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Research article

Using the Sonic Pi Application for Educational Purposes – A Literature Review

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Abstract

The Sonic Pi app has been available since 2013, the main purpose for which it was developed being to make teaching programming accessible to students as young as 10 years old. The present study traces the impact of the academic literature on the educational use of Sonic Pi during the first 10 years its availability, conducting a literature review based on the querying of 3 databases. During the search, there were identified 18 relevant, 4 theoretical and 14 research articles. It was found that the theoretical articles put forward a series of assumptions that come with the premise of improving the teaching-learning process, through an interdisciplinary openness of the didactic act, making contents accessible, offering a positive experience with a first programming language, as well as achieving funny activities and products. These aspects were correlated with the results of the research articles selected for analysis. The amount of work published on this topic, even if it is not large, remains unchanged in relation to the time variable and recommends the use of Sonic Pi in education as a suitable tool for working on creativity through a programming language, including young ages, because playing with codes and sounds respects a child's right: the right to play.

Keywords:
Sonic Pi; literature review; digital technologies; digital music; first programming language.

Zusammenfasung

Die Sonic Pi-App gibt es seit 2013. Der Hauptzweck, zu dem sie entwickelt wurde, bestand darin, Schülern bis 10 Jahren das Unterrichten von Programmieren zugänglich zu machen. Die vorliegende Studie untersucht die Auswirkungen der wissenschaftlichen Literatur auf den pädagogischen Einsatz von Sonic Pi während der ersten 10 Jahre der Anwendung und führt eine Literaturrecherche auf der Grundlage der Konsultation von drei Datenbanken durch. Im Anschluss an die Suche wurden 18 relevante, 4 theoretische und 14 Forschungsartikel identifiziert. Es wurde festgestellt, dass in den theoretischen Artikeln eine Reihe von Annahmen aufgestellt wurden, die mit der Prämisse einhergehen, den Lehr-Lern-Prozess durch eine interdisziplinäre Offenheit des didaktischen Akts zu verbessern, Inhalte zugänglich zu machen und eine positive Erfahrung mit einer ersten Programmiersprache zu bieten sowie das Erreichen unterhaltsamer Aktivitäten und Produkte, Aspekte, die mit den Ergebnissen der für die Analyse ausgewählten Forschungsartikel korrelierten. Die Menge der veröffentlichten Arbeiten zu diesem Thema, auch wenn es sich nicht um eine große handelt, bleibt im Verhältnis zur Zeitvariablen unverändert und empfiehlt den Einsatz von Sonic Pi im Bildungsbereich als geeignetes Werkzeug, um mithilfe einer Programmiersprache an Kreativität zu arbeiten, auch bei jungen Menschen Alter, denn das Spielen mit Codes und Geräuschen respektiert das Recht eines Kindes: das Recht zu spielen.

Schlüsselworte:
Sonic Pi; Literaturische Rezension; digitale Technologien; digitale Musik; erste Programmiersprache.

1. Introduction

The use of digital technologies has made the teaching-learning process able to approach the contents in more depth. If, in the past, students were told in school about the highest mountain peaks in the world, now digital technologies through virtual reality can lead the student from the base to the top of the mountain. The student can also visit, virtually, famous buildings, historical monuments or museums, and these are just a few examples of the fact that digital technologies have made knowledge more accessible. This means not only an easier assimilation of information, but also a better one, such as Wong et al. (2007) have shown through a study that, in general, the presentations of educational materials using modern media possibilities are superior to traditional presentations.

About the use of digital technologies in education, two aspects are recognized. The first one refers to socio-emotional skills, students' motivation being positively influenced using digital technologies (Ruiz-Banuls et al., 2021), as they like to learn through interaction with appropriate technologies (Webster, 2002). The second aspect concerns cognitive and practical skills, as it is recognized that as digital technologies are integrated into the education process, new opportunities are being offered for innovative teaching, creative learning, which should lead to improved student outcomes (Albulescu, 2021).

A proposal for increasing students' motivation and achieving learning in a creative way is the integrated approach of music with computer programming. An example of the development of such practices, involving music and programming in a formal learning framework, comes from the reforms brought to the Italian education system. With these reforms there are proposals put into practice, which combine "pedagogical advantages of coding and music education in primary school thanks to *music coding*, a new discipline that couples algorithmic thinking, technological tools, and computer interaction with musical experience, creativity, and social processes" (Ludovico & Mangione, 2015, p. 454). This is not only an example of creative activity, but also of creative pedagogy, which can allow students to switch their inspiration base from one of the fields of study in which music or programming is found, to the study of the other. Writing computer software to enable learning in various fields, including that of music, resonates with any projection of didactic act in which the processing of educational content through Computer Assisted Instruction (CAI) is considered. Such an approach transforms the concepts of the discipline into a concrete activity that can be applied and tested (Brown, 2007).

Nowadays, children can learn programming in various ways, which also allow them to value their creativity, and this can be triggered and supported with the help of music. Perhaps the most successful tool, designed as a teaching tool that allows simultaneous exploration of music and programming, is the Sonic Pi app, a project started in November 2013 (Aaron, 2016a). The purpose of this study is to review articles written on the Sonic Pi application to analyze its operationalization in an educational context, during the first 10 years of the software's existence. Before getting to the details of the literature review, a brief presentation of the application will be made.

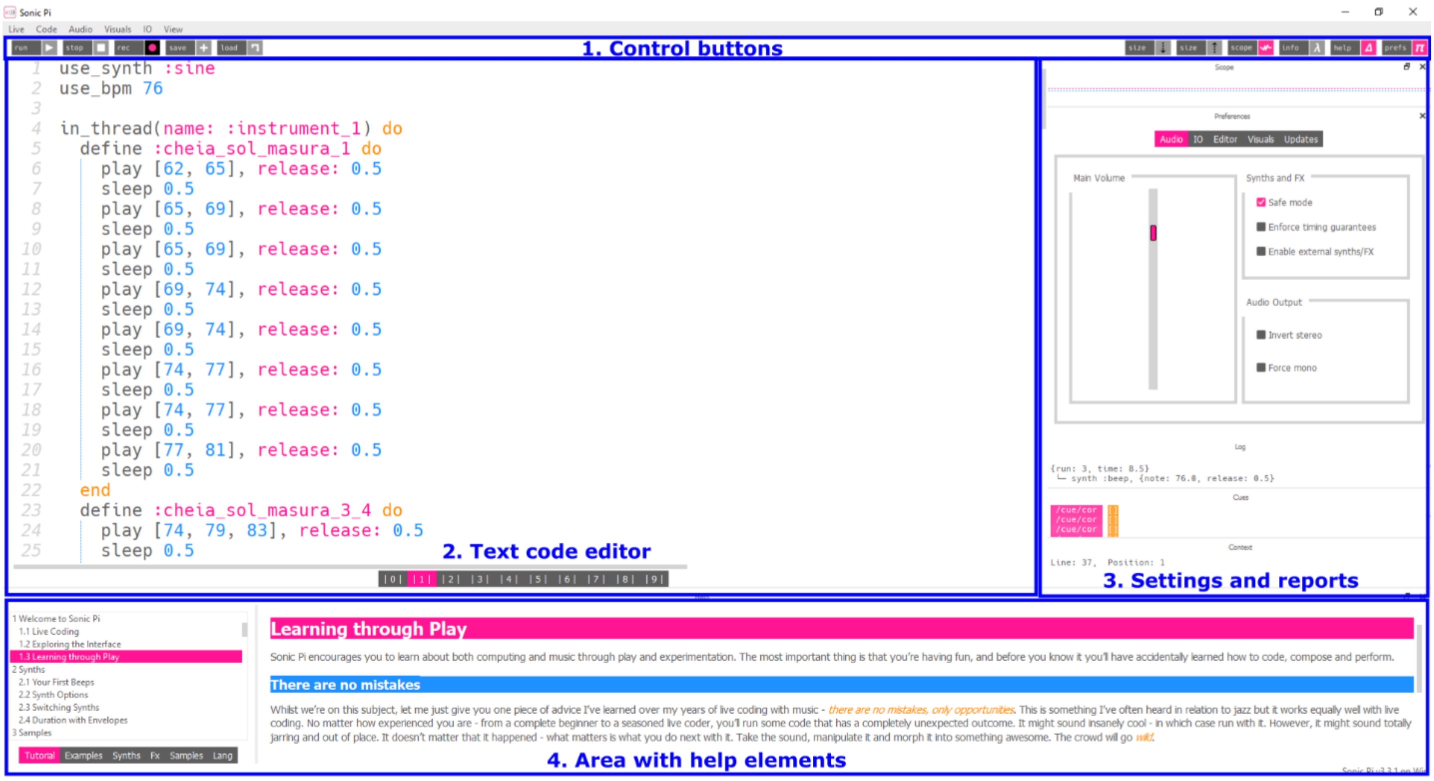
2. Soni Pi overview – background for literature review

Created in 2013 (Aaron et al., 2016), Sonic Pi was designed for educational purposes, to run on the Raspberry Pi computers which were released in 2012 (Aaron, 2016a) and also aimed for the education sector, small computers the size of a deck of playing cards that students could purchase at a low cost. The app is also available for Windows and macOS users and they can get it for free (Cass, 2019). The educational purpose is disclosed by the author of the application itself, who states that "the remit was to explore a new software system that might have the potential to engage schoolchildren in the UK's newly drafted Computing curriculum" (Aaron, 2016b, p. 172). The application comes from the academic environment, given the fact that "Samuel works as a Research Associate at University of Cambridge Computer Laboratory, where he has created Sonic Pi, a powerful live coding environment for real-time sound synthesis targeted for education" (Aaron et al., 2016, p. 93). In addition to teaching programming and music in school, Sonic Pi is also used to create live coding music for people to enjoy and dance in clubs. From an educational point of view, the apps used in education are relevant and valuable when they provide opportunities to create music which were previously unavailable to students (Brown, 2007), and Sonic Pi fits this belief very well as it makes music creation accessible through hands-on programming for kids. Since it can also be used in social contexts, the application has multiple uses, it is not limited to satisfying a single need, having the ability to offer, computationally thinking, creative experiences regarding the generation of digital music, both for children and adults (Aaron & Blackwell, 2013).

In detail, the Sonic Pi app's interface, shown in Figure 1, is extremely simple and easy to use, allowing simple text commands to be matched with immediate feedback that brings concrete sonic appearance (Traversaro et al., 2020).

For a brief but to-the-point description, the application interface has been divided into 4 work areas. The most used is zone 2 (text code editor), the zone where text instructions are written from the keyboard and which represents the input data in the music program that will be created. The completed program, which will generate a melodic fragment (output data), will reveal a cause-effect relationship, between input and output data, that can be tested immediately, by pressing the Run button in zone 1 (Control buttons). As the program can be tested immediately, the application providing immediate feedback through the sound effect determined by the written commands, Traversaro et al. (2020) have mentioned the direct connection between the written commands and the tangible, concrete, prompt response. The control buttons in zone 1 also offer other possibilities, to record or save the melodic fragment made or to open/ hide other windows intended for various configurations within the program. Such windows are located in zone 3 (settings and reports), but also in zone 4 (area with help elements), where the user can find a tutorial of the application, examples of functional codes of some songs, as well as other useful information.

Figure 1. Sonic Pi app user interface (version 3.3.1)



Sonic Pi is a teaching tool that emphasizes the role of creativity in learning because the application is a gateway to the heart of the principles of electronic music and also a great way to work on creativity, giving students the opportunity to think and translate instantly personal musicals ideas into finished products, the process being realized through play. This aspect is particularly important for the teaching-learning process, bearing in mind that performing music live, compared to recordings or listening to music, provides an enhanced experience with a better effect on learning (Váradi, 2018), because "creation processes involve cognitive change" (Koper, 2014, p. 13). At the same time, the benefits or utility of the application can be extended from the individual level to the institutional level, as "the Sonic Pi project addresses ways in which schools can be innovative spaces for nurturing new collaborative learning digital communities through digital making" (Burnard et al., 2016, p. 346). Sonic Pi, providing the possibility of digital music creation, responds to Webster's model of creative thinking in music (Hickey & Webster, 2001), in the sense that it covers this whole complex process, from the beginning of an idea to the formulation of a solution and the realization of the creative product. Thus, a complex process is developed that does not exclude any of the dimensions: conceptual (computational thinking), procedural (programming language) and applicative (the application and the performer, the computer, the musical field).

3. Research methodology

This paper falls under the category of literature reviews. In general, literature reviews deal with the breakdown of literature written in a certain field, with the aim of summarizing the state of knowledge in that field (Rowley & Slack, 2004). In particular style, the paper is a literature review made around the Sonic Pi application. The literature review was carried out in stages, which will be described in the following.

3.1. Research questions

The research questions, to which the genesis of this study is related to, are:

Q1. How much research has been done, on the use of Sonic Pi in education, during the first 10 years of the app's existence?

Q2. Which are the forms of education in which the Sonic Pi application has been mainly tested?

Q3. Are the results of the research articles in which the Sonic Pi application was used, correlated with the educational assumptions made by the theoretical articles?

Regarding the first research question (Q1) it was mentioned that the Sonic Pi application was developed in 2013 (Aaron et al., 2016), aimed for education and for conducting lessons in school (Aaron, 2016b). The application being made with such a purpose, in the first instance, of interest was the extent to which the application was tested in an educational context.

Regarding the second research question (Q2), it was emphasized that Sonic Pi could play an important role in developing new pedagogical practices and improving learning in various educational contexts (Burnard et al., 2017). For this reason, the next aspect of interest was the accounting of the forms of education for which these assumptions were verified.

Regarding the last research question (Q3), in contrast to question Q1 where a quantitative evaluation of the testing of the Sonic Pi application in an educational context was pursued, now qualitative aspects were pursued, the interest being focused on the results of the testing in terms of knowledge, skills or attitudes formed in the research subjects.

3.2. Data collection

The search and data collection process was manual, checking three databases. As we aimed to conduct a review that considered important academic literature, articles were screened in the Web of Science databases (Clarivate, n.d.) and Mendeley which provide high-quality literature and data indexed in Scopus (Elsevier, n.d.). In order to expand the search spectrum, articles were also searched in Google Scholar, which, even though it does not offer full peer-reviewed articles, has become an extremely useful source of documentation, allowing access to a range of journals that would otherwise not be possible to consult even through institutional libraries and databases (Denney & Tewksbury, 2013).

Therefore, multiple databases were consulted, and the data extracted from the analyzed papers included a series of information, among which we mention: the authors of the papers, the year of publication, the title of the paper, the type of the paper (if it is a research article or a theoretical one), the number of research subjects, their age, the framework of the research as well as the results obtained.

3.3. Article filtering criteria

Certain criteria were applied to include relevant articles and exclude those that do not fit the scope of the paper, which will be listed below.

In terms of article inclusion, even theoretical articles were counted as they generally advance a number of premises and looked for a relationship between what is assumed by using the Sonic Pi application (theoretical articles) and the results of its use (research articles). In identifying relevant articles from journals or conference proceedings, a search criterium was that the terms Sonic and Pi were joined in the title, abstract or keywords.

Regarding the exclusion of articles, papers in other fields than Educational Sciences will not be considered, papers other than those written in English will not be considered, and also papers in which the Sonic Pi application is provided as an example being only mentioned tangentially in papers in computer education, music education, or educational sciences.

3.4. Data analysis

The data collected and mentioned above were arranged in tabular form to highlight, in the first stage, that the articles selected for the review correspond to the inclusion and exclusion criteria described above and that they represent relevant studies for the purpose of the present study. Later, the data centralized in the tables will be reflected in a section dedicated to a more thorough discussion of the issue of interest in this case.

4. Results

As a result of searching on the topic “Sonic Pi”, Web of Science returned 7 results, Mendeley 32 results, and Google Scholar 930. After a first filter in which articles written in other fields, such as environmental science and engineering were removed, noting the use of the term Sonic Pi in the respective field. Also, were removed articles dedicated to the software application but written in various languages (German, Spanish, Korean, Russian) or articles dealing with related digital technologies such as Raspberry Pi or TunePad and tangentially mentioning the Sonic Pi application. This filtering resulted in 26 viable articles.

After reading all the 26 articles in full, another 8 articles were eliminated because they did not correspond to the purpose of the paper in that they were articles aimed for a professional context of using the application, given the fact that a second objective stated in the design of the application was to support artists in the actions of offering moments of live musical performance (Aaron, 2016b). This was the case for the articles that have dealt with topics related to live coding (Blackwell & Aaron, 2019; Blackwell et al., 2014; Brown, 2016; Heyen et al., 2022) or software development (Blackwell & Aaron, 2015; Du Bois & Ribeiro, 2019). The use of the Sonic Pi application in bioinformatics was also identified, by representing information in another format and transposing it from visual language to auditory language, in cases such as protein sequence (Martin et al., 2021) or DNA sequence (Plaisier et al., 2021). These papers were not included in the final analysis, as they did not correspond to the purpose of the literature review. After the second stage of article filtering, 18 papers remained, which are presented in Table 1:

Table 1. Literature review articles over the use of the Sonic Pi application for educational purposes

No.	Batabase	Author	Date	Article type
1	WoS, Mendeley, GS	Aaron	2016a	Theoretical article
2	Mendeley, GS	Aaron	2016b	Theoretical article
3	Mendeley, GS	Aaron and Blackwell	2013	Research article
4	Mendeley, GS	Aaron et al.	2014	Theoretical article
5	Mendeley, GS	Aaron et al.	2016	Research article
6	GS	Bănuț et al.	2023	Research article
7	GS	Burnard et al.	2016	Research article
8	GS	Burnard et al.	2017	Research article
9	GS	Cass	2019	Theoretical article
10	GS	Cheng	2018	Research article
11	Mendeley, GS	Dimitri	2015	Research article
12	GS	Köppe	2020	Research article
13	Mendeley, GS	Lusa Krug et al.	2021	Research article
14	WoS, Mendeley, GS	Petrie	2022a	Research article
15	WoS, Mendeley, GS	Petrie	2022b	Research article
16	Mendeley, GS	Sinclair	2014	Research article
17	GS	Thieme et al.	2017	Research article
18	Mendeley, GS	Traversaro et al.	2020	Research article

Note. WoS – Web of Science; GS – Google Scholar

Therefore, following the search process and the analysis of the search results, 18 unique results were identified, 4 being theoretical articles and 14 research articles, the frequency of publication by year being presented in Table 2, for a subsequent correlation of these data with the question of research Q1.

Table 2. Articles included in the literature review by publication date

Type	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
TA	-	1	-	2	-	-	1	-	-	-	-	4
RA	1	1	1	2	2	1	-	2	1	2	1	14

Note. TA – Number of Theoretical Articles; RA – Number of Research Articles

In order to be able to answer the other two questions formulated (Q2 & Q3), the data of the research articles were split in Table 3, going into the details of the research design, with their objectives and results.

Table 3. Data from articles research design included in the literature review

No.	Author	Date	Number of participants	Age of participants	Forms of education	Tracked aspects
1	Aaron and Blackwell	2013	2 classes	11-12	formal	programming competence
2	Aaron et al.	2016	1 teacher	-	formal	teaching-learning process
3	Bănuț et al.	2023	25	10-11	formal	creative expression skills
4	Burnard et al.	2016	6 teachers 44 students	13-14	formal &	interdisciplinary activities & attitudes that express enjoyment
			60 children		informal	
5	Burnard et al.	2017	54 students	12-14	formal &	teaching-learning process
			60 children	10-16	informal	
6	Cheng	2018	39	+19	formal	pedagogical context, motivational effect & effective learning
7	Dimitri	2015	10	+18	formal	problem solving: debugging
			1	13		
8	Köppe	2020	85	12-15	informal	experiences & motivating context
			90	15-17		
9	Lusa Krug et al.	2021	45	10-12	informal	engagement and attitude towards informatics
10	Petrie	2022a	22	11-12	formal	knowledge in programming
11	Petrie	2022b	22	11-12	formal	attitude towards programming
12	Sinclair	2014	12	+18	formal	programming concepts retention
13	Thieme et al.	2017	10	8-12	informal	programming skills at visual impairment children
14	Traversaro et al.	2020	131	+18	formal	engagement and competences in programming

Therefore, through the articles resulting from some research in which the Sonic Pi application was used, a series of essential aspects in the teaching-learning process were targeted, which will be reflected in the following discussions.

5. Discussions

The present section is addressed to some preliminary findings made after the data collection process, along with the inventory of some assumptions brought by the few theoretical articles included in the study, as well as the discussion of the answers to each of the research questions.

First, starting from the statement about the way the Sonic Pi application was designed, which had in mind the expansion of the possibilities of teaching computer science in schools, but also the opening of new possibilities of making live musical performances (Aaron, 2016b), has been found that the application was used for the purposes for which it was developed (Du Bois & Ribeiro, 2020), but also for purposes that exceed the imagination of the design and that were not foreseen or taken into account. This category includes the use of Sonic Pi in the field of bioinformatics sonification (Martin et al., 2021; Plaisier et al., 2021), but also in making the teaching of programming accessible to visually impaired students (Thieme et al., 2017), and these aspects confirm the fact that the product is an important and versatile one, with utility in several fields.

While articles dealing with the use of Sonic Pi in bioinformatics were not included in this literature review because the application was not used in an educational context and this is not consistent with the purpose of the paper, the use of the application to introduce visually impaired students to programming is of interest for the desired analysis. Even though the app was only a connected tool with which the students did not interact physically, but only auditory, as it was used in learning contexts where working with visually impaired students, this audio component of the Sonic Pi app proved to be a useful one in inclusive programming learning contexts for visually impaired students. To create musical programs, they connected physical elements of various sizes, called "instruction beads", and the way these elements are interconnected generates sounds digitally (sound timbre, pitch) in the Sonic Pi language (Thieme et al., 2017).

5.1. Assumptions of theoretical articles

The theoretical articles highlight the fact that the Sonic Pi application was designed for educational purposes to give students a positive experience with a first programming language (Aaron et al., 2014), being a simple enough tool for teachers who teach programming in schools and which, by integrating audio feedback, manages to facilitate students' learning and understanding of concepts (Aaron, 2016a). Also, the app has a friendly front-end (Cass, 2019), and all these features are essential in the teaching-learning process, because they translate into accessibility, being known that not only many pupils, but also college students fail to learn programming (Bosse & Gerosa, 2017; Piteira & Costa, 2013; Robins, 2015).

In the development of the application, it was started from the premise that its use for educational purposes frames learning with the contemporary daily experience of students, in the digital age, and education could benefit from interdisciplinary learning. Integrating music with programming and being used in the teaching process, Sonic Pi determines learning situations designed to produce performance in everyday life, because Sonic Pi stands for performance in education, technology and art (Aaron, 2016b).

Given the fact that the paper deals with the use of an application for educational purposes, an essential element for capturing attention in the classroom is that the teaching is done in a way that is enjoyable for the students, maybe even funny at times, and the products of the activities in which the Sonic Pi application is used would be fun (Cass, 2019).

5.2. How much research has been done, on the use of Sonic Pi in education, during the first 10 years of the app's existence?

In the search process and in the documentation sources consulted, 18 papers relevant to the purpose of the proposed literature review were identified: 14 of them were research articles and 4 were theoretical articles. This accounting emerges from Table 2, where the distribution of articles by year was also made, the average of publications being a constant one throughout this period. So, the amount of published papers, even if is not a large one, remains unchanged in relation to the time variable. Of the total of 18 works inventoried, 12 have a distinct primary author, which is a good diversity given that only the author of the application, Sam Aaron (Cass, 2019) has more than two papers selected, according to Table 1. Overall, academic publication on the use of Sonic Pi in education is a constant one, and it seems that publishing and indexing of academic literature with this topic is encouraged.

5.3. Which are the forms of education in which the Sonic Pi application has been mainly tested?

It was stated that Sonic Pi could facilitate modern and forward-looking teaching approaches, new pedagogies, for better learning outcomes in different contexts: formal as well as informal, for example summer camps (Burnard et al., 2017). In this sense, the interest was on which of the forms of education the use of the application was researched for, and only this aspect, the research results being of interest for research question Q3. Table 3 shows that, out of the 14 research articles, 9 had the research action carried out in formal learning contexts, 3 informal and two monitored the development of skills, intellectual faculties or some socio-emotional aspects in both contexts. This distribution covers sufficiently both forms of education to see, through the next question (Q3), whether the results of the research processes are congruent, regardless of the learning context.

5.4. Are the results of the research articles in which the Sonic Pi application was used, correlated with the educational assumptions made by the theoretical articles?

As regards the objectives pursued by the analyzed researches, Table 3 summarizes and presents the following aspects:

- 6 articles focused on programming skills and knowledge developed through the use of the Sonic Pi application;
- 4 articles considered the pedagogical contexts of introducing the Sonic Pi application in activities with students;
- 4 articles considered socio-emotional aspects of subjects' interaction with the Sonic Pi app.

Regarding the knowledge and skills measured by the 6 studies, they were correlated with the duration of the activities they took part in and the age of the participants. Regarding the duration of the activities, they took place in the form of tutorials or learning modules and did not have similar durations, each researcher having his own program, some shorter, 5 x 1 hour lessons (Aaron & Blackwell, 2013) or others of longer duration, 24 x 1 hour lessons (Bănuț et al., 2023). Being known been that activities must last long enough to actually have an impact over the outcome (Creswell, 2008), remarkably, the acquisition of programming skills has been reported for relatively short courses (Aaron & Blackwell, 2013), as well as in the other cases with different research durations (Petire 2022a; Sinclair, 2014; Traversaro et al., 2020). These findings resonate with the assumption drawn from the theoretical articles, which rely on audio feedback as a facilitator of student understanding of programming concepts (Aaron, 2016a).

Compared to the average age of the participants, in 6 of the 14 studies analyzed (according to Table 3), it has been worked with students with an average age of 10-12 years. In all these cases, there were obvious skills developed following the work sessions with the Sonic Pi application (Aaron & Blackwell, 2013; Bănuț et al., 2013; Petrie, 2022b), even when working with visually impaired students (Thieme et al., 2017), which confirms the assumption that the Sonic Pi application was designed as a tool for students' successful approach of a first programming language (Aaron et al., 2014). This aspect is reinforced by the interesting case in which the researchers worked with a group of students from the 1st year of college, but also with a 13 years old student, the performances reported at the end of the training period being similar for the two age categories (Dimitri, 2015).

In some of the studies, the research subjects included teachers (Aaron et al., 2016; Burnard et al., 2016), who were surveyed to collect a series of reflections about the teaching-learning process. In these cases, as well as in other cases where pedagogical aspects were pursued (Burnard et al., 2017; Cheng, 2018), the Sonic Pi app was found to offer new learning routes, which resonates with the premise that education could benefit from interdisciplinary learning (Aaron, 2016b), especially since music can be a motivational factor (Blackwell & Aaron, 2015).

The motivational power of music, not just in a general way, is confirmed by the experiences, engagement and attitude towards the programming activities shown by the students who used the Sonic Pi application to produce melodic-rhythmic fragments (Köppe, 2020; Lusa Krug et al., 2021; Petrie, 2022b; Traversaro et al., 2020). They confirm the premise that the products of students' activity using the app would be fun (Cass, 2019), because Sonic Pi, in the hands of students, becomes a musical toy. From the didactic perspective of the music education approach at a young age, the school curriculum of the subject *Music and movement* (MEN, 2014) highlights the use of musical toys in a variety of forms as an essential requirement in the study of music, the studies in this literature review showing that the Sonic Pi can convincingly be a valid tool for use in music classes and beyond.

To answer the research question, yes, the theoretical articles make several assumptions, and these are correlated with the results of the research articles, in all education forms and cases analyzed.

6. Conclusions

The Sonic Pi digital tool was created for the formal educational environment, in the first instance, in the perspective of teaching in schools, the main objective being to obtain an application that simplifies the transmission of programming concepts so much that it can be used by students from the age of 10 years (Aaron, 2016a; Blackwell & Aaron, 2015). The age barrier falls so much because Sonic Pi ensures a child's right, the right to play, the digital tool being engaging and fun, so that students can play and learn implicitly through this play.

Thus, students can express their creativity both through music and programming, creating a context through which computer science education can make musical education great again for the mainstream educational system. In this context, students are given the opportunity to create interesting artefacts, such as digital audio materials, and this aspect is particularly important because students will not be educated in music without feeling the joy of creating (Váradi, 2018). There is another way of music creation that is relevant to the digital age, and that is digitally obtained music, and the Sonic Pi does a great job of it. This type of creative experience can be an outcome of a formal learning context, as the application can cover a wide range of activities and content. Students can explore various content areas such as: (a) vocal singing, obtaining the sound lines of songs from children's folklore, on which to perform a vocal performance, (b) instrumental singing, the application being able to reproduce a variety of musical timbres, (c) elements of music language, musical notation being able to be translated and written in another symbolistic, that of codes or (d) movement on music, these being able to take place simultaneously, a general idea that reflects the concept of eurythmy.

Creatively using digital technologies, along with computer programming, are distinct skills within digital competence (Vuorikari et al., 2022), and if these capabilities are well formed, they will be the engine of future innovative processes and products. On the other hand, stimulating creativity will lead to opportunities and implications in the development of other key competences, not just digital competence. Knowing the possibilities of creative use of digital technologies increases the possibilities of development, and if students do not know such possibilities, the training of future adults will not have a significant impact on the economy, because digital technologies set the tone for changes in society and, at the same time, require new skills for future generations.

Sonic Pi is an appropriate tool to work on creativity and provide a positive first experience for students with a programming language, and the aspects mentioned in the conclusions emphasize the usefulness of the application, even under the limits of this literature review, to be conducted by a single author, the data being interpreted and discussed from a single perspective. The results of the studies selected for evaluation are encouraging, and new directions for both research and teaching can be advanced. In terms of teaching, there is an intention to use the app at university level, for the training of future teaching staff, as creativity should be a component of CAI, and Sonic Pi does well in this regard. In terms of research, there is an intention to use the Sonic Pi app for another context which it might be proper for, using it in a gamified setting. It is known that Sonic Pi was designed to be a motivational factor in learning, an effect that gamification also aims at, which is why it is interesting to know if used simultaneously in the act of teaching they can represent a motivational booster, and the framework of teaching would be a song contest, with the stake: "The prize for the most creative student in the school".

Authors note:

Marius Bănuț is an engineer and a PhD. in Educational Sciences with research interest in looking for relationships between the domain-specific knowledge and digital technologies that can be capitalized and correlated with the particularities of the young students, through digital education and interdisciplinary openings. These interests aim for a didactic act capable of producing contextualized learning and the development of digital competence, useful in: current student activity (efficiency and motivation), transition to higher levels of schooling, participation in active citizenship and the economy of the future, and a life-long love for technology and knowledge.

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