

Research Article

A Report on Conducting a Fundamental Mechanics Course as a Student-Led Community Contribution Activity

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ABSTRACT

In recent years, educational institutions have been actively engaging in robotics and STEAM education as part of their contributions to the local community. To address the issue of students losing interest in science, classes are being developed to stimulate early interest in mathematics among elementary school students. In this study, the students selected their own theme, developed teaching materials to convey the enjoyment of mechanics, and conducted workshops as a community outreach activity.

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1. Introduction

There is a field called “mechanics,” known as the study of the mechanical elements of robots, but it is often considered a difficult subject for many students. It is regarded as challenging even in industrial courses at high schools and is especially difficult for elementary and junior high school students. One major reason is the mathematics involved in mechanics. To address this, some lessons are designed to promote intuitive learning through hands-on experiences, such as using LEGO parts in instruction. In this educational research, the lessons are designed to teach the practical mathematics used in mechanics by utilizing LEGO blocks and scientific calculators. There are also other outreach programs that integrate engineering and mathematics [1].

In the future, community collaboration activities such as these will become increasingly important. It is essential to spark interest in elementary and junior high school students at an early stage and foster motivation toward science-related subjects. Community outreach efforts play a key role in preventing young people from turning away from science and engineering.

These activities include teacher-led projects [2]-[4] and student-led projects [5]-[10]. The former include the development of a robot racer (line-tracing robot) using a microcomputer at Kumamoto National College of Technology [2], and embedded systems education using a line-tracing robot at Shibaura

Institute of Technology [3]. There is also a robot project involving programming with Mindstorms NXT [4].

The latter include a sumo robot class for elementary school students [5] and a robotics class for science and technology education for elementary and junior high school students [6]. As part of the development of teaching materials for robot education, programming materials for “maze exploration” were developed using a commercially available product called Viewtrovers, and a workshop was held [7][8]. Furthermore, interdisciplinary teaching materials connecting mathematics and physics were developed using Viewtrovers, and a workshop was conducted and evaluated [9] [10].

In a previous study, we conducted interdisciplinary (STEAM) learning through the process of building a pendulum clock as part of a student-led extracurricular activity [11].

In this study, we propose a short-circuited version of the pendulum clock and develop teaching materials that can be used for mechanics lectures, assembly exercises, and experiments for elementary school students. In addition, as part of our community outreach activities, we hold summer and winter workshops for elementary and junior high school students, in which faculty members also participate in programs featuring multiple themes that allow participants to experience the enjoyment of science and engineering. Therefore, to convey the appeal of mechanism theory to children in the surrounding community, we planned and conducted a workshop.

2. Preparation for the Workshop

As shown in [11], the students' project was selected for the Shimane Monozukuri Challenge, where they received guidance from experts during monthly meetings. Through study sessions and hands-on creation activities at school, they ultimately completed a pendulum clock. In this chapter, we discuss the preparation of the workshop conducted as part of our regional collaboration efforts.

2.1. Workshop planning and announcement to the local community

The title of the event was “Student Project ♪ ~Let's Create a Mechanism that Uses the Principles of an Analog Clock~,” reflecting the educational goal of conveying the appeal of mechanics to the public. Information about the workshop was posted on social media as part of Matsue National College of Technology's winter craft class, as shown in Fig. 1. As a result, there was an overwhelming response, with 43 people applying. Ultimately, five participants were selected by lottery.

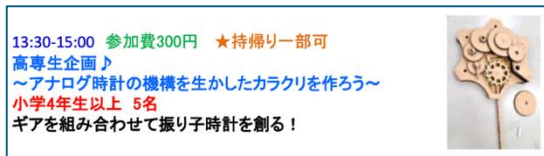


Fig.1 Advertising (Matsue National College of Technology's Winter Craft Class) A Workshop with Steam Education in Mind

2.2. Teaching material development and lesson design

(a) Creation of teaching material kit

In the previous study [11], a full “pendulum clock” was created; however, in this study, a “shortened version of the pendulum clock” (Fig. 2(a)) is produced. A component configuration that elementary and junior high school students can easily assemble is provided, and it is proposed as an instructional material (Fig. 2(b)). Table 1 shows the list of parts required for the clock.

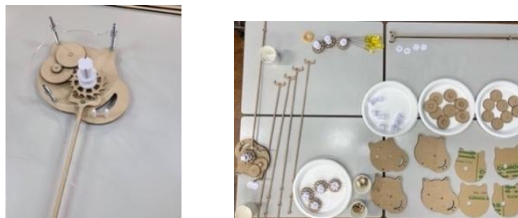


Fig. 2 Pendulum clock assembly material (a). Whole mechanism (b). Parts of the mechanism

Table 1 List of Parts Required for a Watch

Parts	Number of Parts
Base	1
Top plate (acrylic)	1
18-tooth gear	1
54-tooth gear	3
Escape wheel	2
Bolts and nuts	3
Bearings	2

(b) Lesson design

Below, we present Steps 1–5 and the three mechanisms involved in “Making a Pendulum Clock.” Table 2 also summarizes key instructional points and cautions for each step.

[Details]

Step 1: Understand the role of bearings and learn how to install them (Fig.3(a)).

Step 2: Learn about the meshing and rotational speed ratios of gears with different numbers of teeth and recognize the need for adequate clearances during installation(Fig.3(b)).

Step 3: Learn about the relationship between the escape wheel and the gears (Fig.3(c)).

Step 4: Learn how to adjust the meshing of gears (Fig.3(d)).

Step 5: Learn about the role of the pendulum and how to install it (Fig.3(e)).

Step 6: Learn how to install bolts (Fig.3(f)).

In Mechanism 3-1, students learn the relationship between the number of teeth and rotational speed using the concept of ratios (Fig.3(g)).

In Mechanism 3-2, they learn about the relationship between the pendulum and its period, as well as the necessity of the escape wheel (Fig.3(h)). In Mechanism 3-3, they learn about the relationship between motion, continuity, and the period of the escape wheel, as well as the force transmitted to the clock (Fig.3(i)).

Table 2 Points to Note when Assembling (Class Slides)

	Fitting the bearings	Item Instruction points -
1-1 (Step1)	Fit the bearings	-
1-2 (Step2)	Fit the gears	Leave a very small gap between the gears
1-3 (Step3)	Fit the escape wheel	Place the dish-shaped part on 1
1-4 (Step4)	Adjustment	Lightly turn the escape wheel with your fingers
1-5 (Step5)	Attach the pendulum	Make sure the height matches the escape wheel
1-6 (Step6)	Attach the bolts	Lightly tighten the bolts on the top two bases with nuts one at a time from below
3-1	Gears	Relationship between number of teeth and number of rotations
3-2	Pendulum and period	Relationship between pendulum and period
3-3	Escape wheel -	-

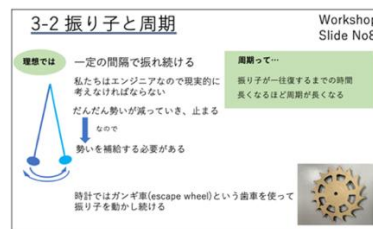
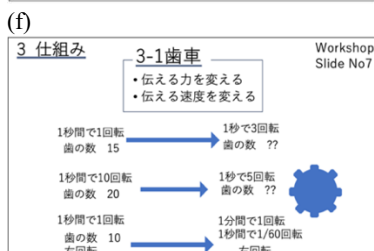
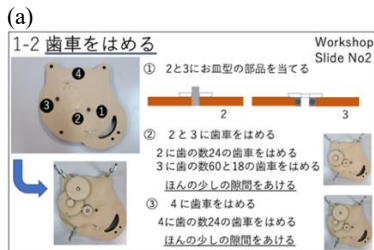
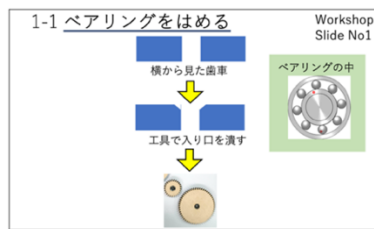


Fig. 3 Lecture Flow Class Slide (a) Assembly Lecture by Student Instructor (b) Individual Support by Assistant Students (c) Operation Test of the Finished Product (d) Summary of the Day and the Mechanism of the Pendulum (e) (f) (g) (h) (i)

3. Holding craft classes



Fig. 4 Lecture Scene (a) Assembly Lecture by Student Instructor (b) Individual Support by Assistant Students (c) Operation Test of the Finished Product (d) Summary of the Day and the Mechanism of the Pendulum

The workshop was conducted within a time limit of 90 minutes. Since the required time may vary depending on the participants' learning progress, the student staff adjusted the schedule while sharing information with one another.

Regarding the instructional structure, as shown in Fig. 4(a), the instructor introduced the mechanisms and assembly procedures. Fig. 4(b) shows the participants engaging in the hands-on activities. Fig. 4(c) illustrates the individualized support provided by student assistants during the assembly exercises. Finally, as shown in Fig. 4(d), both the blackboard and slides were used simultaneously to explain the theory and mechanisms of the pendulum clock as a concluding summary of the workshop.

4. Conclusion

In this study, in order to provide basic lectures on mechanism theory for elementary school students, we proposed an instructional version of a pendulum clock and planned and conducted a workshop that included lectures, assembly exercises.

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Authors Introduction

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