Improvement of Project Activities Based on Method of Project Management through Manufacturing Educational Material in University

Masahisa Shinoda

***Abstract*—Improvement and investigation about a quality of a product and a process of a project activity is discussed. Manufacturing an educational material used in university was proceeded as the project activity based on a method of project management. The educational material was designed and manufactured by project team students according to orders directed by the professor. Several parts of the educational material were designed by the students, and molded by a 3D printer. Two major problems occurred in the designing process are introduced. The educational material was finally realized with necessary specifications and was used at an open class for high school students. Experience of this project activities gives the students involved in this project their confidence.**

***Index Terms*—Design, educational materials, manufacturing, project activity in university, project management.**

I. Introduction

Professors and lecturers belonging to the Mathematics and Science Education Research Center in Kanazawa Institute of Technology are making various efforts to improve students' understandings in fundamental subjects [1]-[6]. Besides class works, students with various grades and courses of study are working in group on their interested project activities, for examples, a robot contest, a hand aircraft, and an artificial satellite. The author and his colleagues are managing the project based on fundamental science and engineering. In this project, students propose project subjects individually. Next, the students and the teaching staff certify the physical principle of the proposed subjects. After that, the students start to manufacture their products of project subjects. The teaching staff is studying how to improve the quality of both a process and a product from each project activity.

The author had the chance of an open class to lecture on "technology of digital audio" to high school students. Therefore, the author planed that the students belonging to the author's project in Kanazawa Institute of Technology manufacture an educational material about "digital audio" as the author's presentation material for high school students. In this project of manufacturing the educational material, the author applied the method of project management to this activity. This method was established and published as the body of knowledge, "PMBOK" [7] by Project Management Institute, and is widely used on business world.

The author investigated the quality of both the process and the product of this project, and studied the relationship between these qualities and a contribution of the author.

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II. Outline of Educational Material

The author designed an experimental apparatus as the educational material for the open class. This apparatus explains the principle of a digital audio set such as a compact disc (CD) player. This apparatus consists of a mechanical unit and an electrical circuit. The mechanical unit works so that coded scales painted on surface of a printable type CD-R on a turn table rotates by a hand through rubber belts. The electric circuit consists an optical detecting unit and a signal processing unit. The optical detecting unit detects the coded scales which are marked as three-bit digital codes using light emitting diodes (LEDs) instead of a laser diode in the real CD player, and photo diodes. The signal processing unit transforms three-bit digital signals to octal numbers which represent eight sounds, "C", "D", "E", ... , "C" as the scale. This unit also drives a speaker to generate these sounds.

The author planed the sequence of the open class. At the beginning, the mechanical units are disassembled into parts beforehand. High school students can experience to assemble these parts into the mechanical unit during the open class, and enjoy digital audio sounds using the completed experimental apparatus. As a result, high school students can understand the fundamental principle about "technology of digital audio", and become interested in the science and engineering field through this open class using the above mentioned apparatus.

In proceeding to manufacture this apparatus, the author divided the students of his project team into two teams, one team was in charge of the mechanical unit, and the other was in charge of the electric circuit.

TABLE I: Details of Students

Team	Course of Study	Number of Students		
		First-year	Second-year	Third-year
Mechanical Unit	Mechanical Engineering	0	0	2
	Robotics	8	1	0
Electric Circuit	Electrical Engineering	1	1	0
	Robotics	2	1	0

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Table I shows the details of number of students. Total number of students who involved in this project was sixteen. The necessary number of this apparatus was twelve.

III. Application of Project Management

The author applied the method of project management [7] to the students involved in this project.

At first, the author appointed a student leader for each unit. The appointed leader of the mechanical unit was the three-year student of the mechanical engineering course. He was so suitable that he had various experiences about manufacturing products and had great skill in dealing a 3D printer. As for the leader for electric circuit, the two-year student of the electrical engineering course was appointed because he was the only student who understood the basis of electric circuits.

Next, the author directed two leaders to report progress, problems if happened, and plans of the next week every week. The author checked technical subject, schedule, and cost according to students' reports mainly, instead of the strict management based on the method of project management, because they were beginners for these managed project.

IV. Manufacture of Educational Material

A. Mechanical Unit

The author showed three special orders of the mechanical unit to its team, as follows:

(1) a structure of the mechanical unit must be confirmed visually so that high school students understand the structure of the apparatus and the mechanism of disk rotating,
(2) the mechanical unit must be able to manufactured easily by hands without any tools within ten minutes, and
(3) the mechanical unit must be disassemble easily without damage and can be re-assemble for reuse.

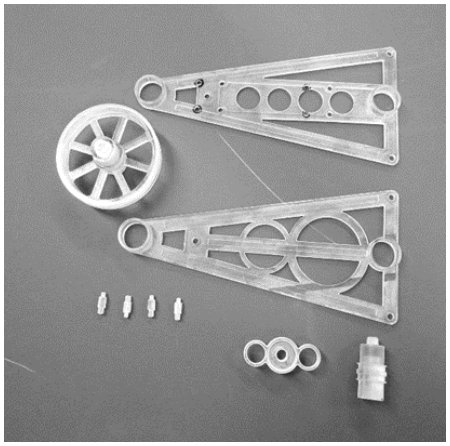

Fig. 1. All parts molded by the 3D printer.

The leader of the mechanical unit team understood the above orders and broke down the total design into sub blocks for each team members. Each student took charge of the sub block given by the leader. They frequently gathered to verify the designs of sub blocks and checked for the existence of problems. Most of the parts except screws and nuts were designed by a 3D CAD software and were molded by the 3D printer.

Fig. 1 shows all parts molded by the 3D printer for the mechanical unit. Fig. 2 shows the appearance of the mechanical unit. The CD-R is mounted on the turn table and can be rotated by the handle through the rubber belts.

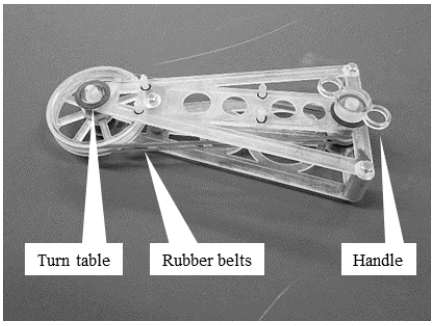

Fig. 2. Appearance of the mechanical unit.

B. Electrical Circuit

The printed wiring boards for the electrical circuit was designed and prepared by the author, because there was no student who could designed an electrical circuit for this educational material. The author showed three special orders to manufacture the electrical circuit unit to its team, as follows:

(1) mounting and soldering all electrical parts to the printed wiring boards,
(2) confirmating that the electrical circuit works normally as designed, and
(3) turning the resistance values of variable resisters to generate appropriate sounds of scale.

Fig. 3 shows the appearance of the electrical circuit. This circuit consists of two board. The small board with LEDs and photo-diodes (PDs) is for detecting the digital codes marked on the printable surface of the CD-R which is shown in Fig. 4. The black and white painted portions represent "0" and "1" in digital signal, respectively. The large board is for signal processing and speaking the scale using a speaker.

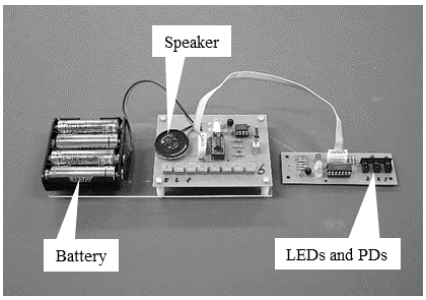

Fig. 3. Appearance of the electrical circuit.

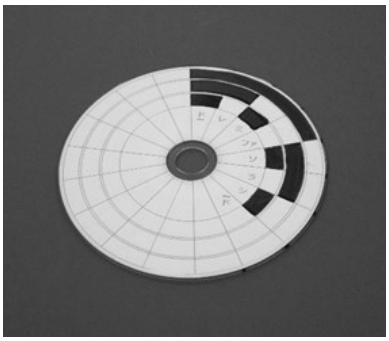

Fig. 4. The printable surface with painted marks of CD-R

Three-bit signals are transformed to the scale with octal numbers in this board, such as,

"0" represents "C",
"1" represents "D",
"2" represents "E", and so on.

C. Whole Set of Educational Material

Fig. 5 shows the whole appearance of the educational material. This set was actually able to be manufactured from parts within ten minutes, which was the target time by high school students at the open class.

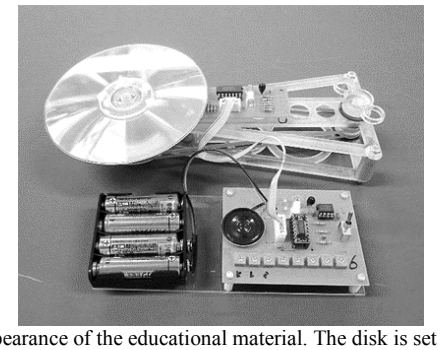

Fig. 5. Appearance of the educational material. The disk is set the surface with painted marks downwards.

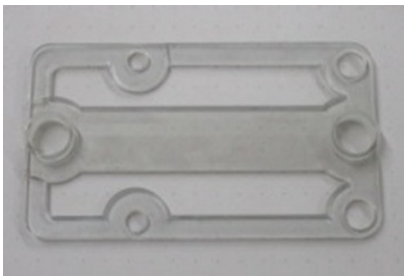

Fig. 6. The primarily designed plate.

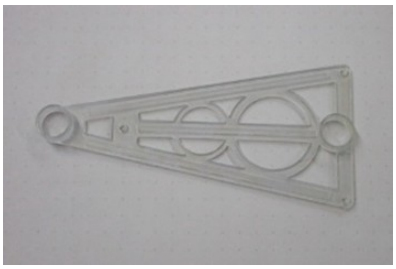

Fig. 7. The finally designed plate.

Table II shows the activity terms of each team to complete this project. All activities were completed within two months.

TABLE II: THE ACTIVITY TERMS

Team	Activity		
	Design	Manufacturing	Total Tuning
Mechanical Unit	6 weeks	2 weeks	1 week
Electric Circuit	3 weeks	5 weeks	

V. EVALUATION OF PROJECT ACTIVITIES

The students involved in this project completed their missions until the deadline. In the process of this project, some problems happened. Here, two major problems are introduced.

The first problem was the cost of molding using the 3D printer. The cost is almost proportional to the amount of resin. Fig. 6 shows the plate which was primarily designed and molded. This shape actually needed a large amount of resin for 3D molding and resulted in a high cost. Therefore, the team member examined necessary function of this plate and redesigned many times to reduce the amount of resin by cutting unnecessary structures. Fig. 7 shows the appearance of the final plate. The cost of the final design was reduced by almost 30% against the primary design.

The second major problem was mismatching in dimensions among the mechanical parts. This problem was mainly caused by insufficient communication among the team members.

Experiencing these problems, the students were able to understand the importance about the cost in the product, and information interchange among not only team members but also all persons concerned in the same project during the process of the project.

Fig. 8 shows the scene at the open class, where the high school students manufactured the education materials according to the guidance of project team students. As the result, no problem happened on manufacturing, and the high school students experienced a meaningful class with these apparatus.

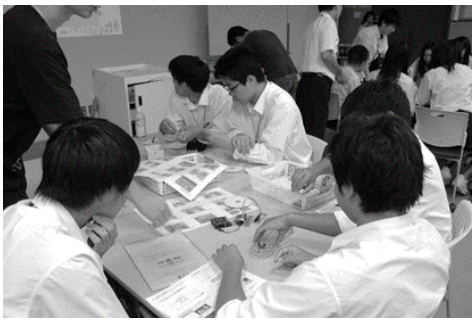

Fig. 8. The scene at the open class. The high school students manufactured the education materials according to the guidance of project team students.

After the open class, the author obtained project team students' impressions through a questionnaire. Answers were obtained from fifteen students. Typical questions were the followings.

(A) Are you satisfied to participate this project?
(B) What is your impression of participating this project?
(C) What is your impression of the author's guidance?

Tables III to V show the results of the above questions.

TABLE III: THE RESULT OF QUESTIONNAIRE (A)

Question (A) Are you satisfied to participate this project?	Number of students
Highly satisfied	13
Satisfied	1
Not highly satisfied	1
Not satisfied at all	0

Table III shows that most of students expressed their satisfaction at contributing to this project. One student who

answered "not highly satisfied" participated in this project halfway and became in charge of a manufacturing manual. Therefore, it is supposed that he had a negative impression because he could not be involved in designing the mechanical unit.

TABLE IV: THE RESULT OF QUESTIONNAIRE (B)

Question (B) What is your impression of participating this project?	Number of students
Highly meaningful in the future	11
Meaningful in the future	4
Not meaningful in the future	0

Table IV shows that experiencing this project was meaningful and helpful in students' future.

Table V shows that the author's guidance was appropriate. It can be imagined if the author's guidance had been more than enough, an unique design would had not been realized, and if the author's guidance had been insufficient, a design satisfied the author's request would had not been realized.

TABLE V: THE RESULT OF QUESTIONNAIRE (C)

Questionnaire (C) What is your impression of the author's guidance?	Number of students
Excessive	0
Appropriate	15
Insufficient	0

The students, who were beginner of manufacturing before this project, could learn how to use the 3D printer, the turning lathe, the oscilloscope, and other tools. Eight students of first-year robotics course could learn the 3D CAD software through this project. Since the skill of 3D CAD is necessary for the robotics course, they could mastered the skill about 3D designing partially in advance of a class. They felt confidence in themselves that they could carry out a next project with respect to not only fundamental science and engineering but also the project activity. Most of students had a new appreciation how to success the project from viewpoints of term, cost, communication, and the quality of both the product and the process of the project activity. They also understood that these factors were very important in the project management.

VI. CONCLUSION

The author planed the project that the project team students manufactured the educational materials at the open class for high school students. The project team students pursued their missions with enthusiasm. As the result of their activities, the optimum educational materials were realized and introduced at the open class. The project team students expressed that the author's guidance was proper.

The author applied partially the method of project management [7] to this project. This method was established so that projects on business must be managed to succeed, but a method for education in universities is not existed. The author strengthens his idea that a method of project management for education must be established.

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REFERENCES

[1] A. Nakamura, "Log analysis of mobile user behavior for a public-facing math e-learning site," *GSTF Journal on Education*, vol. 2, no. 2, pp. 38-42, Nov. 2013.
[2] A. Nakamura, "Visualization of knowledge structure of mathematics," in *Proc. the International Symposium on Education, Psychology, Society and Tourism*, Tokyo, Japan, pp. 1533-1536, 2014.
[3] A. Nakamura, "Hierarchy construction of mathematical knowledge," *Lecture Notes on Information Theory*, vol. 2, no. 2, pp. 203-207, Jun. 2014.
[4] A. Nakamura, "Graph drawing of knowledge structure of mathematics," *The SIJ Transactions on Computer Science Engineering & its Applications (CSEA)* , vol. 2, no. 4, pp. 161-165, Jun. 2014.
[5] A. Nakamura, "Graph drawing of knowledge structure of mathematics combined with knowledge level," *INTED2015 Proceedings*, pp. 2576-2579, 2015.
[6] A. Nakamura, "Self-adaptive e-learning website for mathematics," *International Journal of Information and Education Technology*, vol. 6, no. 12, pp. 961-965, 2016.
[7] Project Management Institute, *A Guide to the Project Management Body of Knowledge: PMBOK Guide*, 5th ed. PA: Project Management Institute Inc., 2013.

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