The Introduction of a Thin-bending Wood Horn Speaker as Multipurpose Teaching Material in Japanese Junior High School Technology Classes

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Abstract

As a case study of the introduction of efficient and effective teaching materials and methods that enhance students' technological literacy in different areas despite the relative lack of classroom hours devoted to technology education in Japanese junior high schools, a front-loaded horn speaker system was proposed as a component of multipurpose teaching materials and methods integrating several areas. Following the development of teaching materials and lesson plans, their effectiveness was evaluated through implementation.

Acoustic measurements showed that the horn speaker provided high efficiency in the midrange. Moreover, the results of a post-lesson questionnaire administered to junior high school indicated that the speaker system was highly effective as teaching material. It was therefore concluded that the new design enhanced not only student interest but also their technological literacy, as they demonstrated an understanding of the acoustic mechanism and high satisfaction with their final products.

Keywords: horn speaker, technology education, multipurpose teaching material, teaching practice, teaching material, technological literacy

1. Introduction

The technology portion of the compulsory curriculum in Japanese junior high schools focuses on raising organisms, materials and processing, energy conversion and information. These four different content areas must be dealt with in one class totaling 87.5 hours over three years, which is insufficient. In recent years, the necessity of effective teaching materials capable of integrating these different content areas has increasingly attracted attention because of the decrease in time allocated to technology education. Moreover, it has been thought that the teaching material and method on the technology education should be changed to integrate with different areas because various technologies have become more correlatively dependent with each other and used together on one product in the recent real life.

Against this background, this study was conducted to develop teaching materials involving the production of a front-loaded horn speaker system, which integrates materials and processing through the construction of a wooden speaker enclosure and energy conversion through the assembly and installation of speaker units and an amplifier. A further aim was to enhance students' technological literacy through an experiential understanding of traditional Japanese techniques of shaping thin bending wood, as well as acoustic changes in frequency resulting from the effect of the horn.

The ultimate goal of this study was to propose an example of multipurpose teaching materials and methods of effective teaching that enhance students' technological literacy in different areas in spite of the relatively insufficient class time for technology education in Japanese junior high schools.

A lesson plan was established, classes were implemented, and the results of a questionnaire were used to evaluate the effectiveness of this new type of teaching material and method.

2. Development of Teaching Material

2.1. Characteristic Design Concept

In this study, a small 2-inch speaker unit characterized by poor middle-bass and strong treble ranges was used as teaching material because it was inexpensive and easily obtained. The characteristic horn design, with two (stereo) front-loaded horns consisting of three pieces of thin bending wood (as shown in Figure 1), was adopted not only to improve the sound quality of the mid-low range but also to provide an empirical understanding of the effect of the horn and active bending wood processing. The horn has a horizontal baffle plate installed in each speaker unit.

The enclosure was placed below the horn and hinge-jointed on the back side so that it could be opened to install and control electronic parts. Students were also able to devise their own acoustic adjustments by adding materials such as cotton, resulting in an experiential understanding of the effect of the enclosure.

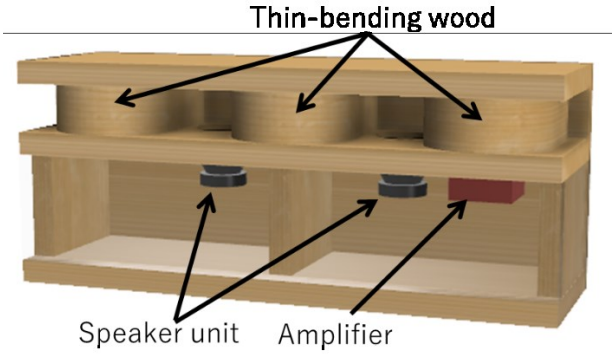

Figure 1. 3D Modeling of Design Concept

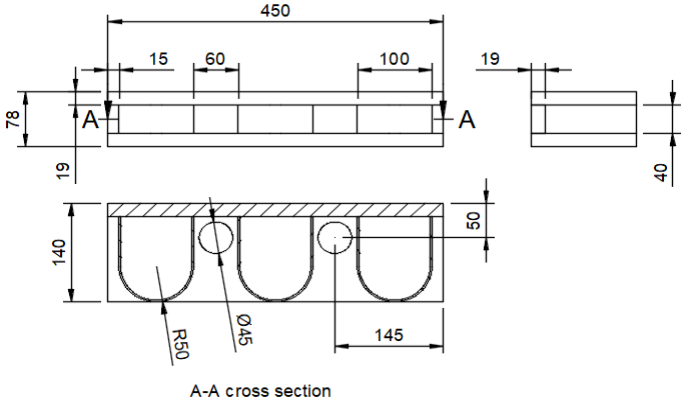

Figure 2. Tree Views of the Horn Section

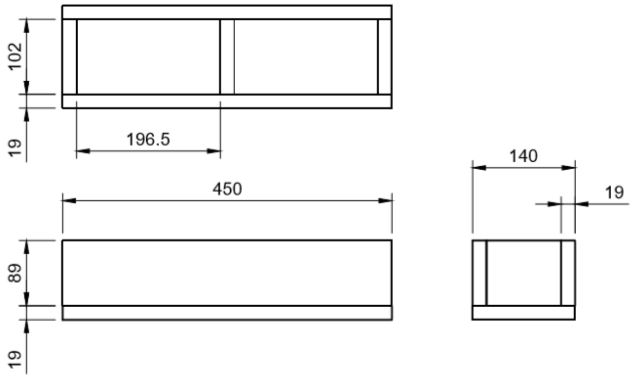

Figure 3. Tree Views of the Enclosure

Table 1. Materials

Material	Number
・Spruce (19×140×450)	3
・Spruce (19×89×102)	3
・Spruce (19×89×450)	2
・Spruce (19×40×450)	1
・Spruce (2.5×40×300)	3
・Hinge-joint	2
・Screws and nails	as needed
・Adhesive (Vinyl acetate resin)	as needed
・2-inch speaker unit (φ50)	2
・USB power cable	1
・AUX cable	1
・Amplifier kit (AKIT-2VR2822)	1

Figure 4. External View of the Front-loaded Horn Speaker System

2.2 Processing

Assembly can be divided into three steps: the horn, the enclosure, and the assembly and installation of electronic parts. For the horn section, as shown in Figure 2: a) each wooden plank was drawn and cut; b) three pieces of thin spruce wood (300mm(L)*50mm (R)*2.5mm(T)) were shaped, dried and seasoned in a process requiring 1 week; c) two holes were drilled in the baffle with a 40mm drill for each 2-inch speaker unit installation; finally, d) the horn section was finished by bonding two planks and three thin curved pieces of wood with adhesive. For the enclosure, as shown in Figure 3: e) each wooden plank was drawn and cut; f) several small holes were made for electric cables before nail-jointing and bonding. At this point, g) hammered nail-jointing was adopted as an executive-skill process; h) the horn and enclosure sections were hinge-jointed at two points on the back to finish the assembly of wood parts.

Assembly and installation of electronic parts was completed as follows: i) after amplifier assembly, speakers were fixed on the baffle and the circuits were connected to complete the process as shown in Figure 4.

2.3 Evaluation of Acoustic Properties

Prior to lessons, acoustic properties were verified through an instrumental sound test. As a control, a normal hornless type was constructed. The test method is illustrated in Figure 5, and Figure 6 shows the results of the acoustic test. The horn speaker had a relatively higher range (400-1000Hz) compared to the normal hornless type. Thus, it had abundant mid-low frequencies, comparable to a 6-8 inch speaker, which is generally considered adequate in a full-range speaker. It was concluded that the mid-low frequency was enhanced by the effect of the curved-wood horn.

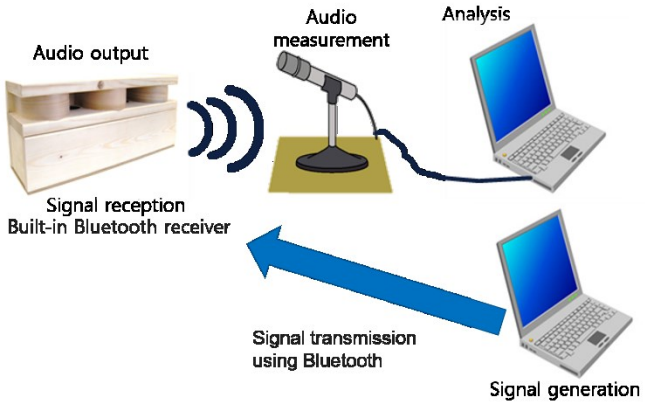

Figure 5. Illustration of the Acoustic Test Method

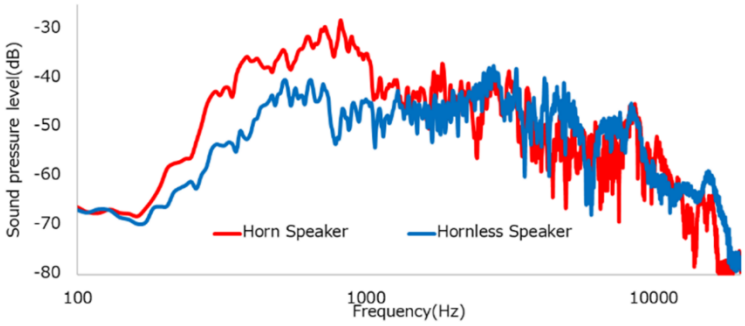

Figure 6. Acoustic Test Results

3. Implementation in Technology Classes as Teaching Material

3.1 Lesson Design

According to Jung et al. (2018), technology education using bending wood changes students' stereotypes of wood as relatively difficult to bend without breaking compared to pliable materials like soft iron. It is reported that this helps deepen technological literacy regarding materials and processing and also enhances students' creative and aesthetic design skills by allowing them to introduce their own elements. This study sought to extend this approach by enhancing students' technological literacy regarding energy conversion through an experiential process involving the acoustic effects of the horn speaker, combined with embodiment through the shaping of the bending wood used in the horn as design and process elements. The lesson plan was established as shown in Figure 7.

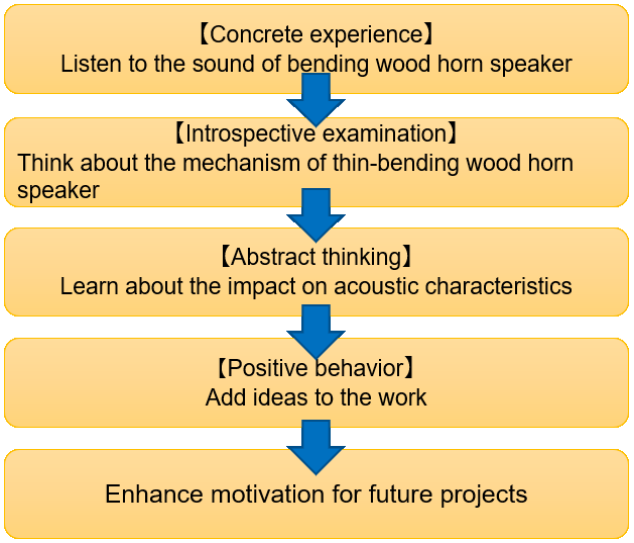

Figure 7. The Strategy for Lecture

3.2 Lesson Plan

The lesson plan was designed to distribute the new learning points and processing practice so as to balance skill level and improvement without losing student interest.

The plan is shown in Table 2, where a) through i) corresponds to Section 2.2 Processing. The lessons were implemented with 2 classes (60 students) in the 2nd year of junior high school. Figures 8-10 show the steps of the lesson.

Table 2. Lesson Plan

Hour	Objectives
1	Listening and surveying for the horn speaker
2-5	Process a) and e)
6-7	Process c) and f)
8-10	Bending wood learning and Process b)
11-12	Process d) and g)
13-17	Circuit learning and amplifier assembly
18-19	Process h) and i)
20	Listening and evaluation for own product

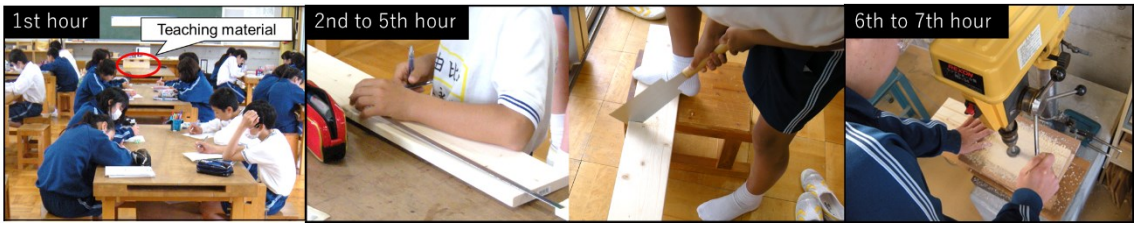

Figure 8. 1st to 7th Hour

Figure 9. 8th to 12th Hour

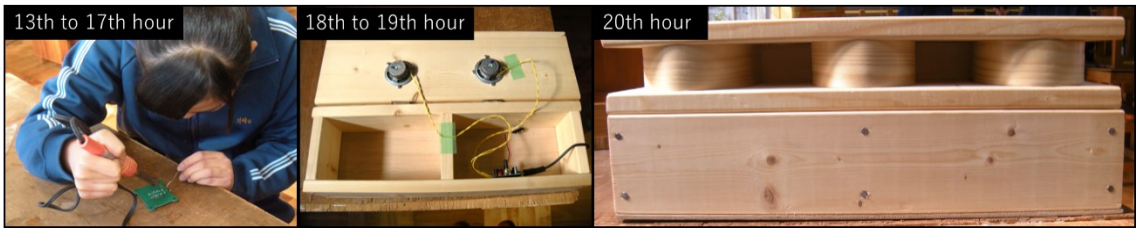

Figure 10. 13th to 20th Hour

3.3 Questionnaire Results and Discussion

A questionnaire was administered after the lessons. Questionnaire contents are shown in Table 3. A five-point Likert-scale was used to evaluate student interest and difficulty level. In order to evaluate how much students learned about the properties of wood and acoustic structures, free-description items were also included. Questionnaire results are displayed in Figure 11 and 12. A large percentage (97%) of students were positive about lesson interest, while 57% were positive about difficulty level. Based on responses to the free-description items, it was concluded that they learned about the principles of shaping wood, horn effects, and enclosure mechanisms.

In order to investigate satisfaction with the speaker as a musical device used in daily life and its influence on musical environments in the home, a questionnaire was administered after a 2-week vacation. In addition, the impressions of students' families were investigated via free-description items. The content and results of the questionnaire are shown in Table 4 and Figure 13. Results indicated that 79% of students were satisfied with the sound quality of the speaker and 83% were satisfied with their own products. In addition, responses to the free-description items by family members included positive evaluations such as "beautiful sound" and "well made." This suggests that the lesson contributed to the enhancement of self-esteem and communication in the home after the lessons.

Table 3. Content of the Questionnaire

	Contents				
Item 1	Impression of bending wood horn speaker production				
Item 2	Difficulty of construction of bending wood horn speaker				
	Answer①	Answer②	Answer③	Answer④	Answer⑤
Item 1	Interesting	Somewhat interesting	Neither	Somewhat boring	Boring
Item 2	Easy	Somewhat easy	Neither	Somewhat difficult	Difficult

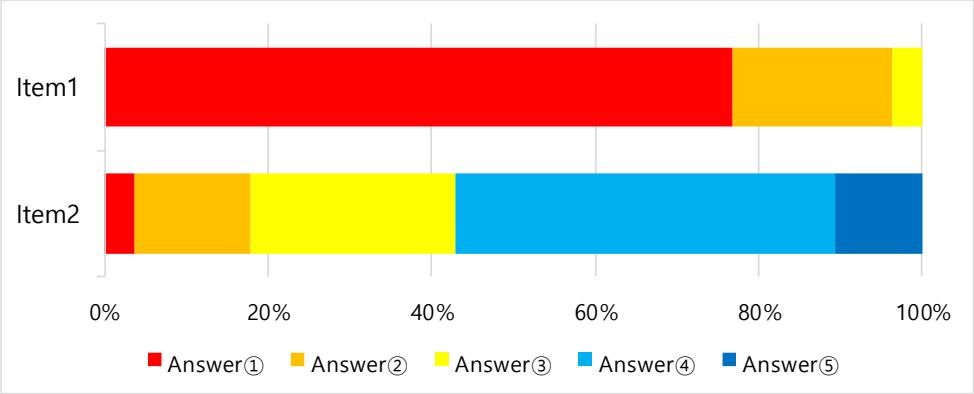

Figure 11. Five-point Evaluation of Interest and Difficulty Level

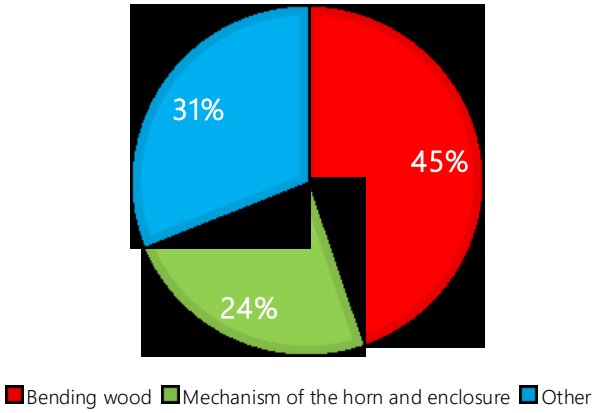

Figure 12. Free-description Items Regarding Learning of Wood Properties of Wood and Acoustic Structure

Table 4. Questionnaire for Own Products

	Content
1-1	Satisfaction with the sound of the speaker
1-2	Did you notice a difference in sound by opening and closing the speaker?
2	Satisfaction level with the appearance of the finished product
3	Did you think that you would like to make something by yourself based on this experience?

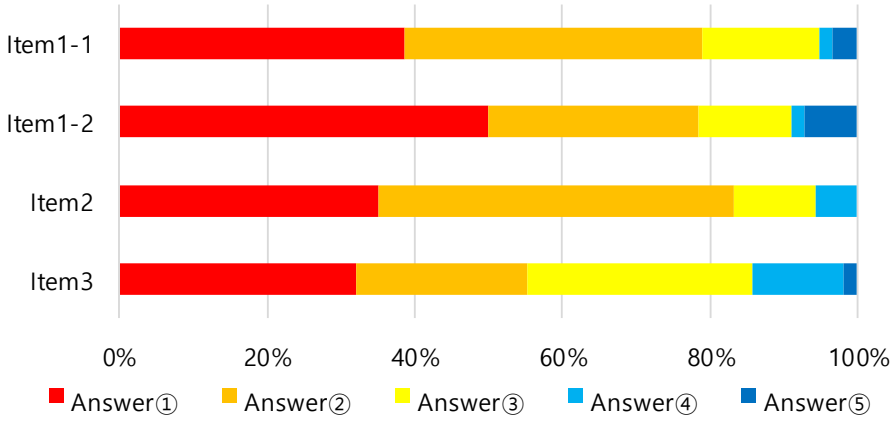

Figure 13. Evaluation of Speaker as a Musical Device in Daily Life and Influence on Home Musical Environment

4. Conclusion

This case study introduced efficient and effective teaching materials and methods that combined different areas in order to address the lack of classroom hours devoted to technology education in Japanese junior high schools. The horn speaker using thin bending wood provides a combination of teaching materials and methods integrating different areas. The implementation of these materials and methods resulted in satisfactory responses to the questionnaire.

In conclusion, the results of this study can be summarized as follows.

- A front-loaded horn speaker using thin bending wood displayed relatively high quality in the 400-1000Hz range and was characterized by abundant mid-low frequencies.
- On the post-lesson questionnaire, 97% of students responded positively regarding the lessons and 57% responded positively regarding difficulty level.
- Seventy-nine percent of students were satisfied with sound quality and 83% were satisfied with the finished product.
- Free-description comments suggested the positive responses of family members such as "beautiful sound" and "well made."

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