American Journal of Educational Research, 2019, Vol. 7, No. 3, 244-248
Available online at http://pubs.sciepub.com/education/7/3/9
Published by Science and Education Publishing
DOI:10.12691/education-7-3-9

Think-Pair-Share Strategy Enhances the Understanding of High School Students in Physics: The Case of Japanese Stem Educators

Takekuni Yamaoka[1,*], Shinichi Okino[2], Kimihito Takeno[3], Tomokazu Yamamoto[4], Shinji Matsumoto[5]

[1]Science Teacher, Ehime University Senior High School, Matsuyama City, Japan
[2]Science Teacher, Kanazawa Nishikigaoka Upper Secondary School, Kanazawa City, Japan
[3]Faculty of Education, Shiga University, Otsu City, Japan
[4]Advanced Elementary Teacher Education, Hyogo University of Teacher Education, Kato City, Japan
[5]Curriculum Instruction Development for Expert Teachers, Hyogo University of Teacher Education, Kato City, Japan
*Corresponding author: yamaoka.takek@gmail.com

Received December 22, 2018; Revised January 27, 2019; Accepted March 13, 2019

Abstract This research designed a lesson that allowed students to consider the principle of a magnetic top while utilizing the teaching method "Think-Pair-Share," which promotes discussion. The purpose of this research is to practice lessons in high school science classes, analyze them, and evaluate "Think-Pair-Share." This science class was conducted in December 2016 for 54 high school students in 11th grade in Japan. Two groups were formed among the students to enhance their understanding of electromagnets. The breakdown was as follows: from a total of 54 students, the stainless-steel group contained 27 students and the iron group contained 27 students. Each lesson was conducted over two hours. The stainless-steel group used stainless steel and iron bolts to promote discussion on the properties of an electromagnet and the iron group used iron bolts only. Apart from this teaching strategy to foster discussion, "Think-Pair-Share" was used. As a result, it was revealed that the discussion was deepened and promoted in the stainless-steel group for which the experiment was not successful the first time, rather than the iron group for which the experiment succeeded the first time. Therefore, the "Think-Pair-Share" strategy was effective in encouraging discussion that was wide-ranging and conducted from various perspectives. It was considered that discussion between two people was an important factor. In particular, it became clear that Think-Pair-Share is effective under circumstances that generate cognitive conflicts.

Keywords: *magnetic top, cognitive conflicts, think-pair-share*

Cite This Article: Takekuni Yamaoka, Shinichi Okino, Kimihito Takeno, Tomokazu Yamamoto, and Shinji Matsumoto, "Think-Pair-Share Strategy Enhances the Understanding of High School Students in Physics: The Case of Japanese Stem Educators." *American Journal of Educational Research*, vol. 7, no. 3 (2019): 244-248. doi: 10.12691/education-7-3-9.

1. Introduction

In Japan's courses of study revised in 2018, there is a requirement for deep learning through inquiry-based learning activities. According to Sawyer (2006), the concept of deep learning is pursued somewhat differently by each learning sciences researcher [1]. Based on Hammond (2008), active and deep learning with carefully designed projects and design tasks focuses on central questions in academia, with students engaging in the work of scientists [2]. This includes designing, practicing, evaluating, and expressing scientific research and experiments. Students use higher-level skills to develop knowledge and apply meaningful questions in their learning process. This is also demonstrated by the higher-order thinking skills included in Bloom's taxonomy. Bloom, Englehart, Furst, Hill, and Krathwohl (1956) were pioneers in persuading teachers and students to plan objectives on all levels of the cognitive domain [3]. Bloom's taxonomy describes analysis, synthesis, and evaluation as "high order thinking skills," which are often referenced in inquiry-based learning. Anderson and Krathwohl (2001) proposed a modified version of this taxonomy based on understanding [4]. Research in cognitive science has illustrated that making, planning, and producing creative works requires more difficult and complicated thinking than evaluation. Therefore, "synthesis" replaces "evaluation" in the new model and the item of "creation" is added. According to their taxonomy, questions eliciting scientific terminology require "remembering" and questions eliciting an explanation of phenomena require "understanding." In this case, "understanding" is the more complex task.

According to David (2017), lesson designs incorporating such complexity are common in science, technology, engineering, and mathematics education (hereafter, "STEM education") [5]. Teaching materials based on STEM education can be used in class practice. The learning process of STEM education leads to inquiry, problem solving, creativity development, collaborative research, and so on, transcending class subjects, school types, and grade frameworks, and it includes elements that are useful in lifelong learning. Specifically, this kind of education creates new concepts by linking fragmentary concepts, and as some questions are resolved, new questions are raised. In a scene related to new questions that came out during the class, a very vigorous debate is important. Lyman (1981) developed a teaching strategy which engages all students in discussion [6]. This is a more effective strategy than the manner of asking a question and calling on one child to respond. This strategy known as “Think-Pair-Share”.

Furthermore, the concept of STEM education can also be used for continued learning at higher levels, including independent learning. Its in-depth discussions on exploratory activities and practices ultimately result in lifelong learning.

However, few studies have been conducted to encourage deep learning of this type in Japan. Therefore, in this research, we decided to practice lessons based on discussion activities by incorporating the viewpoint of STEM education for the purpose of recommending deep learning.

2. Purpose of Research

For this research, a lesson was designed that incorporated the viewpoint of STEM education, which allowed students to consider the principle of a magnetic top while utilizing the teaching method “Think-Pair-Share,” to promote discussion. A magnetic top comprises permanent magnets and electromagnets, and is a well-known science toy in Japan.

The purpose of this research was to investigate the effect of “Think-Pair-Share” under circumstances that generate cognitive conflicts. In questioning study, “Think-Pair-Share” was introduced by Walsh and Sattes (2011) and Pope (2013) as a teaching strategy to involve all students and stimulate their responses [7,8]. It is a strategy that is based on social constructivism. First, students think individually and write their opinions on paper. Next, they discuss the content of their individual descriptions with a partner.

This teaching strategy involves the comprehensive evaluation of the results their reflection, which are then shared with the class.

3. Research Method

3.1. Investigation Timing and Object

This science class, while incorporating the viewpoint of STEM, practiced lessons that focused on discussion activities, and was conducted in December 2016 for 54 high school students in an 11th grade Physics class in Japan.

3.2. Science Class Design

This research designed a lesson that allowed students to consider the principle of a magnetic top while utilizing the teaching method “Think-Pair-Share,” which promotes discussion. Two groups were formed among the students to enhance their understanding of electromagnets. The breakdown was as follows: from a total of 54 students, the stainless-steel group contained 27 students and the iron group contained 27 students. Each lesson was conducted over two hours. The stainless-steel group used stainless steel and iron bolts to promote discussion on the properties of an electromagnet and the iron group used iron bolts only. Apart from this teaching strategy to foster discussion, “Think-Pair-Share” was used.

Next, regarding the composition of the lesson, this lesson adopted the viewpoint of STEM education. The National Research Council of the National Academies (2012) describes the method for implementing STEM education in the “K-12 Framework for Science Education.” [9]

Additionally, according to STEM education practitioners, Myers and Berkowicz (2015), this lesson adopted 4C, “Critical thinking, Communication, Collaboration, Creativity.” [10] Referring to this method, we adopted the following flow of activities, as shown in Table 1.

Table 1. Instruction plan of science class

Step	Main learning activities	4C
1	Asking questions and defining problems.	Critical thinking
2	Developing and using models.	Collaboration
3	Planning and conducting investigations.	Communication
4	Analyzing and interpreting data.	
5	Mathematics and computational thinking.	Creativity

3.3. Implementation of Worksheet

To analyze the enhancement of the students’ understanding, a “Think-Pair-Share” worksheet was created for use in the class, focusing on descriptive content. The worksheet asked the following two questions:

Question 1: How do you make a top that keeps turning forever?

Question 2: How do you explain this phenomenon?

3.4. The Network of Collocation for “Think-Pair-Share”

Descriptions from the worksheet were analyzed using the text mining technique. This was carried out using the text analysis system KH Coder Ver. 2.Beta.32 (“KH Coder”), developed by Higuchi (2014) [11].

KH Coder divides data into units called morphemes, the smallest possible units of text, and can thereby extract more apparent term patterns. The extracted terms are arranged in a circle; circles with patterns that appear to be similar can create a network of collocation that is connected by a line. The greater the number of occurrences of an extracted term, the larger the circle becomes, and the more similar the appearance pattern, the thicker the line connecting the circles. In this study, the term patterns that appeared in the worksheet descriptions were extracted using KH Coder.

4. Results and Discussion

4.1. Developing Teaching Materials

The method of creating a magnetic top is shown by Yamaoka et al. (2017) [12]. We created a magnetic top using the tools shown in Figure 1.

Normally, a top will stop rotating after some time has passed. However, as shown in Figure 2, the magnetic top in this activity rotates continuously until the battery runs out.

This phenomenon could be used as teaching material to start a dialogue among students based on the evident cognitive conflicts. In other words, the question of “Why does the magnetic top keep rotating?” is considered more effective.

Figure 1. Preparations for making a magnetic top

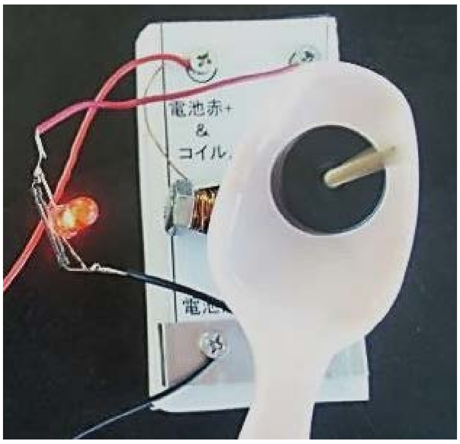

Figure 2. The top keeps turning

This experiment involved winding an enameled wire around a bolt to make an electromagnet. As shown in Figure 3, a straw was placed on the bolt and an enameled wire was wound from above. As a result, it was possible to easily replace the bolt after winding the enameled wire.

As shown in Figure 4, two types of bolts were prepared. One was a stainless-steel bolt, and the other an iron bolt. The bolts were somewhat different in color, but were made using the same standards. Two groups were formed: one group used iron bolts, and was therefore the iron group and the other used stainless-steel bolts, and was therefore the stainless-steel group.

Through this intentional setting of conditions, we designed lessons that induced cognitive conflict and encouraged debate to explore the lesson objective.

Figure 3. The bolt inserted into a straw

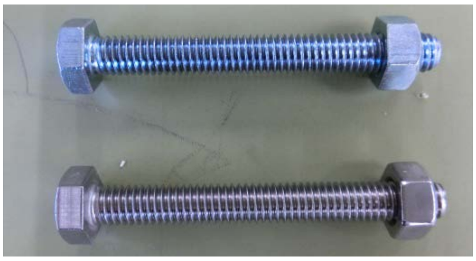

Figure 4. Two types of bolts used

4.2. Implementation of Science Class

In Table 1, after showing that the Magnetic top actually seemed to rotate in step 1, students were asked “Why does the magnetic top keep rotating?” Then, in step 2, students were asked to actually create a“Magnetic Top.” For this step, students were divided into two groups. The iron group succeeded in the experiment, whereas the stainless-steel group failed, as expected, as the activity cannot be completed successfully using stainless steel. An electromagnet energizes a coil wound around an iron core. The class then discussed the activity using the teaching method, “Think-Pair-Share,” which focused on why the iron group succeeded while the stainless-steel group did not. In step 4, students examined the experiment result. In the final step, students reflected on the stainless-steel results.

The strength of an electromagnet is proportional to the product of the number of turns in the coil and the strength of the current flowing through it. Based on the properties of these coils, students reformulated their stainless-steel plans and tried again. The stainless-steel group attempted to increase the number of turns, but still failed. One student noticed that the color of the iron cores was somewhat different. Therefore, students hypothesized that the materials were different. Groups who noticed the difference in materials repeatedly explored how they might prove their observation. The top material was a ferrite magnet. The magnet was brought close to the coil, and students determined if it was iron based on whether it could be attracted. By checking the definition of an electromagnet, students were able to confirm the effect caused by the iron core.

4.3. Analysis of Free Descriptions from the Worksheet

From the worksheet descriptions created during the lesson, the emerging patterns formed by the words used during the lesson were extracted. As a result, in the iron group, terms indicating material, such as coils, magnets, and so on were frequently observed. In contrast, in the stainless-steel group, scientific terms to explain principles such as “Fleming's left-hand rule,” “electromagnetic induction law,” etc. were observed.

Table 2 and Table 3 summarize the number of word occurrences extracted from the descriptions. Table 2 summarizes the description results of the iron group, and Table 3 those of the stainless-steel group.

As shown in Table 2, the words “motor” and “centripetal force,” which had not been used in the discussions between the pairs of students, were found to be frequently used in discussions by the whole class. It was presumed that this scene was shared by the whole class, as it described the content provided by the presenter directly. In this case, it was seemingly not a useful argument.

In contrast, as shown in Table 3, the terms shared by the whole class were used to some extent in discussion between two people. It can be inferred that this would prompt a good conversation between two students. Therefore, the "Think-Pair-Share" strategy was effective in encouraging discussion that was wide-ranging and conducted from various perspectives. It was considered that discussion between two people was an important factor. In particular, it became clear that Think-Pair-Share is effective under circumstances that generate cognitive conflicts.

Table 2. Occurrence of extracted words from the iron group (A part)

Question	Extracted word	Think (n=27)	Pair (n=27)	Share (n=27)
Question1	Coil	4	3	38
	Motor	0	0	25
	Magnet	7	9	25
	Centripetal force	0	0	17
	Magnetic force	11	7	14
Question2	Coil	12	7	17
	Repulsive forces	6	2	17
	The N poles and S poles	4	1	16
	Rotation	8	1	8
	Magnet	5	1	7

Table 3. Occurrence of extracted words from the stainless-steel group (A part)

Question	Extracted word	Think (n=27)	Pair (n=27)	Share (n=27)
Question1	Motor	2	4	25
	Coil	0	1	21
	Magnet	4	3	20
	Magnetic force	9	9	17
	Current	7	5	8
Question2	Motor	2	2	16
	Current	3	3	13
	The plus electrode and the minus electrode	2	4	12
	Magnetic force	6	10	9
	Force	5	5	8

4.4. The network of collocation for "Think-Pair-Share"

Networks of collocation were drawn based on the worksheet descriptions of both the iron and stainless-steel groups. All descriptions from the worksheets were analyzed. The minimum number of occurrences was five. The resulting networks of collocation concerning the "Think-Pair-Share" activity are shown in Figure 5 and Figure 6.

As Figure 5 and Figure 6 indicate, more related words and phrases were extracted from the stainless-steel group than the iron group. Additionally, the stainless-steel group not only had a number of extracted words, but many also extracted words and phrases to explain principles. For example, related phrases were observed, such as "Coil" and "Magnetic force," and "Motor" and "Current." This is evidence that discussion took place explaining the principles of the motor and the magnetic top. Understanding the phenomena and explaining their principles led to an essential understanding. In this sense, it appears that the stainless-steel group conducted a constructive debate, which triggers the kind of independent learning attitudes facilitated by STEM education. Therefore, it was inferred that active discussion took place among those in the stainless-steel group.

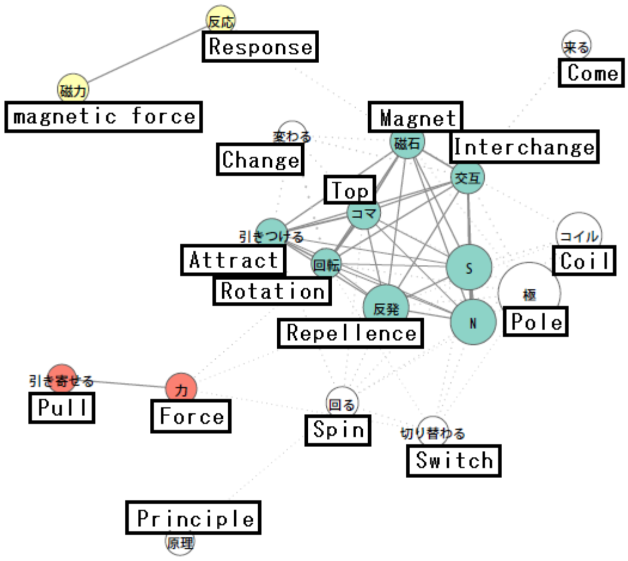

Figure 5. Networks of collocation for the "Think-Pair-Share" activity (iron group)

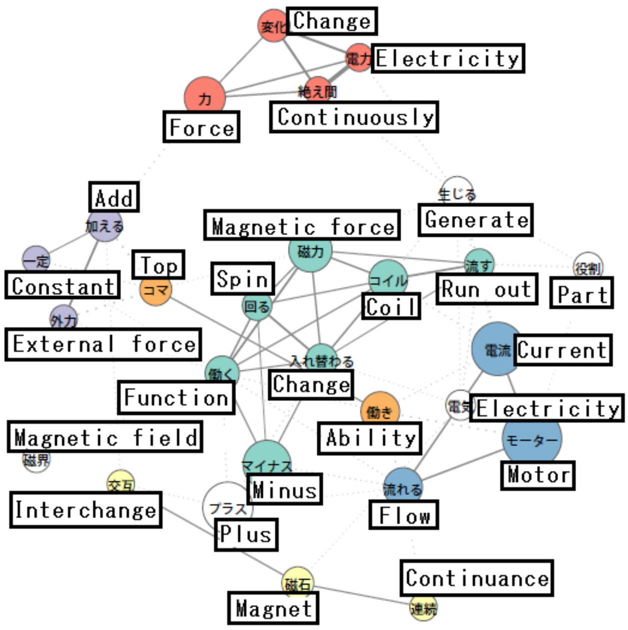

Figure 6. Networks of collocation for the "Think-Pair-Share" activity (stainless-steel group)

5. Conclusion

For this research, a lesson was designed that allows students to consider the principles of a magnetic top while utilizing the teaching method "Think-Pair-Share," which promotes talks. The purpose of this research is to practice lessons in high school science classes, analyze them, and evaluate "Think-Pair-Share." As a result of its implementation, three important findings were noted: 1) The group using stainless-steel bolts contributed more to the discussion since their outcome was negative. 2) The "Think-Pair-Share" strategy was effective in encouraging discussion that was wide-ranging and conducted from various perspectives. It was considered that discussion between two people was an important factor. 3) The teaching strategy of inducing cognitive conflicts could deepen discussion.

In this study, we focused on the number of words used in the discussion. However, we could not investigate the contents of the discussion in this study. Therefore, future study should focus on the contents of the discussion and their consistency with STEM education.

Supplementary Note

Some parts of this paper were presented at the Japan Curriculum Research and Development Association, Japan in 2017 and the TENZ/ICTE Conference, New Zealand in 2017.

Yamaoka, T., Okino, S., Takeno, K & Matsumoto, S. (2017). Implementation of teaching materials for high school students: In case of the creation of magnetic top. Japan Curriculum Research and Development Association 2017 Conference Proceedings, 46-47, Japan .

Yamaoka, T., Okino, S., Takeno, K & Matsumoto, S. (2017). Development and implementation of teaching material based on stem education for Japanese high school students to create a "magnetic top": Discussions for enhanced understanding. TENZ/ICTE 2017 Conference Proceedings, 364-372, New Zealand.

References

[1] Sawyer, R.K. (2006). The Cambridge handbook of the learning sciences. Cambridge University Press, 4-5.

[2] Hammond, L.D., Barron, B.B., Pearson, P.D., & Schoenfeld, A.H. (2008). Powerful learning: What we know about teaching for understanding. Jossey-Bass, 196-197.

[3] Bloom, B.S., Englehart, M.D., Furst, E.J., Hill, W.H., & Krathwohl, D.R. (1956). Taxonomy of educational objectives, The classification of educational goals handbook 1. David McKay, 62-77.

[4] Anderson, L.W. & Krathwohl, D.R. (2001). A taxonomy for learning, teaching, and assessing; A revision of Bloom's taxonomy of educational objectives. Addison Wesley Longman, 27-37.

[5] David, A.S. & Thomas, J.P. (2017).From stem to stem. (Munegumi, T., Trans). Gentosha Inc, 223-243. Corwin, a SAGE company.

[6] Lyman, F. (1981). The Responsive Classroom Discussion. (Anderson, A.S., Ed), Mainstreaming Digest, 109-113. College Park, MD: University of Maryland College of Education.

[7] Walsh, J.A., & Sattes, B.D. (2011). Thinking through quality questioning: Deeping student engagement. Corwin Press, 169-170.

[8] Pope, G. (2013). Questioning technique pocketbook. Teachers' Pocketbooks, 84-85.

[9] National Research Council of the National Academies. (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. The National Academies Press, 41-82.

[10] Myers, A., & Berkowicz, J. (2015). The STEM Shift: A Guide for School Leaders, Corwin Press, 14-24.

[11] Higuchi, K. (2014). Quantitative text analysis for social research toward the inheritance and development of content analysis. Nakanishiya publication, 1-16.

[12] Yamaoka, T., Takeno, K., Okino, S., & Matsumoto, S. (2017). Developing and evaluating elementary-level teaching materials "magnetic top": An analysis of questionnaire using text mining. American Journal of Educational Research, 5(2), 189-195.