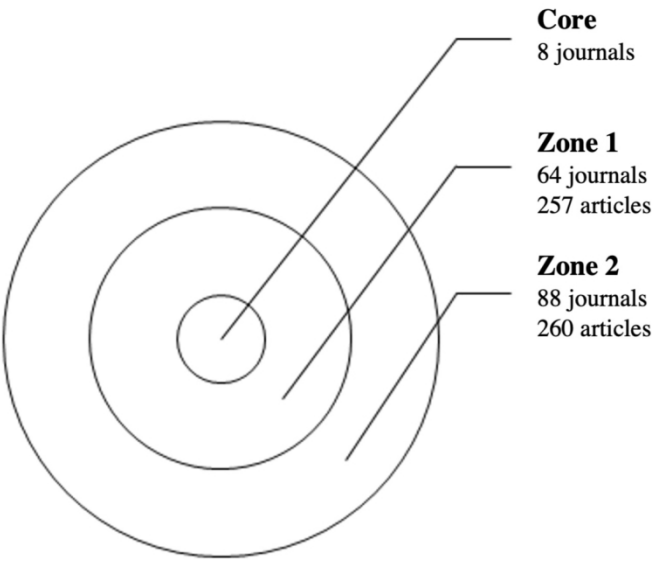
Flow chart showing the phases of the procedure. Source: own elaboration.

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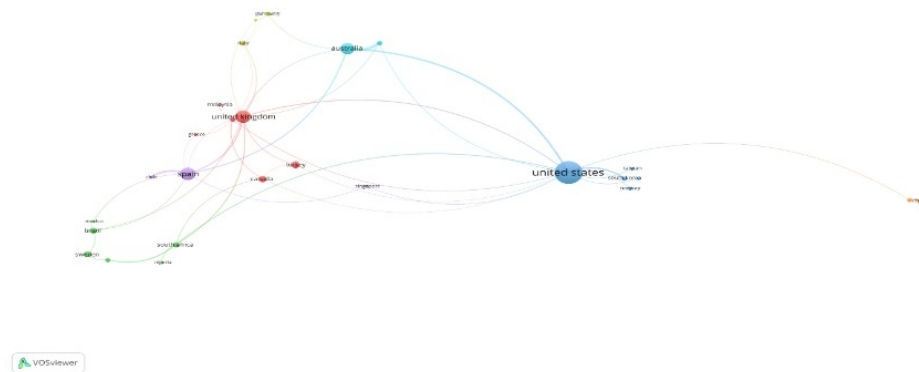
Evolution in quantity of publications over the last decade. Source: Own elaboration based on Scopus data.

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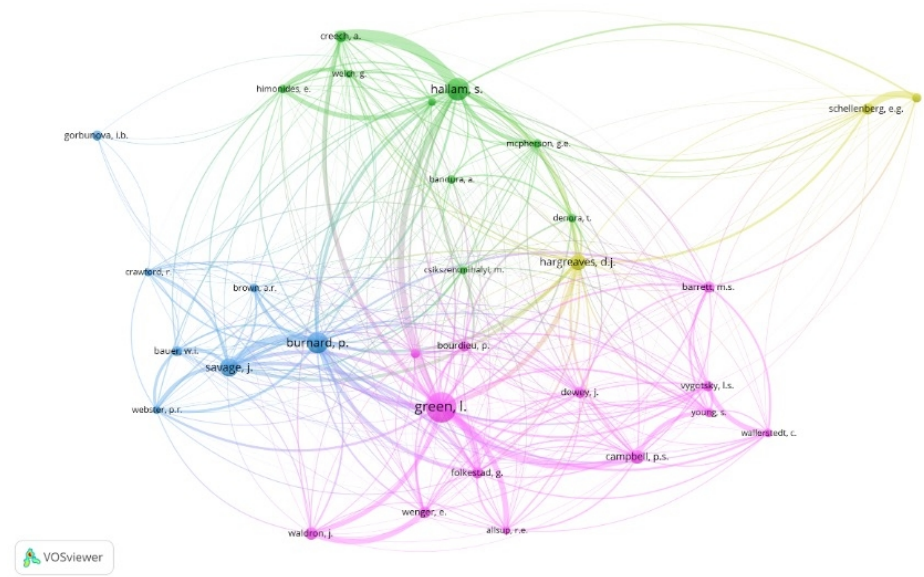
Areas according to Bradford's Law. Source: Own elaboration.

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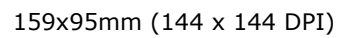
Collaboration among countries. Source: VosViewer

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Most cited authors. Source: VosViewer.

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Journal	SJR quartile 2020	no. articles	no. citations	Impact Factor
<i>Journal Of Music Technology And Education</i>	Music Q2 Education Q4	73	313	4.29
<i>International Journal Of Music Education</i>	Music Q1 Education Q2	49	283	5.77
<i>Music Education Research</i>	Music Q1 Education Q1	38	197	5.18
<i>Turkish Online Journal Of Educational Technology</i>	Education Q4	23	34	1.48
<i>Journal Of Research In Music Education</i>	Music Q1 Education Q1	21	208	9.9

Impact data by journal

157x138mm (144 x 144 DPI)

Identification Data	Title	Journal	Citations
Przybylski et al. (2013)	<i>Rhythmic auditory stimulation influences syntactic processing in children with developmental language disorders</i>	<i>Neuropsychology</i>	87
Cayari (2011)	<i>The YouTube effect: How YouTube has provided new ways to consume, create, and share music</i>	<i>International Journal of Education and the Arts</i>	83
Norgaard (2011)	<i>Descriptions of improvisational thinking by artist-level jazz musicians</i>	<i>Journal of Research in Music Education</i>	55
Waldron (2013)	<i>YouTube, fanvids, forums, vlogs and blogs: Informal music learning in a convergent on- and offline music community</i>	<i>International Journal of Music Education</i>	62
Wise, Greenwood & Davis (2011)	<i>Teachers' use of digital technology in secondary music education: Illustrations of changing classrooms</i>	<i>British Journal of Music Education</i>	58
Garvis & Pendergast (2011)	<i>An investigation of early childhood teacher self-efficacy beliefs in the teaching of arts education</i>	<i>International Journal of Education and the Arts</i>	55

Impact of articles

158x212mm (144 x 144 DPI)