BABEȘ-BOLYAI UNIVERSITY

FACULTY OF PYCHOLOGY AND EDUCATIONAL SCIENES

"EDUCATION, REFLECTION, DEVELOPMENT" DOCTORAL SCHOOL

ABSTRACT - DOCTORAL THESIS

The Use of Digital Technologies for Improving the Teaching-Learning Process in Primary Education. Applications on the Object *Music and Movement* (4th grade)

Scientific coordinator,

Professor, Ph.D., Ion ALBULESCU

Doctoral student,

Ioan-Marius BĂNUȚ

Cluj-Napoca

2020-2023

Keywords: musical education; digital education; sonic pi; creative thinking; computational thinking; transdisciplinary approach; scaffolding; gamification; didactic transposition

TABLE OF CONTENTS

PART I

THEORETICAL FOUNDATION

PART II

EXPERIMENTAL RESEARCH: THE DEVELOPMENT OF THE OBJECT *MUSIC AND MOVEMENT* SPECIFIC COMPETENCES THROUGH THE INTERVENTION PROGRAM *MUSIC AND PROGRAMMING IN SCHOOL CONTEXT - LITTLE AMATEUR MUSICIANS, GREAT DIGITAL ARTISTS*

PART I

THEORETICAL FOUNDATION

CHAPTER I
INTEGRATION OF MUSIC EDUCATION WITH DIGITAL EDUCATION IN PRIMARY SCHOOL TEACHING-LEARNING PROCESS

I.1. Music Education in Primary School. The Object *Music and Movement* in the School Curriculum

Music is that way of creating and receiving beauty, through which the human being feels the aesthetic emotion. Music and aesthetic education are united by a bow beyond time, because, in all cultures and times "music was clearly held sacred, providing man with a sense of beauty and perfection that could be aspired to" (Auerbach & Delport, 2018, p. 2). The object *Music and Movement*, in primary education, focuses its activity on achieving such a goal, the specifics of music education being to contribute to the achievement of aesthetic education (MEN, 2014a; Simion, 2020), to promote among students cultural values, to bring a good mood, the reasons in favor of the achievement of musical education among young school children are that the discipline encourages the manifestation of talent and sets the students' imagination in motion.

In a study that included 805 young schoolchildren from four European countries: Hungary, Romania, Serbia and Slovakia, it is shown that "singing is the main activity which children encounter in primary music education" (Váradi, 2018, p. 72) , feeling the need to shift the emphasis from vocal performance to musical improvisation (Alekseeva & Usacheva, 2018), to encourage students to apply knowledge in the field of music in the most creative ways. For example, "the creation of simple melodic-rhythmic fragments, using computer programs" (MEN, 2014a), an activity suggested by the school curriculum, favors the development of students' creative thinking skills, "giving young musicians the opportunity to create and practice their own songs ” (CRED Project, 2019b, p. 17), students of this age being expected to know how to obtain creative compositions (Hickey & Webster, 2001).

The integrated approach is the methodological suggestion adopted for making connections between music and programming and shaping learning situations that offer students opportunities for creative expression. It was pursued throughout this chapter to collect of those useful indicators in the development of an educational project in order to achieve the best possible correlation between the design of the learning tasks and the current educational and curricular demands.

I.2. Digital Education in Primary Education

In an integrated music-programming approach, didactic efficiency translates into educational purposes subsumed by both music education and digital education. Educational policies expressed through the *Strategy Regarding the Digitalization of Education in Romania* (MEC, 2020) and through the *Digital Education Action Plan 2021-2027. Resetting Education and Training for the Digital Age* (European Commission, 2020), recommend intensifying the development of digital competence, emphasizing the importance of introducing Informatics at an early age to students. Most of the European Union states have identified and implemented the teaching of digital competence at the primary education level, with the exception of Romania, as shown in the *Digital Education at School in Europe* Report (European Commission, 2019).

This chapter advances the premise of covering this gap identified in the National School Curriculum, through an integrated music-programming approach, and also presents how the curriculum reform was carried out in England, where the importance of Computer Science was upheld, as a school subject that every child it is recommended that they learn it at least at the elementary level (Jones et al., 2013). Thus, in 2012, the UK Department for Education undertook to develop the new school curriculum, which would transform the old ICT object into *Computing*, which it submitted to public debate in 2013, revising it in 2014 based on the feedback received, and since 2015 it has been applied at the national level, starting with primary education (Brown et al., 2014).

I.3. Media Expansion, Opportunity to Achieve Music Education in a Digital Context

Digital technologies, a must-have for young people nowadays, integrate audio elements determining the user experience, which is why it is necessary to consider the impact of sound from educational software, films, games or other applications, as well as the creation of digital audio materials for such contexts.

In a study looking at the influence of auditory stimuli in a violent video game (Tafalla, 2007), where even though the game was rated as more violent with the soundtrack, men did not appear to be bothered by this, their performances being twice as good, on the other hand, for female subjects, the resulting conditions represented a stress factor. In another study involving car racing simulation video games, subjects who drove with the sound effects on have moved faster, but also made the most mistakes, such as running off the track or hitting traffic cones (Cassidy & MacDonald, 2009). It is obvious that sound effects integrated in digital technologies can improve or reduce performance in the activities carried out, which is why the importance of music education in a digital context should be reiterated.

I.4. Integrated Teaching in Primary School. Ways to Integrate Digital Education Elements into the Study of the *Music and Movement*

Integrated teaching is a characteristic element in curriculum design at the level of primary education, being an essential action benchmark in the *National Curriculum Reference Framework*, which aims at developing key competences through a Curriculum capable of creating interdisciplinary bridges (Fartușnic et al., 2020).

From the set of key competences, Digital competence is at the core of the conceptualization of the *Digital Competence Framework for Citizens* (DigComp), which starts from the ideea that being digitally competent is a task for the 21st century and specifies with examples the types of digital content, among which it also lists digital audio material (Vuorikari et al., 2016). The improvisation of some songs using the computer is part of the characteristics derived from the digital competence, similarities between the two competences being presented in Table I.1, especially since no one associates music with a musical score nowadays (Devlin, 2014), and "mastery of *Western music notation* and mastery of an instrument can now be replaced by mastery of composing software" (Laato et al., 2019, p. 3).

Specific competence	Key Competence: Digital Competence
3.3. – Song improvisation, associated with body movements (MEN, 2014a)	- creating digital content, including through computer programming (Sarivan et al., 2020), similar to concrete life situations; - understanding the possibilities of supporting creativity, communication, collaboration, innovation and the ability to use digital technologies for all these purposes (Sarivan et al., 2020).

Table I.1. Descriptors for the correlation relationship of the specific competence *Song improvisation, associated with body movements*, of the object *Music and Movement*, with the *Digital competence*

The research aims at identifying ways in which digital technologies can best contribute to the achievement of educational objectives, narrowly referring to the object *Music and Movement* object and more broadly to the teaching-learning process and key competences.

I.5. Creative Approaches to Teaching and Learning Music and Computer Science in Primary School. Sonic Pi Application

From the didactic perspective of approach the object *Music and Movement*, the school curriculum highlights the need for the mandatory use of musical toys in the most varied forms, to stimulate creativity and flexible thinking in students (MEN, 2014a). Creative thinking is a test of imagination that triggers the ideas that are the basis of the new products creation (Kampylis & Berki, 2014; Simion, 2020), and when it is nurtured with the help of digital technologies, in a musical improvisation activity, the process becomes a digital cognitive training.

Such digital cognitive training, involving precisely music and programming, can be found in the reforms brought to the Italian education system, where there are proposals put into practice in primary school, which capitalize the pedagogical advantages of such integration through a discipline called *Music Coding* (Ludovico & Mangione, 2015, p. 454). Such an approach is extremely valuable, all the more so as it is stated about students that "if children do not know the joy of creating [...] then they will not be educated into music" (Váradi, 2018, p. 67).

Perhaps the most successful tool, designed as a teaching tool that allows simultaneous exploration of music and programming, is the free Sonic Pi application created by Sam Aaron (Cass, 2019) originally for Raspberry Pi, later also available for Windows or macOS. Sonic Pi was designed for educational purposes, highlighted by the author of the application, a research associate in the computer labs at the University of Cambridge (Aaron et al., 2016), who aimed to "engage schoolchildren in the UK’s newly drafted Computing curriculum" (Aaron, 2016, p. 172). The interface of the Sonic Pi application, shown in Figure I.1., "is simple and clear, allowing the user to interact with it using only simple commands, directly linked to a tangible response" (Traversaro et al., 2020, p. 144):

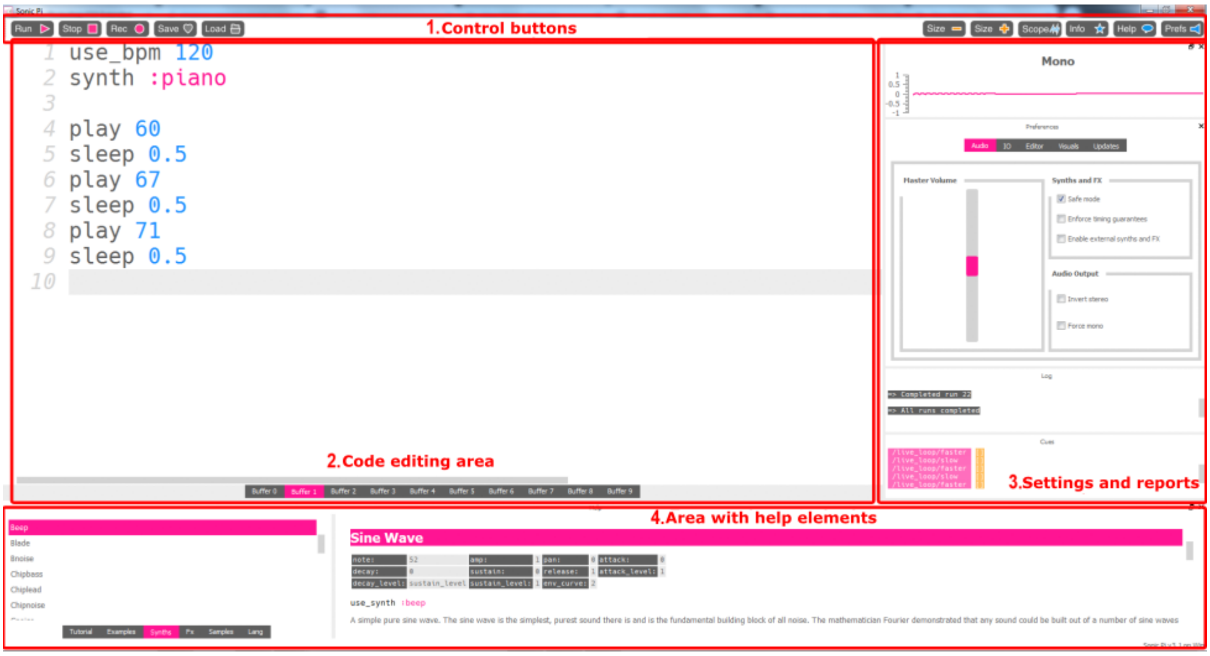


Figure I.1. Sonic Pi application interface (version 3.1.0)

The application described is a teaching tool that emphasizes the role of creativity in learning because "Sonic Pi allows access to the heart of the principles of electronic music and is also an excellent way to work on creativity" (Agostini, 2020, p. 8), and these aspects are particularly important because "creation processes involve cognitive change" (Koper, 2014, p. 13).

CHAPTER II
DIGITAL EDUCATION, ZONE OF PROXIMAL DEVELOPMENT IN PRIMARY SCHOOL

II.1. Computational Thinking

Computational thinking has received increased attention in recent years, which Wing (2008) stated that it would be an integral part of children's education, meanwhile becoming a desirable learning outcome in primary education in Cyprus as a result of curriculum reform (European Commission, 2019), as well as in New Zealand, where it became compulsory for all the students from 2020 (Petrie, 2021).

In a narrow sense, computational thinking represents the use of cognitive skills to face a problem with the help of a computer, directly aiming at computer programming (Angeli, 2020), and in a broader sense, computational thinking refers to those processes dedicated to solving problems (Bogliolo, 2020), based on a multitude of characteristics, including: information analysis, making connections between information, identifying patterns, logical ordering, creating algorithms for solving specific problems or abstraction. Students who develop such characteristics in thinking will discover interdisciplinary bridges between the subjects studied at school with perspectives to identify the applicability of learning acquisitions in everyday life (ECDL Romania - Bebras, 2022).

II.1.1. The Premises of Solving Problems Formulated Through Coding Activities

The computer is proving its usefulness for a wide range of problems, but "computer science is not primarily about computers. The famous aphorism *Computer science is not more about computers than astronomy is about telescopes*, widely attributed to Dijkstra, slightly overstates the case, but it has the right idea" (Jones et al., 2013, p. 4), as evidence that computer science and programming can be learned without a computer.

One such example is coding, which is a playful activity based on the intuitive use of basic principles in computer programming (Bogliolo, 2020) and implemented in an interdisciplinary manner through tools available in the classroom. This type of activities have reached the classrooms in Europe, targeting primary education, for example: Estonia (Pisoň, 2020), Portugal (Balanskat & Engelhardt, 2015) or Italy (Ludovico & Mangione, 2015).

II.1.2. Unplugged Activities

Coding provides an accessible entry point to computer science for all students. Coding activities which do not use any electronic device, are part of the unplugged activities category of studying computer science. In this sense, the introduction of non-computerized coding tools, such as card games or stage games, significantly improve the accessibility of essential features in computer program development, for example algorithm design (Klopfenstein et al., 2019).

A popular example of learning computer science without a computer, training computational thinking through games, playing cards or moving on predetermined routes, is provided by New Zealand, which promotes a web platform (https://csunplugged.org) available for all forms of education: formal, non-formal and informal. Studies such as those of Javier del Olmo-Munoz and collaborators (2020) or Busuttil and Formosa (2020) show that Unplugged activities are a pedagogical practice that favors the development of computational thinking. This acquisition of learning makes accessible the transfer from non-computer activities to text-based programming, which can then be capitalized, in an interdisciplinary manner, as an operationalized acquisition in digital music composition.

II.2. Content of Programming Languages Adapted to the Age of the Students

Education and digitalisation stand out as natural development priorities and are being associated in digital education. This is valuable in an information society because it corresponds to the present, European strategic vision including two priority areas: the development of a digital education ecosystem and the development of digital skills (European Commission, 2020). The literature shows that 10-12 year old students are particularly ready to develop their digital competence (Duncan et al., 2014), which includes computer programming (Vuorikari et al., 2016).

II.2.1. The Language of Objects in the Context of Ubiquitous Digitization

Languages help both the expression between people and also in their relationship with the environment: animals or objects. From the perspective of the language of objects, "to fully understand its potential without going into details, one can think of programming as a language that allows talking to objects, asking them to do something for us" (Bogliolo, 2020, p. 39). Thus, it can communicate with the surrounding objects, communication being the rationale behind every language.

Today, 7139 languages are spoken today on the world map (Eberhard et al., 2021), in order to communicate. But how many programming languages are there? The HOPL website (*Online Historical Encyclopaedia of Programming Languages*) lists 8945 programming languages that have existed throughout time (Pigott, 2021). All these represent the language of objects, which helps us in communicating and interacting with smart objects. Learning these languages, through the lens of common concepts (Brennan & Resnick, 2012), represents a general, common, predominant skill, namely computational thinking.

II.2.1.1 Computer Programming and Learning to Program

Computer programming is a key element in enhancing the quality of life because programming is a form of delegating tasks (Bogliolo, 2020) and relieving the individual. In this context, there are efforts to introduce informatics from an age as young as possible, even at preschool level (Bers et al., 2020, Kandemir et al., 2020). Although kindergarten is not the place where it is expected to see children programming, the mentioned studies show that these children were interested and able to learn aspects related to programming and computational thinking.

In New Zealand, “the term digital technologies refers to standards that allow schools to address programming and CS aspects” (Hubwieser et al., 2015, p. 72). This is the meaning with which the term "digital technologies" is used in this paper, but because programming, first of all, is a language, it also has great potential in the expressive and artistic-aesthetic fields (Agostini, 2020). Music and programming support artistic expressiveness, and this research paper that merges the two disparate fields attempts to find the appropriate talent-work homogeneity necessary for student development in the digital age.

II.2.1.2 Sonic Pi Integrated Development Environment, Musical Toy for Children

Ubiquitous digitization offers countless applications, which are also designed in an application, but intended for software production: IDE (Integrated Development Environment). Thus, an IDE could be described, in simple terms, as an application with a friendlier graphical interface that makes it easier to write instructions for computer.

These features fit the Sonic Pi application for two reasons. The first, because "Sonic Pi IDE provides a friendly front end" (Cass, 2019, p. 14), the front end being the Graphical user interface (GUI) for the learning user and the second because of the simple syntax and appeal of the music domain, which makes programming accessible to beginners (Traversaro et al., 2020), transforming the instrument into a musical toy, used in experimental studies carried out in classes where children were between 11-12 years old (Aaron and Blackwell, 2013).

II.2.1.3 The Ruby Programming Language

With the help of the Sonic Pi application, one can practice writing in the programming language Ruby, which has been chosen because "it was important to use a language which was used in industry such as Python" (Aaron & Blackwell, 2013, p. 37). Ruby is used in the software industry, and the TIOBE index, which is an indicator of the popularity of programming languages, places Ruby on the 13th place, in the year 2021, with an increase of two positions compared to the year 2020 (TIOBE Software, 2021), which also recommends it as an educational tool or educational content. Many of the great companies use Ruby and have their applications built using this programming language, including: Airbnb in the lodging field, GitHub in the software development field, Shopify in the e-commerce field, Bloomberg in the financial field or SoundCloud, online music platform (Heinemeier Hansson, 2022).

Analyzing the use of Ruby in an educational context, the methodological suggestions of the school program for the study of *Informatics and ICT*, in 5th-8th grades, include this programming language among the 4 accepted ones, noting that the development of specific programming skills in the grades 7th and 8th, will be done using one of the following languages: Python, Ruby, C or C++ (MEN, 2017a). Also, the programming language Ruby (along with Python) is given as an example for the development of the competency *3.4 Computer programming*, within the competency domain DigComp 2.1 - *3. Digital content creation* (Carretero et al., 2017).

II.2.2. Concepts Specific to Programming Languages Used for Integration with Musical Language Elements

Concepts of computational thinking are common across programming languages (Brennan & Resnick, 2012), and concepts such as sequences, loops, parallelism were used in a study that looked at interdisciplinary skills and knowledge transfer in music (Petrie, 2021). The study shows an obvious similarity between music and programming, which makes the transmission of the concept of sequential structures accessible by the fact that the sequence of musical notes on a stave composes a song, and the sequence of instructions in the integrated development environment, composes a program. This analogy can be presented in a graphic form as in Figure II.1.:

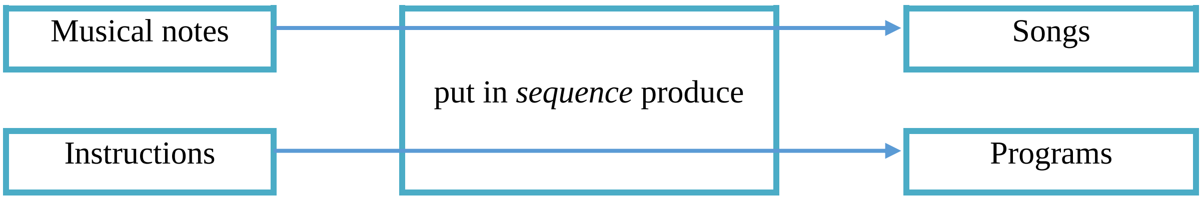


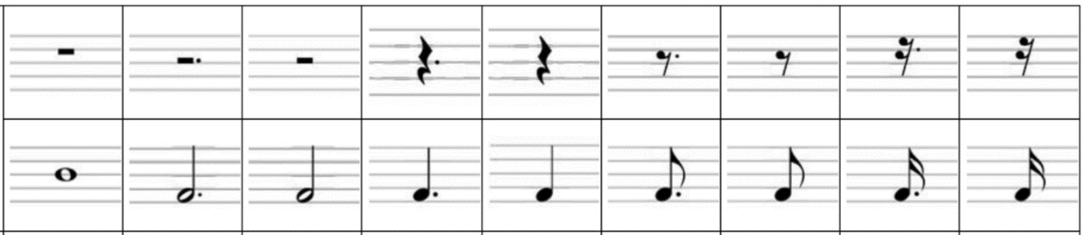
Figure II.1. Analogy: Sequence of Musical Notes – Sequence of Computer Instructions

This is just one example of how music and programming prone to have related forms of thinking, but computational thinking includes other core programming concepts that become powerful resources for expressing musical ideas.

II.2.3. Converting Musical Language Elements into Programming Language Elements, through Mathematics

Mathematics is a universal language (Ben-Jacob, 2017) and it integrates very well with many other disciplines, including Computer Science (Stigberg & Stigberg, 2019) or Music (Jones & Pearson Jr., 2013), which is defined as an organized sound (Dexonline, n.d.).

Numerous synapses are made between the fields of Music and Mathematics (Sârb, 2019), Music being "the first intermediary of the introduction of science into children's lives" (Simion, 2022). Also, MIDI notes are represented mathematically, by numbers in the range 0-127, the notes from 21 to 108 covering the tonality of a piano (Cass, 2019).



Time signature									
2/2	2	1.5	1	0.75	0.5	0.375	0.25	0.1875	0.125
2/4	4	3	2	1.5	1	0.75	0.5	0.375	0.25
2/8	8	6	4	3	2	1.5	1	0.75	0.5

Table II.1. The matrix of musical note durations as exact mathematical ratios and as values for input data in making a musical program (Bănuț, 2022b)

The conversion of the musical notation notions, from the stave, into mathematical variables, as in Table II.1., offers levers for transposing the elements of musical language into programming language. Music and computing share common concepts (Bell & Bell, 2018), and in a pilot study where all students were experiencing programming for the first time and used the Sonic Pi application, they were shown to have successfully acquired basic programming skills, music being a determining factor (Aaron & Blackwell, 2013).

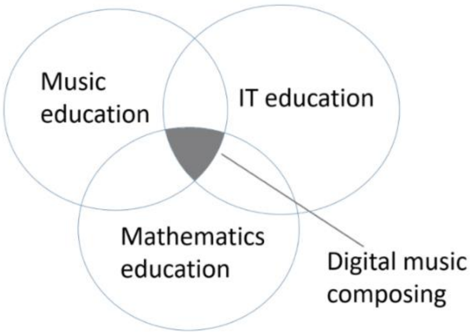


Figure II.2. Integrating music, IT and mathematics education through digital music composing (Laato et al., 2019, p. 2)

The specialized literature emphasizes numerous connections between Music, Computer Science and Mathematics. Digital music composing, is what connects all these three objects, as presented in Figure II.2.

II.3. The Role of Computational Thinking in the Formation of Skills Specific to the object *Music and Movement*

Digital music composing is a feature of contemporary culture where computers dominate audio production. Almost everything people listen to is being passed through digital signal processing, which is reflected in the key competency *Cultural awareness and expression*, for which the European Union Council, through the new recommendation from 2018, explicitly addresses the forms of cultural communication, mentioning both established conventional forms, but also newer or hybrid forms (Sarivan et al., 2020). Starting from a traditional form of cultural communication, such as musical symbolism, where "in both music and mathematics, the symbols are merely static representations on a flat surface of dynamic mental processes" (Devlin, 2014, p. 78), the animation of these symbols through computer programming represents mental processes that lead to the correlation of the notation on the stave with the effect of its interpretation. Thus, the association between the key competence *Cultural awareness and expression* and the specific competence *1.2. The correlation of pitches and values of notes and pauses with musical notation* (MEN, 2014a) is brought to a high degree of correspondence by means of specific descriptors, presented in Table II.2.

Specific competence	Key competence: Cultural awareness and expression
1.2. - The correlation of pitches and values of notes and pauses with musical notation (MEN, 2014a)	- recognition of a set of visual, auditory, kinesthetic languages, specific to the field of culture (MEN, 2019a); - creating simple products through various forms of cultural expression (Fartușnic et al., 2020).

Table II.2. Common descriptors for *The correlation of pitches and values of notes and pauses with musical notation* competence and *Cultural awareness and expression* key competence

Approaching music education alongside programming is a great way to give kids a different perspective for looking at music composing, music theory and of course computer science. Digital technologies increase the deepening of musical knowledge, and expression through them provides a contextualized framework for knowledge application, where all students can activate and express ideas without being conditioned by vocal talent, but only by their own learning.

II.4. Digital Technologies, *Scaffolding* Agents in Music Lessons

Digital education, from the perspective of the digital competence development, is treated in this chapter as an zone of proximal development in primary school, because it promises students a series of skills that they are close to being able to master, and in this sense, the term "proximal" is used in Vygotsky's theory (1978; apud McLeod, 2012).

Considering that the ZPD (Zone of Proximal Development) theory, translated into practice, gives shape to the emerging concept of assisted transition of the learner between two points of knowledge, "yet probably the most common way of describing the provision of assistance to learners has been related to the use of the building metaphor, scaffolding" (Yelland & Masters, 2007, p. 363). So, there is a strong connection between the concepts of ZPD and scaffolding, and the term "scaffold" has been adopted in educational language to describe what the translation of this word provides, a scaffold, that is, a temporary auxiliary in the growth of the student through learning. Thus, the original meaning of the concept of scaffolding referred to temporary and adaptive support in the adult-child dyadic interaction (Smit et al., 2013).

The initial concept in which adults or more capable peers were mentioned as sources of support in development has been extended beyond these possibilities, other resources or tools for mediating learning under the term *scaffolding* being mentioned by the specialized literature. After extensive documentation, consulting multiple studies, and holding conferences on this single theme, *scaffolding,* Davis and Miyake state that "in general, multiple agents provide scaffolding in the classroom including the teacher, other students, paper-based artifacts, classroom decorations, technology, and far more" (2004, p. 267). Another study carried out over a period of two years, in which primary school students around the age of 8 participated and which deals with this extended form of providing support in learning, in the information society era, claims that the activity carried out "indicated that the computer and the type of tasks used create a context which is a type of scaffold" (Yelland & Masters, 2007, p. 380). Given the fact that students often work in groups to program (Stigberg & Stigberg, 2019), a learning situation conducive to the student's transition to his proximal development can be envisioned, and computers can represent *scaffolding* agents for the fulfillment of learning objectives from the area of certain cognitive processes, and once they have been fulfilled, the support can be withdrawn and used to fulfill other learning objectives, from the same hierarchy of cognitive processes (Krathwohl, 2002).

CHAPTER III
COMPUTER, MUSIC, GAMIFICATION AND OTHER SYNERGIZE FACTORS IN CREATING AN EFFICIENT LEARNING ENVIRONMENT

III.1. The Transdisciplinary Vision in the Process of Teaching at Early School Age

Development is driven by digital technology, the environment becoming a digital habitat. In such an environment, "learning in a digital context [...] is a smart learning" (Catalano, 2021, p. 98), allowing connections to be made between information because digital technology makes everything interconnected: people, products, services, etc. Thus, "the problems of society are increasingly complex and interdependent. Hence, they are not isolated to particular sectors or disciplines” (Klein, 2004, p. 517), and such interrelated issues in the extracurricular space are pleading for transdisciplinary approaches in the school environment. That is precisely why an integrated Curriculum, by focusing on the specificities of transdisciplinarity, is connected to the surrounding reality, focusing on significant problems, as they are encountered in real life and which individuals and society must face (Popovici Borzea, 2017).

Avoiding monodisciplinary approaches is a curricular feature of primary education in an attempt to create efficient learning environments. For example, "in Switzerland, primary schools already have a long tradition of transdisciplinary learning in environmental studies" (Kuebler & Catani, 2000; apud Klein, 2004, p. 522), and the option is argued because "the concept of unified content is better associated with the learning conditions, satisfying the different cognitive styles to a greater extent" (Popovici Borzea, 2017, p. 78).

In a study where Music, Mathematics and Computer Science were structured into a unified content through the production of audio-digital materials with the help of the Sonic Pi application, it is stated about the students' knowledge that the seamless connection of various disciplines was realized, often in a way that the students did not even note they were learning transdisciplinary concepts (Burnard et al., 2016). Studies with the same integrated approach (Bell & Bell, 2018; Ludovico & Mangione, 2015) find didactic efficiency, because music-programming transdisciplinarity comes along with the premise of raising the borders between arts and technologies as well as those between informative and formative, Popovici Borzea (2017) claiming that integration has been achieved, at the transdisciplinary level, when the fusion of knowledge has been achieved.

III.2. Concept Maps for Representing and Assimilating Information

Supporting the knowledge fusion, "pictorial or graphical representations of knowledge are often more concise, unambiguous, and easier to understand than textual depictions of the same knowledge" (Coffey, 2015, p. 123), because "without the underlying concepts, words are akin to isolated weeds and seeds likely to be blown away by the winds of time, usually mere hours after an exam" (Boettcher, 2007, p. 5). Concepts can be reinforced through concept maps, which have been successfully used in primary school (Yorulmaz et al., 2021), establishing that they play an important role in promoting meaningful learning. This happens because "all learners do not need to learn all course content; all learners do need to learn the core concepts" (Boettcher, 2007, p. 5). This is one of the 10 basic principles that author Boettcher lists in designing an effective learning environment.

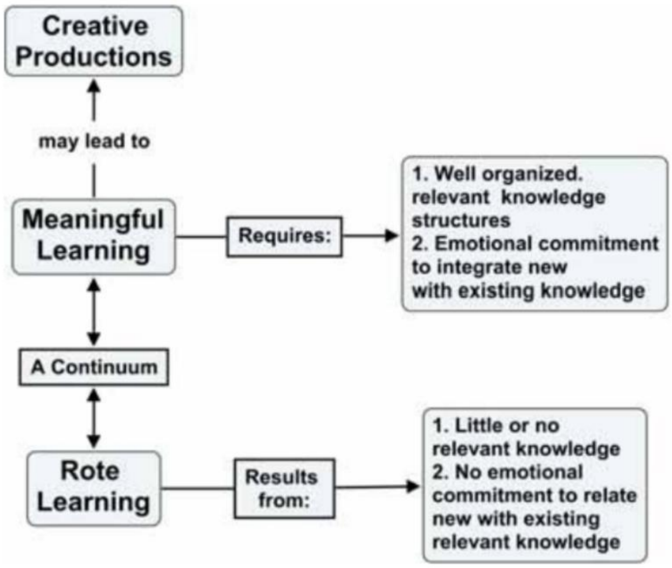


Figure III.1. Creative productions result from meaningful learning (Novak & Cañas, 2008, p. 5)

Figure III.1. shows that, depending on the presence or lack of two elements, commitment and structured knowledge, learning can vary from intensive memorization to meaningful learning that, practiced at a high level, leads to creative productions, and the object *Music and Movement* needs such learning products.

III.3. Didactic Transposition in Creating an Efficient Learning Environment

The current discoveries of scientific knowledge as well as their teaching involve the use of digital technologies, the didactic transposition ensuring the path delimited by the two poles, up to the form of an object taught in school, and if the pole which the student interacts with lacks digital technologies, it is possible for the student to face a reality he does not know.

Didactic transposition is explicitly defined in the first title of the book published on this topic, mentioned by Bosch and Gascón: "Didactic Transposition. From Scholarly Knowledge to Taught Knowledge (Chevallard 1985)" (Bosch & Gascón, 2006, p. 52). This represents a transition of concepts, which is seen by Insuasti and Dodero Beardo (2015), on a concrete case of teaching computer programming, as a phenomenon of didactic transposition on several levels, the most important being the level equivalent to the teaching-learning process itself, where the object to be taught is converted into a taught object and where the intense activity takes place in the classroom, because this is where most variables come into play, such as: identifying the students' zone of actual development, their motivation, communication, etc.

At this level, the didactic transposition process can make programming learning more efficient, in the context where many students fail to achieve this result (Robins, 2015). It is said that "the main point of agreement and conclusion in the hunt for a more accessible entry point into programming […] is that a social barrier is in finding a real reason to program" (Kelleher & Pausch, 2005; apud Sinclair, 2014 , p. 215). Music can be a real reason to program because it stimulates the imagination, engages the subject emotionally, arouses interest in creativity, and it also creates a context in which the audiovisual mediates the understanding of music (audio) through programming (visual) and vice versa of programming through music.

III.4. Gamification in the Context of Didactic Methodology

It is known that motivation is a *sine qua non* condition of successful learning, and a motivated student cannot be stopped (Prensky, 2003). In this regard, "one way of getting children motivated is to design educational tools which are as engaging and motivating as popular commercial games" (Nand et al., 2019, p. 2), and "the success of video games has encouraged the appearance of two derivatives, gamification and serious games" (Stan, 2021, p. 225).

Gamification meaning "to identify and facilitate the motivations behind desired activities, using game design" (Deterding, 2012, p. 17), its introduction represents the enhancement of game elements, acting as a motivational booster. Thus, the praxeological value of gamification in pedagogy is represented by the psychological, motivational efficiency of the actions derived from the game design and mechanics, and the game design elements that Koper (2014) highlights as a series of incentives introduced by the teacher through gamification, are: grades, points, rankings, all of these being conditioning placed in the learning environment, i.e. interventions in learning.

The positive effect of these learning interventions is proven by studies which show that groups of students who have been engaged in the teaching-learning process through gamification elements, from an academic point of view, achieve a better learning performance compared to groups that did not benefit from a stake introduced in learning through gamification (Folgieri et al., 2019; Nand et al., 2019). Based on such results, gamification is "currently considered as one of the most useful and implementable resources in modern education" (Ruiz-Banuls, 2021, p. 1), because it increases students' motivation and decreases their anxiety in the didactic process (Folgieri et al., 2019). It is natural that in an educational climate where anxiety is absent, commitment increases, this type of intervention being, at the same time, an argument for creating an efficient learning environment, because it "ensures a climate favorable to learning activities" (Verza & Bratu, 2020 , p. 347), a particularly important aspect, since "learning comes as the result of the framework or environment that fosters learning rather than as a result of teaching " (Brown, 2002; apud Pivec, 2007, p. 387).

III.5. Learning Communities and International Events

On the background of continuous digitization, many jobs in the near future will need basic coding skills, and their development is the idea behind the EU Code Week event (European Commission, 2021), especially since the effect is already visible, because, "according to the European Commission, the demand for ICT practitioners is growing annually by 3% while the number of graduates from computer science is not keeping pace" (Moreno-León & Robles, 2015, p. 561). The Ministry of Education in Ireland (Moreno-León & Robles, 2015), in the Czech Republic, Poland, Portugal and Spain (Balanskat & Engelhardt, 2015) supports the annual organization of the EU Code Week, in Romania, this being an operational objective specified by the *Education Digitalization Strategy in Romania* (MEC, 2020).

Eu Code Week offers, as a whole, a learning environment that promotes programming, the development of computational thinking through education, economic development, social inclusion and is not the only initiative of this type, other examples being: code.org (Kukul & Çakır, 2020), Hour of Code (Klopfenstein, et al., 2019), Code Club (Brown et al., 2014) or CodeMOOC (Klopfenstein, et al., 2017). All of these examples provide a package of online learning resources that, in most cases, also address primary school students, and political and educational factors in some "countries promote specific coding websites and community platforms (e.g. Bulgaria, France, Norway, Poland)" (Balanskat & Engelhardt, 2015, p. 61), many of the sites being the ones previously presented.

In terms of learning efficiency, if learning situations become meaningful by integrating an experiential component, the results can be quantified in terms of time and quantity, learning being done faster and being more solid (Popovici Borzea, 2017), and participation in international events and using programming to produce music is an experiential component of an efficient learning environment.

III.6. Formative Values of Music Education in Contexts Familiar to Students

Musical fragments, at the age of little pupils, "form impressions, arouse interest in music, contribute to the formation of musical taste and stimulate aesthetic sense, imagination and creativity, developing children's musical hearing, rhythmic sense and musical memory" (MEN, 2014a, p . 2). Such formative values of music education have been confirmed by specialized studies and are translated into concrete development possibilities, such as:

– cognitive, in terms of memorization, imagination (Köksal et al., 2013);

– socio-emotional, in terms of mood, relaxation (Eerola & Eerola, 2013);

– behavioural, in terms of calmness, operating according to the rules (Auerbach & Delport, 2018).

All these are different forms of gains recorded in learning and which have been retained in multiple scholastic contexts: foreign languages, mother language, mathematics, geography or arts in various forms. In conclusion, in education carried out through objects outside the arts curriculum area, music and the arts are key elements through which students can learn transferable skills such as problem solving or social skills (Tervaniemi et al., 2018).

III.7. Mechanisms of Relating the Specific Competences of the object *Music and Movement* with the Competence Learning to Learn and with the Students' Social Competences

Communication is a common goal of the human beings, for the fulfillment of which music and language go hand in hand (Köksal et al., 2013). Music, therefore, serves communication (the expression of ideas and feelings) and, then, integrates very well with personal or social skills, for which, Table III.1. presents common descriptors.

General competence	Key competence: Personal, social and learning to learn competence
3. - Expressing ideas, feelings and experiences through music and movement, individually or in a group (MEN, 2014a)	– constructive communication, teamwork and negotiation, carried out in different environments (Sarivan et al., 2020); – psycho-social aspects, which include the desire and curiosity to exploit the learning opportunities that can arise (Sarivan et al., 2020); – self-knowledge, as well as discovering and knowing the qualities of colleagues, developing constructive collaborations (Fartușnic et al., 2020).

Table III.I. Descriptors for correlating the competence *Expressing ideas, feelings and experiences through music and movement, individually or in a group,* to the key competence *Personal, social and learning to learn* competences

The use of digital technologies emphasizes transversal competences, while descriptors of a competence, such as those previously mentioned, can be transferred so that, in the same learning situation or in others, they could support the development of another competence. Such a connection is supported by the competence of learning to learn, which "can be defined as a meta-competence because it has a significant impact on the acquisition and application of other competencies" (Letina, 2020, p. 1). Looking at the use of digital technologies "as a mode of expression, computer languages provide both an alternative mode of thinking and opportunity to communicate ideas" (Brown, 2007, p. 8), and in this sense the use of programming to create digital materials can place creativity in the form of a habit of learning or a way of expression.

PART II

EXPERIMENTAL RESEARCH: THE DEVELOPMENT OF THE OBJECT *MUSIC AND MOVEMENT* SPECIFIC COMPETENCES THROUGH THE INTERVENTION PROGRAM *MUSIC AND PROGRAMMING IN SCHOOL CONTEXT - LITTLE AMATEUR MUSICIANS, GREAT DIGITAL ARTISTS*

CHAPTER IV
THE RESEARCH DESIGN

IV.1. The Research Premises

The experimental approach starts from the premise that the use of digital technologies is not limited only to the development of some skills specific to the object *Music and Movement*, but it also involves, challenges and improves the entire teaching-learning process for a number of reasons, such as: the development of key competences, contextualization of learning, didactic efficiency, holistic learning or the determination of pedagogical values in the sphere of creative thinking.

IV.2. The Aim and Objectives of the Research

The aim of the research is to verify the effectiveness of the experimental intervention in the study of the object *Music and Movement*, in the 4th grade, by monitoring the educational influences on some competences provided by the school curriculum of this object and subordinated to the key competences, on which the teaching-learning process is based.

The objectives for the empirical investigation within the doctoral research are:

1. Designing an intervention program that trains the digital skills of primary school students, skills that support the exploitation of the educational potential of the object *Music and Movement*.

2. The selection of content units from the school curriculum for the object *Music and Movement* and their integration, in a transdisciplinary manner, with content units specific to the object *Informatics and ICT*, in order to establish a theoretical and applied model (the intervention program *Music and Programming in School Context – Little Amateur Musicians, Great Digital Artists*) which could contribute to the improvement of the teaching-learning process.

3. Testing the functionality of the integrated education model, music and programming, through experimental investigation.

4. The analysis of the didactic efficiency of the intervention program by observing and measuring some variables (performance indicators) that attest, on the 4th grade students, the development of some general competences, and specific to the object *Music and Movement*, provided by the school curriculum.

5. Capitalizing on research results at the level of pedagogical practice.

IV.3. The Research Questions

The research questions, related to learning situations, means and experiences, are:

1. To what extent can digital technologies, especially computer programming, constitute teaching tools that contribute to the development of general and specific competences in the object *Music and Movement*?
2. Which are the possibilities of adapting the classes of *Music and movement* to the online format, by integrating digital elements from the field of computer programming?
3. Can students' musical creative ability be enhanced through logical thinking, such as computational thinking, and which would these possibilities be?
4. How realistic is the possibility that 10-11-year-old students acquire new knowledge in computer science, and this to be the result of an education achieved through music?
5. What are the arguments to support the statement that students in primary school could access, conceptually and procedurally, elements of programming languages, this representing *scaffolding* agents in achieving learning objectives in the field of memorizing and understanding musical notation?
6. How would it be possible for the sound phenomenon to represent a successful didactic transposition phenomenon for the programming approach in the teaching-learning process in primary school?
7. To what extent can computer programming be used for pedagogical purposes, for student development through a teaching-learning process specific to music education?

IV.4. The Research Hypotheses and Variables

General Hypothesis (G.H.): The application of the intervention program *Music and Programming in School Context - Little Amateur Musicians, Great Digital Artists*, in teaching *Music and Movement* to students in the 4th grade, contributes to the effective development of general and specific competences.

In order to clarify the general hypothesis, three auxiliary hypotheses have been added, closely related to the object *Music and Movement* and the verification of them directly influences G.H.

Secondary Hypothesis 1 (S.H. 1): The application of the intervention program *Music and Programming in School Context – Little Amateur Musicians, Great Digital Artists,* in teaching the object *Music and Movement* to students in the 4th grade, contributes to the effective development of the specific competence: C.S. 3.3. – *Song improvisation, associated to body movements* (MEN, 2014a).

Secondary Hypothesis 2 (S.H. 2): The application of the intervention program *Music and Programming in School Context – Little Amateur Musicians, Great Digital Artists*, in teaching the object *Music and Movement* to students in the 4th grade, contributes to the effective development of the specific competence: C.S. 1.2. - *Correlation of pitches and values of notes and pauses to musical notation* (MEN, 2014a).

Secondary Hypothesis 3 (S.H. 3): The application of the intervention program *Music and Programming in School Context – Little Amateur Musicians, Great Digital Artists*, in teaching the object *Music and Movement* to students of the 4th grade, contributes to the effective development of general competence: C.G. 3 - *Expressing ideas, feelings and experiences through music and movement, individually or in group* (MEN, 2014a).

Independent Mariable (I.V.): Application of the intervention program, *Music and Programming in School Context – Little Amateur Musicians, Great Digital Artists*, designed for the study of the object *Music and Movement* to students of the 4th grade.

The Dependent Variables (D.V.):

- Dependent Variable 1 (D.V. 1) - the level of development of specific competence C.S. 3.3.: *Song improvisation, associated to body movements* (MEN, 2014a);
- Dependent Variable 2 (D.V. 2) - the level of development of specific competence C.S. 1.2.: *Correlation of pitches and values of notes and pauses to musical notation* (MEN, 2014a);
- Dependent Variable 3 (D.V. 3) - the level of development of general competence C.G. 3.: *Expressing ideas, feelings and experiences through music and movement, individually or in group* (MEN, 2014a).

IV.5. The Participant Samples

The samples of participants were divided into two groups: experimental group and control group, each of them including students of three different classes of the 4th grade, these classes remaining intact, without the students being grouped according to certain considerations and having in mind that the groups should be comparable regarding: the gender, number of students or year of birth. The participants sample description, by research groups and according to their gender, is presented in Table IV.1.:

Gender	Experimental group	Control group	Total
Girls	45	44	89
Boys	42	34	76
Total	87	78	165

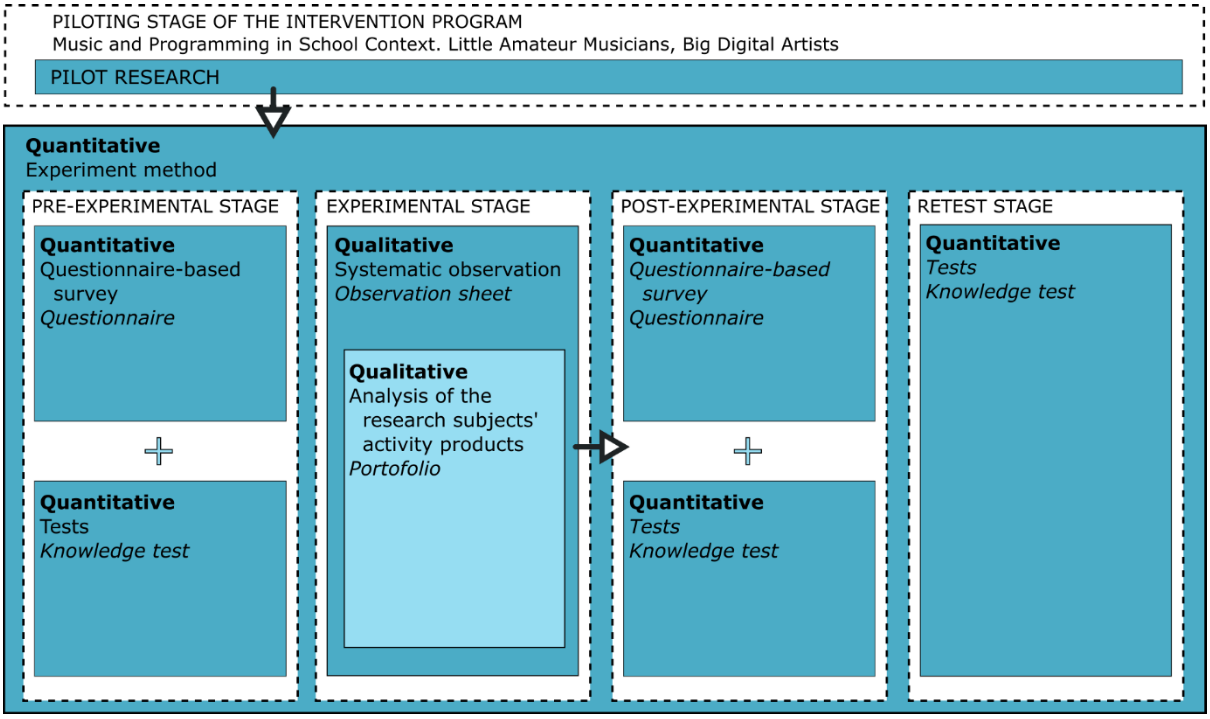
Table IV.1. Participants sample distribution by gender

To the 165 students included in the experimental research, carried out in the 2021-2022 school year, 25 students included in a pilot research, carried out in the previous school year, 2020-2021 were added, so that the doctoral research project counted 190 4th grade students.

IV.6. The Research Methods and Tools

The conduct of the quantitative and qualitative research was based on the following set of research methods: the experiment (the predominant research method), the questionnaire-based survey, the tests, the systematic observation and analysis of the research subjects' activity products. Also, there were designed several research tools, such as: an observation sheet, a product portfolio, a questionnaire and a knowledge test.

The research methods system in Figure IV.1 was staged in an action research in which the researcher taught and studied the effects of a piloted 24-lesson intervention program alongside the research tools included in the designed methodologicall complex. The arrow represented in the drawing, between the experimental and post-experimental stages, indicates that the data collected in the experimental stage will be analyzed in the post-experimental stage, when the data collection process has been completed, even more so as the observations made in the experimental stage could explain the results obtained later.



Note: (bold text: type of data analysis; normal text: research method; italics: research instrument)

Figure IV.1. General diagram of the research methods design in relation with the process of data analysis and interpretation

Data with student results were analyzed using the JASP statistical interpretation application (Version 0.16.3; JASP Team, 2022), software and version that was used throughout the entire research.

IV.7. Intervention Program and Content Sample

IV.7.1. The Inductive Digital Training Strategy, Characteristic of the Intervention Program

Form of organization

The didactic scenario is adapted, inclusively, to the online format, with a high degree of implementation for cases of possible fluctuations between emergency situations, alert or normal states of activities in school and society, related to the evolution of the epidemiological situation determined by the Covid-19 pandemic.

Lessons gamification, methodological approach for the involvement in classroom activities

The improvisation of some songs was designed to be staged in a long-term competition throughout the intervention, a competition called "The Best Music Producer in the School", to emphasize those motivations that would lead young pupils to successfully engaging in activities which aim at expressing musical ideas. Thus, the content sample includes a dynamic, multi-stage contest that comprises scored activities, kept in a ranking table that will determine the winner of a trophy, and that, as a whole, outlines a gamified educational product. The gamification elements are: the contest, the points, the ranking, the diplomas and the trophy.

Unplugged activities, playful option to learn some specific principles of programming

The basic concepts in computer programming were selected from the content units of the object *Informatics and ICT* in secondary school, but although the concepts taught in the 4th grade are identical to those taught in the 7th grade, there is something different, namely their approach. This includes typical examples, presented through unplugged activities designed for forming some concepts in computer science, and for this reason we call the digital instructional strategy an inductive one. The example shown in Figure IV.2. is a example of the content sample related to unplugged activities, with the function of making accessible knowledge about the meaning of a procedure, a concept that will be used later through the Ruby programming language and the Sonic Pi application, in order to develop digital skills.

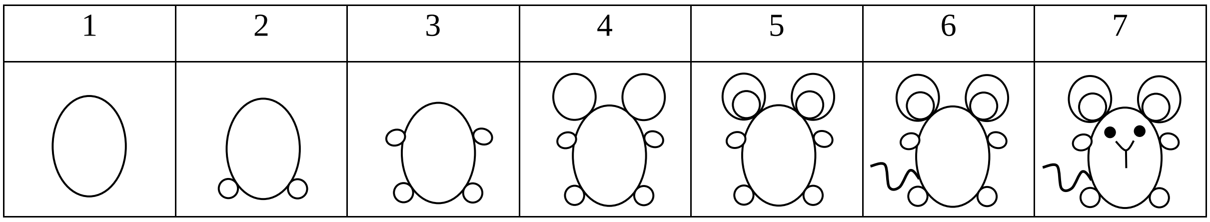


Figura IV.2. Analogy between computing procedures - drawing procedures (Bănuț, 2022b)

Digitalising the process of learning music theory

The predominant activity, within the intervention, will be the musical creation game. All songs produced will be digital products, meaning that music theory will be learned by composing. To obtain songs in digital format, musical notes are translated into numerical notes, called MIDI notes, which correspond to standard musical notes. Thus, musical notes are simply written in a way that the computer can read and understand. Table IV.2. shows the correspondence of musical note symbols with 4 different notation systems, including MIDI notation. So, content sample such as pitch and duration of sounds or other qualities of sound, become topics that are the subject of didactic activities designed for experimental intervention.

Notation systems	Musical notes							
								
Syllabic	DO	RE	MI	FA	SOL	LA	SI	DO
Alphabetic	C	D	E	F	G	A	B	C
Mathematical (MIDI notes)	60	62	64	65	67	69	71	72
Acoustic	262 Hz	294 Hz	330 Hz	349 Hz	392 Hz	440 Hz	494 Hz	523 Hz

Tabel IV.2. Notation systems for musical notes (Bănuț, 2022b)

The relation: activities - learning objectives

The sample content related to the learning activities, an example being "the creation of simple melodic-rhythmic fragments, using computer programs" (MEN, 2014a), has a strong practical-applicative character, the predominant activity being composing songs using digital technologies. The contents specific to the IT education will be levers through which students will experience the improvization of digital music, the teaching-learning process being oriented towards the development of three distinct competences, which thus become learning objectives, in the sense that the relationship activities-learning objectives is a relationship of determination.

The songs repertoire digitized in the classes of *Music and Movement*

The songs repertoire selected from the school textbooks (two songs being proposals of the researcher), which will be digitized in the classes of *Music and Movement*, are connected to the content sample that is the object of some sequences of lessons, as well as of the experimental research, through the prism of connecting to the dependent variables and includes the songs that will be found in the annual planning, presented in the description of the experimental stage.

The digitization of songs from cultural heritage or children's folklore, involves reading and interpreting musical notes on the portable, which means learning musical theory through a practical example, outlining the inductive digital instruction strategy adopted for this experimental research. Therefore, the use of the *Ruby* programming language is designed to make the connection between the musical notation used in writing the staves of the songs addressed and the qualities of the sounds symbolized on the stave, which will be the central themes of the experimental intervention.

The study topics and the contents of the teaching-learning process achieved through the intervention program

The contents related to the object *Music and Movement*, which were explored in an applied manner by composing digital music, are presented in Appendix 3. The table of educational content, presented graphically, develops the themes processed within the experimental intervention, and these themes are part of the research content sample.

IV.7.2. Piloting the intervention program and the purpose of the pilot research

During the 2020-2021 school year, a pilot research was carried out which meant a process of validating the research tools: knowledge test, questionnaire, product portfolio and observation sheet. At the same time, the pilot research had the role of piloting the organization of the experimental research and identifying some gaps or difficulties in its implementation.

IV.7.3. Validated Research Tools

Observation sheet and protocol

The observation sheet is one of the research tools used to collect data through systematic observation, data related to events and behaviors developed as a result of the intervention. Thus, an observation sheet was designed for a two-dimensional data collection, which will be recorded in two categories related to the framework and context that promote learning (category 1) and to the experiences determined by the new framework for conducting the music learning process (category 2), this representing the dependent variable with no. 3 of the research (D.V. 3). The purpose of using the observation sheet in the pilot research is to track how testing the intervention program generates important data for the research and whether the instrument created can be a mean of collecting this data.

The students' product portfolio

The digital portfolio of products in the context of the pilot research aims at applying and validating the application of the tool for indicating some performances in the course of concrete tasks, along with the observation of some visible behaviors, by inventorying some musical creations as a result of the students' imagination. Thus, it is desired that the portfolio highlights the students' basic competences, given the fact that this is a way in which the practical aspects of the competence reveal the student's creativity.

The questionnaire

There were three aspects monitored in the pilot stage:

- Objectivity, in the sense that the questions are quite explicit and clear to be processed by 4th grade students.
- Validity, in the sense that the questionnaire items can provide information about the measured variables.
- Reliability, in the sense of calculating the Cronbach's Alpha index.

After the piloting of the instrument, starting from the three considerations mentioned and if necessary, an adjustment of the questionnaire will follow by modifying some questions.

The knowledge test

The pilot research, as a stage of piloting the research tools, also included the piloting of the knowledge test, in order to validate it. This stage becomes an opportunity to evaluate learning acquisitions, taking into account, at the same time, the validity of the test in terms of its applicability, related to the quality of the instrument to be administered, but also easily interpreted.

IV.7.4. The Sample of Participants in the Pilot Research

The participants in the pilot research were the students of a single 4th grade, coming from the urban environment, the school being located in Cluj-Napoca, Romania. The class included 25 students (N=25), 14 girls and 11 boys, and at the end of piloting the intervention program, which coincided to the end of the 2020-2021 school year, the students had an average age of 10.64 years (M=10.64).

IV.7.5. The Conducting of the Pilot Research

The sequence of the actions in the piloting of the intervention program *Music and Programming in School Context - Little Amateur Musicians, Great Digital Artists*, is presented in the calendar that integrates the lessons and their progress during the 2020-2021 school year. Table IV.3. presents the structure of the intervention program as it was applied in the first version and describes, in a comprehensive manner, the research content sample, reflecting the volume of scientific content in relation to the number of themes and lessons designed:

No.	Contents of activities			Responsible persons
	Musical language elements	Programming language elements	Date of lesson	

1.	Sound Wave, Voice, Noise	The integrated development environment	Transmission of new knowledge: 19.11.2020 Consolidation of knowledge: 26.11.2020	Marius Bănuț
2.	Musical Notes / MIDI Notes, Notation system	Instructions	Transmission of new knowledge: 03.12.2020 Consolidation of knowledge: 10.12.2020	Marius Bănuț
3.	Stave, SOL Key, Octaves	Sequential structures	Transmission of new knowledge: 17.12.2020 Consolidation of knowledge: 14.01.2021	Marius Bănuț
4.	The duration of a musical note, Break, Note values	Repetitive structures	Transmission of new knowledge: 21.01.2021 Consolidation of knowledge: 28.01.2021	Marius Bănuț
5.	Pitch of musical notes, Frequency of musical notes, Tonality, Registers: high, medium, low	Alternative structures	Transmission of new knowledge: 11.02.2021 Consolidation of knowledge: 18.02.2021	Marius Bănuț
6.	Chords, Scale, Orchestra	Threads	Transmission of new knowledge: 25.02.2021 Consolidation of knowledge: 04.03.2021	Marius Bănuț
7.	Timbre (color), Synthesizers, Effects: echo and reverberation	Inheritance	Transmission of new knowledge: 11.03.2021 Consolidation of knowledge: 18.03.2021	Marius Bănuț
8.	Measures, Repetition sign	Procedures, Functions	Transmission of new knowledge: 25.03.2021 Consolidation of knowledge: 01.04.2021	Marius Bănuț

9.	Intensity, Amplitude of a musical note, Dynamics (nuances)	Parameters, Variables	Transmission of new knowledge: 06.05.2021 Consolidation of knowledge: 13.05.2021	Marius Bănuț
10.	Number of beats, Rhythm/ Tempo	Recursivity	Transmission of new knowledge: 20.05.2021 Consolidation of knowledge: 27.05.2021	Marius Bănuț
11.	Stanza, Refrain, Arpeggio	Data structures, Algorithms	Transmission of new knowledge: 03.06.2021 Consolidation of knowledge: 10.06.2021	Marius Bănuț
12.	Melody, Intervals: tone, semitone; Alterations	Debugging	Transmission of new knowledge: 17.06.2021 Consolidation of knowledge: 24.06.2021	Marius Bănuț

Table IV.3. Themes and lesson progress of the intervention program *Music and Programming in School Context – Little Amateur Musicians, Great Digital Artists*, piloted before the experimental research

IV.8. The Stages of the Experimental Research

The research design in Figure IV.3. describes the process, with the sequence of stages, through which the experimental research was carried out.

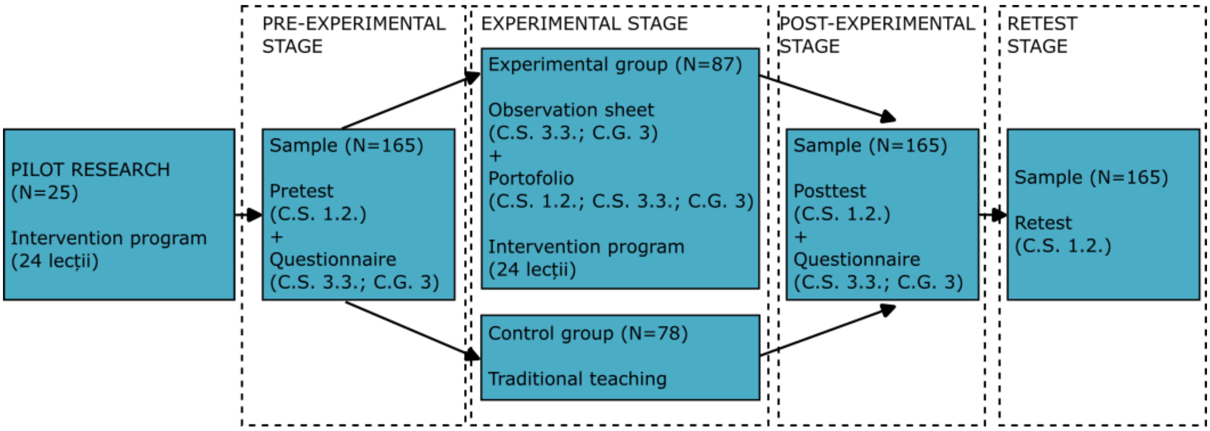


Figure IV.3. Research design in relation to the stages of the experiment

According to the previous figure, the experiment is a consequence of piloting the intervention program and is designed to be carried out in 4 stages. The details of the empirical research specific to each stage: pre-experimental, experimental, post-experimental and the retest are presented next.

IV.8.1. The Pre-experimental Stage

The first stage of the experiment is dedicated to the pre-testing the participants sample of the experimental research, a stage where the identification of the initial level of students' development on the coordinates of knowledge, skills and attitudes that characterize the competencies included in the three dependent variables.

IV.8.2. The Experimental Stage

According to the rules of logic, it is known that "the intervention must last long enough and be strong enough to actually have an impact on the outcome" (Creswell, 2008, p. 326). For this reason, the extended duration of the intervention, of 24 weeks, can be considered a strength of the experimental research. The annual planning, presented in Table IV.4., presents the number and themes of the lessons in a structured way, the didactic contents being organized in 24 lessons, with 24 worksheets:

Class: 4^{th} grade

School year: 2021-2022

Object: *Music and Movement*

Number of hours/ week: 1 h / week

School curricula: OMEN 5003/02.12.2014

Textbook: Intervention program for studying the *Music and movement* object in an integrated way: "Arts & Technologies"

Author: Marius Bănuț

ANNUAL PLANNING

No.	**Thematic unit**	**SC***	**Targeted content** / activated	**Period**	**No. h.**	**Obs.**
SEMESTER I (16 weeks)						
1.	**The sound studio**	1.1.; **1.2.**; 2.2.; 3.1.; 3.2.; **3.3.**	Sounds from the environment; Noise pollution; Vocal/ instrumental musical sounds; Musical notes from C1 to C2; notation systems; mathematical notation (MIDI notes). **Songs repertoire**: *Acum e toamnă, da*!; *Baba oarba*; *Mișcă vântul frunzele*	W2 - W5	4	

			Music audition: *Piano Phase* de Steve Reich (for two pianos)			
2.	**All at their time**	**1.2.**; 2.2.; 3.1.; **3.3.**	The stave; Sol key; Octave; Long/ short sounds; Notes values; Duration; Pause; Elements of musical notation. **Songs repertoire**: *Lanțul*; *Vrăbiuța*; *Ceasul*; *Câte țări sunt pe pământ* **Movement on music**: free movements	W6 – W9	4	
3.	**The lessons around you**	**1.2.**; 2.2.; 3.1.; **3.3.**	Pitch of musical notes; Sounds frequency; Musical registers: high, medium, low; Scale; Chords; Synchronization in accompaniment **Songs repertoire**: *Podul de piatră*; *Azi, Grivei e mânios*; *Cântecul gamei*; *Bat din palme* **Movement on music**: movements suggested by the text	W10 – W13	4	
4.	**Elements of musical language**	1.1.; **1.2.**; 2.2.; 3.1.; **3.3.**	Timbral diversity; Instrumental musical sounds; Musical toy orchestra; Echo; Reverberation; Measures; Repetition; Musical genres: dances **Songs repertoire**: *Ghicește cine te-a strigat*; *Drag mi-e jocul românesc*; *Ceata lui Pițigoi*; *Cine știe să răspundă*! **Music audition**: *Menuet* by Johann Sebastian Bach **Movement on music**: games inspired by the action scenario taken from the song, social dances	W14 – W17	4	
SEMESTER II (8 weeks)						
5.	**Childhood songs**	**1.2.**; 2.2.; 3.1.; **3.3.**	Sound intensity parameter; Dynamics (shades); Rhythm; Tempo; Various body percussion; Musical genres: Children's folklore	W18 – W21	4	

			Songs repertoire: *Bingo dog*; *O vioară mică*; *A Ram Sam Sam*; *Ode to Joy* **Movement on music**: body percussion movements, movements suggested by the rhythm			
6.	**Tărâmul melodiilor**	**1.2.**; 1.3.; 2.2.; 3.1.; **3.3.**	Arpeggios; The connection between the text and the melody: the verse-chorus; The melody; Tone; semitone; Alterations **Songs repertoire**: *Uf, de i-ar vedea pisica*!; *Căsuța din pădure*; *Alunelul*; *Limba românească* **Movement on music**: folk dances	W22 – W25	4	

* SC –specific competences

Table IV.4. Annual planning of the contents of the intervention program *Music and Programming in School Context – Little Amateur Musicians, Great Digital Artists*

IV.8.3. The Post-experimental Stage

At this stage, the knowledge test and the questionnaire will be applied to verify the level of competence achieved, on the three dimensions delimited by the dependent variables, following the application of the intervention program, these being benchmarks in the evaluation of the teaching efficiency and to the integration of digital technologies in the study of the object *Music and Movement*.

IV.8.4. The Retest Stage

At this stage, the knowledge test will be applied in order to verify the solidity and durability of the knowledge acquired and determined by the intervention they took part in. Since in this stage the knowledge of the students stored in the long-term memory will be measured, and not the opinions or attitudes of the students towards the learning experiences, in the retest stage only the knowledge test will be applied, not the questionnaire.

IV.9. Considerations of the Research Ethics

The entire research was carried out in accordance to the ethical standards regarding the transparency of the application of an intervention program within the teaching-learning process specific to a subject in the Core Curriculum, as well as the prior information of the participants and their parents. Both for the pilot research and for the experimental research, an educational project approved at the county level was carried out, this being the instrument through which the intervention program *Music and Programming in School Context* - *Little Amateur Musicians, Great Digital Artists* was applied, in the study of the 4th grade object: *Music and Movement*.

CHAPTER V
THE RESEARCH RESULTS

V.1. The Results Obtained in the Pre-experimental Stage

V.1.1. The Results of the Pilot Research

In the process of identifying some gaps in the intervention program design and implementation, although the content units, specific to music and IT education, were satisfactorily selected and integrated, it was not necessary to reconsider the contents, following the conduct of the pilot research, it was found that the worksheets need some extra-elements that help students. In this sense, the worksheets were completed with the presentation of the educational objectives for each lesson, the integration of some suggestions necessary for the students to approach the learning tasks as well as some tasks formulated orally and initially transmitted through the e-Learning platform used in the class, marking some key concepts to remember at the end of the lesson as well as completing them with graphic markings and design elements, agreeable and indicative for the students.

Qualitative data analysis through the systematic observation method

Two-category data recording marks the observation protocol used in systematic observation. This research method, "in contrast to other forms of data collection, it builds up data on the basis of careful recording of ongoing behavior" (Blatchford et al., 2005, p. 457), so notes on the two categories, which capture effects of the intervention program on student behavior, was recorded in the various stages of piloting, an example being presented in Table V.1.:

<table>
<tr><td colspan="2">Observation sheet - Intervention program Music and Programming in School Context - Little Amateur Musicians, Great Digital Artists
Observation frame: 4th grade A
Observer: Marius Bănuț
The role of the observer: participant observer
Period of time: November 11, 2020 – June 24, 2021</td></tr>
<tr><td>The framework and context of the implementation of the intervention program activities
----
Descriptive notes</td><td>Expressing ideas, feelings and experiences through the independent variable
----
Reflection notes</td></tr>
</table>

<u>December 03, 2020 – Lesson 3</u> Being their first attempts at writing code for a song, the students tried to basically make a song in the programming language, and after writing the code and running it, one of the students said that the codes didn't work for him, returning an error. The classes were conducted online and the requirement was that all students should keep the microphone off during the lesson.	Another student opened his microphone and replayed to his colleague: "But look carefully that you either did not leave a space between the commands or you did not put a comma between them. That's what I did in my first attempt and it didn't work for me". On this occasion, it was noted that the learning activity which was aimed at creativity and expression of ideas through music, through the use of digital technologies in composing music, puts students in a position to collaborate and learn through cooperation, using linguistic communication and commuting thus between individual learning and group learning.

Table V.1. Notes from the observation sheet, focusing on students' experiences regarding expression in the piloting of the intervention program *Music and Programming in School Context* - *Little Amateur Musicians, Great Digital Artists*

The collected data, which capture the expression of students' ideas and feelings through the independent variable, were supplemented with personal reflections of the researcher, so that indicators were recorded on the fact that the application of the intervention program has the ability to contribute to the efficient development of G.C. 3 competence, *Expressing ideas, feelings and experiences through music and movement, individually or in group*.

Qualitative data analysis: analysis of students' activity products

While integrating the method of analysis of the students' activity products into the systematic observation, it was noted that the process of digital music creation is a game, which brings fun and leads to general well-being and enthusiasm. Starting from the presumption that the musical value of the materials created will not be great, since the educational unit in which the students were enrolled did not come from the vocational, artistic profile, the emphasis was on arousing the curiosity to explore and improvise songs. However, the students contradicted this opinion based on deductions: at least 6 of the audio materials which they produced, provided exceptionally pleasant musicality. The portfolio of creative products, made as part of the pilot research, is available on the Wakelet webpage (Bănuț, 2020). Therefore, the portfolio analysis of students' activity products provides valuable information and clues along with concrete evidence of student development in relation to the educational requirements of the object *Music and Movement* alongside the digital competence development.

Quantitative data analysis through the questionnaire survey method

In two of the questions, there were identified answers in which the participants selected all or most of the options, which causes a lack of constancy in the way of giving the answer. This, affecting the fidelity of the instrument and in order to fulfill this requirement for the experimental research, the questions of the respective items were completed with the mention of choosing only the preferred discipline, even if the answers collected during the piloting of the instrument were favorable to the measured variables. Therefore, the final form of the questionnaire, available in Appendix 1, was obtained for the experimental research, the pilot research representing a stage in the completion of the questionnaire (Creswell, 2008), modifying and adjusting questions and completing the instructions provided when administering the questionnaire.

The modification and adjustment of the two questions is expected to improve the Cronbach's Alpha index of the instrument's reliability, which is currently 0.64, the result of the calculation of the index being presented in Table V.2. Although some opinions show the reporting to an index that exceeds the value of 0.70, the obtained value is tolerated all the more since, for example, "in social science, the acceptable α value is .60 (Ghazali, 2008), which is also practiced by other researchers" (Mohamad et al., 2015, p. 165). Given that the value obtained, following the calculation of the reliability index of the research instrument, is within a limit practiced in research and which is also estimated to be improved by adjusting two questions, for the experimental research, we consider the instrument as a reliable one.

Estimate	Cronbach's α	Guttman's λ2	Guttman's λ6
Point estimate	0.639	0.698	0.837
95% CI lower bound	0.414	0.405	0.784
95% CI upper bound	0.797	0.846	0.961

Table V.2. The questionnaire reliability indexes

Quantitative data analysis by the test method

The knowledge test, available in Appendix 2, contains 8 questions through which students' notions of musical notation and a number of elements of musical language are assessed. The test was applied at the end of the intervention, when 23 students (N=23) were present at the school. According to the evaluation grid, at the base of the knowledge test and as shown in Table V.3., 14 students obtained the grade "Very good" (60.87%), 7 students obtained the grade "Good" (30.43%) and 2 students , "Satisfactory" (8.70%). Students’ results are consistent, with the majority of students (91%) rated as "Good" and "Very Good". Consistency is a factor of reliability, and the knowledge test has this characteristic. In the same category, of instrument reliability, "it should be noted that the reliability of an instrument is closely associated with its validity. An instrument cannot be valid unless it is reliable" (Tavakol & Dennick, 2011, p. 53). These results of the evaluation of the tool as well as of the evaluation of the students using the tool, allow the verification of the validity of the knowledge test in the sense that they are satisfactory results that encourage us to carry out the research, in an experimental setting, on an extended sample.

Calificativ	Freqency	Percent	Valid Percent	Cumulative Percent
Very Good	14	60.870	60.870	60.870
Good	7	30.435	30.435	91.304
Satisfactory	2	8.696	8.696	100.000
Missing	0	0.000		
Total	23	100.000		

Table V.3. The frequency of grades obtained in the knowledge assessment

The conclusions of the pilot research

At the end of the pilot research, conclusions can be established about the potential impact that the intervention may have on the group and the experimental approach. In conclusion, the records collected through the research instruments used provide useful information for their validation and for the potential of the intervention program. Thus, the research questions, the hypotheses and the research tools were tested, the pilot research being of real use in obtaining a complete and valid picture of the implementation of the research tools. Regarding the intervention program *Music and Programming in School Context – Little Amateur Musicians, Great Digital Artists*, the pilot research facilitates an easier implementation of it in the experimental study. As regards the testing of the hypotheses of experimental research, pilot research predicts expected results. The completing of the observation of the educational phenomena determined by the intervention program, within the pilot research, leads to the reflections presented and leads us to take the research hypotheses to the basis of an experimental research.

V.1.2. The Results of the Pre-test of the Dependent Variables

Interpreting the questionnaire results through the comparative analysis of the experimental and control groups in the pre-experimental stage

The experimental research is, at this stage, in the first week of the 2021-2022 school year didactic activities, the first hour allocated to the object *Music and Movement* being the moment when the questionnaire and the knowledge test were applied to establish the level of starting competence for the two groups, the control and the experimental ones.

Since the results of the two groups are congruent and the same tendency prevails in the pre-experimental stage,for all 9 questions of the questionnaire, an example being presented in Table V.4., they will be analyzed comparatively in the post-experimental stage.

Group	Item-6	Freqency	Percent	Valid Percent	Cumulative Percent
Control group	Over 10	4	5.797	5.797	5.797
	6-10	5	7.246	7.246	13.043
	3-5	7	10.145	10.145	23.188
	1, 2	13	18.841	18.841	42.029
	0	40	57.971	57.971	100.000
	Missing	0	0.000		
	Total	69	100.000		
Experimental group	Over 10	6	7.317	7.317	7.317
	6-10	2	2.439	2.439	9.756
	3-5	4	4.878	4.878	14.634
	1, 2	20	24.390	24.390	39.024
	0	50	60.976	60.976	100.000
	Missing	0	0.000		
	Total	82	100.000		

Table V.4. The consistency of musical improvisation, among students, through the annual frequency of their own melodic creations

Pre-test: test results of testing the initial level of knowledge in music theory

The configuration of the research tool presents 8 tasks to be solved, structured in 8 items presented in Appendix 2. If in terms of the limits of the groups presented in Table V.5., the values are identical, but the central tendency differs for each group, in terms of mean, median and mode. Therefore, the mean score obtained by the experimental group (M_{GE1}=3.60) is noticeably lower than the mean score obtained by the control group (M_{GC1}=4.29), of interest in this case being whether the difference is significant.

	Control group	Experimental group
Valid	73	82
Missing	5	5
Mode	4.000	3.000
Median	4.000	3.500
Mean	4.288	3.598
Std. Deviation	1.438	1.617
Minimum	1.000	1.000
Maximum	7.000	7.000

Table V.5. Descriptive statistical analysis of test results from the pre-experimental stage

In order to compare the two groups, the *Independent Samples t Test* facility provided by JASP, the statistical interpretation program selected for quantitative data analysis was used. When applying the knowledge test, there was no indication to see which group's results will be better, which is why this type of analysis is a non-directional one (*two-tailed test*), at the end of which the results could vary in any direction.

In two-tailed test configuration with a significance level of .05 and 153 degrees of freedom (relative to the number of participants), the critical value is 1.984, which can be either positive or negative, depending on the position of the groups in the comparative analysis. So any t-test value above 1.984 will indicate that one of the groups is statistically significantly different from the other group.

Independent Samples T-Test

						95% CI for Mean Difference	
	t	**df**	**p**	**Mean difference**	**SE difference**	**Lower**	**Upper**
Values	2.793	153	0.006	0.690	0.247	0.202	1.178

Note. Student's t-test.

Table V.6. Analysis of the difference significance in the initial level of knowledge between the groups, by means of the *t-test*

The results of the initiated analysis, presented in Table V.6., return a value of 2.793 for the *t-test*. This result, t(153)=2.793, exceeds the critical value of 1.984, showing statistically significant differences. All *t-test* result values indicate the same thing: the means of the two groups, shown graphically in Figure V.1, differ statistically significantly at the start of the intervention. So, *the initial level of knowledge of the control group (M_{GC1}=4.29, SD_{GC1}=1.44) differs significantly from that of the experimental group (M_{GE1}=3.60, SD_{GE1}=1.62), at a value of t(153)=2.793 for the t-test , with a probability p=.006.*

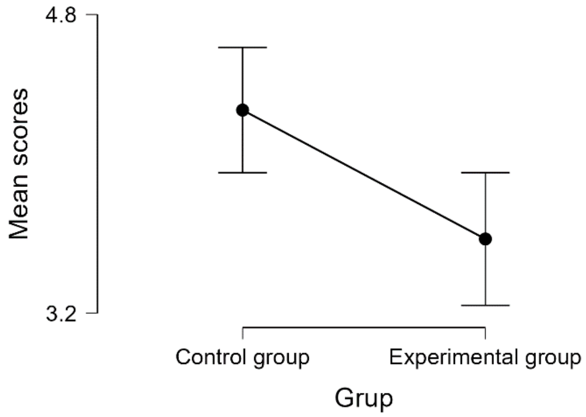


Figure V.1. Comparative statistical graph of the two groups mean scores in the pre-test stage

V.2. The Results Obtained in the Post-experimental Stage

V.2.1. Post-test Results for the Dependent Variables

Quantitative analysis of the questionnaire results by comparing the research groups between the pre-experimental and post-experimental stages

At the end of the application of the intervention carried out in the *Music and Movement* classes, in the 4th grade, to ensure that the results are statistically comparable to those of the previous stage, the same questionnaire was applied. If for the control group there are no notable changes between the two stages of the experiment, within the experimental group a different and contrasting tendency of the responses is noticed. For example, with 71 answers for *Yes* and only 6 answers for *No*, in the post-experimental stage, as represented in the graphs of the Figure V.2., the majority of students in the experimental group claim that they now possess the musical improvisation skill that is based on electronic sound generation techniques.

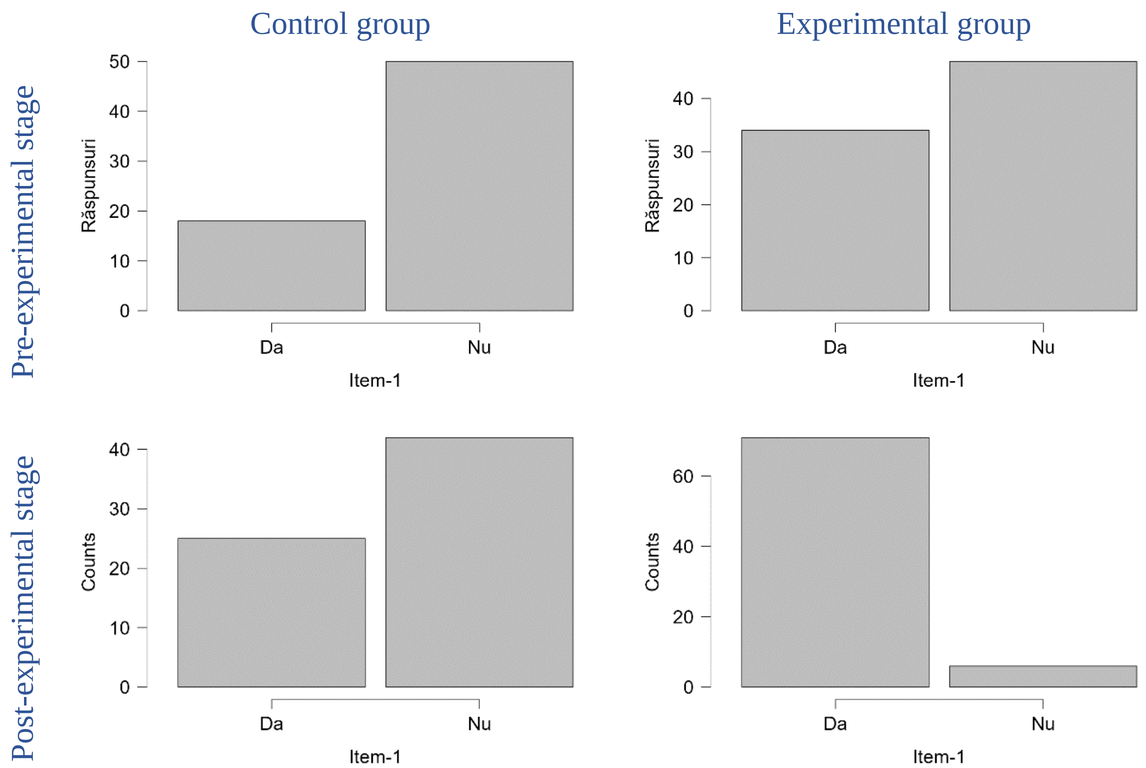


Figure V.2. Representation of the students' opinions distribution from the pre-experimental and post-experimental stages on their own abilities to improvise songs using the computer

Following students' musical creativity, another questionnaire item investigates the creativity of ideas when computer programming is involved. In this sense, as Figure V.3. also reflects, a considerable sample from the experimental group, after the experiment, believes that the programming supports the creative expression of ideas through music, with 65 answers for *Yes*, which means a substantial increase compared to the pre-experimental stage, where 34 responses were recorded for this option. The registered changes in the opinions, respectively the experiences of the experimental group are evident and in contrast with those of the control group where the results obtained have a similar distribution between the two stages of the experiment.

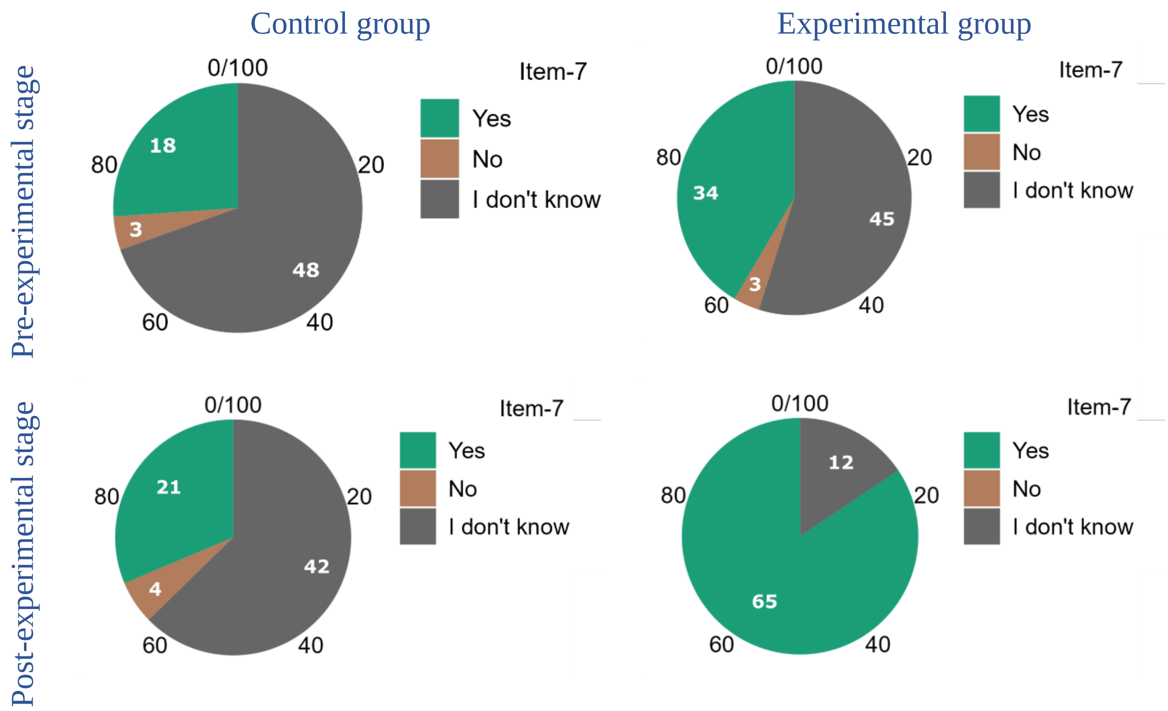


Figure V.3. Distribution of answers in terms of programming as a propellant of creative expression of ideas through music

The same way, all the answers analyzed, regarding the questions which concerned components of experiences, ideas, feelings expressed through music and determined by the teaching-learning process which the research subjects took part in, different tendencies and behaviors can be distinguished between the groups of participants, which indicates that the level of development, on the component of the general competence *Expressing ideas, feelings and experiences through music and movement, individually or in group (G.C. 3), is significantly improved in the case of the experimental group, after the formative experiment*. Thus, secondary hypothesis no. 3 (S.H. 3) is correct and is confirmed.

For the secondary hypothesis S.H. 3 to be clearly validated, we will proceed to calculate a correlation between the scores obtained by the research subjects on two questions from the two different categories by which the answers to the questionnaire were classified, questions 1 and 6, addressing the assessment of the competence *Song improvisation, associated with body movements* (S.C. 3.3.), and the other questions addressing the assessment of the competence *Expressing ideas, feelings and experiences through music and movement, individually or in* *group* (G.C. 3). Thus, question 1 was selected from the first category, and question 7 from the second category, and because we will measure the strength and direction of a relationship between two variables of the questionnaire and, at the same time, two dependent variables in the research, we will use the *Pearson correlation*.

In establishing the level of significance, it will be taken into account that the relationship can be both positive and negative, which marks a non-directional analysis. In this case, for a significance level of 5% (α=.05), with 142 degrees of freedom, the critical value is VC=1.984. From Table V.7. it is to be observed that the two variables of the questionnaire are positively correlated, both evolving in the same direction. *SC 3.3. is directly correlated with C.G. 3., at a value of the correlation coefficient r(144)=0.424, with a probability p < .001, which indicates that the analyzed correlation is statistically significant.*

Pearson's correlation

			N	Pearson's r	p
Item-1	-	Item-7	144	0.424***	< .001

* p < .05, ** p < .01, *** p < .001

Table V.7. Correlation analysis between dependent variables, by *Pearson Correlation*

The results obtained are subject to normality because the specific competence *Song improvisation, associated with body movements* (S.C. 3.3.) is theoretically a form for *Expressing ideas, feelings and experiences through music and movement, individually or in group* (G.C. 3), being derived from it. At the same time, this in-depth analysis of the data through the correlation of the variables reveals a relationship between the cognitions, concentrated in the form of the C.G. 3 competence and concrete behaviors aimed at improvising songs (S.C. 3.3.). *In conclusion, it can be stated that the secondary hypothesis S.H. 3 is confirmed.*

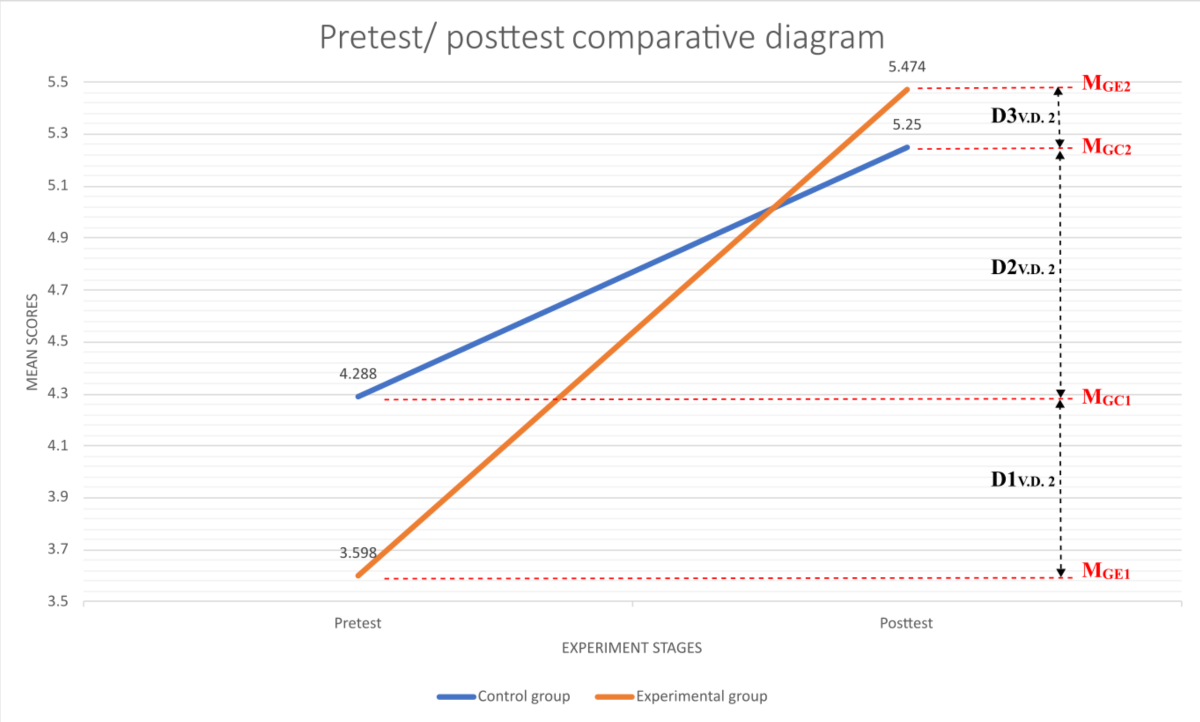
The quantitative analysis of the knowledge test results

The research subjects were tested at the end of the intervention, during the last lesson, using the same knowledge test that was also applied in the pre-test stage.

	Control group	Experimental group
Valid	68	76
Missing	10	11
Mode	6.000	6.000
Median	5.000	6.000
Mean	5.250	5.474
Std. deviation	1.559	1.259
Minimum	1.000	2.000
Maximum	8.000	7.000

Table V.8. Descriptive statistical analysis of the test results from the post-experimental stage

As can be seen from the data presented in Table V.8., although none of the students of the experimental group obtained the maximum score (8 points), the average score of the experimental group of 5.474 (M_{GE2}=5.474) is higher than the average score of the control group, its value being 5.250 (M_{GC2}=5.250).



Legend:

D1$_{V.D.2}$**, D2**$_{V.D.2}$**, D3**$_{V.D.2}$: measured differences for the dependent variable V.D. 2 (level of development of specific competence C.S. 1.2., *Correlation of pitches and values of notes and pauses with musical notation*)

Figure V.4. Comparative diagram of the mean scores obtained by the research groups in the pre-test and post-test stages

The comparison chart in Figure V.4. presents synthetically the 4 levels of development (M_{GE1}, M_{GC1}, M_{GC2} and M_{GE2}), which correspond to the average scores obtained by the two groups in the pre-test and post-test stages and between which 3 differences on the measured levels of development ($D1_{V.D.2}$, $D2_{V.D.2}$ and $D3_{V.D.2}$) are established. In order to check if there is effectiveness following the intervention carried out and if it produces significant statistical differences, statistical comparison will be used by *t-test* of the statistical difference between the obtained means.

So the first difference recorded is $D1_{V.D.2}$, which is, in fact, the difference recorded for the initial level of knowledge between the two groups and analyzed in the pre-test stage, where it was established that *the initial level of knowledge of the control group (M_{GC1}=4.29, SD_{GC1}=1.44) differs significantly from those of the experimental group (M_{GE1}=3.60,*

SD_{GE1}=1.62), at a value of t(153)=2.793 for the t test, with a probability p=.006. Therefore, as the experimental group recovered this initially recorded difference, the analysis carried out signals that the dependent variable D.V. 2 changed significantly after the intervention has been completed.

Comparative analysis of control group test results between pre-test and post-test

The second difference $D2_{V.D.\ 2}$ marked in the comparative diagram, coincides with the difference between the scores obtained by the control group between the first two stages of the experiment. Because there are reasons to predict an increase in the school performance of the students, since the post-test occurs following an instructive-educational process, the analysis carried out is a directional one (*one-tailed test*), at the end of which increasing results are expected. The critical value (CV) for a significance level of 5% (α=.05) and 139 degrees of freedom (*d*f=139), is ±1.660.

Independent Samples T-Test

	t	df	p	Mean difference	SE Difference
Values	-3.813	139	< .001	-0.962	0.252

Note. Student's t-test.

Table V.9. Significance analysis of the difference in the control group average scores, in the pre-test and post-test stages, by means of the *t-test*

In the results of Table V.9., + or – are interpreted the same, the symbols only showing that the ratio of an average from one stage reported to the average from the other stage is lower or higher than the compared value. Therefore, *the results of the analysis indicate that the knowledge level of the control group, in the post-test stage (M_{GC2}=5.250), is significantly higher than the initially established level, in the pre-test stage (M_{GC1}=4.29), at a value of the test t of t(139)=-3.813 which represents a progress made, to the same extent, by the experimental group*. Added to the originally calculated difference, $D1_{V.D.\ 2}$, the experimental group recovers the deficit in the development of the measured competence and reaches the level of the control group.

The level of development of the competence S.C. 1.2., measured for the control group in the post-test stage and calculated at the mean of the scores obtained in the knowledge test (M_{GC2}=5.250), is the maximum achieved by this group of subjects, but the experimental group obtained a higher mean score (M_{GE2}=5.474), the difference between the two values being denoted by $D3_{V.D.\ 2}$ and interpreted in the following.

Comparative analysis between experimental and control groups, in the post-test stage

Since the theoretical considerations of the present research, related the role of digital technologies in the achievement of music education as well as the formative valences of the integrated music-programming approach, predict differences in a certain direction, in favor of the experimental group, the ongoing analysis will be a directional one (*one-tailed test*). The critical value (CV) at the intersection of $df=142$ with $\alpha=.05$, in the *Student's t-Distribution* table (Federighi, 1959), is ±1.660.

Independent Samples T-Test

	t	df	p	Mean Difference	SE Difference
Values	-0.951	142	0.172	-0.224	0.235

Note. Student's t-test.

Table V.10. Analysis of the significance between the means of the groups, in the post-test stage, by the *t-test*

After the evaluation of the mean scores obtained by the research groups in the post-test stage and presented in Table V.10., no significant differences were found, the *t test* value $t(142)=-0.951$ not exceeding the critical value (CV=±1.660) obtained by calculation. Therefore, the difference $D3_{V.D.2}$ recorded in favor of the experimental group in the post-test, although not a significant one, is not necessary for validating the secondary hypothesis S.H. 2, because it was tested bidirectionally, at both extremes of the evolution of the experimental group, targeting both the remedial nature of the accomplished intervention, through the difference $D1_{V.D.\,2}$, which is a significant one, and the school performance after completing the intervention, reflected by the difference $D3_{V.D.2}$. Therefore, the difference $D2_{V.D.2}$ in the level of development of the measured competence, between the two stages of the experiment, is common to both groups, but what is not common to them and is specific only to the experimental group are the differences $D1_{V.D.2}$ and $D3_{V.D.2}$. *The difference $D1_{V.D.2}$ being a statistically significant one, the secondary hypothesis S.H. 2 is confirmed, and $D3_{V.D.\,2}$ is a bonus that the intervention program brings to the subjects involved in its activities*.

Comparative analysis of the experimental group results between pre-test and post-test

The present analysis reflects the entire evolution of the experimental group after the application of the intervention program. Since one of the research objectives (O1) was the design of an intervention program that addresses digital competence on the object *Music and Movement*, to support the development of specific competences in primary school music education, the direction of the students' results can be predicted, in a positive sense, so that the analysis carried out will be a directional one (*one-tailed test*). For a significance level of 5% (α=.05) and 156 degrees of freedom (*d*f=156), *Student's t-Distribution* (Federighi, 1959) specifies a critical value (CV) of ±1.660.

Independent Samples T-Test

	Test	Statistic	df	p	Mean Difference	SE Difference	Cohen's d
Test	Student	-8.093	156.000	< .001	-1.876	0.232	-1.289
Values	Welch	-8.169	151.600	< .001	-1.876	0.230	-1.295

Note. Student's t-test; Welch test.

Table V.11. Significance analysis of the difference in the mean scores of the experimental group, in the pre-test and post-test stages, by means of the *t-test*

The results from Table V.11. were presented through two distinct analysis of the significance of the difference in mean scores: the common analysis of the *t-test* (Student's t-test), as well as the Welch test, because the results, in this variant, are not affected by the variations of some samples of subjects that are not equal, which represents a thorough and deeper analysis of the data. Thus, the difference between the two tests lies in the degrees of freedom (df) which, in the case of the Welch test, are estimated based on an equation, and that is why the calculated value is a rational number, not an integer one. As regarda the obtained results, in both variants of the analysis the statistical value of the *t test* exceeds the limits of the critical value, so we may, in conclusion, state that *the level of development measured for V.D. 2, in the post-test stage for the experimental group (M_{GE2}=5.474, SD_{GE2}=1.259), is significantly higher than the initially established level, in the pre-test stage (M_{GE1}=3.598, SD_{GE1}=1.617), at a t-test value of t (156)=-8.093, with a probability p=.001*. The results obtained by applying the knowledge test are congruent to those obtained following the application of the questionnaire, both being convergent to the same truth value of the general hypothesis and which is, thus, confirmed based on the existing experimental data.

V.2.2. Qualitative Analysis of Student Expression through Music and Programming in the 4th Grade School Context

Complementary to the results analysis of the two groups, following the questionnaire applied in the post-experimental stage, the observations made on the students in the experimental group were analyzed, their behavior and evolutions being treated as descriptors of the results obtained by applying the questionnaire. All this set of didactic measures carried out with the occasion of the intervention and especially their effects on the students' behavior, which competed for the development of general and specific skills in the object *Music and Movement*, in the case of the experimental group of 4th grade students, have been analyzed at the end of the intervention, in the post-experimental stage. Therefore, the systematic observation through the observation sheet captures the influences of the intervention program, an example being presented in Table V.12., on the development of students according to the educational requirements specified by the school curriculum that is applied to the object *Music and Movement*.

Observation sheet - *Music and Programming in School Context - Little Amateur Musicians, Great Digital Artists* intervention program **Observation frame: 4th grades B, C & G** **Observer: Marius Bănuț** **The role of the observer: participant observer** **Period of time: September 19, 2021 – March 31, 2022**	
The framework and context of the implementation of the intervention program activities **--** **Descriptive notes**	**Expressing ideas, feelings and experiences through the independent variable** **--** **Reflection notes**
October 21, 2021 – Lesson 5 For adapting the learning to their universe of knowledge, it was explained to the students that by learning programming languages, they will be able to create computer games, but, necessarily, they must provide a song along with them. In this context, it was presented to the students the song of the old video game Super Mario Bros, a song reproduced with the Sonic Pi application.	Although the game is quite old, from 1983, the character is still alive and the students showed reactions of amazement and joy when they heard the song, knowing it and standing up to move by the rhythms of the song. The moment represented a spontaneous and natural reaction of the students, in which they associated the music with the movement, the expressive manifestation of the students, related to the observed competence, being realized through music and in group.

Table V.12. Notes from the observation sheet, from the stage of the actual experiment

This observation sheet compares the reflective notes to the descriptive ones, so that the recorded data reflect the cause-effect relationship between the application of the intervention program and the dependent variables of the research. The descriptive notes reflect pedagogical facts that guided the learning activities towards the fulfillment of the predetermined objectives and taken from the school curriculum of the object *Music and Movement*. The reflection notes represent a series of qualitative data regarding the development of the competence *Expressing some ideas, feelings and experiences through music and movement, individually or in group* (G.C. 3) and *Song improvisation, associated to body movements* (S.C. 3.3). The notes taken during the systematic observations explain and confirm the results of the questionnaire applied in the post-experimental stage, *which affirms the validity of the secondary hypotheses S.H. 1 and S.H. 3*.

V.2.3. Qualitative Analysis of the Students' Activity Products during the Experimental Intervention

The ranking of the contest "The Best Music Producer in the School" meant, at the same time, a first analysis of the students' activity products. The use of programming languages to create an audio-digital product, according to the ranking presented in Table V.13., is a skill that can be developed to girls to the same extent as to boys, in the present case the first three positions of the ranking being occupied by the students of female gender. Didactic gamification, being introduced with the aim of motivating students for learning, achieved its objective, with all students being involved in the dynamics of changing the ranking, based on scores, from one stage to another.

Class	Gender	Acronym names	Match 1 Artist pseudonym	Match 2 A, a, a, Acum e toamna da!	Match 3 Song improvisation	Match 4 Song improvisation	Match 5 Luck	Match 6 Team songs	Match 7 The secret sentence	Match 8 DJ diploma	Match 9 Class melody	Match 10 Difference between staves	Match 11 Song improvisation	Bonus: Debugging	TOTAL
IV G	F	M. O.			4	8		4			7	1	8		**32**
IV G	F	M. P.	5					4		4	7		10		**30**
IV C	F	Ș. S.	2		4	8		4		10					**28**
IV G	B	C. D.	2	10				4		4	7				**27**
IV B	B	C. D.	2	10				4	3		4				**23**
IV G	B	N. R.	2							4	7		8		**21**
⋮															**⋮**

Table V.13. Gamification scores and overall ranking of "The Best Music Producer in the School" contest

The materials created by the students were saved, structured and published on the Wakelet platform (Bănuț, 2021). By processing the object of study, starting from the school curriculum, operational knowledge for contents such as: sound parameters, their differentiation, rhythm, tempo, timbre, dynamics etc., were integrated into the audio products. Within each lesson, the stave of a song such as *Podul de piatra, Azi, Grivei e mânios* etc. was processed, according to the annual planning, so that the elements of musical notation were correlated to the conceptual knowledge behind the symbols on the stave, which the step to musical improvisation was made from. Therefore, the products of the students' activity are artifacts with positive value as results of the instructive-educational process which they took part in and which helped them to develop academically, even more, in some cases to surpass themselves in the realization of aesthetic education, as part of the artifacts created by them are delightful creations.

Based on the game of musical creation, a level of development has been reached where primary school students know basic programming concepts, and this knowledge allows them to contextualizedly operate with these concepts. The creation made by a subject of the experimental group, from 4th grade G class and published in the product portfolio under the name *Etapa11-4G-MoPa*, is an eloquent example of digital competence training and development.

```
use_synth :pretty_bell
use_bpm 20

in_thread do
  loop do
    sync :cindele
    sample :drum_snare_soft
  end
end

define :versul_unu do
  play_pattern_timed [60,60,72], [0.5,0.5,1]
  wait 0.25
end

define :versul_doi do
  play_pattern_timed [60,62,64,65], [0.5,0.5,0.5,1.5]
  wait 0.25
```

```
end

define :versul_trei do
  play_pattern_timed [67,62,60.71], [0.5,0.5,0.5,1]
  wait 0.25
end

3.times do
  versul_unu
  versul_doi
  versul_trei
end
```

Although the presented code is a synthetical one, it condenses and exposes a number of programming structures in only 30 lines of code, such as: loop (loop **do** […] **end**), repetitive structure (3.times **do** […] **end**), threads (in_thread **do** […] **end**), functions (define :versul_unu **do** […] **end**) or list type data structure (**[**60**,**60**,**72**]**, **[**0.5**,**0.5**,**1**]**). The analysis of the products portfolio made by the students constitutes an assessment of the computational thinking development in which a personal idea is transposed into a musical program and denotes an internal growth in terms of digital and transversal skills, to which the unplugged activities included in the contents of the didactic process also contributed.

At the same time, the music creation game involves the application of knowledge specific to the music field, the final product created as a result of the learning activity incorporating elements such as tempo (use_bpm 20), exploring values from the extremes of the execution speed of a musical work or the instrumental timbre of sounds through the use of synthesizers (use_synth :pretty_bell). All these musical creations are products that can determine learning situations corresponding to the realization of accompaniment through body percussion, and directly observing this creative process, the development of the competence *Song improvisation, associated to body movements* (S.C. 3.3) can be attributed to the application of the intervention program *Music and Programming in School Context – Little Amateur Musicians, Great Digital Artists*, confirming S.H. 1.

Summarizing, observing the conduct of the experiment and analyzing the products of the students' activity, we may say that the intervention program can be a powerful source of nurturing cognitive processes centered on the students’ expression in particularly creative ways. Precisely in this sense, "the use of the digital portfolio in combined forms - with pieces prepared individually, but also collaboratively, in different curricular areas or fields, with different evaluation objectives, is an example of harnessing the potential of digital technologies to contribute in building a complex picture of the competences acquired by students, including the metacognitive ones" (Popa, 2020, p. 288), proving the functionality of the music-programming integrated education model, beeing created an efficient learning environment with the valorization of the educational potential of the discipline by stimulating musical creativity.

V.3. The Results Obtained in the Retest Stage

V.3.1. Results of the Retest on the Acquisitions Solidity Determined by the Intervention Program

Retest: quantitative analysis of the knowledge test results, distant in time from the end of the intervention

The research is now in the last week of the 2021-2022 school year, 10 weeks away from the end of the intervention, when the knowledge test for the two groups of the experiment came back. The period of time of 10 weeks was the maximum that could be established between the post-test and retest stages, given the fact that the intervention was carried out over 24 weeks of school, to ensure an impactful teaching-learning process, as well as of the fact that the subject groups were tahen from the 4th grade pupils, at the end of which the class-samples will dissolve.

	Control group	Experimental group
Valid	71	82
Missing	7	5
Mode	6.000	4.000
Median	6.000	5.000
Mean	5.155	5.280
Std. Deviation	1.687	1.509
Minimum	2.000	1.000
Maximum	8.000	8.000
25th percentile	4.000	4.000
50th percentile	6.000	5.000
75th percentile	6.000	6.750

Table V.14. Descriptive statistical analysis of test results from the retest stage

As can be seen in Table V.14, the mean score of the experimental group of 5.280 (M_{GE3}=5.280) is higher by 0.125 points than the mean score of the control group, its value being 5.155 (M_{GC3}=5.155). The evolution in time of the two groups is presented, through a comparison diagram, in Figure V.5.:

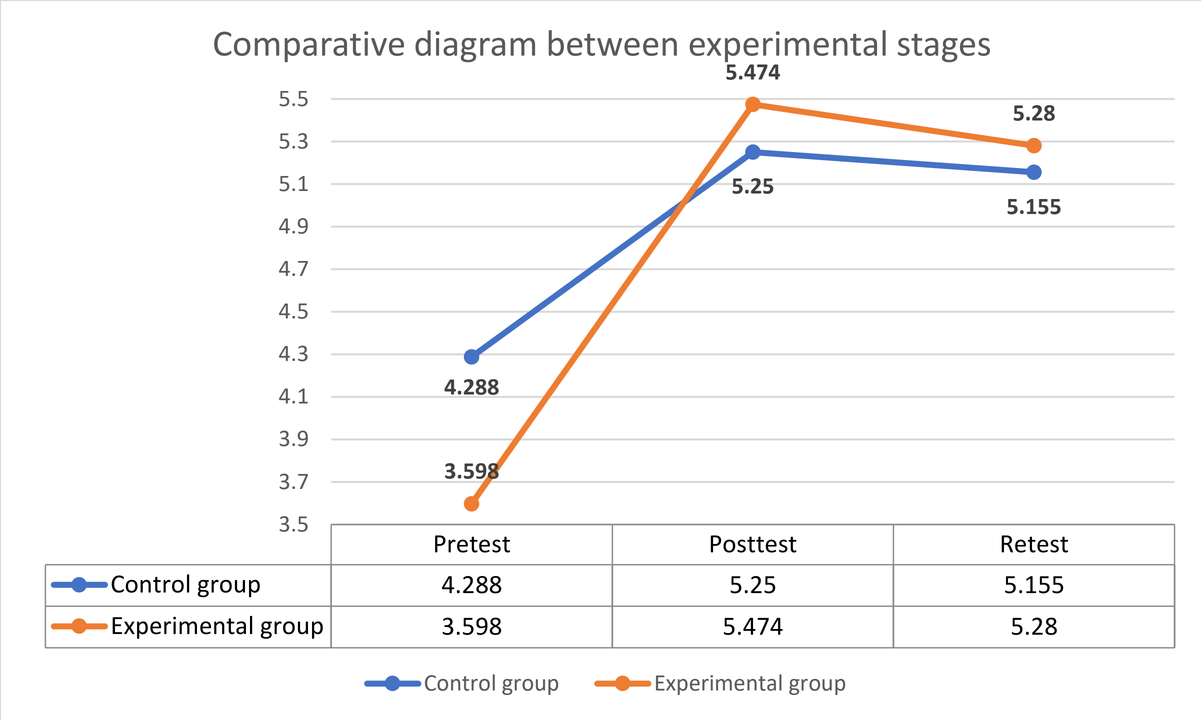


Figure V.5. Comparative diagram of the mean scores obtained by the research groups in the pre-test, post-test and retest stages

Comparative analysis of the experimental group results between post-test and retest

For the retest stage, when it was found that both groups obtained a sensible lower score than in the post-test stage, it is of interest if this difference between the stages is statistically significant, in order to appreciate the stability in time of the verified knowledge. In this sense, the results of the experimental group obtained in the last two test stages were compared, through a *t-test*. At the time of test applying, in the retest stage, no direction could be seen in which the results would evolve, given the fact that, from the end of the intervention period, until the end of the school year, the students in the experimental group returned to the traditional teaching of the object *Music and Movement*. In this case, the initiated analysis is a non-directional one (*two-tailed test*), both possibilities having a probability rate, that the students will register a regression due to the lack of activities they took part in during the intervention, which proved its effectiveness or for students to make progress, by consolidating knowledge or making new connections with previously acquired knowledge. The critical value, for a significance level of 5% (α=.05) and 156 degrees of freedom (If=156), is ±1.984.

Independent Samples T-Test

	t	df	p	Mean difference	SE Difference
Values	0.870	156	0.386	0.193	0.222

Note. Student's t-test.

Table V.15. Significance analysis of the difference between the means of the experimental group, between the post-test and retest stages, by means of the *t-test*

The results of the comparative analysis in Table V.15. presents the calculated value of the *t-test* of 0.870, which does not exceed the critical value established for noting some significant statistical differences, also the significance level not being reached, at a calculated probability of .386. Therefore, *the mean of the scores obtained by the experimental group, in the post-test stage (M_{GE2}=5.474, SD_{GE2}=1.259), does not differ significantly from the mean obtained by the same group in the retest stage (M_{GE3}=5.280, SD_{GE3}=1.509), at a value of t(156)=0.870 for the t-test, with a probability p=.386, which demonstrates the preservation, over time, of the knowledge accessed during the intervention*. In this regard, it can be stated about the general hypothesis not only that the application of the *Music and Programming in School Context - Little Amateur Musicians, Great Digital Artists* intervention program, in the study of the object *Music and Movement* in the 4th grade, contributes to the efficient development of students competences, but also that this development is enduring.

V.3.2. The Analysis of the Intervention Program Effect Size over the Experimental Group

The comparative analysis of the experimental group results, between the pre-test and the post-test, shows a significant increase, and then between the post-test and the retest, it shows the preservation over time of the knowledge assimilated during the intervention. Consequently, the learning activities designed and carried out within the psychopedagogical experiment had an effect on the students' development, through the prism of the monitored dependent variables, but for an extended perspective over the results of the empirical investigation approach, the magnitude of the intervention effect is of interest, that is why it was proceeded to calculate the effect size, through the *Cohen's d* index.

Independent Samples T-Test

	t	df	p	Mean Difference	SE Difference	Cohen's d
Values	-6.890	162	< .001	-1.683	0.244	-1.076

Note. Student's t-test.

Table V.16. The magnitude of the intervention effect, calculated by the *Cohen's d* index

Table V.16. presents the magnitude of the intervention effect on the experimental group, calculated between pre-test and retest by *Cohen's d* index, the value of which is -1.076. The negative meaning obtained as a result of the calculation does not have implications on the size of the effect, as it is determined by the means of examining the two scores, more precisely by which of the group means was chosen first for comparison. It is understood that the references to the magnitude of the effect apply equally to negative and positive values, in the present case the significant progress of the experimental group, compared to the control group, being established by the comparative analysis between the stages of the experiment, carried out previously.

According to McLeod (2019), a large intervention effect size will be suggested by a *Cohen's d* index value above 0.8. Therefore, *the calculated value (d=-1.289) exceeding the reference value for a significant magnitude, it can be stated that the effect size of the intervention is large*, and the difference achieved by the experimental group, between the pre-test and retest stages, in addition to the fact that it is significant, it is valuable and it cannot be neglected.

V.4. The Conclusions of the Experimental Research

Through this research, it was aimed to determine the implications of the digital technologies application for improving the teaching-learning process in primary education, by using computer programming as a means of creation in a specific school context, that of the object *Music and Movement*, in the 4th grade. In the conclusions of the experimental research, at the end of the investigation of the framework outlined by the application of digital technologies in the realization of music education, the results of the research are discussed in close connection to the purpose of the research formulated in the design stage of the experiment.

The O4 objective within the research, was the analysis of the didactic efficiency of the intervention program by observing some variables (performance indicators) that should attest, among the 4th grade students, the development of general and specific competences, provided by the school curriculum for the object *Music and Movement*. Related to the research methodology, through the methodological complex used and presented, the merits and scholastic success of the students of the experimental group are recognized and highlighted, supporting, verifying and confirming the General Hypothesis (G.H.) according to which the application of the intervention program *Music and Programming in School Context - Little Amateur Musicians, Great Digital Artists,* in the teaching of the object *Music and Movement* to students of the 4th grade, contributes to the efficient development of general and specific competences. Thus, the predictions advanced by the hypothesis on the results have been confirmed, the didactic efficiency obtained through experimental intervention beeing verified, so the experimental research fulfilled its purpose.

CONCLUSIONS

The present research work proposed an integrated music-programming approach of teaching and learning of the object *Music and Movement*, and the following elements of the teaching-learning process framework briefly present the way the intervention was carried out, this being directed towards obtaining an efficient learning environment because: learning took place in a pleasant way (by gamification), information was structured (by concept maps), students benefited from the experience of a large-scale event (Eu CodeWeek) and, last but not least, the integrated approach represented an element of consistency for the formative valences of the intervention, students constantly and simultaneously using their two senses: visual (codes) and auditory (sound).

Thus, students were given the chance to express themselves musically in a way that would not have been possible in a conventional music teaching-learning setting. Audition, interpretation, routine school experiences limit the imagination, from the point of view of the human being's ability to create new ideas. Music has an increased capacity to contribute to the development of students' imagination and creativity, and the integrated approach of music with programming is an impulse that propels the imagination and places the student, within the teaching-learning process, in a creative posture, aspect desirable from the perspective of music education pedagogy.

The result of the music-programming integration fulfills the axiological function of education, valuing and developing the potential of cultural creation, resonating with the aesthetic dimension of education, to cultivate the passion for the beautiful, and pleasant and, why not, to combine the useful with the pleasant. Thus, we find another dimension of the disciplines fusion, at the level of attitudes, and a fusion towards the positive meaning of variation for each sub-dimension (pleasant, easy, useful), represents a facilitator in achieving integrated transdisciplinary learning at a young school age.

Beyond the fact that there were certain limits of the research, for example the intervention was carried out during the Covid-19 pandemic, in which the connection to the classroom was made online, through digital technologies, this mitigating to some extent the dynamics of systematic observations, the relevance of the created learning framework can be estimated in spatio-temporal terms, targeting the national educational space and the need to accomplish the educational needs of students in the short, medium and long term, as follows:

- On short term: the results obtained are relevant in relation to the possibility of teaching online or to the satisfaction of some curricular requirements for the 4th grade object *Music and*

Movement, as well as in relation to the usefulness in other contexts, extracurricular, for example, creating the background sound for songs performed during school festivals. The Sonic Pi application can be used to orchestrate the soundtrack of songs used in classroom celebrations. I propose an an imagination exercise: you are at the Christmas celebration and the students will prepare the carol *O, Christmas tree*!, both the vocal performance component and the instrumental background component. After the students' performance, parents will be asked: "*Did you like how your children have sung? What about the melody line, what do you think? Well, it was also made by your kids, in a programming language*!"

- On medium term: the students have formed a series of pre-requisites for the successful approach of a compulsory object, available through the education framework plan for the schooling level immediately following the 4th grade, the object *Informatics and ICT* and, they also accumulated a useful experience in the perspective of developing skills that count for the National Baccalaureate Exam, where digital competence is evaluated through a dedicated test.

- On long term: the digital competence development can be called an added value resulting from the application of the intervention program, which can be transposed in terms of sustainability, developing skills, for future generations, to be able to carry out activities over a long period of time, as long as the digital age will last.

The capitalization of the educational potential of the didactic music-programming product obtained at the end of this research endeavor, is transposed into the development of certain programming skills, along with the possibilities of placing these developed skills in a school context or in the current socio-cultural context, where learning music can be carried out for certain contexts: producing film music, music for video games, music for commercials etc. If "innovation is an act of transferring the result of creativity to the society in a real-life situation" (Aleinikov, 2013, p. 331), then the learning instrument which was a product of the doctoral studies, the book *Little Musicians, Great Programmers. The Integrated Music-Programming Curriculum for the Digitalization of the Didactic Process* (Bănuț, 2022), which became available to the general public, is part of the didactic innovation efforts, being a result of creativity transferred to society. This is a feature, in terms of the sustainability of the research activity within the doctoral thesis, which provides, for future generations of students, a means of learning music through computer programming and learning computer programming through music, connecting the teaching-learning process to the current and future reality, which the students are and will be part of.

BIBLIOGRAFIE

1. Aaron, S., & Blackwell, A. F. (2013). From sonic Pi to overtone: creative musical experiences with domain-specific and functional languages. In *Proceedings of the first ACM SIGPLAN workshop on Functional art, music, modeling & design* (pp. 35-46). http://dx.doi.org/10.1145/2505341.2505346
2. Aaron, S. (2016). Sonic Pi–performance in education, technology and art. *International Journal of Performance Arts and Digital Media, 12*(2), 171-178. http://dx.doi.org/10.1080/14794713.2016.1227593
3. Aaron, S., Blackwell, A. F., & Burnard, P. (2016). The development of Sonic Pi and its use in educational partnerships: Co-creating pedagogies for learning computer programming. *Journal of Music, Technology & Education, 9*(1), 75-94. https://doi.org/10.1386/jmte.9.1.75_1
4. Agostini, R. (2020). Rock around Sonic Pi. *Servizio Marconi - Tecnologie della Società dell'Informazione*. IC9 Bologna.
5. Aleinikov, A. G. (2013). Creative Pedagogy. *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship*, Springer New York Heidelberg Dordrecht London. https://doi.org/10.1007/978-1-4614-3858-8_13
6. Alekseeva, L., & Usacheva, V. (2018). Improvisation in elementary and primary school musical education (Part 1). *Педагогика искусства*, (4), 200-207. http://www.art-education.ru/electronic-journal/improvisation-elementary-and-primary-school-musical-education-part-1
7. Auerbach, C. & Delport A.C. (2018). Developing mindfulness in children through participation in music activities, *South African Journal of Childhood Education* 8(1), a519. https://doi.org/10.4102/sajce.v8i1.519
8. Balanskat, A., & Engelhardt, K. (2015). *Computing our Future: Computer Programming and Coding. Priorities, School Curricula and Initiatives across Europe*. European Schoolnet, Bruselles, Belgium. http://www.eun.org/documents/411753/817341/Computing+our+future_final_2015.pdf
9. Bănuț, M (2020). *"Music and programming. Development for life and for the future" - Project*. Wakelet. https://wakelet.com/wake/MjHmKmz4ohSyRf89i8BST
10. Bănuț, M (2021). *„Muzică și programare în context școlar - Mici muzicieni amatori, mari artiști digitali"*. Wakelet. https://wakelet.com/wake/7fgh4FJGik5adcagbwWRg

11. Bănuț, M. (2022). *Mici muzicieni, mari programatori. Curriculum integrat muzică-programare pentru digitalizarea procesului didactic*. Editura Paralela 45, Pitești, România.
12. Bell, J., & Bell, T. (2018). Integrating computational thinking with a music education context. *Informatics in Education*, 17(2), 151-166. http:// 10.15388/infedu.2018.09
13. Ben-Jacob, M. G. (2017). Assessment: classic and innovative approaches. *Open Journal of Social Sciences, 5*(1), 46-51.. http://dx.doi.org/10.4236/jss.2017.51004
14. Bers, M. U., Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education, 72*, 145-157. http://dx.doi.org/10.1016/j.compedu.2013.10.020
15. Blatchford, P., Bassett, P., & Brown, P. (2005). Teachers' and Pupils' Behavior in Large and Small Classes: A Systematic Observation Study of Pupils Aged 10 and 11 Years. *Journal of Educational Psychology, 97*(3), 454-467. https://doi.org/10.1037/0022-0663.97.3.454
16. Boettcher, J. V. (2007). Ten core principles for designing effective learning environments: Insights from brain research and pedagogical theory. *Innovate: Journal of Online Education, 3*(3). Disponibil pe https://www.learntechlib.org/p/171446/
17. Bogliolo, A. (2020). *Coding in your Classroom, now! Il pensiero computazionale è per tutti, come la scuola*. Giunti Editore. ISBN 978-88-09-87254-7
18. Bosch, M., & Gascón, J. (2006). Twenty-five years of the didactic transposition. *ICMI bulletin, 58*(58), 51-65. Disponibil pe https://edisciplinas.usp.br/pluginfile.php/54469/ mod_resource/content/1/Texto%20ATD/25%20anos%20de%20ATD.pdf
19. Brennan, K., & Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. In *Proceedings of the 2012 annual meeting of the American educational research association*, Vancouver, Canada (Vol. 1, p. 25). Disponibil pe http://scratched.gse.harvard.edu/ct/files/AERA2012.pdf
20. Brown, A. R. (2007). Software development as music education research. *International Journal of Education & the Arts, 8*(6), 1-14. http://www.ijea.org/v8n6/v8n6.pdf
21. Brown, N. C., Sentance, S., Crick, T., Humphreys, S., (2014). Restart: The Resurgence of Computer Science in UK Schools. *ACM Transactions on Computing Education, 14* (2), Article Number 9, ISSN 1946-6226. https://doi.org/10.1145/2602484
22. Burnard, P., Lavicza, Z., & Philbin, C. A. (2016). Strictly coding: Connecting mathematics and music through digital making. In *Proceedings of Bridges 2016:*

Mathematics, Music, Art, Architecture, Education, Culture (pp. 345-350). https://archive.bridgesmathart.org/2016/bridges2016-345.pdf

23. Busuttil, L., & Formosa, M. (2020). Teaching Computing without Computers: Unplugged Computing as a Pedagogical Strategy. *Informatics in Education, 19*(4), 569-587. doi: 10.15388/infedu.2020.25
24. Carretero, S., Vuorikari, R., Punie, Y. (2017). *DigComp 2.1: The Digital Competence Framework for Citizens with eight proficiency levels and examples of use*. Luxembourg, Publications Office of the European Union, EUR 28558 EN. doi:10.2760/38842
25. Cass, S. (2019). Illuminating musical code: Program an electronic music performance in real time-[Resources_Hands On]. *IEEE Spectrum, 56*(09), 14-15. doi:10.1109/MSPEC.2019.8818581
26. Cassidy, G., & MacDonald, R. (2009). The effects of music choice on task performance: A study of the impact of self-selected and experimenter-selected music on driving game performance and experience. *Musicae Scientiae, 13*(2), 357-386. https://doi.org/10.1177/102986490901300207
27. Catalano, H. (2021). Designul strategiilor didactice din perspectiva instruirii online, în Ion Albulescu, Horațiu Catalano (coord.), *e-Didactica. Procesul de instruire în mediul online*, Didactica Publishing House, București, pp. 91-120.
28. Coffey, J. W. (2015). Concept mapping and knowledge modeling: a multi-disciplinary educational, informational, and communication technology. *Systemics, Cybernetics and Informatics, 13*(6), 122-128. Disponibil la http://www.iiisci.org/journal/pdv/sci/pdfs/ZA404WE15.pdf
29. Comisia Europeană/EACEA/Eurydice, (2019). *Digital Education at School in Europe. Eurydice Report*. Luxembourg: Publications Office of the European Union. doi:10.2797/763
30. Comisia Europeană (2020). *Comunicare a Comisiei către Parlamentul European, Consiliu, Comitetul Economic și Social European și Comitetul Regiunilor. Planul de acțiune pentru educația digitală 2021-2027. Resetarea educației și formării pentru era digitală* (COM 2020/624 final)
31. Comisia Europeană (2021). *Europe Code Week*. https://codeweek.eu/about
32. Creswell, J. W. (2008). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*. Pearson, 3rd edition, United States

33. Davis, E. A., & Miyake, N. (2004). Explorations of scaffolding in complex classroom systems. *The journal of the learning sciences, 13*(3), 265-272. http://dx.doi.org/10.1207/s15327809jls1303_1
34. del Olmo-Muñoz, J., Cózar-Gutiérrez, R., & González-Calero, J. A. (2020). Computational thinking through unplugged activities in early years of Primary Education. *Computers & Education, 150*. https://doi.org/10.1016/j.compedu.2020.103832
35. Deterding, S. (2012). Gamification: designing for motivation. *interactions, 19*(4), 14-17. https://doi.org/10.1145/2212877.2212883
36. Devlin, K. (2014). The Music of Math Games. *The Best Writing on Mathematics,* 74–86. doi:10.1515/9781400865307-008
37. Dexonline (n.d.). Copyright © 2004-2022 dexonline [software liber]. Accesat la 03.03.2022 pe https://dexonline.ro
38. Duncan, C., Bell, T., & Tanimoto, S. (2014). Should your 8-year-old learn coding?. In *Proceedings of the 9th Workshop in Primary and Secondary Computing Education* (pp. 60-69). https://doi.org/10.1145/2670757.2670774
39. Eberhard, D., Simons, G., Fennig C. (coord.) (2021). *Ethnologue: Languages of the World*. Twenty-fourth edition. Dallas, Texas: SIL International. Disponibil pe http://www.ethnologue.com
40. ECDL România S.A. (2022). Concurs Bebras Romania. *European Computer Driving Licence*. Disponibil pe https://concurs.bebras.ro
41. Eerola, P. S., & Eerola, T. (2014). Extended music education enhances the quality of school life. *Music education research, 16*(1), 88-104. https://doi.org/10.1080/14613808.2013.829428
42. Fartușnic, C., Teșileanu, A., Horga, I., Preoteasa, L., Moșoiu, O., & Irimia, T. M. (2020). Repere pentru proiectarea, actualizarea și evaluarea Curriculumului Național, în Eugen Palade (coord.) *Cadrul de Referință al Curriculumului Național*, București.
43. Federighi, E. T. (1959). Extended tables of the percentage points of Student's t-distribution. *Journal of the American Statistical Association, 54*(287), 683-688. doi: 10.1080/01621459.1959.10501529
44. Folgieri, R., Vanutelli, M. E., Galbiati, P. D. V., & Lucchiari, C. (2019, August). Gamification and Coding to Engage Primary School Students in Learning Mathematics: A Case Study. In *CSEDU (1)* (pp. 506-513). doi:10.5220/0007800105060513

45. García-Peñalvo, F. J. (2018). Editorial computational thinking. *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje, 13*(1), 17-19. doi:10.1109/RITA.2018.2809939
46. Heinemeier Hansson, D. (2022). *Ruby on Rails - A web-app framework that includes everything needed to create database-backed web applications according to the Model-View-Controller (MVC) pattern*. Disponibil pe https://rubyonrails.org
47. Hickey, M., & Webster, P. (2001). Creative thinking in music. *Music Educators Journal*, 88(1), pp. 19-23. https://doi.org/10.2307/3399772
48. Hubwieser, P., Giannakos, M., Berges, M., Brinda, T., Diethelm, I., Magenheim, J., ... Jasute E. (2015). A Global Snapshot of Computer Science Education in K-12 Schools. *ITICSE '15: Innovation and Technology in Computer Science Education Conference 2015* (pp. 65–83), Vilnius, Lituania. Published by Association for Computing Machinery, New York, NY, United States. https://doi.org/10.1145/2858796.2858799
49. Insuasti, J., & Beardo, J. M. D. (2015). About Didactic Transposition: Teaching programming fundamentals at different levels of the school system. In *2015 International Conference on Learning and Teaching in Computing and Engineering* (pp. 91-94). IEEE. doi:10.1109/LaTiCE.2015.53
50. JASP Team (2022). JASP (Version 0.16.3) [Computer software]. Disponibil la https://jasp-stats.org
51. Jones, S. M., & Pearson Jr, D. (2013). Music: Highly engaged students connect music to math. *General Music Today, 27*(1), 18-23. doi:10.1177/1048371313486478
52. Jones, S., P., Mitchell, B., Humphreys, S. (2013). *Computing at school in the UK*. CACM Report, v5. https://www.microsoft.com/en-us/research/wp-content/uploads/2016/07/ComputingAtSchoolCACM.pdf
53. Kampylis, P., Berki, E. (2014). *Nurturing creative thinking*. Gonnet Imprimeur, Belley, France. https://unesdoc.unesco.org/ark:/48223/pf0000227680
54. Kandemir, C. M., Kalelioğlu, F., & Gülbahar, Y. (2021). Pedagogy of teaching introductory text-based programming in terms of computational thinking concepts and practices. *Computer Applications in Engineering Education, 29*(1), pp. 29-45. doi: 10.1002/cae.22374
55. Klein, J. T. (2004). Prospects for transdisciplinarity. *Futures, 36*(4), 515-526. doi:10.1016/j.futures.2003.10.007

56. Klopfenstein, L., Fedosyeyev, L., Bogliolo A. (2017). Bringing An Unplugged Coding Card Game To Augmented Reality. *International Technology, Education and Development Conference* (INTED Proceedings), Valencia, Spain, march 2017, pp. 9800-9805. doi:10.21125/inted.2017.2327

57. Klopfenstein, L. C., Delpriori, S., Maldini, R., & Bogliolo, A. (2019). CodyColor: Design of a Massively Multiplayer Online Game to Develop Computational Thinking Skills. In *Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts* (pp. 453-458). https://doi.org/10.1145/3341215.3356315

58. Koper, R. (2014). Conditions for effective smart learning environments. *Smart Learning Environments, 1*(1), 1-17. https://doi.org/10.1186/s40561-014-0005-4

59. Köksal, O., Yağışan, N., & Çekiç, A. (2013). The effects of music on achievement, attitude and retention in primary school English lessons. *Procedia-Social and Behavioral Sciences, 93*, 1897-1900. doi:10.1016/j.sbspro.2013.10.136

60. Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice, 41*(4), 212-218. https://doi.org/10.1207/s15430421tip4104_2

61. Kukul, V., & Çakır, R. (2020). Exploring the Development of Primary School Students' Computational Thinking and 21st Century Skills Through Scaffolding: Voices from the Stakeholders. *International Journal of Computer Science Education in Schools, 4*(2), 36-57. https://doi.org/10.21585/ijcses.v4i1.84

62. Laato, S., Laine, T., & Sutinen, E. (2019). Affordances of music composing software for learning mathematics at primary schools. *Research in Learning Technology*, 27. https://doi.org/10.25304/rlt.v27.2259

63. Leifheit, L., Jabs, J., Ninaus, M., Moeller, K., & Ostermann, K. (2018). Programming unplugged: An evaluation of game-based methods for teaching computational thinking in primary school. In *ECGBL 2018 12th European Conference on Game-Based Learning,* pp. 344-353. http://ps.informatik.uni-tuebingen.de/publications/leifheit18unplugged.pdf

64. Letina, A. (2020). Development of students' learning to learn competence in primary science. *Education sciences, 10*(11), 325. doi:10.3390/educsci10110325

65. Ludovico, L. A., & Mangione, G. R. (2015). Music coding in primary school. In *Smart Education and Smart e-Learning* (pp. 449-458). Springer, Cham. doi: 10.1007/978-3-319-19875-0_40

66. McLeod, S. A. (2012). *The Zone of Proximal Development and Scaffolding*. Disponibil pe www.simplypsychology.org/Zone-of-Proximal-Development.html
67. McLeod, S. A. (2019). *What Does Effect Size Tell You?* - Simply Psychology. Disponibil pe https://www.simplypsychology.org/effect-size.html
68. Ministerul Educației și Cercetării [MEC] (2020). *Strategia privind digitalizarea educației în România 2021-2027*. https://www.edu.ro/sites/default/files/SMART.Edu%20-%20document%20consultare.pdf
69. Ministerul Educației Naționale [MEN] (2014a). Programa școlară pentru disciplina *Muzică și mișcare* clasele a III-a - a IV–a și aprobată prin Ordinul MEN nr. 5003/02.12.2014, http://programe.ise.ro/Portals/1/Curriculum/2014-12/28-Muzica%20si%20miscare_clasele%20a%20III-a%20-%20a%20IV-a.pdf
70. Ministerul Educației Naționale [MEN] (2017a). Programa școlară pentru disciplina *Informatică și TIC* clasele a V-a - a VIII–a și aprobată prin Ordinul MEN nr. 3393/28.02.2017, http://programe.ise.ro/Portals/1/Curriculum/2017-progr/117-INFORMATICA%20si%20TIC.pdf
71. Ministerul Educației Naționale [MEN] (2019a). *Repere pentru proiectarea, actualizarea și evaluarea Curriculumului Național. Document de politici educaționale*. Document în consultare publică, disponibil pe https://www.edu.ro/sites/default/files/DPC_31.10.19_consultare.pdf
72. Mohamad, M. M., Sulaiman, N. L., Sern, L. C., & Salleh, K. M. (2015). Measuring the validity and reliability of research instruments. *Procedia-Social and Behavioral Sciences*, 204, 164-171. doi: 10.1016/j.sbspro.2015.08.129
73. Moreno-León, J., & Robles, G. (2015). The Europe Code Week (CodeEU) initiative shaping the skills of future engineers. In *2015 IEEE global engineering education conference (EDUCON)* (pp. 561-566). IEEE. doi:10.1109/EDUCON.2015.7096025
74. Nand, K., Baghaei, N., Casey, J., Barmada, B., Mehdipour, F., & Liang, H. N. (2019). Engaging children with educational content via Gamification. *Smart Learning Environments, 6*(1), 1-15. https://doi.org/10.1186/s40561-019-0085-2
75. Novak, J. D. & Cañas A. J. (2008). *The Theory Underlying Concept Maps and How to Construct Them*. Technical Report IHMC CmapTools 2006-01 Rev 01-2008, Florida Institute for Human and Machine Cognition. Disponibil pe http://cmap.ihmc.us/

publications/researchpapers/theorycmaps/TheoryUnderlyingConceptMaps.bck-11-01-06.htm

76. Petrie, C. (2021). Interdisciplinary computational thinking with music and programming: a case study on algorithmic music composition with Sonic Pi. *Computer Science Education*, 1-23. Disponibil pe https://doi.org/10.1080/08993408.2021.1935603

77. Pigott, D. (2021). *Online Historical Encyclopaedia of Programming Languages*. Disponibil pe https://hopl.info

78. Pillemer, D. B. (1991). One-versus two-tailed hypothesis tests in contemporary educational research. *Educational Researcher, 20*(9), 13-17. https://doi.org/10.3102/0013189X020009013

79. Pisoň, Z. (2020). The Future of Tech Startups in Central & Eastern Europe. *GLOBSEC Policy Institute*. https://www.globsec.org/wp-content/uploads/2020/10/The-Future-of-Tech-Startups-in-Central-Eastern-Europe.pdf

80. Pivec, M. (2007). Play and learn: potentials of game-based learning. *British Journal of Educational Technology, 38*(3), 387-393. doi:10.1111/j.1467-8535.2007.00722.x

81. Popa, N. L. (2021). Evaluarea performanţelor şcolare şi academice în medii educaţionale digitale, în Ciprian Ceobanu, Constantin Cucoş, Olimpius Istrate, Ion-Ovidiu Pânişoară (coord.), *Educația digitală*, Editura Polirom, Iași, pp. 286-301.

82. Popovici Borzea, A. (2017). *Integrarea curriculară și dezvoltarea capacităților cognitive*. Editura Polirom, Iași

83. Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment (CIE)*, 1(1). https://doi.org/10.1145/950566.950596

84. Proiectul CRED (2019b). Modulul II: Aplicarea noului Curriculum național pentru învățământul primar. Disciplina de studiu din perspectiva didacticii specialităţii. Disciplina Muzică și mișcare. Program de formare continuă a cadrelor didactice. Proiectul CRED – *Curriculum relevant, educație deschisă pentru toți* (cod SMIS 2014+: 118327). https://www.scribd.com/document/443475566/CRED-P-M2-suport-Muzica-si-miscare

85. Robins, A. (2015). The ongoing challenges of computer science education research. *Computer Science Education, 25*(2), 115-119, doi: https://doi.org/10.1080/08993408.2015.1034350

86. Ruiz-Bañuls, M., Gómez-Trigueros, I. M., Rovira-Collado, J., & Rico-Gómez, M. L. (2021). Gamification and transmedia in interdisciplinary contexts: A didactic

intervention for the primary school classroom. *Heliyon, 7*(6), e07374. https://doi.org/10.1016/j.heliyon.2021.e07374

87. Sarivan, L., Teșileanu, A., Noveanu G., Fartușnic, C., Horga I. (2020). Analiza Comparativă a Recomandărilor Europene Referitoare la Competențele Cheie. Proiectul CRED – *Curriculum relevant, educație deschisă pentru toți* (cod SMIS 2014+: 118327).
88. Sârb, D. E., (2019). Connections between Musical and Logical-Mathematical intelligences. *Educatia 21 Journal (17)*. https://doi.org/10.24193/ed21.2019.17.11
89. Simion, A. (2020). *Formarea identității emoționale la școlarii mici prin intermediul audiției muzicale*. Editura Casa Cărții de Știință, Cluj-Napoca, România.
90. Simion, A. (2022). *Muzica de la informativ la aplicativ*. Editura Presa Universitară Clujeană, Cluj-Napoca, România.
91. Sinclair, A. (2014). Educational Programming Languages: The Motivation to Learn with Sonic Pi. In *PPIG*, pp. 215-228. http://users.sussex.ac.uk/~bend/ppig2014/25ppig2014_submission_23.pdf
92. Smit, J., AA van Eerde, H., & Bakker, A. (2013). A conceptualisation of whole-class scaffolding. *British Educational Research Journal, 39*(5), 817-834. doi: 10.1002/berj.3007
93. Stan, E. (2021). Joc și gratuitate, în Ciprian Ceobanu, Constantin Cucoş, Olimpius Istrate, Ion-Ovidiu Pânişoară (coord.), *Educația digitală*, Editura Polirom, Iași, pp. 221-230.
94. Stigberg, H., & Stigberg, S. (2019). Teaching programming and mathematics in practice: A case study from a Swedish primary school. *Policy Futures in Education, 18*(4), 483-496. doi:10.1177/1478210319894785
95. Tafalla, R. J. (2007). Gender Differences in Cardiovascular Reactivity and Game Performance Related to Sensory Modality in Violent Video Game Play 1. *Journal of Applied Social Psychology, 37*(9), 2008-2023. https://doi.org/10.1111/j.1559-1816.2007.00248.x
96. Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International journal of medical education*, 2, 53. doi: 10.5116/ijme.4dfb.8dfd
97. Tervaniemi, M., Tao, S., & Huotilainen, M. (2018). Promises of music in education?. In *Frontiers in education* (p. 74). doi:10.3389/feduc.2018.00074
98. TIOBE Software. (2021). *The TIOBE Programming Community index*. Disponibil pe https://www.tiobe.com/tiobe-index/

99. Traversaro, D., Guerrini, G., & Delzanno, G. (2020). Sonic Pi for TBL Teaching Units in an Introductory Programming Course. In *Adjunct Publication of the 28th ACM Conference on User Modeling, Adaptation and Personalization* (pp. 143-150). https://doi.org/10.1145/3386392.3399317

100. Váradi, J. (2018). Musical education in the primary schools of Hungary, Romania, Serbia and Slovakia. *Život i škola: časopis za teoriju i praksu odgoja i obrazovanja*, 64(2), 67-75. https://doi.org/10.32903/zs.64.2.5

101. Verza, F., Bratu, M. (2021). Avantaje şi limite ale utilizării tehnologiilor moderne în predarea disciplinelor din aria STEM la elevii cu deficienţe de intelect, în Ciprian Ceobanu, Constantin Cucoş, Olimpius Istrate, Ion-Ovidiu Pânişoară (coord.), *Educația digitală*, Editura Polirom, Iași, pp. 337-349.

102. Vuorikari, R., Punie, Y., Carretero Gomez S., Van den Brande, G. (2016). *DigComp 2.0: The Digital Competence Framework for Citizens. Update Phase 1: The Conceptual Reference Model*. Luxembourg, Publication Office of the European Union, EUR 27948 EN. doi:10.2791/11517

103. Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 366*(1881), 3717-3725. doi:10.1098/rsta.2008.0118

104. Yelland, N., & Masters, J. (2007). Rethinking scaffolding in the information age. *Computers & Education, 48*(3), 362-382. doi:10.1016/j.compedu.2005.01.010

105. Yorulmaz, A., Uysal, H., & Sidekli, S. (2021). The Use of Mind Maps Related to the Four Operations in Primary School Fourth-Grade Students as an Evaluation Tool. *Journal of Education and Learning (EduLearn), 15*(2), 257-266. doi: 10.11591/edulearn.v15i2.19894

APPENDIX

Appendix 1

The questionnaire used in the experimental research

1. Can you make the computer play the piano?

a) Yes	b) No

2. In music class I would like to learn with a computer:

a) Always	b) Most often	c) Periodical	d) Occasional	e) Never

3. What would be the object where play can be used in learning? Choose one of them:

a) Mathematics	b) Romanian Language and Literature	c) Modern Language	d) Natural Sciences	e) History
f) Music and Movement	g) Visual arts and practical skills	h) Geography	i) Civic education	j) Physical education

4. How would you feel to be able to change the melodic line of a song?

a) Satisfied	b) Amazed	c) Curious	d) Fearful	e) Dissatisfied

5. What do you think it would make you feel better?

a) To listen to music	b) To produce music	c) To reproduce music (through a musical instrument or voice)

6. How many musical creations have you made in the last year?

a) 0	b) 1, 2	c) 3-5	d) 6-10	e) Over 10

7. Can music help you in learning programming or vice versa, programming in music?

a) Yes	b) No	c) I don't know

8. It happened to you or do you like to create music (melodic-rhythmic fragments) in your spare time?

a) Every weekend	b) Every month	c) 2-3 times a year	d) Once a year	e) Never

9. What is your favorite object, among those studied in the last year? Choose only one:

a) Mathematics	b) Romanian Language and Literature	c) Modern Language	d) Natural Sciences	e) History
f) Music and Movement	g) Visual arts and practical skills	h) Geography	i) Civic education	j) Physical education

Appendix 2

Knowledge test

1. What is the syllabic name of the following musical note? 

a) Do	b) Re	c) Mi	d) Fa	e) Sol	f) La	g) Si

2. The lengthening point causes the duration of the musical note to ...?

a) increase	b) decrease	c) does not change

3. Which of the following musical notes has a higher pitch?

a) La 	b) Si 

4. How many beats does the next musical note  get in $\frac{2}{4}$ measure?

a) 4 beats	b) 2 beats	c) 1 beat	d) 0.5 beats	e) 0.25 beats

5. How many beats does the measure of $\frac{3}{4}$ have? 

a) 1	b) 2	c) 3	d) 4

6. Which of the following breaks has a shorter duration:

a) The quarter break 	b) Halftime break 

7. In which of the following musical measures, the duration of the musical notes is longer?

a) $\frac{2}{8}$	b) $\frac{3}{4}$	c) $\frac{4}{2}$

8. If the tempo increases, the duration of the musical notes ...

a) increases	b) decreases	c) does not change

Assessment	
Very good	7 – 8 correct answers
Good	5 – 6 correct answers
Sufficient	3 – 4 correct answers

Appendix 3

The conceptual map with the contents of the object *Music and Movement*, processed through the intervention program