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MUSIC AND PEDAGOGICAL TECHNOLOGY FOR CREATING AN ALGORITHMIC COMPOSITION

ABSTRACT

of thesis for awarding the educational and scientific degree

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The doctoral thesis is discussed and focused to be defended in front of the extended council of the department „Music aesthetics, music education and performance“ at the Faculty of Education at Konstantin Preslavsky University of Shumen.

The thesis has a volume of 168 pages, 135 of which are main text statements, 9 including literature and 24 applications. The bibliography includes 156 sources, 99 of which are in foreign language.

The defense will happen on .... 2022, at ..…… .

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INTRODUCTION

In the twentieth and the beginning of twenty first century, great changes took place in science and art. Compositional and expressive forms in the art are changing. The theories of chaos and fractals are entering science. Fundamental changes began in natural science, which gave rise to the theory of self-organization (synergetics), which makes it possible to look at the world in a new way according to the principle of nonlinear thinking. One of the most important issues is the problem of analyzing art through mathematics. This union between art and science is expressed in a brand new musical instrument - the computer, the computer generated music that appeared in the second half of the last century is based on the theory of algorithms. The idea of formalizing music through algorithms dates back to long before the creation of the first computers, but only with their appearance this process took shape in an independent direction, capable of developing the boldest composers' ideas.

Many compositional methods that composers have used over the centuries in music practice are actually algorithmic procedures. The computer generation of music, especially algorithmic music, actually demonstrates the interdisciplinary relationships of mathematics with music and computer technology.

The modern concept of algorithmic composition includes a range of actions applied to the parameters of the composition process - from making certain patterns in the future work at an early stage to creating automated algorithmic works using computer programs.

The use of specialized software for algorithmic music in the education of students meets the current requirements of our time related to the application of information technology in education, which is state policy in many European countries and Bulgaria.

The thesis research is relevant, because it is based on the requirements for modernization of music education using methodological models which are developed on the basis of modern information and communication technologies. It is aimed at building key competencies through the resources of the musical art. The trend of this topic stems from the incompleteness of the scientific literature on the problem of the bulgarian language.

The current study is provoked by the relevance of the researched problem and its practical significance. It is motivated by the need to optimize the conditions for effective learning of students through the application of science-based music and pedagogical technology to create an algorithmic music composition.

In terms of content, this study includes:

1. Using the possibilities of modern technologies to create algorithmic music as a tool for teaching students.
2. Discovering the possibilities of the proposed music and pedagogical technology for active involvement of students in music education, mastering knowledge, skills and competencies, formation of personal-semantic and creative attitude to music.

The use of music and pedagogical technology to create algorithmic music in the learning process has theoretical and practical significance - the acquisition of theoretical knowledge, skills and competencies (KSC) to create an algorithmic composition and their practical application in working with software tools. The application of pedagogical technology in the education of students contributes to the modernization and optimization of music education, to improve the quality of education.

The structure of the doctoral thesis includes introduction, four chapters, conclusion, literature and application.

CONTENT OF THE DOCTORAL THESIS

In the first chapter, a theoretical analysis of the modern literature is made, referring to the algorithmic composition.

In paragraph 1. reveals the main characteristics, essence and development of algorithmic music.

"Algorithm" is a term used in mathematics and computer science. It is defined as a set of rules or a series of operations designed to perform tasks or solve a problem.

Algorithmic music is mainly related to composition, in which the computer takes a significant part. Therefore, algorithmic composition means the use of computers to perform compositional procedures leading to the generation of music.

The leading concept in algorithmic composition is the code-graphic transformation, in which a direct connection is established between the data of the mathematical model and the musical parameters. Depending on the application of different code-graphic conversion, the same algorithm can play different music, each with its own unique imprint.

This paragraph discusses the general principles of algorithmization of computer-generated music compositions, as well as the principles of melody modeling.

In their programs, a number of authors of algorithmic compositions use mainly two approaches based on the application of deterministic or stochastic procedures.

A common feature of all known ways of synthesizing melodies on a computer is following the same sequence of steps. In the *rhythmic-melodic* principle of modeling melodies, first a specific rhythm is created, and then - the melodic line. The other principle, called *melodic-rhythmic,* first synthesizes the melodic line, then the specific rhythm.

Due to the mathematical formalism of music, it can be composed by systematically applying algorithmic procedures, even without the use of computers. There are many examples of algorithmic composition practices before computers.

Historically, the earliest example of code-graphic transformation dates back to the 11th century and is associated with the Italian composer and theorist Guido D'Arezzo (991/992-ca.1050). His method consists of creating a connection between vowels in a text and a number of pitches. In 1206, G. Marzano offered each vowel to be compared to a certain pitch and to compose music this way. In the fourteenth and fifteenth centuries, the musical technique of isorhythmic motet was used - a repetition of rhythmic patterns called talea in at least one vocal part (most often the tenor part) throughout the composition. Later, other techniques appeared, such as soggeto cavato, Musikalisches, Schillinger System of Musical Composition, serial technique and others.

Strict mathematical study of music at the beginning of the last century was the system formulated by the American music theorist Joseph Schillinger (1895-1943) in 1920 and 1930. In Schillinger's system, for the first time, there is a complete application of a scientific method to all components of musical composition and to the main problems of the composition itself.

In the 1950s, scientists used electronic computing technology to synthesize music. That is how the algorithmic music appeared and the principle of which was proposed in 1206 by G. Marzano and later - applied by WA Mozart for automated creation of minuets using random numbers.

The founders of algorithmic music are considered to be the composers Pierre Boulez, Yannis Xenakis, Paul Lansky, Ledger Hiller.

In the 1950s, Yannis Xenakis was the first to study stochastic processes, which involved the use of probabilistic functions.

In the mid-1960s, Paul Lansky was one of the first to experiment with computer sound synthesis. Sounds coming from real-world sources are the predominant focus of Lansky's computer music.

In the 70s and 80s of the twentieth century, the behavior of systems of nonlinear dynamic equations aroused interest in their use in algorithmic composition. The composer David Little studied algorithmic composition with the help of chaos theory. Many of his compositions are based on mathematical models that show chaotic behavior.

In the 1980s, composers now had the opportunity to use computers equipped with special programs that could save, play and edit music, create new timbres, and print the sheets of their works.

The desire to find a new direction in musical composition led Xenakis to formulate a new paradigm for music, which he called stochastic music. The field of stochastics in music appeared before the introduction of computers in music and is a special case of algorithmic music, so in his thesis a special place is given.

Paragraph 2. is dedicated to fractal music, which can be considered in 2 ways: as a special case of algorithmic music using algorithmic equations that generate fractal images or as a very separate section concerning music understood as a fractal model.

Fractal music, which is based on the mathematical concept of fractal, is connected to the chaos as a result of the process. Therefore, attention is paid to the relationship between fractal geometry and chaos theory.

The first elements of chaos theory appeared in the 19th century, but this theory received real scientific development in the second half of the 20th century. Chaos theory is significantly stimulated by the computing and graphics capabilities of modern computer technology. It is a theory of ever-changing complex systems based on the mathematical concept of recursion. Chaos theory explains the fact that complex and unpredictable results can and will occur in systems sensitive to initial conditions.

One of the scientific models that deserves the attention of musicians and researchers is Mandelbrot's concept of fractal geometry. The discovery of fractals caused a revolution not only in geometry but also in physics, chemistry, biology and art.

In recent years, many relationships have been found between fractals and music. At the heart of this research is the theory of Richard Voss, who found that every sound has fractal properties. He identified 3 categories of sounds based on mathematical elements: white noise, brown noise and pink noise.

Algorithmic music is actually music made from fractals. Fractal music is the result of a recursive process in which an algorithm is applied repeatedly to previous results. More generally, all musical forms can be modeled with this process.

In paragraph 3. basic ways of creating algorithmic music are presented.

Algorithms are used for composing, which can be conditionally divided into 6 intersecting groups according to the structure and way of processing the musical data: mathematical models; knowledge-based systems; training systems; grammar; evolutionary methods; hybrid systems.

Some methods for creating algorithmic music are presented - L-systems, cellular automation, fractal music.

The L-system is a kind of substitution grammar, allowing to strictly define the relationships between algorithmic languages, as well as to model the growth of living organisms. L-systems are a formalized language for building fractals as well. To use this language, you need to build an interpreter that understands the commands of the language and executes them by applying computer graphics to visually represent the result.

Cellular automata were introduced in the mid-1960s by John von Neumann as a model for computer-simulated biological self-reproduction. This model consists of a two-dimensional network of cells in which a certain number of different states are allowed on each cell. Cells change their states in the network according to a predefined set of rules.

Nowadays, one of the most popular methods for creating music based on algorithms is the so-called fractal composition method. Fractals are quite useful for composing, as they are built on self-similarity. In fractal compositions, the new musical material is obtained by systematic transformation of the previous one. David Cl. Little was the first to consciously use fractals as a compositional tool.

The above methods for creating algorithmic music are considered in order to find the most optimal method for teaching students who do not have specialized musical training. The analysis shows that the most suitable for this purpose is the method in which ready-made algorithms are used and the generation process is automated. Cellular automata are proven to be productive and give very good results when creating an algorithmic musical composition.

It should be noted that in this study the concept of composition should be understood rather as selection, selection of different variants generated by the machine, according to the parameters and preferences set by the student. Algorithmic composing is just a learning tool that helps students to acquire knowledge, skills and competencies in the art of music, for the new technologies in the field of music, the process of creating music in a very exciting, fun and attractive way.

In chapter 2, on the basis of the theoretical analysis of the studied literature, the conceptual formulation of the present work, the theoretical foundations of the music and pedagogical technology for creating an algorithmic composition, the organization and the research methodology are derived.

In paragraph 1. the modern theoretical positions on which the staging of the present work is based are determined. These propositions are the basis for deriving the subject, object, aim, hypothesis and tasks of the present study.

Object of the research is the creation of an algorithmic musical composition by students in the lower secondary stage of the basic level of education.

Subject of the research is the development of music and pedagogical technology for creating algorithmic music by students who do not have specialized music training.

The aim of the research is to establish the applicability and effectiveness of the developed music and pedagogical technology in music education at school.

To achieve this goal, the following **TASKS** are set:

1. Researching and analyzing the theoretical foundations of algorithmic music and their application in music practice.

2. Developing and testing of science-based music and pedagogical technology for creating algorithmic music composition by students.

3. Experimental testing the effectiveness of music and pedagogical technology and analyzing the results.

According to the set of goals and objectives, the following working **HYPOTHESIS** is raised, which includes two assumptions:

1. It is assumed that the application of music and pedagogical technology will provide an intensive and productive music-educational process in which students will master the knowledge, skills and competencies to create a musical algorithmic composition.

2. It is assumed that students will master the knowledge, skills and competencies to work with a new type of software tools, as a result of which they will be able to independently compose algorithmic musical compositions.

In paragraph 2. a characteristic of the music-pedagogical technology for creating an algorithmic composition is made.

The offered pedagogical technology meets the requirements of our time for the modernization of education through the use of new technologies. Its specific feature is the mastery of knowledge, skills and competencies for working with a new type of software tools, with an emphasis on creative thinking. The offered technology is intended for students who do not have specialized musical training. It is in line with the State educational standard for general education and music curricula, which determine the curriculum, specified in topics related to various aspects of musical art and the development of various competencies in students.

In connection with the topic Music and modern technologies, training is offered with a new type of technology for creating algorithmic music. The aim is for students to acquire knowledge, skills and competencies to use new technologies in the field of music art.

The application of technology in the education of students has two meanings – on the one hand, the students are mastering the technological sequence of creating an algorithmic musical composition, acquiring knowledge, skills and competencies to work with a new type of software tools, and on the other - improving their digital and cultural competence and skills to express through music.

The presented theoretical model of music and pedagogical technology for creating an algorithmic composition (Diagram 1) consists three components: teaching methods; teaching aids; mastering knowledge, skills and competencies (KSC).

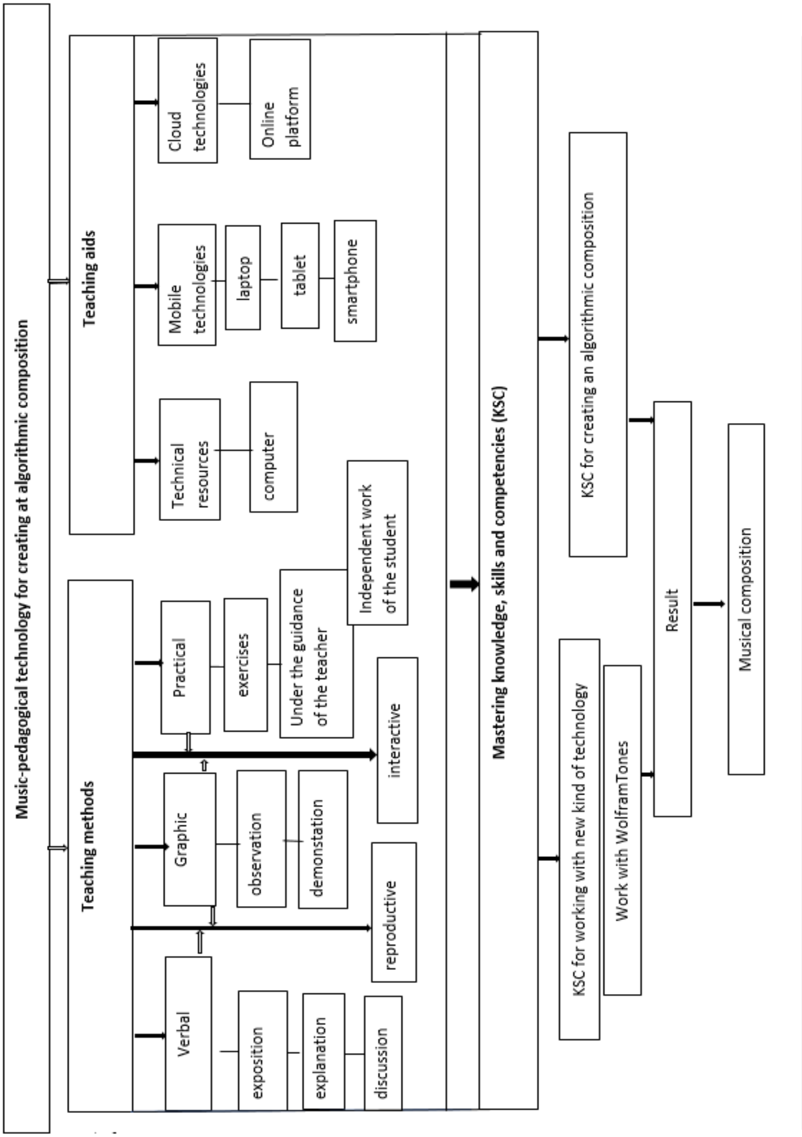

Diagram 1. Theoretical model of music and pedagogical technology for creating an algorithmic composition

The organization of the present study, compliant with the requirements for conducting this type of research, is described in **paragraph 3.** It includes the following three stages:

1. Finding experiment (initial stage) aimed at establishing the entry level of the studied students.
2. Forming experiment (second stage), in which the students' education is tested by scientifically based music an pedagogical technology for creating an algorithmic composition.
3. Control experiment (final stage) with control-evaluation functions and possibilities for establishing the effectiveness of the applied experimental music and pedagogical technology for creating an algorithmic composition.

The experimental training involves 87 students from seventh grade of primary school 'Hristo Botev' and primary school 'Khan Asparuh', Dobrich city. The experiment is conducted in the period from February to May 2021 in two forms of training - face-to-face and online (in electronic environment).

In paragraph 4. The current work reveals the methods used in the research methodology:

Theoretical analysis of the scientific literature related to the creation of algorithmic musical composition.

a) in connection with a more comprehensive clarification of the researched problem, a study of a wide range of issues in the field of algorithmic music and its application in music practice is carried out.

b) theoretical and methodological sources, research, articles in periodicals, educational documentation (curricula and programs), textbooks and teaching aids have been studied to reveal the pedagogical aspects of education through the use of a new type of technology (software) for creating algorithmic music.

Pedagogical observation - monitoring the mastery of knowledge, skills and competencies for the creation of algorithmic music by students.

Pedagogical experiment - conducting an experiment by applying music and pedagogical technology to create a musical algorithmic composition.

The methodology for assessing student achievement is described in **paragraph 5.** to establish the effectiveness of the proposed music-pedagogical technology, 3 criteria are used with 2 indicators for each criterion, determining the level of mastery of knowledge, skills and competencies needed to create a musical composition.

To diagnose the acquisition of knowledge, skills and competencies for the individual criteria, through their indicators there are 5 levels: *high, very good, good, medium and low*.

The criteria and indicators for establishing the level of mastered knowledge, skills and competencies for creating an algorithmic musical composition are:

Criterion 1. Creating a model of the musical composition: *Knowledge, skills and competencies for choosing a musical style; Knowledge, skills and competencies for choosing an algorithm of musical composition.*

Criterion 2. Choice of musical instruments: *Knowledge, skills and competencies for choosing musical instruments according to the style of composition; Knowledge, skills and competencies for choosing the function of the selected musical instruments.*

Criterion 3. Completeness of the composition: *Knowledge, skills and competencies for choosing a style according to the style of the composition; Knowledge, skills and competencies for determining the duration of the composition.*

In paragraph 6. the statistical methods for processing the results of the studied students are presented. The results of the survey of each student on each indicator are filled in a table. The dynamics of the input and output levels of the students' results are monitored by calculating the arithmetic mean weighted value. The formulas for calculating the correlation and reliability coefficients are indicated.

Chapter 3 is dedicated to the music-pedagogical technology for creating an algorithmic composition.

In paragraph 1. the knowledge, skills and competencies necessary for the realization of a musical composition are considered. These are knowledge, skills and competencies for: choosing a musical style, choosing an algorithm for composing, choosing musical instruments to create a musical composition, determining the duration of the composition, storing and distributing the resulting composition, working with software tools.

The mastering of knowledge, skills and competencies for creating an algorithmic musical composition is realized in two successive stages:

- Under the guidance of the teacher, who sets the parameters, directs and controls the process of creating the musical composition;
- Independent and meaningful application of the acquired knowledge, skills and competencies for the realization of algorithmic musical composition.

The WolframTones cellular automaton is used to create an algorithmic musical composition. That’s why in **paragraph 2.** describes the software tools through which the composition is realized.

WolframTones is based on the basic discovery of Stephen Wolfram that in the computational universe, even extremely simple rules or programs can give behavior with great complexity. Wolfram first found evidence of this surprising fact in the early 1980s in his experiments on systems known as one-dimensional cellular automata.

Each composition is created by starting a program found by searching in the computing universe, taking the model that the program creates, and transforming it into a musical score. Each program at a certain stage can be considered as a set of rules that determine the state of each cell in the next generation depending on its own condition and that of its neighbors in the current generation. Visual images of the behavior of the programs in the computing universe appear on the generator screen, the steps of which pass sequentially. Because the system follows a certain sequential rule, the compositions inevitably have a certain internal sequence, which probably makes them as effective as music. That’s how WolframTones manages to create many different intricate musical compositions. The music produced by WolframTones is completely original and authentic. Sometimes it resembles different styles, and other times it may sound like completely new and unfamiliar music.

Paragraph 3. presents the pedagogical technology for creating an algorithmic musical composition.

In the process of creating music composition by working with the generator, few simple steps must be followed:

1. *Choosing musical style of composition*

WolframTones can generate music only in the styles it offers - classical style, pop rock, dance, jazz, country, world music, experimental music and more.

2. *Choosing algorithm for creating a composition*

The generator uses various Wolfram algorithms to generate music from the cellular models of the automaton. The program to generate the composition is selected through the generator controllers. Ready-made algorithms for generating music can be used or entered manually.

3. *Choosing musical instrument for each part of the composition*

First select the appropriate rhythm from the Percussion drop-down menu, and then select the other instruments according to the style. From the Roles drop-down menu, you choose exactly what function each instrument will perform - melodic, harmonic, bass, etc. The same instrument can perform different functions.

4. *Determining the scale of composition*

The scale is selected and listened to. You can choose the tones to include them in the musical composition. The height of the Tonic and its octave affiliation are determined.

5. *Determining the duration of the composition* - by using 3 separate sliding menus, the tempo, the music values per unit time and the number of automatic steps are determined.

The composition can be listened to at any time and the changes that are made can be monitored. Once the resulting musical composition is approved, it is stored.

6. *Saving of the received musical composition*

The music composition can be downloaded in 4 formats (MIDI, MP3, WAV and FLAC), saved and sent by e-mail or shared on social media. You can also copy the URL, take a screenshot of the data of the resulting composition, which can then be used for re-listening or editing.

Fourth chapter is dedicated to the presentation and analysis of the results of this study.

In paragraph 1. the aim and objectives of the experimental test are presented.

The effectiveness of the applied music and pedagogical technology is determined by its purpose:

- To find out what are the possibilities of the technology used in music education for students to learn KSC.
- To establish whether the 7th grade students can comprehend the specifics of a new type of software toolkit for them and use it to compose algorithmic musical compositions.

Achieving this goal is closely related to solving the following **tasks:**

1. To test and establish the effectiveness of the applied music and pedagogical technology for creating a musical composition.
2. To establish the level of KSC of students to independently create a musical composition.

The effectiveness of the application of music and pedagogical technology to create an algorithmic composition in the education of students in this work is established by tracking the formation of KSC in each student.

In paragraph 2. the results of the entry level of the students for each indicator are presented. The results are presented in tables in which the percentage of students who received the corresponding grade is calculated.

The interpretation of the obtained results is aimed at establishing the level of mastery of KSC by students through the used assessment levels of the criteria and indicators presented in Chapter Two.

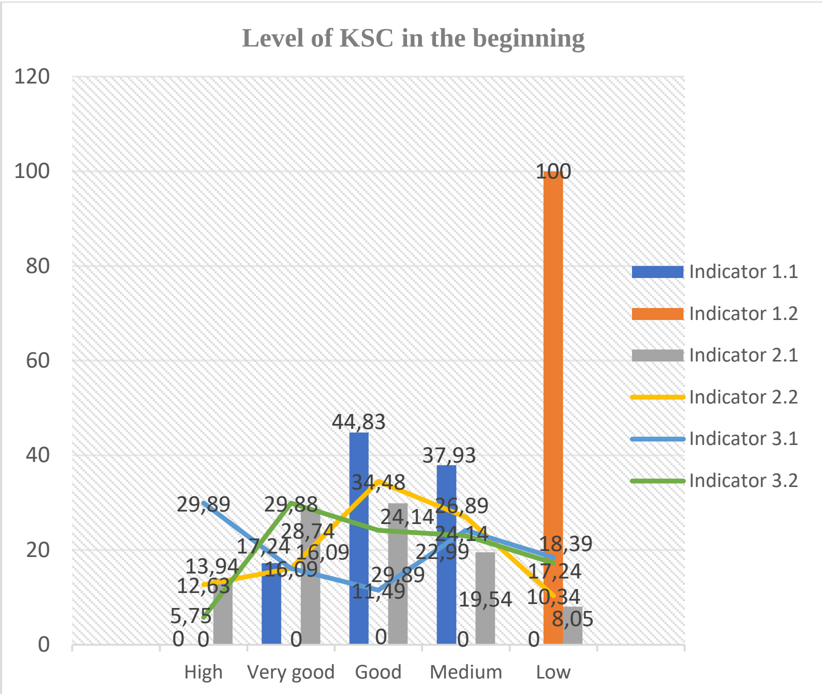

Diagram 2

Diagram 2 shows that at the beginning of the training the highest percentage of students showed low, medium and good levels of KSC (71.62%). Only 28.38% of the students performed at a very good and high level.

The analysis of the results at the entry level shows that the students did relatively well, despite the lack of some knowledge, skills and competencies.

Paragraph 3. presents the results from the students' starting level (Diagram 3).

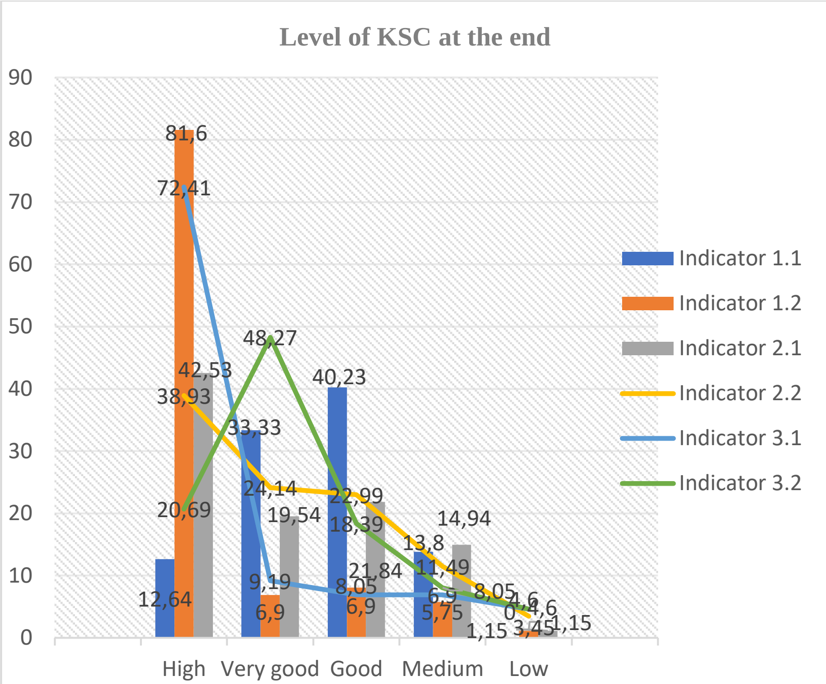

Diagram 3

At the end of the training, an analysis was made of the compositions that were created independently by the students and the mistakes that were made. Appropriate grades have been set.

The analysis of the initial results of the students shows a positive change in all indicators (see Diagram 3). The percentage of students who have shown a very good and high level has increased significantly - from 28.38% to 68.36%. At the same time, the percentage of students who showed good, medium and low levels of KSC decreased from 71.62% to 31.64%.

Therefore, at the end of the training, the seventh graders prevail, who have improved their KSC and have passed to a very good and high level.

These high results prove the efficiency of the used pedagogical technology. These results also show that the experimental training was successful.

Students have improved their KSC on musical expression, style diversity, musical instruments and their functions. At the end of the training, they have acquired skills to work with a new type of technology, which they apply in the creation of musical compositions.

Paragraph 4. provides a comparative analysis of the results of the experimental training.

The analysis of the results obtained from the application of music-pedagogical technology for creating an algorithmic composition makes it possible to trace the dynamics of mastering the knowledge, skills and competencies of each student (see Table 1, Diagram 4).

The results of the survey of students after the training show that students have improved their knowledge, skills and competencies in all indicators and criteria.

The comparative analysis shows:

1. Students have the highest achievements **in Criterion 1. Creating a model of musical composition.** As a result of the training, **82.19% of the students have a positive change** and have moved to a higher level. Table 1 and Diagram 4 show that the average weighted value under Criterion 1 increased by 2.12, with students changing the level of their KSC - *from average at the beginning of training to very good at the end.*

Table 1

Arithmetic mean weighted value					
Criterion 1		Criterion 2		Criterion 3	
$\overline{X}$		$\overline{X}$		$\overline{X}$	
Beginning	End	Beginning	End	Beginning	End
2,90	5,02	4,07	4,95	3,99	5,05

One of the reasons for this high result is due to the fact that at the beginning of the training on one of the indicators (ind. 1.2) the seventh-graders have a low starting level. At the end of the experiment on the same indicator, the seventh-graders showed that they have high achievements, which are definitely a result of the training.

The analysis of the results **of Criterion 1** shows that students have enriched their knowledge of music, musical styles, mastered new KSCs for choosing algorithms and creating a model of musical composition. They have developed their musical-auditory and creative abilities, as a result of which they create a model of composition in 14 different styles according to their personal choice and preferences.

2. According to Criterion 2. Selection of musical instruments, high results are also reported.

The analysis of the data shows that as a result of training with the WolframTones generator, **71.42% of students have improved their KSC for musical instruments.** Based on this knowledge at the end of the experiment, they can consciously choose musical instruments and their functions according to the style of composition. **The arithmetic mean weighted criterion according to Criterion 2.** shows that at the beginning of the training the seventh graders have a good level of KSC, and at the end - a very good one (see Table 1). The weighted average increased by **0.88, which shows that students have significantly increased their KSC according to Criterion 2.** These data show that students have a good starting level ($\overline{X}$ =4,07), but the work of creating an algorithmic composition helps them to enrich their knowledge of musical instruments. As a result, at the end of the training they move to the next very good level ($\overline{X}$ = 4,95).

3. The results show a positive change **in Criterion 3 as well**. **Completeness of the composition**. According to this criterion, **74.71% of students have improved their KSC and have also moved to the next higher level.** As a result of the training, the students have understood the elements of musical expression. They have acquired knowledge of different types of frets, octave groups and the need to adapt their choice to the chosen style and rhythm, as well as the range of musical instruments. Table 1 and Diagram 4 show that according to **Criterion 3** at the beginning of the experiment the

students are at a good level ($\overline{X}$ =3,99), and in the end - very good ($\overline{X}$ =5,05). The average value increased by 1.06, which shows a very good result.

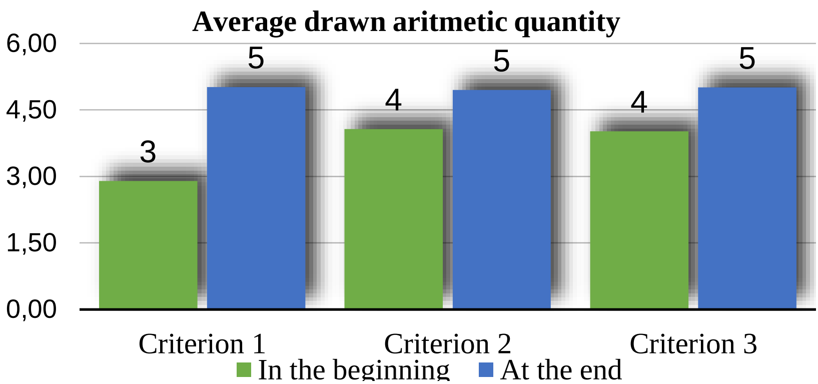

Diagram 4

Compared, the data on the three criteria show that the largest change is in Criterion 1 (2.12), followed by Criterion 3 (1.06) and Criterion 2 (0.88). This means that students have positive changes in all three criteria - they have increased the level of their KSC and have moved to a higher level (see Table 1 and Diagram 4). The diagram shows that at the end of the training on all three criteria students have a very good level of KSC.

These achievements are the result of the training, which uses a new type of technology that is easy to learn and stimulates students to actively participate in the learning process. The automated functions of the generator allow students with elementary actions to create different versions of musical compositions. The use of mobile and cloud technologies further stimulates seventh graders, as they can create compositions anywhere and anytime. The opportunity to use them as ringtones on their own phones, to send them to friends and relatives brings them joyful experiences. These are high achievements that prove that training with the WolframTones generator gives very good results. WolframTones not only generates music according to a given algorithm, but it allows you to control the activity of the algorithm, thus maintaining a certain control over the details in the musical composition. Working with the generator is pleasant, entertaining and engaging students, as a result of which they create interesting and original musical compositions, acquire knowledge and skills, acquire key competencies.

With regard to the created musical compositions, it can be said that there are those that sound creative, logical, meaningful and complete (for example, compositions 63, 4, 44, 36, 19, 18, 25, 14, etc.). These compositions speak eloquently that if a person has the necessary KSC and makes an effort, really good results can be obtained.

The statistical processing of the results shows that the total coefficient of reliability of the results on all criteria K = 0.94 is interpreted as excellent according to N. Oleynik. This means that the results of the evaluations of all criteria and indicators are interpreted correctly and the test system guarantees high repeatability, i.e. high stability of the obtained result.

The above proves that as a result of the applied music and pedagogical technology the students have achieved high results and have acquired knowledge, skills and competencies necessary for the creation of an algorithmic musical composition. The reason for this statement is the change in the level of the studied students and the presence of positive, qualitative changes.

The presented results by criteria and indicators, the data from the analysis of the compositions, as well as the statistical processing of the results show that the conducted experimental verification confirms the hypothesis of the thesis research.

The results of the conducted experimental training confirm the effectiveness of the applied music-pedagogical technology as a means of teaching students.

CONCLUSION

The analysis of contemporary literature related to algorithmic composition, the limited number of publications in Bulgarian and the need to modernize the learning process are the basis and motivation for the choice of topic and research.

The review of normative documentation concerning the system of school education revealed topics and opportunities for the application of music and pedagogical technology in the teaching of music to students.

The developed and tested music and pedagogical technology is intended for training students who do not have specialized music training. It meets the current requirements of modern education to provide modern and high-tech training.

The use of music and pedagogical technology for creating algorithmic music in the learning process has theoretical and practical significance - the acquisition of theoretical knowledge, skills and competencies for creating algorithmic composition and their practical application in working with software tools.

The analysis of the research results confirms the working hypothesis, it also shows that the aim of the research – *to establish the efficiency and applicability of music and pedagogical technology for creating an algorithmic composition,* has been achieved and the set tasks have been completed. The reason for this statement is the high results achieved, which are due to the training and mastering of KSC to create a musical composition.

The tested music-pedagogical technology for creating an algorithmic music composition is applicable because:

- The applied music and pedagogical technology provides an intensive and productive music-educational process in which students master the knowledge, skills and competencies to create a musical algorithmic composition.
- By mastering the technology of creating algorithmic music, students improve their knowledge, skills and competencies to work with new modern technologies in the field of musical art.

- The use of a new type of software (WolframTones generator) to create algorithmic music stimulates students to actively participate in the music education process.
- The music and pedagogical technology used gives high results.

All this gives grounds to draw the following **CONCLUSIONS:**

In essence, the proposed music-pedagogical technology for training is aimed not only at mastering knowledge, skills and competencies, but also at creating an attitude towards music and the art of music.

Music and pedagogical learning technology is practically applicable even to people who have limited knowledge of music. The automatic functions of the generator allow students to achieve good musical results (musical compositions) through simple actions.

Music and pedagogical technology creates favorable conditions for music education in the school education system through the application of modern technologies - mobile and cloud.

Working with the generator is enjoyable, fun and engaging. Through training, they gain not only practical skills, but also knowledge and skills in the field of musical art.

As a result of training with the WolframTones generator, students acquire the following key competencies:

Cultural competence and skills for expression through creativity manifests itself in the creative interpretation of new ideas in the process of creating a musical composition; emotional experience while listening to the created compositions; creating and selecting music suitable for various events, sounding greeting cards, animations, etc.

Digital competence – use of computer technologies and mobile devices (tablet, phone, laptop) to create and store the created compositions, use of modern technologies and the Internet to distribute the musical composition.

Mathematical competence and basic competencies in natural sciences and technologies - application of algorithmic models in the creation of musical composition; awareness of graphic models and regularities in the visualization of the musical composition; comprehension of the more important elements of musical expression;

awareness of the influence of technology on the art of music in creating a musical composition.

Learning skills – acquisition of new knowledge about musical styles, musical instruments, musical means of expression, etc .; acquiring knowledge for choosing an appropriate algorithm for working with a new type of software; comparison of different musical variants of the compositions, etc.

Simultaneously with the acquisition of knowledge, skills and competencies, students develop their musical-auditory, musical-cognitive, emotional-evaluative and musical-creative abilities.

The conducted experimental training shows the existence of an effective music and pedagogical technology for creating an algorithmic music composition and mastering KSC by students, in line with the latest trends in music education. This technology is related to the application of information technology in education and can be successfully applied both in music lessons at school and as extracurricular activities.

CONTRIBUTION MOMENTS OF THE DOCTORAL THESIS

Theoretical significance of the study:

1. An analysis of the relationship between algorithmic music and technology in the context of music education of students in secondary school.

2. Scientifically based music and pedagogical technology for creating a musical composition has been developed as an opportunity to apply a specific organization of learning, in which students acquire knowledge, skills and competencies for creating a musical composition and working with a new type of technology.

3. The application of the developed music and pedagogical technology in the teaching of music in the general education school is argued.

4. The developed music and pedagogical technology offers training with a new type of software - WolframTones, easy to learn, which stimulates students to actively participate in the learning process.

The practical significance of the study is characterized by:

1. Applying music and pedagogical technology to create an algorithmic composition through which students acquire knowledge, skills and competencies in music, music art and modern technology, gain subjective musical experience.

2. The music and pedagogical technology is original and practically applicable in the education of students who do not have special musical training. This technology provides motivated and active involvement of all students in the music-educational process, formation of personal-semantic and creative attitude to music.

3. As a result of the training, the students create a musical product that has an applied character. The created musical compositions can be used as ringtones, for sounding cards, animations, events, etc., as well as to share with relatives and friends.

4. The created music and pedagogical technology for realization of algorithmic musical composition can be used as a methodical guide by a wide range of users - those who have no musical training and have limited musical knowledge, as well as by people with music education.

LIST OF PUBLICATIONS ON THE TOPIC

Baychev, A. Creating a musical composition with the WolframTones generator. // Proceedings, College-Dobrich, University "Bishop K. Preslavski", Volume XII, 2020, p. 42 - 52.

Baychev, A. Software tools for creating an algorithmic musical composition. // FEMACOUSTICS, № 8, S., 2021, p. 13 - 20.

Baychev, A. Application of the WolframTones generator in music education at school. // FEMACOUSTICS, № 8, S., 2021, p. 21 - 27.