

Original paper

**Promoting Programming Education
through Musical Composition and Performance:
Important Insights from a Practice Class with Sixth Graders**

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概要

2020 年度に小学校段階におけるプログラミング教育が必修化されて以降、多くの実践者・研究者が、学会誌、教師向けの図書、YouTube 動画などで音楽科における実践を紹介・報告している。その多くは、音楽の諸要素や、プログラムの構造を支える要素にあたる順次、反復、分岐を学ぶことを目的とした、コンピュータを用いた音楽づくり活動である。他方、このような活動だけでは、音響が固定されない不確定な要素を含む音楽—例えば音遊びや即興的表現など—とプログラミングとの関連がはかれないことも指摘されている。

本論文の著者の 1 人は、以前に発表した論考で、音遊びや即興的表現などの活動における児童の表現行為に順次、反復、分岐といったアルゴリズム的な関係性が内在していることに着目し、音の表現、身体表現、言葉の表現などを織り交ぜた作品をつくる活動をとおしてプログラミング教育に関わる学びを促す可能性を示した。しかしながら、実際の授業実践には至っていなかった。

そこで、本研究では、第 6 学年の児童を対象とした授業実践を行い、このような表現活動において授業者が留意すべき点を検討した。その結果、児童にとってあまり馴染みのない本活動のコンセプトを十分に理解させること、パフォーマンスにおける計画と即興性・不確定性との関係を意識すること、児童の表現に内在するアルゴリズムと児童の身近な生活に内在するアルゴリズムとの親和性についての気づきを促すこと、の 3 点が挙げられた。

Abstract

Since the introduction of mandatory programming education in elementary schools in 2020, many researchers and teachers have reported on integrating it with music education. Several practices focus on computer-aided music-making, emphasizing elements such as sequence, repetition, and branching—core components of programming. However, these activities alone might not encompass the relationship between programming and music that involves indeterminate aspects, such as musical games or improvisation. One of the authors previously highlighted that children's activities, such as musical games or improvisation, inherently contain algorithmic relationships. They proposed intertwining auditory, bodily, and verbal expressions to enhance programming education. Yet, this approach has not been applied in real classrooms. In this study, classroom practice for sixth graders was conducted, aiming to identify key considerations for teachers. Three findings emerged: First, as students might be unfamiliar with linking music-making activity to algorithms, they require ample time and assistance to grasp the concept. Second, balancing between a planned composition and live improvisation is crucial. Teachers must guide students to ensure performances do not deviate too much or adhere too strictly to the original plan. Third, teachers should emphasize the connection between algorithms in performances and those in everyday life.

Key words: elementary school music class, programming education, music composition, improvisation

1. Introduction

Since 2020, programming education has been compulsory in Japanese elementary schools, and has been implemented in all subjects, including music. Many practitioners and researchers have introduced and reported on the practice of programming education in music studies in academic journals, research bulletins, manuals for teachers, and YouTube videos. These practices often involve using computers to compose music, which is suitable for learning the characteristics and functions of various musical elements (e.g., rhythm, melody, and harmony), as well as the three fundamental elements of programming: sequence, repetition, and branching.

However, Terauchi, one of the authors of this paper, argues that because activities using computers often focus on composing determinate music, they provide limited opportunities to learn about the relationship between programming and indeterminate music, such as musical games and improvisational expression. Furthermore, he discusses the possibility of encouraging programming learning through group performances without utilizing computers, with compositions and performances involving indeterminacy that mixes musical, physical, and verbal expression, and positions these activities as “activities to construct algorithms for performance” (Terauchi, 2020). Terauchi (2020) also discusses the significance of such activities in the same discussion, mainly to facilitate the connection between the activity of musical games or improvisational expression and that of composition by constructing sound into music, in order to raise interest in the structure itself of musical notation or programs by encouraging attention on the causal relationship between commands and results. This will allow students to become aware of the characteristics of the subject executing (performing) algorithms and broaden their view of music (Terauchi, 2020). This type of activity has not yet been widely adopted in classrooms, and the Japan Ministry of Education, Culture, Sports, Science and Technology (2020), which provides practical examples of programming activities in various subjects, has not provided examples of such activities.

Therefore, Terauchi (2022a; 2022b) developed a mixed media composition activity, “Next Stage,” as a learning material. It has been proposed that each performer’s performance has algorithmic relationships, such as sequence, repetition, and branching. Of these, branching, in particular, is closely related to indeterminacy.¹ However, this suggestion has not yet been implemented in classroom settings.

2. Aims and Methods

This study aims to discuss and provide insights into what teachers should be conscious of when facilitating programming learning through classroom practice using “Next Stage” and reflection. It involved a practice class for sixth-grade elementary school children aged 11–12, which was conducted by the two teachers utilizing “Next Stage.”

An action research method, with the research team comprising two teachers and an observer, was employed. After the practice class, the research team reviewed the video recordings and artifacts created by the children. The observer is not involved in but advises on classroom practice and participates in post-lesson reviews.

To protect the children's privacy, this paper did not include their names and group affiliations. This research was approved by the Ethical Committee, Graduate School of Humanities and Social Sciences, Hiroshima University (Application Number: HR-ES-000297).

2.1 Outline of “Next Stage”

“Next Stage,” designed for music-making activities by groups of 3–5 children, was developed by modifying the learning material “Stage” (Terauchi, 2016) for programming education. A summary of “Next Stage” is presented below (see Terauchi, 2016; 2022a, for further details).

First, each member writes their expressions based on their strengths and interests on small cards called expression cards. They may write any expression, including musical expression, verbal expression, physical expression, mimicry, or jokes (Figure 1). Children can name each expression card. Group members then show their cards to each other and consider their order and combination to compose their group's performance, using the performance sheet as the entire score (Figure 2). Composing a performance involves trial and error.



Figure 1. Some examples of expression cards

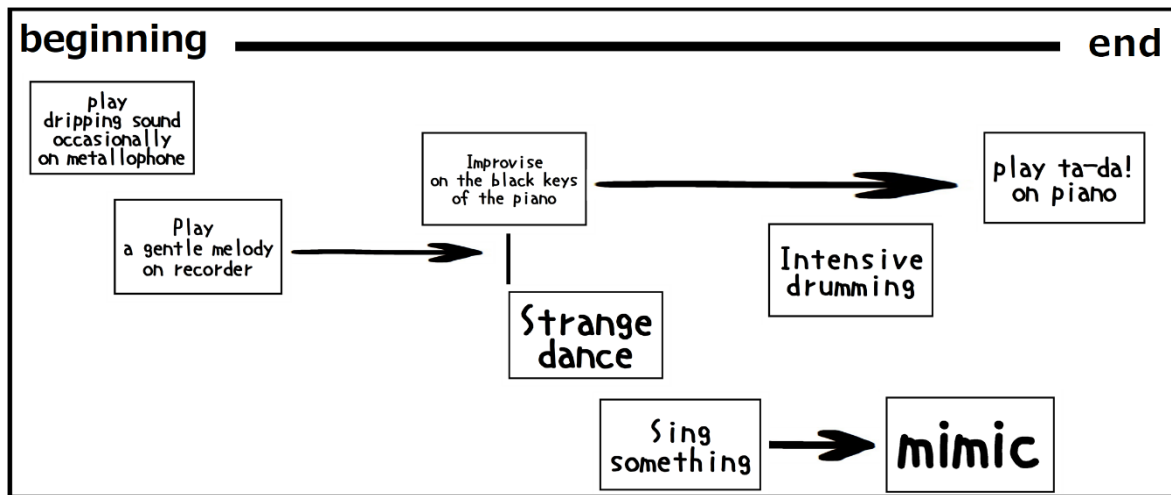


Figure 2. An example of a performance sheet

Terauchi (2022b) discusses the relationship between “Stage,” “Next Stage,” and programming education. He notes that the performance sheet serves as a program to realize music and states that creating the performance sheet constitutes programming while utilizing sequential and repetitive processes (pp. 102–104).

Furthermore, Terauchi (2022b) attempts to increase affinity with programming by introducing branching and integration during “Next Stage” (pp. 104–105). These concepts can be explained as follows:

Branching occurs when a performer’s decision during a performance, an expression with an indeterminate outcome, the audience’s reaction, or an accidental event becomes a condition for changing subsequent performance behavior (Figure 3). Incorporating branching into the performance sheet is expected to yield certain effects; for example, the diversity of musical development will increase as different outcomes are generated with each performance. Introducing uncertainty into the performance process creates more opportunities for performers to respond, thereby enhancing children’s improvisational skills.

Integration involves combining several programming instructions called functions, methods, and subroutines. In “Next Stage,” the idea of integrating multiple expression cards into a single one—called “awasewaza”—is introduced (Figure 3).ⁱⁱ Similar to the case of ordinary expression cards, the children determine the name of the awasewaza card. An advantage of integration is that it makes the performance sheets more concise and easier to read. During the “Stage” and “Next Stage,” the program is executed (performed) by the children and not by a computer. Therefore, a moderate simplification of the performance sheet is practically advantageous for ease of understanding.ⁱⁱⁱ

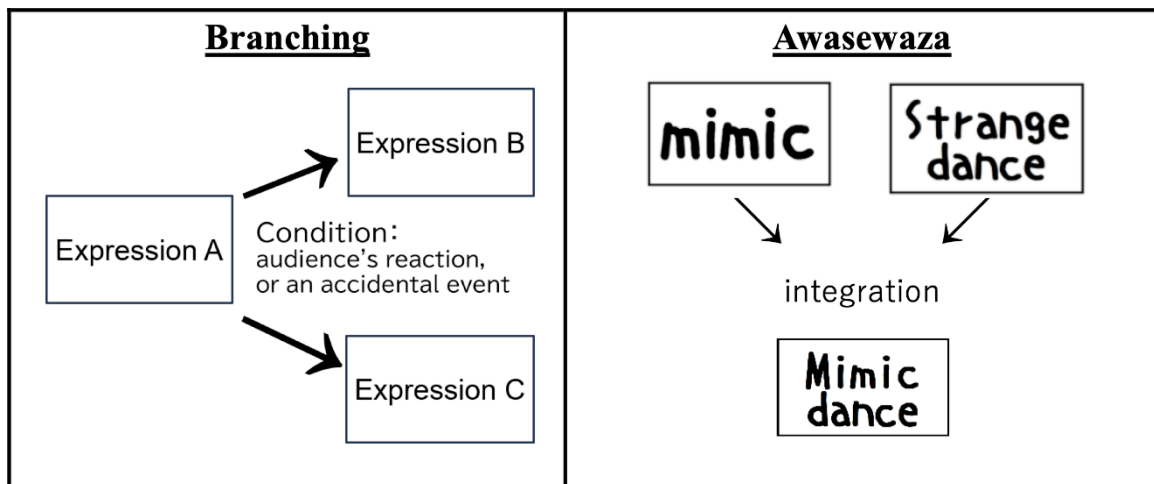


Figure 3. Each example of branching and awasewaza (integration)

2.2 The study outline

Class period: July 2022

Classes: One sixth-grade class comprising children aged 11–12 years at an elementary school in Hiroshima, Japan, participated in this study.

The class comprised 30 children. Five groups of six members each were formed for this activity.

Objectives: To compose and perform based on the group's strengths and interests.

Teachers: Yayoi Kogamoto (school music teacher) and Daisuke Terauchi (guest music teacher).

2.3 Children's backgrounds

Regarding children's experiences with music-making activities, they engaged in various exercises concentrating on distinct musical components such as rhythm, melody, and harmony. For example, they had prior exposure to combining rhythmic patterns and creating melodies matching cyclic chords. However, they lacked experience in a music-making activity such as "Next Stage," which involves mixing diverse forms of expression, encompassing music and physical and verbal modes.

A questionnaire was administered to determine the children's experience in programming activities. Initially, attention was directed toward their engagement with programming activities within the school curriculum, specifically from 2020—when programming education was mandatory (corresponding to the children's fourth grade)—to when the questionnaire was undertaken. Many children responded negatively, indicating that they had not encountered programming activities on any subject. These findings suggest that the children of this class were unfamiliar with programming.

3. The Method of Conducting the Activity

Day 1: July 1, 2022 (45 minutes of activity)

Objectives: To create music by devising an order and combination of various expressions.

Two teachers demonstrated a series of activities to introduce the children to upcoming activities. These included creating expression cards comprising a performance sheet and a final performance. The teachers were mindful of the following during the demonstration:

- Demonstrating the music-making process with teachers and exchanging opinions as they proceed.
- Emphasizing that expression cards can be intuitively named, such as “Puhjaa,” which is an onomatopoeia for blowing hard, to show how cards can be named quickly.
- Demonstrating the structure of the performance sheet using a whiteboard and colored paper for the expression cards.
- Illustrating how music can be a mixture of various expressions, including picture book reading and theatrical expressions.
- Providing concrete examples of utilizing the strengths of each member. For instance, Kabuki Modoki, the performance of the Kabuki-like voice shown in Figure 4, reflects the teacher’s strengths.

Through these demonstrations, the teachers aimed to provide the children with a comprehensive understanding of the activities.

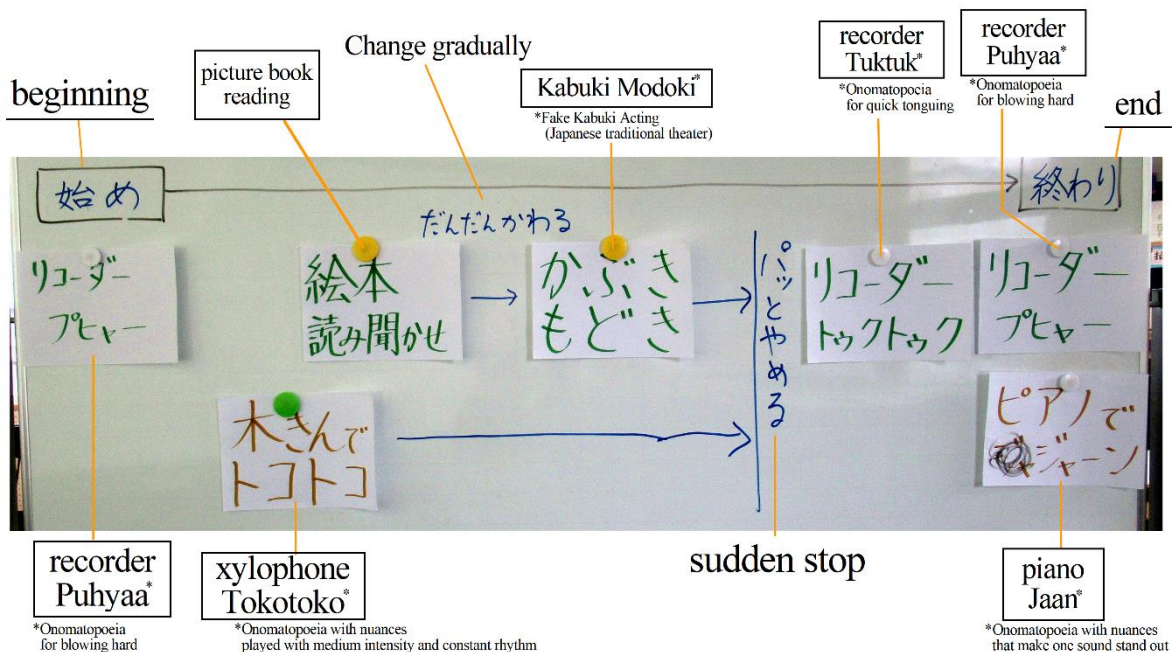


Figure 4. Performance sheet for teacher’s demonstrations on Day 1

Following the demonstration, children engaged in individual activities. They freely experimented with the instruments and created expression cards reflecting their strengths and interests. Subsequently, group activities were initiated. They composed their performance sheets while considering the order and combination of group members' expression cards. Finally, one of the groups performed the task as an interim action.

Day 2: July 4, 2022 (45 minutes of activity)

Objective: To compose an intuitively easy-to-understand performance sheet.

First, the teachers demonstrated creating a performance involving the awasewaza method and branching. During the demonstration, the three expression cards shown in Figure 4—"picture book reading," "Kabuki Modoki," and "xylophone Tokotoko"—were integrated and named "picture book Kabuki Tokotoko." Awasewaza cards were blue to differentiate them from others, shown on yellow cards (or a larger piece of paper). The teachers encouraged the children to search for expression cards that could be integrated as awasewaza cards in the performance sheet created during the previous activity.

To generate further interest in branching, the teachers intentionally covered the branching condition with black paper during the demonstration and asked the children to guess what was written there after the performance ended. Once the black paper was removed, the audience's laughter confirmed that it was a condition for the performance—which branched into different acts depending on the result of the condition—and the way this structure was written on the performance sheet (Figure 5). The children were encouraged to incorporate at least one branch into their performance.

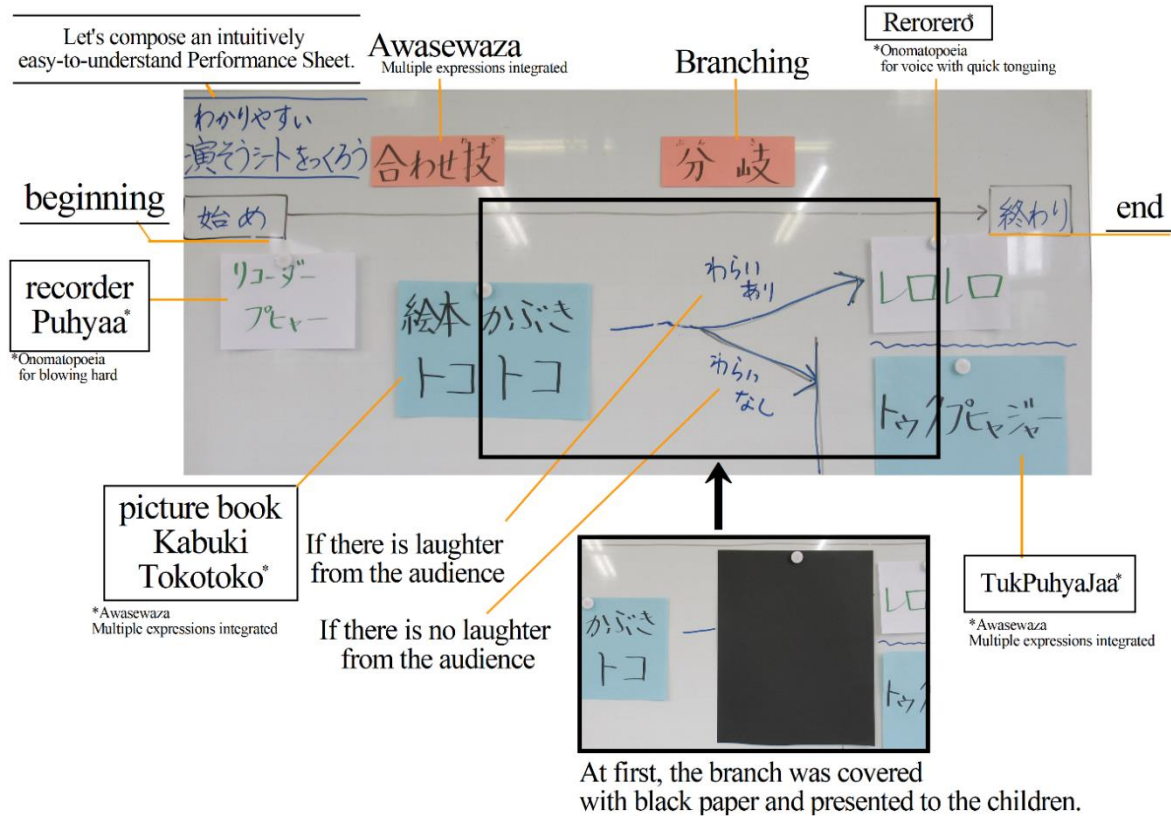


Figure 5. Performance sheet for teacher's demonstrations on Day 2

Day 3: July 6, 2022 (45 minutes of activity)

Objectives: To perform each group's music.

First, a rehearsal session was conducted. Subsequently, they listened to each other's group performances. Class members provided feedback and shared their impressions of each group's performance, including its enjoyableness and effectiveness.

Finally, the teachers provided an explanation that connected the content of the previous three-day classes with the concept of programming. The teachers emphasized that awasewaza and branching are integral to our daily lives and cited several practical examples to support this explanation. An example of an awasewaza is a fully automatic washer/dryer that can perform various functions such as washing, rinsing, dehydrating, and drying clothes by pushing a button. Furthermore, deciding to hold or cancel a scheduled excursion based on weather conditions is an example of branching.

4. Results

4.1 Results of children's activities

The classes gradually taught the children how to use the algorithmic structures that they had learned during their compositions. First, we described the uses of awasewaza; thereafter, during the class, the children tried to create awasewaza. They appeared to be experiencing the positive aspects produced by integrating multiple expressions. For groups that found this difficult, the teachers recommended changing

the order or combination of the expression cards on the performance sheet and confirming their expressions while paying attention to sounds and rhythms. Thus, the children were encouraged to become aware of the positive aspects that can be created by combining multiple forms of expression.

Four of the five groups could incorporate awasewaza into their performance sheets. Among them, the group that utilized awasewaza the most managed to integrate ten expression cards into five, resulting in a more concise performance sheet (Figure 6).

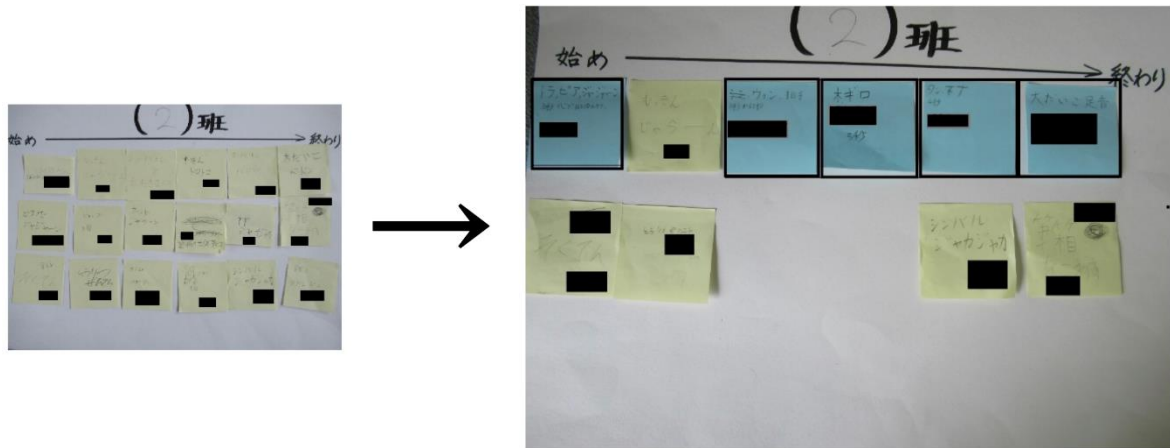


Figure 6. Ten expression cards (yellow tags) into five (blue tags)

*To ensure their privacy, the child's name is blacked out.

In the discussion on the use of branching, the teacher's demonstrations showed that many children were intrigued by the concept of branching. Throughout the activity, the groups engaged in trial and discussion to determine the types of conditions to set and the expressions to use following branching.

By the time of the performance, all groups could incorporate branching into their performance sheets. Specifically, the groups devised the following conditions and performances:

- a) If the audience laughed, the group would play body percussions; if the audience did not laugh, they would shout, "Sole!"
- b) When the xylophone player played the scale, another player played the cymbals; when the xylophone player played the melody, another player played the tambourine.
- c) If the audience reacted indifferently to group members fighting among each other during the performance, they would run; if the audience reacted anxiously, they would lie down.
- d) If the audience applauded the performance of the tambourine and bell, the group played the tambourine; if the audience did not applaud, they played the big drum.
- e) If a certain child in the audience laughed when a performer shouted "an-punch"^{iv} while running, the performer jumped; if the child did not laugh, the performer jumped while snapping their fingers.

During performances, many children could utilize their resources, including music, physical expressions, and verbal expressions. This achievement highlights the success of the lesson's objective, as stated in its title: "Let us compose and perform based on your group's strengths and interests."

However, some children were limited to rehearsals by themselves; consequently, the group might not have been fully prepared for the performance. This situation may have required encouragement from teachers to initiate rehearsals with all group members earlier.

Before the performance began, the teachers emphasized the importance of responding flexibly, even if they could not follow the performance sheet as a performance tip. During the performance, one group demonstrated flexible responses to unexpected situations. In one of the groups, there was a moment when all members lost sight of which expression to perform because the assumed branching condition was not satisfied. However, one of the children quickly and tactfully improvised his expression, while the other children instantly followed suit and completed their performances.

The correspondence between actual performance and the performance sheet was examined when children's learning was evaluated from a programming education perspective. Some groups performed exactly as planned on the performance sheet, whereas others improvised and expressed themselves differently. One group's performance on the performance sheet differed significantly from their actual performance.

On Day 3, in the worksheet completed after class, some children showed interest in the teachers speaking about the relationship between branching and its application in daily life. This indicated that the children were interested in the functions and advantages of the program in relation to their daily lives.

4.2 What children learned beyond the teachers' anticipated outcomes

Here, we present two aspects that the children learned during class that were not initially anticipated by the teachers.

First, during the discussion on the use of awasewaza, the children attempted to make the performance sheet more comprehensible by devising techniques other than the awasewaza instructed by their teacher. Specifically, they attempted to clarify the names of awasewaza to make it easier for them to share with their peers, such as including the name of the child in charge or incorporating symbols, such as arrows and vertical lines. For programming experts, it is crucial to construct programs that are easy to understand.

Second, one of the children wrote on the worksheet completed after the class that the uncertainty created by branching increased the excitement of the performance. This uncertainty provided a new learning experience for children, by which they expanded their possibilities for expression.

5. Discussion

Teachers should be conscious of three main points, as discussed below:

First, since children are unfamiliar with composing algorithms, linking indeterminate elements to conditional execution and performing such compositions, it is crucial to allocate sufficient time for the activity and help them understand the concept. Although it was a new and unfamiliar task, teachers demonstrating the actual process of creating a performance before starting the activity contributed to a positive outcome. This demonstration helped children engage in the activity without any confusion about what was expected of them.

Second, teachers should be aware of the relationship between the planned performance on the performance sheet as a score and the improvisation that occurs during the performance. The performance sheet works as a performance program; however, creating a performance is different from creating a performance sheet. Therefore, there is a discrepancy between the evaluation of music learning and that of programming learning (Terauchi, 2022b, p. 107). For a mixed media performance based on the participants' strengths and interests, it is necessary to realize it as it is written in the performance sheet and to focus on branching and the condition of the performers during the performance and adjust accordingly. Sometimes, a decision needs to be improvised by excluding the expressions written on the performance sheet or using expressions that are not included. This is a major difference from activities that combine music making and programming using computers that play music as programmed. Activities involving children as both composers and music performers demand a balanced combination of proper programming, adherence to the program, and flexible improvisational skills to produce engaging performances. Planning (composition), improvisation, and indeterminacy are interdependent in live performances.

Third, teachers should encourage awareness of the affinities between the algorithms inherent in performances and compositions and those inherent in children's daily lives. In this practice, the teacher provided examples of automatic washing machines and field trips to demonstrate the affinity with the "Next Stage" activities. This approach aligns with Terauchi (2022b), stating this as an expected learning objective in "Next Stage" (p. 106). A positive result of this study was that the reflection worksheet written by the children at the end of the third day illustrated interest in this topic.

Connecting music studies to everyday life is often challenging. In the "Courses of Study Implementation Status Survey" conducted by the National Institute for Educational Policy Research in 2018, only 47.7% of respondents reacted positively to the statement, "Learning music will be useful in everyday life and in society" (National Institute for Educational Policy Research, 2018, p. 9). This is a common topic of discussion in music education in Japan. Despite the doubt concerning the validity of discussing the significance of music education solely from the perspective of its usefulness, the fact remains that students will find it challenging to learn if music is separated from life and society. In this sense, the view of the structure of music as an algorithm may provide an opportunity to realize that the very act of musicking (not sound or music itself) is deeply related to our daily lives.

6. Conclusion

This study investigated the key considerations for teachers when teaching sixth-grade students about programming learning. Although we tried to design a good practice class, there were certain issues that were not adequately addressed. For example, there was not sufficient time for group rehearsals. Moreover, providing opportunities for children to learn more consciously about the interdependence of planning (composition), improvisation, and indeterminacy in this type of performance is advisable. However, we believed we could provide some examples of the issues identified by Terauchi (2022b). Additionally, some of the points discussed in this study may offer generalizable suggestions for “Next Stage” activities and unplugged programming in music classes.

One limitation of this study is that it is based on a single case study. Additionally, this practice could not focus on some of the learning mentioned in Terauchi (2022b). Further insights need to be gained from more classroom practice in the future. However, considering that programming activities without computers in music classes have not yet been widely adopted in Japanese schools, we hope that the report and discussion presented in this paper will provide valuable suggestions for practice in Japanese elementary schools.

Authorship Distribution

This study was a collaborative effort by all authors. Chapters 1, 2, 5, and 6 were authored by Terauchi. Chapter 3 was written by Kogamoto. Chapter 4 was written by Nagayama.

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Notes

- i In general, “music of indeterminacy” is often used to refer to music in which the audible result of the entire performance is dependent on certain conditions, as seen in some works by John Cage. However, the indeterministic element in the practice described in this paper is positioned as a part of the whole performance, in which fixed performances are constructed as material.
- ii “Awasewaza” is a term specific to this activity. The Japanese word “tougou” literally translates to “integration” in English; in the context of programming, it is sometimes referred to as “function,” “method,” “subroutine,” “custom block,” and so on. However, these terms can be unfamiliar and difficult for children to understand. To make these words which mean integration more accessible, we have adopted the term “awasewaza” to convey the idea of combining several expressions, in alignment with the notion of “waza (special skill).” Please note that while there is also a term “awasewaza” in karate and judo, it is different from its usage in the current context.
- iii One of the practices using “stage” in the elementary school was published (Terauchi and Myodo, 2021).

iv “An-punch” is the name of Anpanman’s unique attack. Anpanman is a Japanese children’s superhero picture book series written by Takashi Yanase.

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