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인공지능 기반 음악 프로그램 두들 바흐를 활용한 초등음악창작수업 설계·적용 및 효과

Design, Implementation, and Effects of Elementary Music Creation Class Using an AI-Based Music Program, Doodle Bach

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Abstract This study is a field research aimed at analyzing the effectiveness of utilizing an artificial intelligence-based music program called 'Doodle Bach' in music creation classes based on creative teaching design. The research intends to analyze the effectiveness of incorporating artificial intelligence into music creation classes through learner surveys, teacher interviews, and analysis of music composition results, focusing on the cognitive aspects of music. The study subjects consisted of 50 sixth-grade students from two classes at Seoul Y Elementary School. The classes were divided into an experimental group and a control group based on the presence of 'Doodle Bach' in the creation classes, and five sessions of classes were designed and implemented. The analysis results showed that the musical cognitive abilities of both the experimental and control groups increased in the order of rhythm, harmony, and melody cognition, with the experimental group showing a more tremendous increase than the control group. The surveys, interviews, and analysis of creation results indicated that Doodle Bach effectively played a role as an assistant tool that provided assistance and inspiration during students' music creation process.

Key words: music education, music creation, artificial intelligence, digital media, musical cognitive abilities, Doodle Bach, elementary education

초록 본 연구는 창의적 수업 설계를 토대로 인공지능 기반 음악 프로그램인 '두들 바흐'를 활용한 음악창작 수업을 실행하고 학습자 설문과 수업자 면담, 음악창작 결과물 분석을 통해 음악 인지적 측면에 대한 효과성 및 음악창작수업에 인공지능을 활용하는 것의 효과성을 분석하고자 하는 현장연구이다. 연구대상은 서울 Y초등학교 6학년 2개 학급 학생 50명으로 창작수업에서 두들 바흐의 활용 유무에 따라 실험군과 통제군으로 나누어 5차시의 수업을 설계·적용하였다. 분석 결과 음악인지능력은 실험군과 대조군 모두 리듬인지, 조성인지, 선율인지 순으로 점수가 증가하였으며, 증가폭은 실험군이 대조군보다 높았다. 설문과 면담, 창작 결과물 분석 결과 두들 바흐가 학생들의 음악창작 과정에서 도움을 주거나 영감을 제공하는 어시스턴트 툴로서 효과적인 역할을 했음을 알 수 있었다. 본 연구를 통해 음악창작수업에서의 인공지능 활용에 대한 긍정적인 가능성을 보았으며, 국내 음악 교육 현장에서 인공지능 활용 및 방향성에 대한 지속적인 현장 연구가 이루어지기를 바란다.

주제어: 음악교육, 음악창작, 인공지능, 디지털 매체, 음악인지능력, 두들 바흐, 초등교육

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Ⅰ. Introduction

Music creation activities involve generating and modifying new musical material from intangible auditory elements (Burnard & Younker, 2008; Kwon, 2016). Through addressing various problem-solving situations in the process of music creation, these activities hold educational significance in enhancing musical cognitive abilities and promoting creativity by expressing imaginative thoughts through music (Younker, 2000; Park, 2011; Park, 2021). Especially in elementary education, music composition activities are vital as they often mark students' first experiences with music creation. However, despite this importance, composition requires diverse musical skills and environmental conditions, and it necessitates specialized teaching methods that are not as readily available as those for singing and playing instruments (Webster, 1990; Park, 2011). Additionally, assessment and feedback are challenging (Choi, 2022; Park, 2021; Pitts, 2005; Shin, 2016), making it difficult to implement in elementary education.

Since the Fourth Industrial Revolution marked by hyperconnectivity and superintelligence, education has been garnering significant attention to the use of advanced technology (Chun et al., 2021; Jung & Lee, 2021; Schwab, 2016; Seldon & Abidoye, 2018). Among these technologies, artificial intelligence has garnered considerable attention in music education, particularly in the realm of composition (Choi & Son, 2017; Kang et al., 2018; Oh et al., 2022; Soo et al., 2018; Yu & Ding, 2020; Zulić, 2019). The revised 2022 curriculum blueprint emphasizes the establishment of teaching and learning systems that align with the digital and AI education environment. In music education, the updated curriculum places a higher emphasis on creative activities, encouraging composition activities that integrate digital media and AI technology (Ministry of Education, 2021).

Various AI-based composition platforms such as Google's Magenta Project, Doodle Bach, Chrome Music Lab, Amazon's Deep Composer, and AIVA, recognized as the first AI composer, as well as Korea's EvoM, the first AI composition program(Oh et al., 2022), enable AI-human collaboration in music composition, rapidly expanding the scope and agents of music creation. Integrating these AI-based creative tools in education provides students with support for their creative endeavors, allowing them to invest more time in generating innovative ideas (Holland, 1989; Moon & Seung, 2022; Park et al., 2019; Zulić, 2019).

However, concerns exist regarding the use of AI in music education. For instance, while learners need to study diverse musical concepts and elements before composing music, the automation features of AI could shorten this process, potentially increasing interest and experience in music creation. Nonetheless, relying solely on AI-generated compositions might lack visual

representation or processes for students to infer related musical concepts and principles, potentially leading to insufficient learning outcomes. To address these concerns, it's recommended that a solid understanding of musical concepts and elements, as well as familiarity with AI tools and the ability to evaluate their outputs, should precede the utilization of AI tools (Moon & Seung, 2022). Furthermore, effective implementation of AI in music education requires practical teaching methods that align with curriculum content (Jung & Lee, 2022) and clear learning objectives, with the teacher's role being pivotal in the entire process (Moon & Seung, 2022).

In this study, we aim to analyze the effectiveness of utilizing an artificial intelligence (AI) based music program called 'Doodle Bach' in music composition classes that are designed to align with the context of domestic elementary schools. We will do this by applying 'Doodle Bach' in music composition classes and conducting learner surveys and teacher interviews. Our focus will be on evaluating the effectiveness of AI in music composition classes from a musical cognitive perspective. The specific research questions are as follows:

Research Questions:

(1) What is the creative approach to designing music creation classes for elementary students using the AI-based music program 'Doodle Bach'?

(2) What impact does the developed music creation class have on the musical cognitive abilities of elementary students?

(3) What are the effects of incorporating an AI-based music program into music creation classes?

Ⅱ. Literature Review

1. Research on elementary music creation classes in South Korea

Music creation activities involve creating and modifying new musical material from intangible auditory elements (Burnard & Younker, 2008; Kwon, 2016). These activities, which entail problem-solving during the music composition process, contribute to enhancing musical cognitive abilities and fostering creativity by allowing individuals to express their imagination through music (Park, 2011; Park, 2021; Younker, 2000).

In both domestic and international school curricula, music creation activities are recognized as essential components (Barrett, 2006; Biasutti, 2018; Burnard, 2000; Choi & Oh, 2016; Moon,

2005; Park, 2010; Park & Kim, 2012; Sætre, 2011; Shin, 2016). Particularly, music creation activities at the elementary school level hold significance as they provide most students with their first experience in music composition. South Korea's 2015 music education curriculum, which is aimed at 3rd to 4th graders experiencing music for the first time, emphasizes tasks such as changing the lyrics of existing songs, altering the rhythm or structure of songs, and creatively expressing the sounds from their surroundings (Ministry of Education, 2015). However, music creation activities require diverse musical abilities and environmental conditions compared to singing, instrumental music, and music appreciation activities (Park, 2011; Webster, 1990). They also present challenges in terms of teaching methods, assessment, and feedback in the educational context (Choi, 2022; Park, 2021; Pitts, 2005; Shin, 2016).

Therefore, it is essential to examine research on elementary music creation classes in South Korea to understand the trends and tendencies in music composition education. To achieve this, we conducted a search for papers related to elementary music creation classes published in domestic academic journals from 2001 to 2021. The search was carried out using the Research Information Sharing Service (RISS) and the websites of various academic journals, with keywords such as "music composition," "composition," "composing," "arrangement," "music creation," and "improvisation."

The search results indicated an overall increase in research related to elementary music creation classes from 2001 to 2021. The research topics were primarily focused on the development of programs, case studies, and experimental/applied research. Other topics included teaching methods, assessment, students' creation processes, and teacher perceptions. The research subjects were divided into 3rd-4th graders, 5th-6th graders, integrated classes, and teachers, with a significant emphasis on research involving 5th-6th graders. Notably, research on music creation classes using digital media (web-based programs, mobile applications, MIDI programs, etc.) has been increasing, and the diversity of media used in these classes is expanding. The research topics include the development of music creation teaching methods or programs using digital media (Chae, 2002; Hong, 2007; Im, 2018; Jeon & Lee, 2013; Jung & Kwak, 2004; Kang, 2018; Kil, 2020; Kim, 2004; Kim, 2010; Kim, 2019; Lee, 2002; Park, 2021; Seo, 2002; Shin, 2007; Son, 2004; Son, 2017; Yang, 2003; Yoon, 2015). Additionally, there is research validating the effectiveness of applying digital media and AI technology to music creation classes (Baek, 2021; Kim, 2002; Kim, 2016; Kim, 2016; Kim, 2020; Park, 2007; Park, 2017). Some studies also analyze the music creation process using digital media (Choi, 2022; Park, 2016) and develop teaching methods or models for music creation using digital media (Ham, 2010; Jung, 2015; Jo, 2016; Jung et al., 2021; Song, 2001; Yun, 2021).

This reflects a response to the evolving technological landscape while maintaining interest in traditional topics and research subjects. It is important to note that the introduction of advanced technologies such as AI and the Internet of Things (IoT) in education, alongside the Fourth Industrial Revolution, has prompted changes in education overall. This trend is evident in the 2022 revised curriculum guidelines, which prioritize the establishment of teaching and learning systems suitable for digital and AI educational environments. In the field of music education, the revised guidelines increase the emphasis on creative activities and encourage the integration of digital media and AI technologies into creative activities in music (Ministry of Education, 2021).

In this context, there are studies in South Korea's music education field that explore the use of AI in conjunction with music education. Hong et al. (2020) explored ways to utilize AI in school education and developed scenarios for using various AI-related music programs in classrooms. Yun (2021) derived guidelines for music curriculum creation using AI. Moon and Seung (2022) explored AI-based music tools that can be used in music classes and suggested their potential applications in school settings. While research on the execution and application of such classes is still limited in music education, there is a growing need for active research in the South Korean music education field to integrate AI and explore its applications in various educational contexts.

2. Educational utilization and effects of artificial intelligence tools

Since the advent of the Fourth Industrial Revolution characterized by hyper-connectivity and super-intelligence, advanced technology has become one of the most critical issues facing our society (Schwab, 2016; Seldon, Abidoye, 2018; Chun, Lee, Park, 2021; Jung, & Lee, 2021). Among the advanced technologies gaining recent attention, Artificial Intelligence (AI) stands out. AI, a field that has been developed since before 1943, involves research to implement human intelligence using computers by studying various human capabilities such as knowledge, memory, and reasoning, and organizing them into algorithms (Cho, 2021). AI has evolved further with evolutionary algorithms, artificial neural networks, and advanced deep learning techniques, and it has transcended being a mere "tool."

As a result, AI technology is now a significant concern in education, and countries worldwide are investing in the development of AI education systems (AI Council, 2021; Cho & Choi, 2022; Lee, 2020; Touretzky et al., 2019). South Korea, for instance, is actively promoting lifelong AI education for all citizens through its "National AI Strategy Report."(Interagency Collaboration, 2019) The 2022 revised education curriculum guidelines specifically emphasize the activation of AI

education in public education settings (Ministry of Education, 2021; Digital Education Forum, 2021).

In the field of education, discussions regarding Artificial Intelligence in Education (AIED) can be categorized into AI as "content" and AI as a "tool" (Hong et al., 2020). Holmes et al. (2019) further classified AIED into "learning about AI" and "learning with AI." Learning about AI involves acquiring concepts and literacy about AI, making AI technology part of the educational content. Learning with AI refers to using AI as a tool in various subjects and fields, often expressed as "AI+X" (Holmes et al., 2019; Jung & Lee, 2022; Moon & Seung, 2022). This study primarily focuses on 'learning with AI', exploring ways to effectively utilize AI as a mediating tool in elementary music composition classes.

The use of AI in education can have a positive impact on both teachers and students. For example, AI can provide students with diverse learning opportunities and support personalized education and assessment by analyzing individual learners' characteristics (Heo et al., 2021; Park et al., 2019; Pedró et al., 2019). Teachers can utilize AI in various aspects of teaching and learning activities, such as teaching and learning support platforms, teaching and learning media, Intelligent Tutoring Systems (ITS), Learning Management Systems (LMS), and Auto Writing Evaluation (AWE) systems (Holmes et al., 2019; Park et al., 2019).

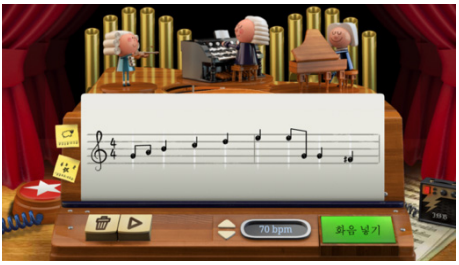
Reviewing prior research, it was found that AI has been applied in various subjects, including Korean language (Jung & Lee, 2022), science (Lee, Lee & Lee, 2019), English (Kim & Kim, 2021; Kim et al., 2021; Sung & Lee, 2021), mathematics (Im et al., 2021), physical education (Kim & Han, 2021), and arts (Yang & Han, 2021). These studies analyzed the effects of AI in enhancing subject-specific and cross-curricular competencies among elementary students, such as cognitive aspects and attitudinal aspects, with a focus on attitudinal aspects, including creativity, problem-solving skills, communication skills, critical thinking skills, and integrative abilities, which are essential competencies for future talents.

3. AI-based music program "Doodle Bach"

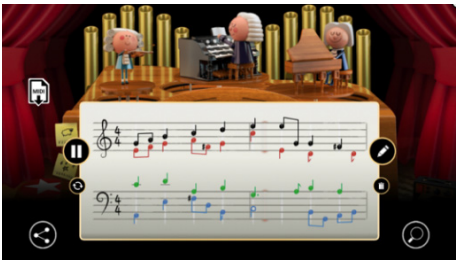
Recently, AI-based creative activities have garnered attention (Choi & Son, 2017; Jang, Lee, 2018; Kang, Oh et el., 2022; Park et al., 2019; Soo et al., 2018; Yu & Ding, 2020; Zulić, 2019). When artificial intelligence technologies like machine learning are embedded within creative tools, individuals can effectively engage in creative activities without the need for computer programming skills. Users can devote more time to generating creative ideas by utilizing AI-based creative tools (Holland, 1989; Moon & Seung, 2022; Park et al., 2019; Zulić, 2019).

In the field of music composition, research applying artificial intelligence is actively underway. Various AI music composition platforms, such as Google's Magenta Project, "Doodle Bach," Chrome Music Lab, Amazon's Deep Composer, and AIVA, the world's first recognized AI composer, as well as South Korea's first AI music composition program, EvoM(Oh et al., 2022), have been developed. These platforms collaborate with users to compose music or provide services for creating music in the desired genre and mood within a short time.

Among these, "Doodle Bach" was created by Google in commemoration of Johann Sebastian Bach. It is an AI-based music program that has learned Bach's works as data through machine learning (Google doodles, 2022.9.27. search). Users can freely create a short melody of two measures, and utilize MIDI to modify it directly or add more to it . By pressing a button, "Doodle Bach" infers the harmony and counterpoint patterns of the Baroque era using machine learning. It generates a four-voice harmony, with the user-created melody in the soprano voice, in Bach's style [Figure 1]. Users can play the generated music [Figure 2], and if they are not satisfied with the finished piece, they can press the button to create a harmony progression with a different pattern. Users can also set the desired beats per minute (bpm) and save the completed music as MIDI to modify it directly or add more to it.



[Figure 1] Doodle Bach user interface (User melody generation)



[Figure 2] Doodle Bach user interface (AI harmony generation)

"Doodle Bach" is an AI music program that incorporates predictive modeling. It analyzes the vast amount of data inherent in algorithmic rules through machine learning, allowing computers to think for themselves by showing various examples instead of providing a set of rules for the computer to follow. Specifically, the model used in "Doodle Bach," called Coconet, was trained on 306 Bach chorales (Google, search date 22.9.27.). Bach's chorales consist of four voices, each with an independent melody that flows while simultaneously creating rich harmonies, a form of polyphony. Coconet learned 306 Bach chorales with rigorous application of mathematical counterpoint rules, allowing it to process and identify user-input melodies through machine learning algorithms and transform them into Bach-style polyphonic music.

By using "Doodle Bach," users can experience creating music through interaction with artificial intelligence. Additionally, they can learn the role of harmony in music by experiencing the theoretical foundation of Baroque music from Western music. Users can easily have musical experiences without requiring specialized musical knowledge or skills. They can obtain satisfactory results based on AI technology and collaboratively with AI, derive various musical outcomes.

In this study, we aim to utilize "Doodle Bach" for the following reasons: Firstly, "Doodle Bach" has a high user affordance due to its game-like introduction and simple, intuitive design. This means it can capture students' interest through game-like introductions and straightforward storytelling. Even users new to the program can easily learn how to use it. Secondly, it is a program that can be effectively integrated with the 5th and 6th-grade music curriculum in elementary schools. Through "Doodle Bach," users experience creating a short melodic phrase of two measures, aligning with the music curriculum's achievement standards for the 5th and 6th grades that involve changing parts of sanctioned music. Furthermore, when "Doodle Bach" complements the user-created melody with Bach-style harmony, students can directly listen and judge whether the resulting music is suitable, understanding concepts like "Main Triads", "consonant" and "Variety of complementary sounds" effectively.

Ⅲ. Method

In this study, we designed a music creation class using an AI-based music program called "Doodle Bach" by reconstructing the curriculum based on a review of prior research and the 2015 Music and Education Curriculum for 5th and 6th grades, as well as music elements and concept charts. The review of prior research examined cases of elementary music creation classes

conducted in South Korea with keywords such as 'music composition,' 'artificial intelligence,' and 'media' as the focus, along with prior research related to the use of artificial intelligence tools in music education and cases of media-based teaching in music creation classes. Furthermore, based on the 2015 Music and Education Curriculum's music elements and concept chart and the 5th and 6th-grade achievement standards, we derived curriculum elements and set learning objectives to design a music creation class targeting 6th-grade elementary school students. The music elements, concepts, and 5th and 6th-grade achievement standards used in the curriculum reconstruction are listed in <Table 1>.

<Table 1> Achievement standards, music elements and concepts used in curriculum reconstruction

Achievement standards	Music elements and concepts
[Achievement standard 01-03] Modify the lyrics of a given song or create new lyrics that fit the song.	Sequential progression and leaping progression of melodies
[Achievement standard 01-04] Alter some melodies in a given song for expression.	Note names
	Major and minor scales
[Achievement standard 01-05] Represent scenes or situations from a story in music.	Main triads
	Harmony of various sounds

Next, through a review of previous studies and an analysis of artificial intelligence music tools, the elements of music creation lessons were derived as follows: First, the role of artificial intelligence in the lessons is that of an "active media(A media that plays an active role beyond being just a tool in the learning process)." Students should not only experience the creative results of artificial intelligence but also be able to develop their own music creation by imitating or modifying the creative results of artificial intelligence. Second, relevant concepts and principles should be included in the lesson content in a way that students can infer visual words or processes (Examples include graphic scores, listening maps, etc.). Teachers should incorporate relevant concepts and principles into all lesson content throughout the pre-, during, and post-lesson phases of music creation lessons using artificial intelligence. <Table 2>

<Table 2> Elements of music creation lesson design using artificial intelligence tools

Design element 1	Set the role of artificial intelligence in the lesson as an active 'media.'
Design element 2	Include visual words or processes in the lesson content that students can infer related concepts and principles from.

The stages of the music composition class using Doodle Bach were based on the creative learning model proposed by Chung et al. (2021). The creative learning model consists of four stages: imagination and exploration, planning and composition, modification and refinement, and finally, presentation and sharing. Throughout the creative process, teachers and peers can provide feedback and reflection (Chung et al., 2021).

1. Research participants

The participants in this study included 50 students who received consent from both the participants and legal guardians. These students were selected from two classes with the most similar scores in a pre-test conducted at a 6th-grade elementary school (School Y) in Seoul. Additionally, two homeroom teachers who had actually conducted the classes were involved. There were 23 students in the experimental group and 27 students in the control group. The variation in the number of participants between the two groups is due to students' absences from school, such as being absent on class days. None of these learners had previous experience with AI-based education, and they had not participated in music composition classes before. The two homeroom teachers had no prior experience teaching music in their classes, and they had not conducted any lessons related to artificial intelligence before. The students participated in surveys before and after the classes, and post-class interviews were conducted with the two homeroom teachers from each class.

2. Research tools

To confirm the effectiveness of the music creation classes using Doodle Bach in this study, interviews and surveys were conducted. In the case of interviews, individual interviews were conducted with homeroom teachers of the experimental and control groups after the classes. The common questions were, "What were the easy and difficult aspects while conducting the music creation class?", and "Did students show any particular difficulties or challenges during the class?". Additional questions were asked to the experimental group teachers, such as "What do you think are the characteristics, advantages, and disadvantages of music composition classes using AI tools?"

In addition to post-assessments, open-ended surveys were conducted. Common questions included, "What aspects of yourself have grown through music creation classes?", and "What

was the most challenging part of creating music?" Additional questions were given to the experimental group students, such as "How did using Doodle Bach, an AI-based music program, help in music creation activities?", while the control group students were asked about the benefits of using real musical instruments in music creation activities. Qualitative analysis was performed to evaluate the effectiveness of using AI-based music programs in music creation classes.

<Table 3> Individual interviews and open-ended survey questions

	Individual interviews	**Open-ended survey questions**
Common questions		What were the easy and difficult aspects while conducting the music creation class? What aspects of yourself have grown through music creation classes?", and "What was the most challenging part of creating music?
	Did students show any particular difficulties or challenges during the class?	What was the most challenging part of creating music?
Experimental group-specific questions	What do you think are the characteristics, advantages, and disadvantages of music creation classes using artificial intelligence tools?	How did using AI-based tools like Doodle Bach assist you in your music creation activities?
Control group-specific questions		How did using real musical instruments assist you in your music creation activities?

Specifically, the coding process involved reading and analyzing students' descriptive responses to categorize them into detailed categories (Creswell, 2016). After open coding to identify concepts and categories in the responses, a labeling technique was applied to define codes. This was done to prevent distorted data interpretation and ensure validity (Choi, 2022). For example, in response to the question, "What aspects of myself have grown through the music creation class," students' descriptive answers were categorized into five common keywords or researcher-defined categories: 'music creation ability,' 'music theory knowledge,' 'emotional aspects (confidence, perseverance, etc.),' 'interest in music,' and 'creativity.' In this process, if a student mentioned multiple elements in their response, they were included in all relevant categories. For instance, if a student's response to the previous question was, *"I have developed an interest in music compared to before, I can think more creatively, and even though making music was challenging, the experience of completing it makes me feel like I can work hard in anything in the future*

(Experimental Group Student A)," this student was categorized under 'interest in music,' 'creativity,' and 'emotional aspects.' The results of categorizing all students' opinions were converted into percentiles (%).

The measurement items for musical cognitive abilities were adapted for elementary school students from the Korean Test of Music Cognition (KTMC), developed by Choi, Kwon, Seog, and Chung (2012). The KTMC is a tool that was validated through three rounds of testing with 5,114 participants nationwide (Choi et al., 2012). The pre-test and post-test used the same questionnaire, and the test results were analyzed by converting them into percentile scores as presented in the KTMC.

3. Lesson design

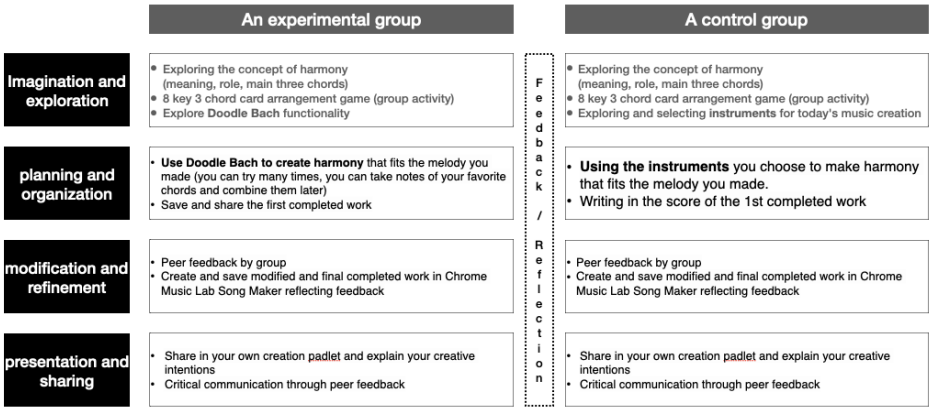
The lesson design in this study first conducted curriculum reconstruction and a review of previous research to derive five musical concept elements and two lesson design factors. Based on these, learning objectives were set, and a draft of the 4-session lesson plan was created. Subsequently, through two discussions with an expert holding a doctorate in music education and fellow teachers who would conduct the lessons, the lessons were refined. In the refinement process, it was suggested that students need to acquire the ability to read staff notation in advance, and that the exploration process of Chrome Music Lab's Song Maker, one of the tools used in the lessons, should be carried out at the beginning of the lessons.

Finally, a 5-session lesson plan and teaching materials were completed, and the learning objective was for students to create a new version of a given piece using technology. In the first session, students familiarized themselves with the note names in the treble and bass clefs and learned the given piece written in staff notation. The given piece of melody was selected as a familiar and easy-to-sing song for students. In addition to singing the piece, students analyzed it in various ways. In the second session, students learned the basic functions of Chrome Music Lab and recreated the given piece from staff notation on Chrome Music Lab. In the third session, students learned concepts necessary for creating melodies, such as stepwise and leapwise motion and the names of notes, and changed the melody of the given piece. In the fourth and fifth sessions, students learned harmony concepts and created harmonic accompaniments that suited the changed melody, considering the combination of various sounds. At this point, experimental group students used Doodle Bach to explore and modify harmonies that fit the melody, while control group students used real musical instruments.

The final creation was input into Chrome Music Lab's Song Maker and shared in digital format using online platforms. Design element 1 was applied in the first session, and both design elements 1 and 2 were applied in the second to fifth sessions. The flow of the lessons followed the flow of the creative learning model, ensuring that feedback and reflection between students and teachers were sufficiently carried out in the previous stages. The course of each session and the content of the fourth and fifth sessions are as shown in [Figure 3] and [Figure 4].

Session	Contents
1	Learning the names of the notes and the songs in the high and low notes
2	Learning the basic functions of the Chrome Music Lab Song-maker and how to read blank music sheet
3	Learning concepts and principles related to melody making and changing some of the melodies of the restricted songs
4-5	Using materials to create and present harmony accompaniment that matches the melody.

[Figure 3] The lesson progression for music composition classes using Doodle Bach



[Figure 4] The flow of classes 4-5th sessions

Ⅳ. Results

1. Creative approach to lesson design

Based on post-lesson interviews, the strengths and areas for improvement of the first and second design elements of this course were discussed with the teachers. For the first design element, "Define the role of AI in the lesson as an active 'media'," it was generally considered effective in this course. Specific feedback included:

> *"The use of artificial intelligence tools as a media in music education has made it easier for students to access the creative aspects where they often encounter difficulties. It seems that the first design element aligns well with the purpose of the lesson, as it has allowed students to maintain interest and engage in learning, even when dealing with challenging content that would have otherwise been difficult for elementary students through theory-based teaching alone."*
>
> <Teacher A Interview Transcript Excerpt>

However, there were some points for improvement raised regarding the timing of utilizing artificial intelligence as a media and the importance of the teacher's role in the lesson. The specific opinions are as follows:

> *"There was a concern that passive students might simply imitate melodies provided by AI, resulting in uncreative activities. Therefore, it was suggested that the design of the lesson should allow students to think critically. The role of the teacher and the timing of AI tool usage were deemed crucial."*
>
> <Teacher A Interview Transcript Excerpt>

Teacher A specifically noted that in the case of Doodle Bach, it could serve as a supportive tool for 'active' creation, particularly in the latter stages of creative work or for more advanced students.

Next, regarding the second design element, "Include visual words or processes that students can infer into the lesson content," both teachers mentioned that it was applied as a strength in this course. They emphasized that visualizing music theory elements such as the principles of melody creation or key triads significantly aided students' comprehension. Additionally, the presentation of various visual or audio materials to spark inspiration and idea generation before engaging

in music creation was found to be highly effective among students, according to both teachers.

Furthermore, although it was not directly related to the course's design elements, both teachers agreed that the process of sharing creative works and providing feedback among peers, which was integrated into the course, proved to be highly effective in fostering students' creative processes and learning.

> *"Sharing what a few students did well and listening to it first seemed to provide a positive stimulus to other students."*
>
> <Teacher B Interview Transcript Excerpt>

> *"There were students who typically had a low profile or even displayed selective mutism, as well as those who approached the class as mere spectators during other subject times. However, in this course, some of these students showed remarkable potential. As a homeroom teacher, I was truly surprised to witness aspects of these students that I hadn't seen in a year. It seems that positive feedback from other students gave these particular students more confidence, and as time went on, they approached music creation activities with great enthusiasm."*
>
> <Teacher A Interview Transcript Excerpt>

2. Music cognitive ability pre- and post-assessment results

To assess whether the AI-based music composition program improved students' music cognitive abilities, two classes were divided into an experimental group and a control group. Music cognitive abilities were assessed using the Korean Music Cognitive Ability Test before and after the music composition course, and the results are shown in <Table 3>.

According to the pre-post-test results, in the experimental group, there was a noticeable difference in scores in the music cognition abilities, including 'tonality cognition,' 'rhythm cognition,' and 'melody cognition.' In both the experimental and control groups, rhythm cognition, tonality cognition, and melody cognition were ranked in that order in terms of score differences. Notably, through interviews with students who were able to recognize musical concepts such as measures during the music creation process using Chrome Music Lab Song Maker or understand note duration in melody and rhythm creation processes, it is considered that the ability to perceive rhythm showed the most significant growth, with scores of 8.12 in the experimental group and 5.34 in the control group.

<Table 4> The percentile score difference in music cognition abilities between pre-test and post-test

Unit(%)	Tonality cognition test		Rhythm cognition test		Melody cognition test	
	Experimental group	Control group	Experimental group	Control group	Experimental group	Control group
Pre-test percentile score average	57.52	67.67	58.88	56.70	74.08	67.93
Post-test percentile score average	63.76	68.78	67.00	62.04	75.64	68.78
Post-Pre (percentile score difference)	6.24	1.11	8.12	5.34	1.56	0.85

- Both the experimental and control groups showed score differences in the order of rhythm, tonality, and melody cognition.
- In all three areas, the experimental group had larger score differences compared to the control group, especially in the tonality cognition test.
- The utilization of the AI-based program "Doodle Bach" implies that students' tonality cognition abilities could further develop.

Furthermore, while the experimental group outperformed the control group in all three areas, the difference in scores was particularly pronounced in tonality cognition. The post-pre-percentile score difference for tonality cognition in the experimental group was 6.24, whereas it was 1.11 in the control group. In other words, the experimental group scored 5.13 higher than the control group in terms of tonality cognition. This suggests that the use of the AI-based program, Doodle Bach, had a more significant impact on students' tonality cognition abilities. Therefore, it can be concluded that utilizing AI-based music-creating programs had a positive influence on the overall enhancement of students' music intelligence in music creation classes.

3. The effect of using AI-based music programs in music creation classes

1) Open-ended survey results

The responses from students to the open-ended survey conducted after the class concluded are as follows. First, in response to the common question, "What aspects of myself have grown through the music creation class," students' answers were categorized into five main categories: 'music creation ability,' 'music theory knowledge,' 'emotional aspects (confidence, perseverance, etc.),' 'interest in music,' and 'creativity.' In both the experimental and control groups, students

ranked their growth in the following order: first, 'music creation ability' (experimental group 39%, control group 34%), and second, 'music theory knowledge' (experimental group 33%, control group 34%). Among these musical elements mentioned by students, 'harmony' was the most frequently cited. For instance, *Student B in the experimental group* mentioned, *"I used to have difficulty distinguishing harmonies or understanding dissonance concepts, but now I have learned how to compose more richly through harmony."* [Figure 5]

[Figure 5] Responses of the experimental and control groups to the question, "What aspects of myself have grown through the music composition class?"

Furthermore, students' responses to the second common question, "What was the most challenging aspect of creating music?" were categorized into six themes: 'harmonizing,' 'creating rhythms,' 'musical notation,' 'idea generation,' 'melody creation,' and 'other.' Among these, the experimental group students identified 'musical notation (35%) and melody creation (35%), harmonizing (13%), idea generation (9%), rhythm creation (4%), and other (program limitations) (4%)' as the most challenging aspects. In contrast, the control group students responded with 'harmonizing (35%), musical notation (31%), idea generation (23%), rhythm creation (8%), melody creation (4%)' as the most challenging aspects.

Both experimental and control group students mentioned musical notation, particularly 'musical notation,' as a challenging point. Experimental group students found it difficult to transfer musical notes from Doodle Bach, which outputs musical notes on a staff, to Chrome Music Lab. Control group students, who did not use Doodle Bach, also encountered difficulties when trying to transfer melodies created on Chrome Music Lab to sheet music. This difficulty seems to stem from the fact that Chrome Music Lab uses a digital media with rectangular graphics to create music, while Doodle Bach outputs results on a staff notation. Additionally, it suggests that students experienced more significant challenges in reading and writing sheet music compared to graphic notation.

In addition to these challenges, experimental group students noted difficulties in melody creation (35%), harmonizing (13%), idea generation (9%), rhythm creation (4%), and other aspects (4%).

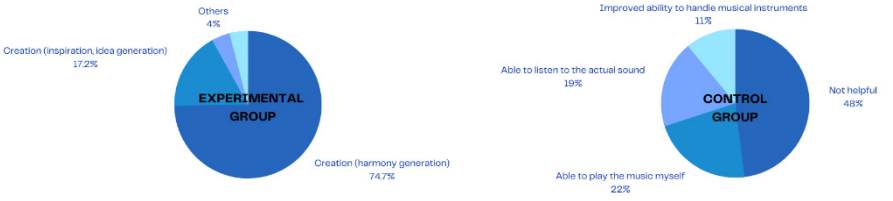
On the other hand, control group students highlighted challenges in harmonizing (35%), idea generation (23%), rhythm creation (8%), and melody creation (4%). Notably, control group students, who used physical instruments for harmonizing, reported higher levels of difficulty in 'harmonizing' and 'idea generation' compared to experimental group students who used Doodle Bach. [Figure 6]

[Figure 6] Responses of the experimental and control groups to the question, "What was the most challenging aspect of creating music?"

Moreover, responses to the question "How did using actual musical instruments benefit you in music creation?" were specific to the control group and categorized as follows: Not Beneficial (48%), Able to Play Directly (22%), Able to Hear Actual Sound (19%), Improved Musical Skills (11%).

On the other hand, responses to the question specific to the experimental group, "How did using the AI-based Doodle Bach benefit you in music creation?" were categorized as follows: Helped with Composition (Harmony Generation) (74%), Helped with Composition (Inspiration, Idea Generation) (17%), Other (4%), Not Helpful (4%).

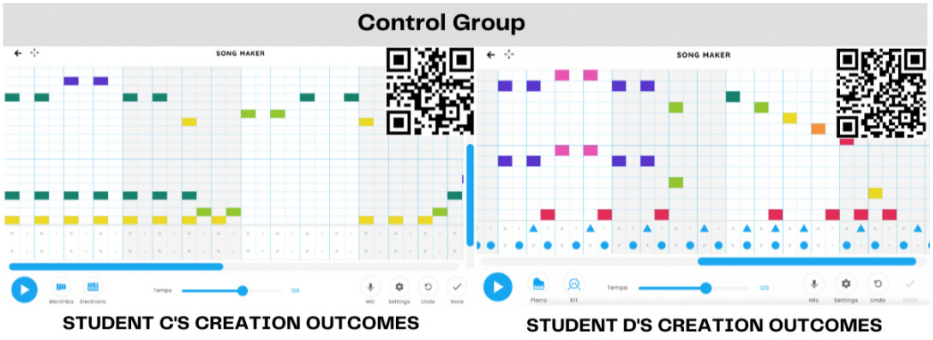
Among these responses, students who mentioned that it was not helpful explained that the AI-generated music did not align with the music they intended to create. Notably, responses from control group students who found playing musical instruments and hearing real sounds beneficial are also worth considering. [Figure 7]



[Figure 7] Responses to the question, " How did using the AI-based Doodle Bach benefit you in music creation?" from the experimental group, and responses to the question, "How did using actual musical instruments benefit you in music creation?" from the control group

2) Analysis of music creation results

Analysis of the students' music creation results revealed differences between the experimental group, who used Doodle Bach to explore and modify harmonies that fit with the melody in sessions 4-5th, and the control group, who used actual musical instruments for a similar purpose. In the control group, students applied the major triads they learned during the lessons to create harmonies that complemented the melody. They often sought to create harmonies that fit the melody while diversifying the rhythm or modifying accompaniment forms like the Alberti bass or arpeggios. However, some students unintentionally departed from the major key and transposed into a different key (tonal shift) while creating the melody. In such cases, they either continued to use major triads within the new key or left it blank, stating that they couldn't find harmonies that matched the melody (as reported by *Student C*), which was a common occurrence. As shown in [Figure 8], *Student D* from the control group used the parallel progression technique to create the melody, resulting in a modulation from the major key to the relative minor key within the middle two measures. However, the student still employed the major triad within the new key, and in the open-ended survey, they mentioned that *"thinking of harmonies that suit me personally was the most challenging part."*

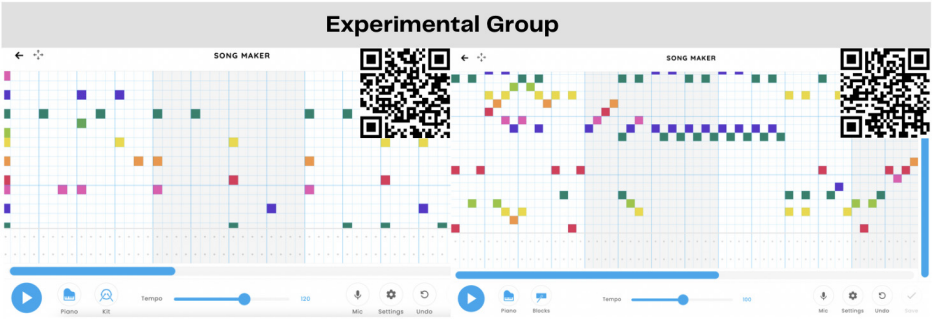


- Applied the Main Triads learned during the lesson to create harmonies that fit the melody (variations in rhythm, Alberti bass, arpeggios, and other accompaniment transformations).
- While creating the melody, unintentionally deviated from the tonic key and experienced difficulty in using the Main Triads within the tonic key or faced challenges in creating harmonies.

[Figure 8] The creative results of control group students C and D

In contrast, the Experimental Group students, with the assistance of artificial intelligence, were able to easily create harmonies even in unintentional modulations. They also used a wider range

of harmonies, including concords beyond the primary triads they had learned in the lessons. Additionally, it was noticeable that many students in the Experimental Group utilized a more horizontal harmonic progression, influenced by Doodle Bach. For instance, *Experimental Group Student E*, as shown in [Figure 9], employed various harmonic progressions beyond the primary triads learned in class. Experimental *Group Student F*'s creative output, displayed in [Figure 9], also demonstrates a more horizontal harmonic progression influenced by Doodle Bach.



- Even during unintentional modulation, the assistance of AI helped in easily creating harmonies that complemented the melody.
- There were significantly more consonant interval and various other harmonies used by the students compared to the control group.
- The influence of "Doodle Bach" resulted in a prevalence of horizontal harmonic progressions rather than vertical ones.

[Figure 9] The creative results of experimental group students E and F

Through this, it can be observed that the artificial intelligence-based program used in this course, Doodle Bach, was effective in providing students with harmony generation and inspiring ideas or creativity in music creation. Furthermore, it was possible to confirm the potential positive impact of music composition education using artificial intelligence on both teachers and students.

In other words, artificial intelligence can serve as an assistant tool in the music composition "process," enabling students to have musical experiences easily, even if they lack specialized musical knowledge or skills, and supporting the generation of various musical outcomes.

V. Discussion & Conclusion

Currently, one of the key issues in education is the utilization of artificial intelligence (AI) technology in music education, especially in the creative domain. The revised 2022 music education curriculum places a greater emphasis on the creative aspect, encouraging activities that integrate digital media and AI technology (Ministry of Education, 2021). Consequently, research on the pedagogical approaches and practical applications of integrating AI and various digital media into music education is essential. It's also crucial to explore how the use of AI in music composition classes impacts students in actual educational settings.

This study applied AI-based music program 'Doodle Bach' to design music creation classes tailored to the context of South Korean elementary schools. It aimed to analyze the effectiveness of integrating AI-based programs into music creation classes from both a cognitive perspective and in terms of their impact on the learning process. Three research questions were formulated, and the data collected through student surveys and teacher interviews yielded the following conclusions: The first research question investigated the effectiveness of using 'Doodle Bach' in elementary music creation classes, considering both the teacher and student perspectives. It was found that both the first and second design elements of the classes were effective in supporting students' music creation activities. However, there is a need to refine the timing of introducing AI as a tool in the classroom and to emphasize the importance of the teacher's role during the entire process.

The second research question examined the impact of the developed music creation classes on elementary students' music cognitive abilities. The results showed that both experimental and control group students exhibited overall growth in music cognitive abilities after the classes, but the experimental group showed more significant improvement.

The third research question focused on the effects of applying AI-based music programs in music creation classes. It was observed that AI facilitated the music composition process for students, even when they lacked specialized musical knowledge or skills. It served as an assistant tool, allowing students to easily engage in musical experiences and produce a variety of musical results.

In summary, the study found that the use of 'Doodle Bach' in music creation classes aligned well with the South Korean education curriculum and its emphasis on integrating AI as a medium. However, the study also highlighted the importance of ensuring that students comprehend relevant musical concepts and theories before using AI tools. Additionally, it emphasized the significance of creating spaces where students can freely share their composition process and receive feedback

from peers.

Furthermore, it was recommended that AI-based tools used for educational purposes should be selected based on their ability to clearly illustrate relevant concepts. The study also noted the need to explore other factors beyond musical cognitive abilities that may contribute to students' composition skills when their musical cognitive test scores were below average.

This research provided insights into the effective design of music creation classes and the potential of AI-based tools in enhancing music education. It also suggested that further research should be conducted to comprehensively understand how AI can impact students' musical development over an extended period and adapt to the rapidly changing landscape of music education in the Fourth Industrial Revolution era.

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