Making High Precision Single Balance in Active Learning Seminar for Hiroshima Univ. Monozukuri Junior Doctor Special Educational Program

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Abstract

New learning materials which can cultivate competency of young people are expected. STEM/STEAM educational materials in technology field are the candidate of them, so that we proposed Active Learning seminar of "Making High Precision Single Balance". The seminar took place in "Hiroshima Univ. Monozukuri Junior Doctor" with around 40 participants of young (11 - 15 in age) students. We prepared a number of pre-fabricated parts of deferent sizes, giving them to young participants teams (about 5 people each) to assemble single balance, putting their own ideas in the design by selecting favorite parts by themselves. Majority of the students could understand key concept of the balance (rule of moment) and assemble single balance with accuracy of milligrams. We believe that the seminar acts as a competency nurturing content.

Keywords: Technology education, STEM, Quantitative evaluation, Accuracy

1. Introduction

A new paradigm is emerging in school education. It puts emphasis on "competency" [1], in contrast to "contents" based current educational curriculums. The word "competency" has many facets in its image, but one simple image related to technology field is "capacity for problem solving". In such context, Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) starts to introduce "Tankyu (Inquiry, in Japanese)" subjects in senior high-school curriculums from 2022 [2], in which students try to solve problems found around their daily life, which contain, on the other hand, some level of complexity.

By the way, giving solutions to real problems are somehow essential aspect of technology. Every engineer around the world struggles to solve problems, by thinking, manipulating, re-combining his/her knowledges and skills in daily job. Actually, problem solving curriculums in technology or engineering subjects have longer history than other subjects, known as Project (or Problem) Based Learning (PBL) [3], STEM/STEAM educations [4], and so on. It is worthy to propose contents from technology field, since it is filled with problems must be solved. However, introduction of such contents to school education is still limited.

One of the major obstacles must be the level of problems that engineers tackle with. Many of them are too much specialized in one aspect, or too much complicated to untangle by young students. This is partly because of dramatic development of technology in 21th century. The technology nowadays becomes very sophisticated huge systems, but at the same time, it also becomes very difficult to grab the whole picture, especially for non-specialized people. We have to manage to extract fragmented problems which are matched to different ages of students to be solved, from such huge entangled situation.

In the present study, we introduced a new theme of "Making High Precision Single Balance" as an Active Learning (AL) material. We tried to deduct the complexity of problem, but maintaining the essential part of the technology in it. This material was given to several special seminars from elementary to high school students, and was positively accepted by the students as good problem (theme) to be solved.

2. Basic Policy on Problem Selection

We proposed several STEM/STEAM educational contents in resent studies [5][6] and found, through those experiences, what are the essentials for problem selection, which are,

1. the problem will be solved by making things using knowledge and skills in STEM fields,
2. but the STEM elements to be used must be reachable for respective students,
3. it is favorable to have room for free design in making process,
4. but evaluating point must be quantitative,
5. precise assembling, exact and smooth movement will result in high evaluation,
6. and it will be better that the problem will be solved by group activity.

In our perspective, the theme of "Making Balance" is one of potency material for STEM education, since the basics of the balance is quite simple, that lever rule is taught from elementary school and the main mechanism is only a pivot, but also there will be a number of variations in solutions, as we see many kinds of balance products in market.

We already proposed a STEM educational material of "Making Electric Balance" in previous study [5], in which ample STEM knowledge and skills are incorporated. The target of the "Making Electric Balance" is junior to senior high school students, and estimated duration of the project will be several months.

The seminar in the present study, on the other hand, was only a half day one, and the participant included elementary school students. Therefore, we have to trim the content to appropriate size, extracting essential part from previously developed material. Eventually, we changed the key of the problem from making "Electric" balance to making "Single" balance.

A STEM program of Making Single Balance was placed in a half day seminar in a weekend. The seminar was originally planned for Hiroshima University Monozukuri Junior Doctor, a special educational program for young (11-15 in age) volunteered students. The program was founded by Japan Science and Technology Agency (JST) with a set of their policy, of only few excellent students will be selected "individually" and nurtured to higher level than current school education. Nonetheless, we introduced distinctive characteristics of "group activity" to Hiroshima University's program, because of the reasons as we mentioned above. The idea of group-based activity was approved and highly evaluated by JST.

3. Active Learning Seminar on Making High Precision Single Balance

3.1. *Preparation*

First idea of material development was preparation of pre-fabricated parts (Fig. 1). In technology classes, processing of each part is usually time consuming. For the seminar, we prepared a number of pre-fabricated parts to omit cutting and finishing process.

The pre-fabricated parts included a stand made by laser cut plywood, plate assembly made by metals, pivot assembly, thread (M6) rods of distinct sizes which will be used beams of balance, and two balancing weights of brass. Students will select favorite parts by themselves,

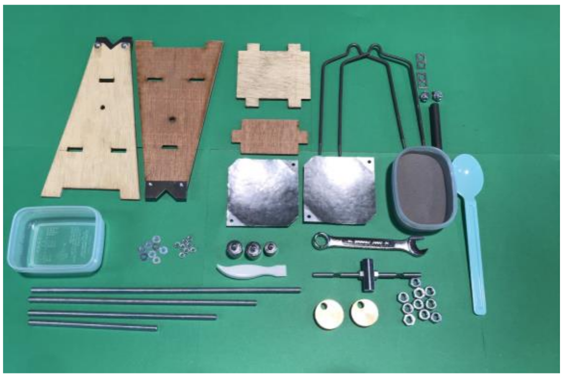


Fig. 1 Pre-fabricated parts.

putting their own ideas in the design, and directly can assemble precise single balance (Fig. 2).

Iron sand, weight (of, 10, 20, 30, 40, 50g) and a high accuracy scale for calibration were also prepared.

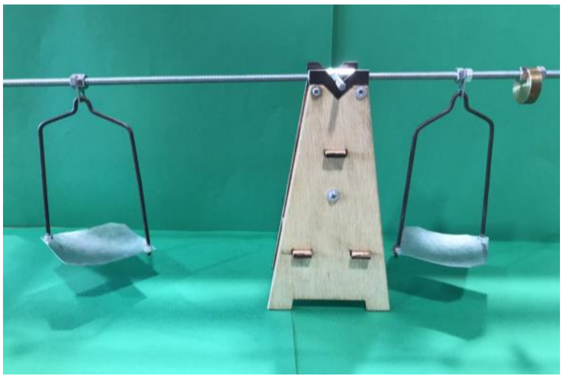


Fig. 2 Example of assembled single balance.

3.2. *Sequence of the seminar*

Sequence of the seminar was as follows. Lectures and exercises were combined. Breaktime was set in each hour since elementary school students are included.

13:10 - 13:30 A single balance and lever rule (lecture)
13:30 - 14:00 Assembling basic parts (exercise)
14:00 - 14:10 Break
14:10 - 14:30 Giving task and designing (lecture)
14:30 - 15:00 Assembling Balance (exercise)
15:00 - 15:10 Break
15:10 - 15:30 Calibrating weight (exercise)
15:30 - 16:00 Trial to improve performance (exercise)
16:00 - 16:10 Break
16:10 - 16:30 Presentation by each group
16:30 - 16:50 Summary

The most important key of the seminar was the "Task". We gave the task of,

"Measuring 80g using only one weight of 10, 20, 30, 40, 50g".

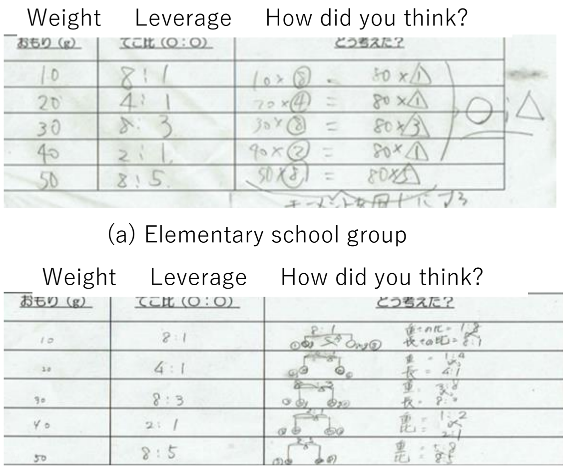
Note that, with this task the students had to choose single balance, that is, the length of left and right levers must be different. We here put a level of complexity, expecting more exercises in their brain, hand and group activities.

4. Results and Discussions

4.1. *Understanding basic concept*

Six groups of junior high school (JHS) students and three of elementary school (ES) students were participated to the seminar.

After giving preliminary lecture, the students found leverage could be used. Typical result from ES and JHS groups are shown in Fig. 3. Surprisingly enough, majority of the students could understand, including ES students, key concept of the balance (rule of moment) and found that every weight (10 to 50g) had a counterpart leverage. It looked that the group discussion helped to lead deeper understanding of the concept.



(a) Elementary school group

(b) Junior high school group

Fig. 3 Calculating leverages with each weight.

There were differences in the way of leading leverages between ES and JHS groups. For ES students, leverages were led by counting numbers of weight, as seen in the figure. In contrast, many JHS groups found that the weight ratio was the inverse of leverages, using fractions.

4.2. *Assembling "Real" balance*

Understanding the key concept was not so difficult for them. However, projection of the concept onto the real single balance was much more difficult. First obstacle was the selection of leverage. The concept showed every weight could be used, but there was no hint which leverage was better than others. Moreover, they had to decide the concrete length of levers. Many groups used somehow linger time to decide them.

After deciding lever lengths, they start to assemble the balance and met the biggest hurdle, that was, problem of "dead weight".

Problems of the balance they met in daily science or mathematics classes always disregarded the dead weight, but real balance had. That is, only understanding main concept was not enough when one wanted to resolve the real problem. Majority of students did not clearly understand the concept of dead weight and role of counter weight. We had to teach dogmatically that the balance must be horizontal before the measurement, putting and moving counter weight in shorter, namely lighter lever. It was somehow disappointed result but was good chance to know difficulty of real problem resolution.

4.3. *Accuracy of the balance*

An example of calibration result for ES group are shown in Fig. 4. It indicates that they were gradually improve the balance and reduces the errors. This group finally reached an error of +0.08g, that is, 0.1% error. Final average error for three ES group was 0.48g, although every group uses the leverage of 1:2 and no dramatic improvements were performed.

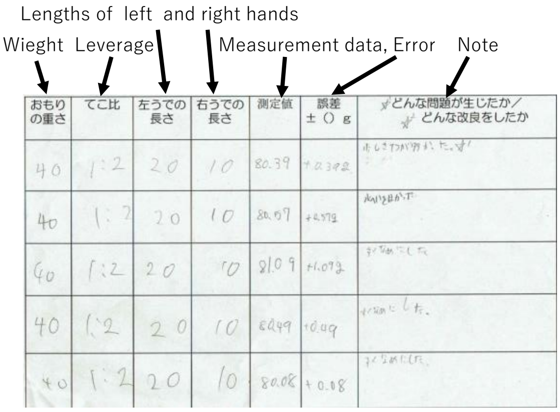


Fig. 4 An example of calibration result for ES group.

On the other hand, improvement of JHS groups were more dynamic. Many groups changed the leverage and lengths of the levers. Final leverages were 1:2 for two groups, 3:8 for 1group and 5:8 for three groups. Final average error in JHS was 1.71g, that was larger than ES result but still kept high accuracy.

5. Summary

An Active Learning seminar of "Making High Precision Single Balance" took place as a seminar in "Hiroshima Univ. Monozukuri Junior Doctor". Around 40 participants of young (11 - 15 in age) people were participated. Preparing pre-fabricated parts made easy to assemble single balance in short time. The group activity also helps to their affirmative cooperation. Although some concepts such as dead weight were difficult to take into accounts, they could assemble single balance of milligram accuracy. We believe that the seminar acts as a competency nurturing content.

Acknowledgements

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