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EVALUATION OF AN INDUCTIVE STRATEGY OF TEACHING MUSIC AND PROGRAMMING TO PRIMARY SCHOOL STUDENTS

Abstract. The traditional teaching strategies have deductive characteristics, while the modern ones have inductive characteristics. But inductive teaching strategies are not always appreciated or recommended in any educational context. Therefore, the present study aimed to design an instructional setting according to the principles of an inductive strategy for teaching content that integrates music with computer programming, and to monitor the effects of teaching, on a long term, on three consecutive generations of fourth-grade students, measuring learning acquisitions through a Learning Achievement Test. In this framework, the students assimilated notions of music notation and formed concepts specific to music education starting from practical exercise, generating sounds electronically using programming languages and the Sonic Pi application, improvising melodies to learn through discovery the variability of sound parameters and reproducing songs from the children's universe, starting from their musical sheets and solving problems of fitting the qualities of sounds into a series of musical notation elements, based on the audio feedback obtained. The analysis of the effects of teaching and the concepts formed in students in the sphere of music education was carried out by measuring the relative state of learning acquisition at the end of the digital instruction based on an inductive teaching strategy, with reference to a fixed criterion: the 25th percentile. Thus, it was found that the percentage of results exceeding the 25th percentile, i.e. 75% of the sample of participants, produced variability at the upper limit of the scoring system. The context of the development of certain transferable computational thinking skills supported learning objectives in the sphere of programming and music composing, and the good results of the students show a concrete performance, and this performance, if considered in proportion to the effort put in, which was a play, a play of music making, i.e. a low effort, can be translated into a good performance and this can be attributed to the inductive teaching strategy.

Keywords: inductive teaching strategy; inductive learning; digital instruction; Sonic Pi; musical education.

1. INTRODUCTION

The problem statement. Digital technologies have become an integral part of daily life, and there is a link and interdependence between their use in professional or social life and the process of developing digital competences in school, which has certain effects on life beyond school.

For example, in the USA, although more than 50% of the total workforce is female, in the IT sectors the female presence does not exceed 20% and, although the explanations for these discrepancies may be diverse, one of the influences cited seems to be deeply rooted in the teaching strategies used since primary school [1]. Gender stereotyping, formed at school, is just one example of the effects visible in life beyond school and issues of post-school life can be better managed through novel approaches to the instructive process in school.

To best meet new challenges and to adapt learning to the needs and social environment of today's young people, content and teaching strategies are influenced by various factors. The

use of digital technologies and the development of digital competences are considered from an early age. Beyond content and learning tools, student motivation is also essential, as it cannot be stated that the younger generation does not like to learn, but learning should be treated as a game [2]. In other cases, digital computer games are even used because they have a number of advantages, including: increasing students' motivation for learning, applicability to various learning objects or facilitating the work of teachers under the auspices of active learning, which does not focus exclusively on memorization [3].

These are all various forms of innovative education that transform traditional teaching, but the factors that determine learning make up a long list that includes a long series of elements such as: student motivation, educational communication, identifying the current area of student development, avoiding overloading students' working memory, the way instruction and problem solving are sequenced etc. The list being open and extremely long, it is natural that teaching strategies are also diverse, but these can be reduced to two main categories: deductive or inductive teaching strategies. Every teacher looks for maximizing the effectiveness of his or her teaching actions in relation to the learning outcomes and uses the teaching strategies which best resonate with these beliefs. Opinions are divided but, from an action perspective, the dominant teaching strategies are deductive [4], and from a functional-operational perspective, inductive teaching strategies are considered at least as effective as traditional deductive ones [5] or even more effective [6] and this variety of statements remains an issue to be studied.

Analysis of recent studies and publications. Research in the sphere of instructional design aims to increase the effectiveness of students' learning activity by examining spheres of activity that are connected to the theory of cognitive load or the conduct of the instructional process in digitized environments. In relation to the cognitive load theory [7], inductive teaching strategies are not free from opinions that consider them to be in a relationship of incompatibility with the human cognitive architecture, suggesting their use in the beginning stages of any educational program, because as learners develop their skills, they become less useful [8]. This is one of the perspectives for which, from a certain level of skill development, reverting from practice to theory is considered a better choice for learners to keep a good pace of development, without this issue being clarified.

The perspective of the incompatibility of inductive strategies with the human cognitive architecture remains an unsolved and still to be further discussed issue in instructional design, all the more so as the results of experimental research [9] show that the academic performance of the experimental group was significantly higher than that of the control group, as the experimental group was taught using an inductive teaching strategy for a programming course, while the control group participated in a traditional instructional process, in which the teaching strategy was deductive, although at the beginning of the experiment the knowledge of the control group was superior. The characteristics of inductive teaching strategies mean that, in these cases, teachers guide the didactic process towards the pre-established objectives, acting as facilitators in learning, with the students playing an active role in the process [9]. In relation to the conduct of the educational process in digitized environments [10], different digital technologies support diverse types of learning, recognizing that different digital tools have different educational potential and that their use in education is selective, depending on a broad set of objectives, content or processes. In any of these cases, the characteristics of inductive teaching strategies give the teacher a role of facilitator, where learning is seen as information processing. This becomes a quality and an attribute that stands out in the presence of digital technologies, a context in which it is easier for the teacher to moderate the interactions and the students are much more relaxed in actively participating [11].

In another scenario where inductive strategies were used to give young students an experience in computer programming, it was noted that such an approach also resonates with objectives in the "learning to learn" sphere, helping students to see beyond the textbook and

learn not only what they are given, but understanding what they should learn and how [1]. In this way, the competence "learning to learn" includes a student's ability to evaluate new knowledge [2].

The fact that often, regardless of whether the subject is in the sphere of arts or of the sciences, students learn what they are given, is a problem. For example, in the arts, music education focuses on this type of teaching, where pupils are given audio materials for listening and vocal performance, while activities in the sphere of musical improvisation, which would give a modern character to schools, are quite rare [12], although digital technologies offer, today, a multitude of possibilities to generate sounds electronically and to empirically and inductively reach the laws governing sounds in general and the rules of organization of musical sounds in particular. The harnessing of digital technologies for music education realized in an inductive form remains a problem to be solved and researched, which we will set as the objective of the present paper.

The research goal. The synthesis of the premises offered by recent studies allows us to formulate the aim of the research, which is to verify the effectiveness of using digital technologies to outline an inductive strategy for music education, by monitoring the educational influences on three generations of fourth grade students.

The objectives of the empirical investigation in this research are:

1. To set an instructional design characterized by an inductive teaching strategy, in an integrated music-programming approach, offering a practical, digitized solution for music education.
2. To describe the learning achievement test indicators used to measure learning acquisition following an inductive teaching strategy.
3. To test the functionality of the inductive teaching strategy with an integrated education model at its basis (music and programming), by testing along three consecutive generations of fourth grade students.
4. To analyze the effects of teaching by measuring the relative state of learning acquisition at the end of digital instruction based on an inductive teaching strategy. Learning acquisition measures are checked against a fixed criterion [6], and the set threshold (fixed criterion) was that the 25^{th} percentile in the distribution of learning outcomes must be below the middle of the scoring system (score 4), on a scale of 0 to 8 [13].

2. THE THEORETICAL BACKGROUNDS OF AN INDUCTIVE TEACHING STRATEGY

The teaching strategy that the teacher adopts, places the teaching act in a classical or modern educational paradigm. Traditional teaching approaches are characterized as deductive and start from teaching theories to their subsequent application, while alternative teaching approaches are characterized as inductive [5], reaching theoretical concepts through typical examples, counterexamples, intuitive data and exploration of the surrounding reality. The ambitions of innovative teachers must be set on improving the act of teaching in a digital context and achieving at least the same results as students in traditionally taught classes [14]. The difference between inductive and deductive teaching strategies lies in the way the instruction and the problem solving are sequenced, and when problem solving is put before instruction, we are talking about an inductive teaching strategy [8].

Inductive teaching strategies are defined as pedagogical approaches in which rules are learned from examples [6], and these examples provide contexts for making observations, analyzing case studies, obtaining experimental data that can be interpreted, solving complex real-life problems etc. [5]. The term "inductive teaching strategy" is associated with an umbrella term that covers a range of teaching methods including: discovery learning, inquiry learning,

problem-based learning and many others [8]. The instructional process becomes a bottom-up process, where the teacher provides the students with examples or a set of data that they can analyze and compare, and finally draw conclusions [6], [9].

Practices that adopt inductive teaching strategies have some likelihood of leading to academic success as there are divided opinions in the literature on the feasibility of the strategy. Not in all cases the scientific literature embraces or confirms the effectiveness of inductive teaching strategies. In relation to the assumptions of cognitive load theory, there are opinions which claim that, starting from examples, the effectiveness of teaching is reduced because students may not have, in their long-term memory, the mental schema necessary to connect to the new examples taught and then the instruction will be beyond their comprehension capacity [8]. From another point of view, by using examples to teach inductively, students are confronted with situations and problems to which they can relate, increasing the chances of making synapses between the information obtained and the cognitive structures of the students [5]. Moreover, the practical examples embedded in inductive teaching strategies are perceived as elements that make students learn for pleasure, which favors the durability of learning acquisition in the long-term memory [6]. Under these conditions, inductive teaching strategies have the potential to improve academic performance and better anchor students in real-life issues [14].

An advantage of inductive-style teaching is that students discover real-life dilemmas, and discovery learning is always an instructional support for the principles of inductive instruction [8]. Discovery learning is a type of student-centered learning and is a product of inductive teaching which imposes greater responsibility on learners for their own learning process [5]. This fosters the development of the learning to learn competence based on constructivist principles, with the learner actively forming representations in the brain by constantly drawing on previous knowledge and experience [2]. If teachers' epistemological beliefs resonate with constructivist learning theory, then inductive teaching strategies in which general knowledge is formed from specific examples [9], can be embraced to address discrepancies between what students know and what they discover through direct exploration of the environment along with confronting misconceptions [5]. Direct exploration and hands-on experience are essential for effective learning under an inductive teaching strategy [4].

Formulating hypotheses and confronting misconceptions are attributes of inductive teaching that approaches problems from the particular to the general, and they are also attributes of discovery learning, inferring rules from the problems solved, and once these rules are discovered, they can be generalized to other problems and exercises of the same type [6]. In this process in which students analyze the data of the problem scenario to formulate hypotheses, there is the possibility of being guided to discover them on their own or being presented with the necessary information [4]. This way, inductive teaching can evolve from demo-type activities, where the necessary examples or information are presented to the students, to guided inquiry, where the teacher guides the students to discover the information, or open inquiry, where the students are given autonomy and responsibility for solving the problem [14]. In either case, learning, treated as a pleasure of discovery, is usually wrapped in a sense of satisfaction [2], which can become a strength of inductive teaching strategies.

Another strength is the fact that inductive teaching strategies can be slipped into problems, fundamental concepts, and prototypes of their solution, focusing on cases that will represent suggestive models and examples in understanding phenomena [4] or processes in nature or society. The particularity of the strategy in question can lead to activities in which students are given autonomy and responsibility for problem solving, although there are some opinions which state that such learning activities should be avoided on the grounds of low efficiency, because tackling problems without being preceded by instruction can produce a very high cognitive load, and the effect can be hamper learning [8]. However, through inductive

learning activities, the students' ability to design their own solutions to the problems raised is valued, rather than the teacher taking over the steps of the procedure for its solution [14]. Promoting problem-solving skills, a learning outcome that every teacher wants for their own class of students, becomes an advantage of inductive teaching strategies [5], all the more so as this is a process from which new ideas can emerge [6].

When digital tools are used in learning, and problem-solving can be approached with them, the processes developed fall into the realm of computational thinking [15]. By definition, computational thinking involves cognitive processes that allow problems to be deconstructed and solved in a systematic, algorithmic, step-by-step manner [16]. In relation to the use of digital technologies from early school age, at which children are deliberate creators of digital content, it is suggested that prototyping digital problem-solving using programming languages is a clever way to teach computational thinking [17]. All approaches regard computational thinking as problem-solving thinking, which is why it can be a collateral objective of inductive learning strategies and can be used in the perspective of solving complex problems in a variety of domains. Under these circumstances it is quite susceptible in discovering interdisciplinary bridges between subjects studied at school, for students who form such characteristics in their thinking, with the perspective of understanding the relevance of what they are learning, the context of that content and how that content is used in the world outside school. A particular case of transferable computational thinking skills that can be developed in a school context is learning activities involving the development of simple computer programs and the creation of digital melodic fragments [18]. This is just one example of an interest in integrating the arts with STAM disciplines, with computational thinking becoming a link between distinct curricular areas, a support for such goals, and an increasingly common learning objective in K-12 curricula [19].

3. RESEARCH DESIGN

3.1. The Inductive Strategy of Digital Training, the Independent Variable of the Study

The study focused on the formation of music concepts in fourth grade students at the music education classes (one hour per week over 24 weeks), starting from practical activities using digital technologies in the classroom. The independent variable of the study was a digital instructional programme based on an inductive strategy of teaching music theory. The inductive teaching strategy was outlined around three pillars, which were sequenced in the projection of the didactic activities: the development of computational thinking, improvisation of melodic fragments using computer programs, and the reproduction of songs from the children's repertoire.

Inductive teaching strategies are said to be appropriate for primary school pupils at the concrete operational stage of development [8]. Innovative teaching should link strategies with technologies to shape the targeted competences [14] and as a developmental objective of the concrete operational stage is the development of logical thinking, which is present in both primary school students and information technology, the starting point in the realization of music education, but also the intersection of teaching strategy with the use of technology was the generation of sounds electronically. For this, the Sonic Pi application was used [17], application designed for the educational environment and to support learning objectives in programming and music composition based on transferable computational thinking skills. Thus, in the first stage, students were familiarized with a number of programming concepts, such as: computer instructions, sequential structures, repetitive structures, functions etc., applied in the Ruby programming language and through the integrated development environment Sonic Pi,

obtaining concrete facts and generating sounds electronically. An example of a repeating structure, which repeats a sound 4 times, is the following:

```
4.times do
  play 60
  wait 1
end
```

Once familiar with a programming concept, students were given the freedom to practice, improvize digital melodic fragments, and learn by discovery how the properties of sounds can be altered. This way, the instructional process was based on the game of musical creation, and this was an important aspect because the game, for primary school students, is a primary activity through which they discover the secrets of the surrounding reality [3]. So, play and discovery learning were supported with the Sonic Pi app, which gave students intuitive data to work with, numbers (MIDI notes, sound durations) and the change of these numbers gave students audio feedback about the implications of changing sound parameters, which is a practical, eloquent example to formulate generalizations about the sound properties.

The idea of the inductive teaching strategy was that, at the end of the lessons, the students would arrive at the musical themes and concepts included in the learning objectives. These were also designed to be introduced and formed by means of typical examples of reproducing songs from the children's world, after having previously familiarized them with techniques for making digital products from the sphere of computer programming and techniques for obtaining various sounds from the sphere of musical improvisation. In planning the learning activities, several songs were introduced for digital reproduction in the classroom as a concrete way to learn music theory concepts within the inductive strategy of digital instruction. The digitization of these songs from the children's universe, involves reading and interpreting the musical notes from the musical sheet, obtaining them on the computer and adjusting the result based on the audio feedback obtained, solving problems of melodic line, which means learning music theory by a practical example, outlining the inductive strategy of digital instruction adopted for this research. Any problematic situation in which the audio result obtained does not resemble the anticipated one, becomes an opportunity for interactive learning, based on the collaboration between students, who are put in the position of finding solutions to solve the rhythmic problem, emphasizing the formative nature of the inductive strategy of instruction, which aims to develop the ability to apply the information and knowledge acquired, to operate with them, to formulate and verify hypotheses, with the aim of solving problems. It is argued that teaching methods such as problematization, which can shape inductive teaching strategies, are compatible with the premises of cognitive load theory [8]. The digital training program was an extended one, a 24-lesson program, and the study topics also included an extended set of musical language elements, such as: pitch, duration and timbre of sounds, measure, rhythm, melody, dynamics, form elements (verse/chorus), tempo and intervals between sounds (tone/ semitone, alternations). Some of these musical language elements are translated into the following code sequence:

```
use_bpm 120
use_synth :piano

define :intro do
  3.times do
    play 60, release: 0.5
    wait 0.5
  end
  play 64, release: 1.5
  wait 1.5
end
```

The specified topics of study are concepts planned to be formed and measured as a result of going through digital instruction, as acquisitions of practical learning through composing digital music, which is the finality of the inductive strategy of digital training. Through the designed inductive strategy, the concepts were formed starting from concrete facts, typical examples, intuitive data, and through the interpretation of sound feedback and generalizations, definitions of the concepts were obtained, which were only exposed at the end of the lessons in order to fix the knowledge. Even the worksheets were designed in such a way that at the end of the papers, the definitions of the concepts worked with and learned were recorded as part of the lesson conclusions. Given the fact that the educational route outlined starts from typical examples, presented above, and includes concrete actions of musical creation, the concepts formed are intended to be a result of the practical-applicative process in which the students took part, which is why we call the digital instruction strategy as inductive and this will be the independent variable of the research that will respond to the first research objective and provide a practical, digitized solution for achieving musical education.

3.2. The Sample of Participants

The sample of subjects for this research consisted of 127 fourth grade students of a public school. The students come from urban area, as the school where the digital instruction program was applied is in Cluj-Napoca, Romania. The pupils in Romania, during the fourth grade, are 11 years old. The study was longitudinal in nature and included three distinct generations of fourth grade pupils, who were enrolled in school from 2020 to 2023. Thus, during the 2020-2021 school year, 23 students in one class were taught using an inductive teaching strategy, during the 2021-2022 school year, 76 students in three separate classes were taught, and during the 2022-2023 school year, 28 students in one class took part in the project. The description of the sample of participants by year of study and by gender is presented in Table 1:

Table 1

Sample distribution of participants by gender

Gender	2020-2021	2021-2022	2022-2023	Total
Girls	12	40	12	64
Boys	11	36	16	63
Total	23	76	28	127

3.3. Methods and Instruments

In the context of the present research, the independent variable was the inductive strategy of teaching music theory, and the dependent variable was students' learning achievement, for the measurement of which an instrument of Learning Achievement Test [6] type was used. The test [13] measured the learning acquisition of music concepts and elements of music notation through 8 questions and was developed in close relation to the principles of inductive learning techniques promoted by the Rubric for Online Competencies and Standards (ROCS) developed by Hodges University [14], the instrument being used even in other research contexts [13]. The second research objective being the description of the indicators of the knowledge test used to measure learning acquisition following an inductive teaching strategy, the 8-item test will be outlined as follows.

The ROCS assessment tool has 6 categories and one of them is dedicated to inductive learning. This category includes 8 indicators to assess an educational pathway characterized by inductive teaching activities and its outcomes, and the inductive teaching strategy is subordinated to all these indicators. The indicators *Academic rigor of course content and*

requirements and *Course processes identified and communicated*, which concern the inductive teaching strategy as a whole, are met because the digital instruction was sufficiently long in duration to claim an impact on student outcomes, and the cyclical processes that the program developed for each lesson were summarized under the three pillars: developing computational thinking, improvising melodic fragments using software and reproducing certain songs from the children's repertoire. Then, the indicators *Interaction among student, instructor, and content* and *Critical thinking and problem-solving activities*, which concern the cause of the effects to be measured, are found in the activities carried out by interacting with the audio feedback in the musical improvisation stages and adjusting the result based on the audio feedback obtained in the stages of reproducing musical works. Perhaps the most relevant of the indicators of an inductive teaching strategy, which is closely related to the integrated music-programming approach, is *Multiple means of representation, action and expression, and engagement (i.e. Visual, textual, auditory etc.)*, because regardless of how the learner best captures information, whether through an iconic or auditory mode, the integrated music-programming approach addresses both, providing visual (codes) and auditory (melodies) processing elements. The last three indicators *Alignment of course goals with learning outcomes*, *Integration of learning outcomes with instructional activities* and *Outcomes are integrated and measurable* are found in the measurement tool through music concepts and elements of music notation, integrated in questions, which students must recognize by making connections with the activities of the inductive teaching strategy they have taken part in and described above. If the results will be satisfactory, it can only be the result of a deep approach in which the instructional conditions induced the formation of certain concepts.

3.4. Statistical Analysis

The data gathered over the three school years were processed with the JASP statistical interpretation software [20], looking for a measure of relative standing of the learning achievement in musical education close to the end of the 4th grade followed by an inductive teaching strategy.

Primary school students in the Romanian mass education system have no notions of music theory and are gradually introduced in music notation in the 3rd and the 4th grade. In the 3rd grade, students are taught the names of musical notes and at the beginning of the 4th grade they have no notions about the qualities of sounds (pitch, duration, intensity and timbre of sounds) or about musical notation, such as measure, tempo, intervals between sounds (tone/ semitone, alterations), which is why an initial test at the beginning of the fourth grade was not necessary, as these topics had not been taught. A test was only carried out at the end of the fourth grade, in order to see, through descriptive statistics, where the learning acquisition stands in relation to the whole group of students and to the three distinct generations of students.

4. FINDINGS

Information about the learning acquisition achieved by an inductive strategy of teaching of a unified music-programming content was obtained by statistically analyzing the students' test results. This testing stage involved 127 subjects (N=127), and the descriptive analysis to be carried out aims at an identification of the relative state at the end of the application of the digital instructional process carried out under inductive teaching influences. The learning achievement test evaluates students' performance, in the field of music, both from the perspective of the contents of the subject dedicated to music education, and from the perspective of the ability to correlate these contents with their musical meaning: symbol-meaning, notation-

application etc. The distribution of results, through descriptive statistics, is presented in Table 2:

Table 2

Descriptive statistical analysis of the results of the participant sample testing

	Total
Valid	127
Missing	0
Median	6.000
Mean	5.732
Std. Deviation	1.417
Minimum	2.000
Maximum	8.000
25th percentile	5.000
50th percentile	6.000
75th percentile	7.000

As shown in the tabular data, the mean of the scores of the sample of subjects, with a standard deviation of 1.417, is 5.732, slightly below the median (the middle value in the distribution of results), which is equal to 6 and has the same value as the 50th percentile. Since the instructional process had a strong practical-applicative character, exploring the variation of sound parameters with the help of the computer and subsequently categorizing the sound feedback obtained into a series of musical notation elements, and the results of correlating these musical notation elements with the sound effects obtained, through the good results (Mean & Median) of the participants' testing, the third objective of the research can be considered fulfilled, which was to test the functionality of the inductive strategy for teaching an integrated music-programming content, by testing three consecutive generations of students. For a broader analysis of the effects of teaching at the end of digital instruction based on an inductive teaching strategy, the fixed criterion set for measuring the relative state of learning acquisition included the 25th percentile value, which is the fourth research objective. We will explain later why such a benchmark was chosen, after reviewing the data in Table 3, which presents the descriptive statistics of the distribution of the distinctive results for each of the three school years:

Table 3

Descriptive and comparative statistical analysis between the three school years, of the testing results of the sample of participants

	Total		
	2020-2021	2021-2022	2022-2023
Valid	23	76	28

	Total		
	2020-2021	2021-2022	2022-2023
Missing	0	0	0
Median	7.000	6.000	6.000
Mean	6.783	5.487	5.536
Std. Deviation	1.413	1.270	1.453
Minimum	4.000	2.000	2.000
Maximum	8.000	7.000	7.000
25th percentile	6.000	5.000	5.000
50th percentile	7.000	6.000	6.000
75th percentile	8.000	7.000	7.000

Measures of learning acquisition are analyzed in this descriptive statistic with reference to a fixed criterion, a fixed value, which is the 25th percentile. The percentile represents the score of participants in a distribution with outcomes at or below a given score. When indices such as the median, which reports a single value in the distribution, are at a high value, only one point away from the maximum scores obtained by each generation of students, the central tendency calculated by the arithmetic mean of the scores obtained by the students lies between the median and the 25th percentile, and this can be better presented by a comparison plot showing the full spread of scores in the statistical distribution of the data. Figure 1 provides an eloquent picture of the spread of the data, useful in analyzing the variability of the responses and explaining them.

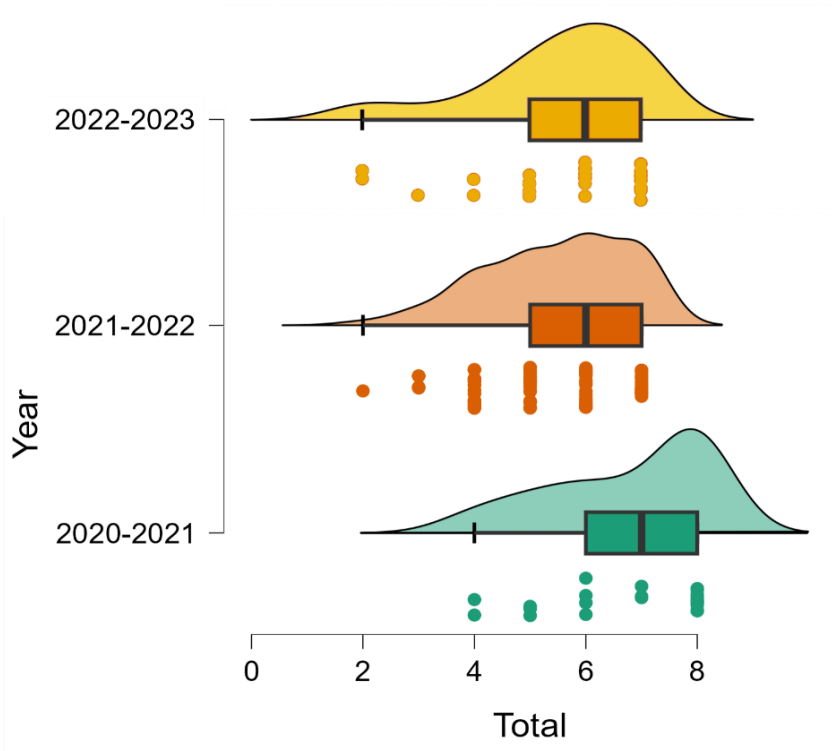

Figure 1. Representation of the variability of knowledge test scores for each of the three generations of pupils

In the realized figure, 5 indices of Table 3 are marked: the minimum realized score (2 for generations 2021-2022, 2022-2023 and 4 for generation 2020-2021), the 25th percentile, the median (50th percentile), the 75th percentile and the maximum score (7 for generations 2021-2022, 2022-2023 and 8 for generation 2020-2021). The maximum possible score was 8, the scale of measurement being 0-8, within which range for the measurement of learning acquisition we referred to a fixed criterion, whereby a minimum acceptable threshold was predetermined to meet the targets pursued through inductive teaching, and this was that the 25th percentile, from the distribution of learning outcomes, should be over the middle of the scoring system (score 4). The 25th percentile was used as a benchmark to see where the majority of the scores were placed, i.e. what was above the 25th percentile, i.e. the results of 75% of the subjects. From the representation of these indicators, it can be observed that in all the three cases, the 25th percentile is above 4 (5 for the 2021-2022, 2022-2023 and 6 for the 2020-2021 generation), which produces a high variability above the upper half of the scoring grid, i.e. 75% of the subjects perform very well, above the drawn threshold. Under these circumstances, following the analysis of the effects of teaching by measuring the relative state of learning acquisition at the end of the digitally based instruction, we can say that the inductive strategy underlying the teaching was a functional one. This finding is confirmed by other indicators, with the 75th percentile in all three cases being equal to the maximum score achieved by each generation, meaning that 25% of the students obtained the maximum score achieved in each school year.

5. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

Although this study aimed to analyze an inductive strategy for integrated music-programming teaching by monitoring three generations of primary school students, it represents only a starting point. It offers a initial set of data on the effects of using digital technologies, particularly the Sonic Pi application, to create an inductive strategy for music education.

Based on the results, it can be concluded that the teaching strategy used in the research context is an effective one, but referring to the theoretical aspects, it was suggested that an advantage of inductive style teaching is the possibility of learning through discovery offered to students. The way the students were given the opportunity to discover aspects of sound phenomenology through the inductive teaching strategy was by playing, playing a game of music making in a digital context. In these conditions, we can talk not only about the effectiveness of such a strategy, but also about its efficiency by relating the learning acquisition to the effort made for obtaining it. The good results of the students, accounted for by this study, denote a concrete performance, but this performance, if compared to the effort made, which was low, a game, can be translated into a good efficiency and this can be attributed to the inductive teaching strategy.

It is important to recognize that an instructor might use the same teaching strategy in different classes but achieve different results [5]. In the present case, the same teaching strategy was applied to the classes of three consecutive generations of fourth grade students and the same good results were obtained, with extremely small differences. The Learning Achievement Test, which verified concepts formed as a result of an educational journey that started from the practical example, and the results which were more than satisfactory, prove that a learning outcome is deep conceptual understanding. The concepts in the sphere of music education having been understood following an instructional process that emphasized generating sounds electronically using programming languages, students were frequently confronted with problems of sound quality or computer-generated instructions, the way of thinking in this context being oriented towards problem solving. Computational thinking was a bridging element between the complex problematizations of the two distinct domains, and since

computational thinking is problem-solving oriented thinking and problematization has its place quite well in an inductive teaching strategy, we can say that such a strategy can subordinate computational thinking as a whole.

From a functional-operational perspective, the learning achievement test verifies the results of an inductive teaching strategy, in which the concepts and elements of music theory, in the sphere of music notation, have been formed based on the practice of generating musical sounds using the Sonic Pi application and also using the symbolism of the field of music, and the test results indicate a high level of knowledge for each of the three generations of students. In these conditions, the inductive teaching strategy has attributes that recommend it, even if, in relation to cognitive load theory, opinions are divided [8].

The results of the present study do not cover all the issues arising from the adoption of an inductive teaching strategy, but they are a starting point for further research. New research perspectives and new results, perhaps even different, but essential for the knowledge and development of good practices in teaching and integrating the content of these two distinct curricular areas, arts and computer science, could be developed based on the application of inductive teaching principles and strategies and their evaluation through a different research design: in an experimental research setting, at other school levels (in classes of children over 11 years old), in a correlational research design in which learning achievement in music is correlated with learning achievement in computer programming etc.

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ОЦІНЮВАННЯ ІНДУКТИВНОЇ СТРАТЕГІЇ НАВЧАННЯ МУЗИКИ ТА ПРОГРАМУВАННЯ УЧНІВ ПОЧАТКОВОЇ ШКОЛИ

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Анотація. Традиційні стратегії викладання мають дедуктивні характеристики, тоді як сучасні – індуктивні. Але індуктивні стратегії викладання не завжди оцінюються або рекомендуються в будь-якому освітньому контексті. Тому метою цього дослідження було розробити навчальне середовище відповідно до принципів індуктивної стратегії викладання, що поєднує музику з комп'ютерним програмуванням, і відстежити наслідки викладання в довгостроковій перспективі для трьох послідовних поколінь учнів четвертих класів, вимірюючи навчальні досягнення за допомогою тесту навчальних досягнень. У цьому контексті студенти засвоювали поняття нотної грамоти та формували поняття, специфічні для музичної освіти, починаючи з практичних вправ, генеруючи звуки в електронному вигляді за допомогою мов програмування та додатка Sonic Pi, імпровізуючи мелодії для навчання через відкриття варіативності звукових параметрів та відтворюючи пісні з дитячого всесвіту, відштовхуючись від своїх нотних аркушів та вирішуючи проблеми вписування якостей звуків у серію елементів нотної грамоти, спираючись на отриманий звуковий зворотній зв'язок. Аналіз ефектів навчання та сформованих у студентів понять у сфері музичної освіти здійснювався шляхом вимірювання відносного стану засвоєння навчального матеріалу наприкінці цифрової інструкції, заснованої на індуктивній стратегії навчання, з посиланням на фіксований критерій: 25-й процентиль. У такий спосіб було виявлено, що відсоток результатів, які перевищують 25-й процентиль, тобто 75% вибірки учасників, спричинив варіативність на верхній межі системи оцінювання. Контекст розвитку певних навичок комп'ютерного мислення, що переносяться, підтримував навчальні цілі у сфері програмування та написання музики, а хороші результати учнів показують конкретні результати, і ці результати, якщо розглядати їх пропорційно докладеним зусиллям, а це була

гра, гра у створення музики, тобто незначні зусилля, можуть привести до хороших результатів, що може відповідати індуктивній стратегії навчання.

Ключові слова: індуктивна стратегія викладання; індуктивне навчання; цифрова інструкція; Sonic Pi; музична освіта.