Development and practice of technology education classes based on product disassembly under the conditions of the Japanese Courses of Study

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Abstract

The Japanese Ministry of Education, Culture, Sports, Science and Technology (JMEXT) devised a new course of study for elementary schools and middle schools in 2017. The syllabus for technology education contains contents like these: "technology of materials and their processing," "technology of nurturing living things," "technology of energy conversion," and "technology of information." Students are taught these contents though several sub-units to enable them to understand technology concept. First, they learn "technology to support life and society," through which they mainly explore the perspective and thinking style of technology and acquire the relevant knowledge and skills for technological problem-solving. Next, students learn "problem-solving by technology." They are encouraged through the contents of this sub-unit to utilize the knowledge and skills acquired and develop attitudes that allow them to devise and create technology products. Finally, students learn "development and technology of society." The contents of this sub-unit enable students to rethink their lives and societies in accordance with the perspective and thinking style of technology. In the sub-unit "technology to support life and society," interactive learning activity and the examination of technology is encouraged. JMEXT suggests that "interactive means to consider engineering concepts and promote creative thinking through activities such as disassembly of products." We adopted the "LED sensor light" that is inexpensive and easy to disassemble as teaching material and reported on the results of planning, practicing, and evaluating technology classes that learn the functions and composition of electric circuits.

Keywords

Middle schools; Disassembly of products; Lesson development;

Introduction

Qualities and abilities in Japanese education

The Japanese Ministry of Education, Culture, Sports, Science and Technology (JMEXT) have devised new Courses of Study (JMEXT, 2017). The JMEXT's Courses of Study represent an outline of the standard curriculum for elementary and middle schools. The revision of the Courses of Study was based on a global trend that emphasizes the development of generic skills and competences. The qualities and abilities that aim to nurture the entire school curriculum were organized as 'knowledge and skills', 'ability to reason, judge, and express', and 'ability to learn and utilization'.

'Knowledge and skills' emphasizes what students understand and are able to do, targeting lessons or 'knowledge and skills' that students can use. 'Ability to reason, judge, and express' focuses on how students use their 'knowledge and skills' when faced with an unfamiliar situation in society. 'Ability to learn and utilization' aims to cultivate motivation and attitude so that students use their learning in life and in the community, engaging in society and in the world.

Learning style in Japanese education

JMEXT shows the objectives and content of each subject that has been reorganized according to these qualities and abilities. JMEXT showed 'subjective, interactive, and deep learning' as an effort to improve classes to nurture these qualities and abilities for students. 'Subjective, interactive, and deep learning' was constructed under the influence of active learning, with particular consideration to relationships with 'deep learning', especially based on 'subjective learning' and 'interactive learning'.

'Subjective learning' is a form of learning that has interests in learning, associating self-career formation, work tenaciously with prospects and feedback on learning activities to connect next learning. 'Interactive learning' broadens and deepens students' ideas based on collaboration among students, dialogue with others, and pioneering ideas. 'Deep learning' means understanding more deeply by relating knowledge to one another, examining information and forming ideas, finding problems and thinking of solutions, and creating based on thoughts and ideas. JMEXT pointed out that 'deep learning' is important with regard to 'the perspective and thinking style' of each subject in the learning process of 'acquisition, utilization, and exploration'.

'The perspective and thinking style' was prescribed by JMEXT as a particular viewpoint and way of thinking to capture aspects unique to each subject. It was regarded as being key to learning the essential meaning behind each subject and connecting the learning of subjects to society. 'The perspective and thinking style' of technology was defined as follows:

Technology:
Perspective: Grasp phenomena in everyday life and society from the viewpoint of relationship with technology.

Thinking style: Optimize technology with a focus on society's demand, safety, environmental burden, and economic efficiency.

Subunit of Japanese technology education

The Japanese technology education curriculum comprises various technologies used in modern society, including 'technology of materials and their processing', 'technology of nurturing living things', 'technology of energy conversion', and 'technology of information'. These four content units must be learned by all students. Each content unit includes the following subunits, according to which learning items are defined (JMEXT, 2018).

Subunit 1: 'Technology to support life and society'

Aim: To acquire scientific understanding of how technology work; to observe the roles and progress of technology; to notice 'the perspective and thinking style' of technology; and to acquire the knowledge and skills necessary for technological problem solving.

Subunit 2: 'Problem solving through technology'

Aim: To use the acquired knowledge and skills for technological problem solving in everyday life and society; to deepen the understanding of technology and proficiency of skills; to develop problem-solving skills through technology; and to nurture attitudes to conceive solutions based on one's new ideas and understanding.

Subunit 3: 'Development and technology of society'

Aim: To understand the concept of technology by reflecting on the results and processes of technological problem solving; to foster the ability to think about evaluating, selecting, managing, operating, improving, and applying technology according 'the perspective and thinking style' of technology; to nurture the attitude to devise and create technologies that can develop the society and the world.

Learning process of Japanese technology education

The learning process of Japanese technology education was defined as 'Understanding existing technologies', 'Setting problems and solutions', 'Designing and planning based on scientific understanding of technology', 'Making, producing, and nurturing for problem solving', 'Evaluation of outcomes', and 'Perspective of solving the next problem'.

This learning process is developed from the philosophy that the qualities and abilities that aim to nurture technology education are not merely activities to make products; they are proposed by the learning process through which the qualities and abilities of technology education can be effectively acquired by students in activities while using 'the perspective and thinking style' of technological thinking, finding problems related to technology in everyday life and society, setting issues and problems, thinking and solving through optimal design, implementing production, producing and nurturing, and evaluating and improving results and solutions. The relationship between this learning process and the subunits, 'the perspective and thinking style', and 'subjective, interactive, and deep learning' can be arranged as shown in Table 1.

Learning process	Subunit	The perspective and thinking style	Learning style
'Understanding existing technologies'	'Technology to support life and society'	To notice (To examine existing technologies through learning activities)	'interactive learning'
'Setting problems and solutions'	'Problem solving through technology'	To utilize (To develop technological problem solving in everyday life and society through learning activities)	'deep learning'
'Designing and planning based on scientific understanding of technology'			
'Making, producing, and nurturing for problem solving'			
'Evaluation of outcomes'			
'Perspective of solving the next problem'	'Development and technology of society'	To conceptualize (To think about social development and technologies in the future through learning activities)	'subjective learning'

Table 1: Relationship between the learning process and the sub-units.

JMEXT suggests 'interactive learning' of technology education, where 'interactive means to consider engineering concepts and promote creative thinking through activities such as disassembly of products'. Therefore, there is a need to examine teaching materials and lesson plans of technology education related to product disassembly. In the history of Japanese technology education, the disassembly and assembly of bicycles and engines has been treated as learning activities. Disassembly and assembly was positioned as a learning activity to acquire and use knowledge and skills through practical training. However, considering the 2017 Courses of Study in Japan, it is necessary to recognize the role disassembly and assembly learning activities have in terms of acquiring the knowledge and skills that are the premise of design and making, producing, and nurturing activities.

Product disassembly in worldwide teaching materials

The positioning of product disassembly is similar to the teaching materials proposed by the International Technology and Engineering Educators Association (ITEEA). ITEEA (2012) provide EbD-TEEMS™ to elementary curricula, which is designed to serve as a model and teaching resource to develop a meaningful foundation in STEM education. For example, 'Our world and me' was part of the proposed sixth grade elementary school curriculum. This teaching tool consists of three units using the framework of 6E Learning by-DeSIGN™ Model. It includes 'Engage', 'Explore', 'Explain', 'Engineer', 'Enrich', and 'Evaluation', for the lesson sequence.

Phase	Purpose
ENGAGE	to pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding.
EXPLORE	to provide students with the opportunity to construct their own understanding of the topic.
EXPLAIN	to provide students with an opportunity to explain and refine what they have learned so far and determine what it means.
ENGINEER	to provide students with an opportunity to develop greater depth of understanding about the problem topic by applying concepts, practices, and attitudes.
ENRICH	to provide students with an opportunity to explore what they have learned in more depth and to transfer concepts to more complex problems.
EVALUATION	for both students and teachers to determine how much learning and understanding has taken place.

Table 2: Phases of 6E Learning byDeSIGN™ Model (Barry N. B (2014))

Product disassembly is done in the 'Explore' phase. Its purpose is to learn the typical crank mechanism through reverse engineering of the automata and to develop a viewpoint on design and construction of mechanisms. According to the recommended worksheets (The Home-school Scientist 2013), 'Reverse Engineering' is defined as 'the science of taking things apart to see how they work'. Through 'Reverse Engineering', the aim is to teach students how to design and construct a crank mechanism with the help of an automaton that uses a crank mechanism. In other words, 'Reverse Engineering' is considered to be a learning activity that helps students understand the structure and function of the system and, as a result of this learning, students can use their own ideas to design and construct products. The idea of 'Reverse Engineering' is similar to the idea of product disassembly presented in the 2017 Japanese Courses of Study.

Purpose

The purpose of this study is to examine technology education classes focusing on the learning activity of 'product disassembly' while incorporating international findings, which should be developed in Japanese technology education. We adopted a 'LED sensor light' device as teaching material since it is inexpensive and easy to disassemble, and reported the results of planning, practicing, and evaluation of technology classes in which students learn the functions and composition of electrical circuits.

Analysis of teaching materials

The purpose of this study is to examine technology education classes focusing on the learning activity of 'product disassembly' while incorporating international findings, which should be developed in Japanese technology education. We adopted a 'LED sensor light' device as teaching material since it is inexpensive and easy to disassemble, and reported the results of planning, practicing, and evaluation of technology classes in which students learn the functions and composition of electrical circuits.

Analysis of teaching materials

Learning process of Japanese technology education

The 'LED sensor light' device shown in Figure 1 was used as teaching material. This device can be attached to a door or a drawer, giving them the function of turning the light on or off when they are opened and closed.

The size of the main body shown on the left side of Figure 1 is 64 × 31 × 21 mm, and the weight (including the battery) is 31 g. In addition, the extension cord from the main body is approximately 1000 mm, and the size of the object connected by the extension cord is 36 × 11 × 11 mm. The object at the top is also of the same size. These two objects are parts of the sensor and the white LED on the main body glows when they are at or more than 20 mm apart. The recommended power off interval is 5 mm or less.

This 'LED sensor light' device is sold in the 100-yen shop, 'The Daiso', and costs 100 yen (excluding taxes) per piece in Japan. It is easy for junior high school students to grasp their composition. Because it is inexpensive, it has few parts and its structure is simple. Moreover, since 'The Daiso' has more than 3000 stores in Japan and 38 stores in Australia, it is easy to obtain this device.

The main body and sensor cases are made of ASB resin. The two sensor cases can be easily removed by inserting a precision screwdriver into the gap. When the two sensor cases are opened, it is seen that the reed switch and magnet are arranged as shown in Figures 2 and 3. When the distance between the two cases is small, an electric current flows in the reed switch, and when the distance between the two cases is large, the electric current is cut off.

Figure 1: 'LED sensor light' device

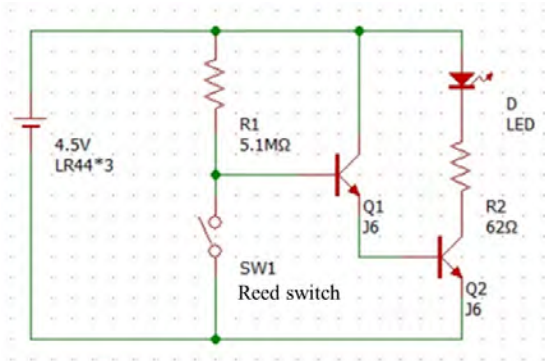
Figure 2: Reed swith

Figure 3: Magnet

Figure 4: Battery box

The main body of the 'LED sensor light' device is composed of LEDs, batteries, electronic circuits, and so on. The cover of the battery box of the main body slides off and can be removed. As shown in Figure 4, this device uses three LR - 44 (AG 13) in series as power supply.
Next, by removing one screwdriver, the transparent cover that diffuses the light can also be removed. By removing the transparent cover, the LED light and electronic circuit can be identified. In the circuit, two surface-mounted electric resistors and two NPN-type transistors are soldered, although the LED model number is unknown. Therefore, as measured with an actual machine, the current value is 23 mA, the forward voltage is 2.9 V, and the brightness is about 95 lx when the distance between the LED and the sensor is 150 mm. The circuit diagram of this teaching material is shown in Figure 5 and the parts used are shown in Table 3.

Figure 5: Circuit diagram



Parts	Quantity
Button battery (LR44)	3
Electric resistor (R1)	2
Electric resistor (R2)	2
Transistor (Q1, Q2)	2
Reed switch (SW1)	1
LED (D)	1

Table 3: Phases of 6E Learning byDeSIGN™ Model (Barry N. B (2014))

Function of circuit section

R2 is the electric resistor that adjusts the current flow through the LED. When the sensor section distance between the reed switch and the magnet is small, the base voltage of Q1 becomes 0 V, as shown in Figure 5. For that reason, no current flows through the LED. However, although the LED does not glow, the current continues to flow to the reed switch. Therefore, R1 has a very large electrical resistor connected so that the standby current is suppressed to about 0.8 μA. In addition, if the distance between the reed switch and the magnet is large, the reed switch is turned off, and the current flows into the base of Q1. Generally, about 10 mA is required to turn on this white LED with a diameter of 5 mm. Therefore, the current required for the LED to glow is guaranteed by the formation of a Darlington transistors between the transistors Q1 and Q2. Through Darlington transistors, it is possible to obtain a large DC current gain.

Usefulness of the 'LED sensor light' as a teaching material

The 'LED sensor light' device uses reed switches for the sensor section, can drawing students' interests toward learning and learning contents. Students learned the concepts of voltage, current, electric resistance, and simple circuits such as flashlights in science classes, and they understood that the flow of electricity was controlled by a switch and corresponded with the ON/OFF command. Therefore, they will assume that light turns on when current flows through a switch. However, as mentioned

Process	Learning activity	Teacher's objective (◇evaluation)
Introduction	Ⅰ Activate the LED sensor light and think about its condition of lighting and how to use it. Ⅱ Confirm the lesson's objective.	○To help students confirm that LED lights turn on when the two sensors are far away and they turn off when the sensors are close.
lesson objective】Let us study the electric circuit by disassembling an LED sensor light.		
Evolution	Ⅲ Disassemble the sensor part and understand that the current flowing to the LED is controlled by the magnet and the reed switch.	○To make students contemplate how the reed switch works, and to explain that the distance between the magnet and the reed switch is related to the LED's light turning on.
	Ⅳ Disassemble the electric circuit and confirm the pattern of the board connected to the power supply. After confirming, colour the placement of the GND and 4.5 [V] on the circuit board pattern in the worksheet.	○To instruct the students about the pattern of the electric circuit board and the function of the conductor, as well as to draw their attention toward the surface mount.
	Ⅴ Visualise the flow of electricity from the power supply to the reed switch. Draw a part of the circuit diagram.	○To develop students' visualisation of the electric flow of the electric circuit.
	Ⅵ Consider the electricity flowing from the power supply through the LED or transistors. Complete the circuit diagram.	○To make students create the circuit diagram by first taking into consideration the LED. ○To make students understand that the transistor has three electrodes.
	Ⅶ Observe the electric circuit. Write electronic parts not understood in the worksheet.	○To point out all parts that make up the LED sensor light and, at the same time, to get students to notice that the role of the transistor is unknown.
	Ⅷ Consider the flow of current in the electric circuit both when the reed switch is ON and when it is OFF. Then, think about the current necessary to light the LED, and predict the role of the transistor.	○To specify the standard current necessary for lighting the white LED. ○To make students notice that they cannot secure the current necessary for lighting the LED with only the reed switch. ○To make students notice that the transistor plays the role of creating a large flow of current.
	Ⅸ Consider the designer's idea and intention behind the electric circuit of the LED sensor light.	○To make students confirm that it is possible to create an electric circuit that turns off when the reed switch is ON. ○To make students confirm that it is possible to make a large current flow with a small current by using the transistor.
Conclusion	Ⅹ Assemble the LED sensor light. Reflect on the lessons learned in this class and think about the idea and intention behind the electric circuit of the LED sensor light.	◇Can students think about the idea and intention behind the electric circuit by disassembling the product? 【Ability to reason, judge, and express】

Table 1: Class plan

above, this product glows when current does not flow through the switch. In other words, the students' thinking and the product's behaviour oppose each other. If this learning material introduce to the class, the students will be aware of this fact. This fact in an increase in student activities, and they will be actively working on understanding unfamiliar electronic circuits.

In Japanese textbooks, transistors are handled developmental content or material. Although transistors are well-known and important components, most junior high school students in Japan have not learned about them in detail. However, with this teaching material, it is possible to gain experience while reproducing a part of the circuit with a breadboard or a similar device, since an electronic circuit has few parts and its structure is simple. In particular, it is valuable because it can help students learn about the Darlington connection with constant comparisons to actual products.

Based this, it can be concluded that the ‘LED sensor light’ device used in this study is an effective teaching material in junior high school technology classes for the following reasons. (1) It is inexpensive and easy to obtain anywhere in Japan. (2) It is easy to disassemble and assemble quickly as it has few parts and its structure is simple. (3) There are no IC and black boxed parts, making it easy to pay attention to the function of each part. In addition, it is possible to think about the circuit by comparing it with the actual product even if students are not familiar with electronic circuits. (4) By using a reed switch, it is possible to introduce a rift between student thinking and product operation. It is also possible to get students interested and raise questions.

Class planning and practice

Planning

In November 2017, a technology education class based on the disassembly of the ‘LED sensor light’ device was attended by 41 eighth-grade junior high school students in Japan. Students had already learned about the ‘technology of materials and their processing’, as well as the design and construction of the multi rack. Furthermore, students learned about the ‘technology of energy conversion’ and the design and construction of machines using the crank mechanism.

Students did not learn about electric circuits in technology class. However, they learned about Ohm's law in science class by observing and experiencing the relationship between current and voltage.

The objective of the class was to think about the designer’s idea and intention behind the electric circuit by disassembling the product. Learning assessment was conducted from the viewpoint of the ‘ability to reason, judge, and express’. The technology education class plan based on the disassembly of ‘LED sensor light’ devices is shown in Table 4.

Two students became a learning group and disassembled one ‘LED sensor light’ devices. Teacher replaced the transistor part name with ‘J6’ in the class. When students handled ‘LED sensor light’ devices in class, teacher gave guidance on safety.

Practice for junior high school students

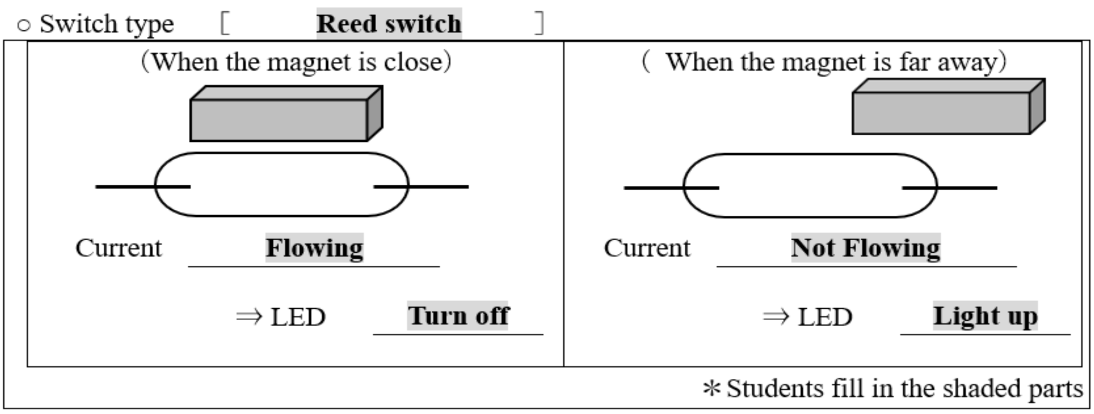
The details of the technology class conducted in accordance with the plan shown in Table 4 are described below.

First, the teacher presented learning activity Ⅰ as an introduction. Specifically, the teacher distributed the ‘LED sensor light’ devices to the students and they pulled out the insulating sheet from between the batteries. The teacher and the students confirmed that the LED was lighting up normally. After that, each student group researched the necessary condition to turn off the LED. Then, the teacher and students concluded that this condition was the distance between the two sensor parts.

In learning activity Ⅱ, the teacher stated the lesson objective as: ‘Let us study the electric circuit by disassembling an LED sensor light’.

Learning activity Ⅲ focused on the contents of the two sensor parts. Each student group disassembled them using a flathead screwdriver, and confirmed that the magnet and the reed switch were present. After that, the teacher mentioned that the distance between the magnet and the reed switch is related to the LED’s lights turning on. The teacher illustrated the function of the reed switch as shown in Figure 6. Thus, students wrote in the worksheet: ‘When the current flows, the LED switches off. When the current does not flow, the LED lights up’.

Figure 6: Worksheet on the function of the reed switch



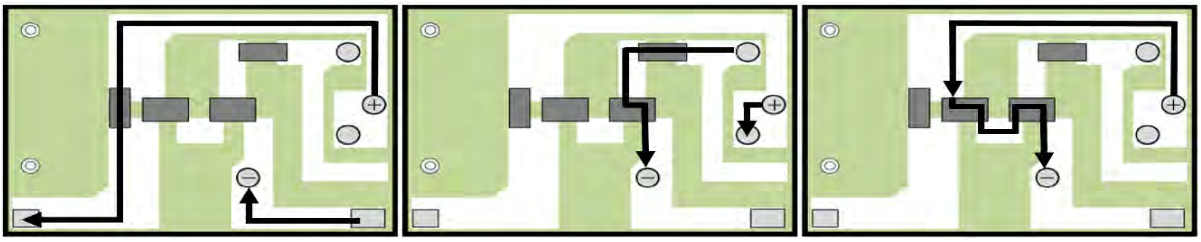


Figure 7: Three types of electric flows

The teacher then gave instructions for learning activity Ⅳ. Each student group disassembled the electric circuit using a screwdriver. The product was dismantled into a protective case, an LED, an electric circuit board, a battery box, and a battery cover. The teacher instructed the students to observe the electric circuit part that creates a working of the 'LED sensor light'. The teacher also explained the pattern of the electric circuit board and the function of the conductor, along with drawing the students' attention toward the surface mount. Students used paints to colour the placement of the 4.5 [V] and GND in the circuit board pattern in the worksheet.

In learning activity Ⅴ, the teacher and students aimed to clarify the diagram of the electric circuit board. As per the teacher's instructions, the students used the pattern of the electric circuit board on the interactive white board and the worksheet, drawing three types of electric flows, as shown in Figure 7. The teacher intended to discuss electric flow gradually, because it would be difficult for students to think of a transistor having three electrodes.

After that, in learning activity VI, students combined the parts to three types of electric flows and completed the circuit diagram. At this time, the teacher instructed them to think of the remaining parts like a puzzle.

In learning activity Ⅶ, students summarized what they understood and what they wanted to know. There were a few students pondering on the role of transistors.

In learning activity Ⅷ, the teacher presented the standard current necessary to light the white LED. The students calculated the current flowing in the electric circuit when the reed switch was ON as well as OFF. The teacher and the students confirmed the lack of a large enough current to turn the LED on with only the reed switch. The teacher then explained that the transistor plays the role of making a large current flow.

Next, in learning activity Ⅸ, the teacher helped the students confirm that 'it is possible to create an electric circuit that turns off when the reed switch is ON' and that 'it is possible to make a large current flow with a small current by using the transistor'. Then, the students wrote down what they understood in a worksheet, as shown in Figure 8.

To conclude, in learning activity Ⅹ, the teacher instructed the students to assemble the 'LED sensor light' devices and reflect on what they learned in this class. The teacher asked the students to consider the idea and intention behind the electric circuit of the 'LED sensor light' devices.

Evaluation

To evaluate in accordance with the objectives of the lesson from the viewpoint of 'ability to reason, judge, and express', the teacher set the criteria shown in Table 5.

Evaluation-level A	Based on the function and properties of the reed switch and the transistor, students can think about the idea and intention behind the electric circuit in relation to the location and method of using the product.
Evaluation-level B	Based on the function and properties of the reed switch and the transistor, students can think about the idea and intention behind the electric circuit.
Evaluation-level C	Students have not reached Evaluation-level B.

Table 5: Evaluation Table

Evaluation-level B students achieved almost all the objectives of the lesson. Those who did not reach evaluation-level B were assumed to fall under evaluation-level C. Students were classified under evaluation-level B when they could think about the idea and intention behind the electric circuit based on the function and properties of the reed switch and the transistor. Those students who particularly excelled in evaluation-level B and could think

Figure 8: Worksheet on students' understanding of 'LED sensor light' devices

2. Intention behind the LED sensor light

○ Intention behind each part

By using the reed switch,

It is possible to switch the current ON and OFF depending on the distance from the magnet.

By using the J6 part,

It is possible to make a large current flow with a small current.

＊Students fill in the shaded part

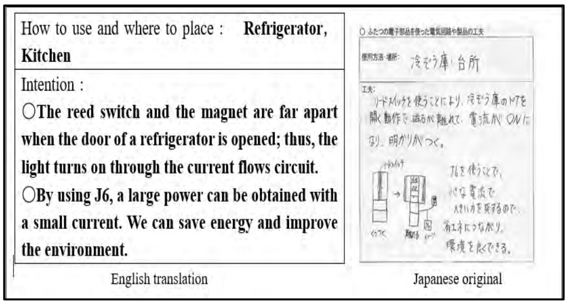
about the idea and intention behind the electric circuit in relation to the location and method of using the product were classified under evaluation-level A.

As a result, 6 students (14%) were classified under evaluation-level A, 26 students (63%) were classified under evaluation-level B, and 9 students (22%) were classified under evaluation-level C. More than 70% of the students were classified under evaluation-levels B and A, and it was considered that the planning and practice of these technology classes were generally effective. However, since about 20% of the students were classified under evaluation-level C, it was suggested that it was necessary to further consider the lesson plans and lesson development after positioning this lesson as an appropriate unit. Example descriptions of evaluation-levels A, B, and C are shown below.

Evaluation-level A

Based on the function and properties of the reed switch and the transistor, the student can consider and describe specific examples of intentions to reduce the power consumption of a refrigerator (Figure 9).

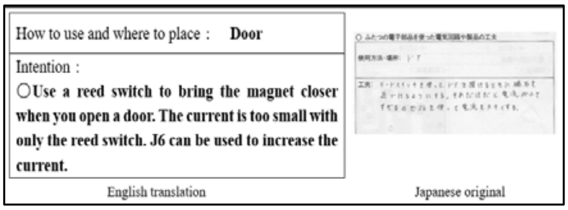
Figure 9: An example answer description for evaluation-level A



Evaluation-level B

The student can grasp the function and properties of the reed switch and the transistor, but there is not enough consideration of what action can be obtained by attaching the mechanism to a door. (Figure 10).

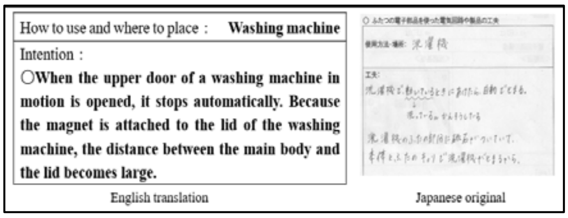
Figure 10: An example answer description for evaluation-level B



Evaluation-level C

The student can grasp the function and properties of the reed switch and consider specific designs to enhance the convenience of a washing machine, but there is no mention of the transistor (Figure 11).

Figure 11: An example answer description for evaluation-level C



Conclusion

Under the conditions of the 2017 Courses of Study, 'interactive learning' is considered to be the better learning style for technology education in Japan, as it can help to understand existing technology and develop a technological perspective and thinking style. 'Interactive learning' in technology education refers to the need 'to consider engineering concepts and promote creative thinking through activities such as disassembly of products'. With regards to technology education in Japan, this study conducted the learning activity of disassembly and assembly of products as practical activity, using knowledge and skills such as the process of designing and making products. Therefore, the learning activity of disassembly and assembly of products was not positioned to acquire knowledge and skills about technology. However, according to the 2017 Courses of Study in Japan, it is necessary to position the learning activity of disassembly and assembly as a learning process for acquiring knowledge and skills. As a result, it was suggested that teachers would have to conduct classes using appropriate teaching materials.

We adopted an 'LED sensor light' device as a teaching material since it is inexpensive, easy to handle, and easy to disassemble, and reported the results of planning, practicing, and evaluating technology classes based on this. The 'LED sensor light' device can help students learn the function of transistors and the composition of electric circuits.

As a result, 6 students (14%) were classified under evaluation-level A, 26 students (63%) were classified under evaluation-level B, and 9 students (22%) were classified under evaluation-level C. More than 70% of the students were classified under evaluation-levels B and A; thus, it was considered that the planning and practice of technology class were generally appropriate. We believe that future studies will need to consider a unit that appropriately positions this developed lesson.

Acknowledgement

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References

Barry N. B (2014) 6E Learning byDeSIGN™ Model-Maximizing informed and inquiry in the integrative STEM classroom, Technology and engineering Teacher,68(4),14-19

ITEEA (2012) EbD-TEEMS™ Grade 1 Agriculture around us

ITEEA (2016) EbD-TEEMS™ Grade 6 Our world and me

The Home-school Scientist (2013) Reverse Engineering Printable Worksheets, https://thehomeschoolscientist.com/reverse-engineering-printable-worksheets/

The Japanese Ministry of Education, Culture, Sports, Science and Technology (2017) The Course of Study for Lower Secondary School, government of Japan.

The Japanese Ministry of Education, Culture, Sports, Science and Technology (2018) Explanation for The Course of Study of technology education for Lower Secondary School, government of Japan.