Journal of Asian Vocational Education and Training
Vol. 11, pp. 22-28, 2018

ISSN 2005-0550

Structure of Consciousness in Reflection on Production Activities: Project Study in Japanese Technical High Schools

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ABSTRACT

The purpose of this study was to examine the structure of consciousness in technical high school students' reflection after the completion of a project study regarding production activities of design-and-make products. The project study was one of the courses in technical high schools in Japan. A survey was conducted on 689 12th graders in Japanese technical high schools. But only 83.5% (575 students) of the respondents returned the valid questionnaires. The study used Shimada et al. (2006) and Kanda and Matsuura (1999) models as the underpinning framework to conceptualize the study. Derived from Shimada et al. (2006), eight categories of students' consciousness were included: (a) the acquisition knowledge and skills, (b) patience and efforts, (c) cooperation and teamwork, (d) accomplishment of *monozukuri*, (e) planning, (f) enjoyment of *monozukuri,* (g) independence, and (h) reflection were the bases for developing the instrument. In addition, based on Kanda and Matsuura's model, five factors were adopted for the study. The factors were consciousness, safety, values, learning, and self-assessment. The key results showed that the structure of consciousness in students' reflection on the production activities in a project study in Japanese technical high schools was affected by the three main factors – consciousness, values, and safety. In addition, the findings also revealed that effective teaching strategies should be designed for certain types of students that were involved in this study. Based on the data, the structure of consciousness is dependent on the goals and contents for production activities and the engagement of the students. In sum, having a bird's-eye view toward the results, validity of the model created in the present study was verified.

Keywords: Structure of consciousness, technical high school students, project study, factor analysis, Japan

AN OVERVIEW ON "PROJECT STUDY"

A project study is a technology subject in technical high schools in Japan and it has been implemented since 2009. The purpose of the project study is to set up a project related to industry so that the students could enhance their problem-solving skills. Through this project study, students' technical knowledge and skills are deepened and integrated, their problem-solving ability as well as creativity can be enhanced. The idea was mooted based on the revision of the technical high school curriculum in 1989. Traditionally, Japanese technical high schools had focused on direct teaching to transmit technical knowledge and skills to the students. Now, as a course, the instructor of the project study puts an emphasis on solving authentic problem-solving so that the students will acquire critical and creative competencies. In addition, project study is designed to use the comprehensive learning approach of *monozukuri* (product-making). The contents of a project study are classified into the four main tasks as

follows: (a) creating a work or a product, (b) conducting survey, examination or experiment, (c) undergoing practical training at industrial workplaces, and (d) acquiring vocational qualifications.

Based on what students have already learned in the basic and foundation courses, they will acquire new knowledge and skills by embarking on a real-world project to solve an industrial problem. It is hoped that the project study will enhance the students' problem-solving ability, creativity and team work. In the project study, students will propose an industry-related research. When configuring the contents, students are allowed to set up appropriate tasks for an individual or a group work, to choose from four content items depending on their interests and to tailor the project to suit their desired career paths. In addition, the students are provided with an opportunity to present the outcomes of their project study. In reality, most Japanese students take this project study course at the 12th grade level. The facilities for the students to embark on the project study are provided in the school.

PURPOSE OF THE STUDY

The purpose of this study was to examine the structure of consciousness among technical high school students after the completion of their project study course regarding their production activities of design-and-make products.

CASES OF THE PROJECT STUDY

A technical high school has decided its own goals for a project study: (a) to encourage students to conduct a needs analysis, (b) propose a plan, (c) collect data, and (d) present their *monozukuri*, and (e) to enhance the students' interests in chemistry, industry and other related fields. The research report regarding the project study pointed out that these experiences enabled the students to solve the problem, to work independently and to be creative in solving the problem. Research conducted by Ueno (1992) revealed the importance of a project presentation, using the example of the performance of a technical high school. The presentation was valuable not only for the students who conducted the project but also for the students in the lower grades who were the audience who listened to the presentation. The aim of the presentation was to describe their project study, the findings and the contributions of their project in solving a real problem.

The benefits of project study have been documented in the literature. Tahara (1996) acknowledged that project study activities have nurtured independent and active learning abilities and enhanced communication skills of the students who conducted the project study. Working on a project would establish a positive and favorable relationship among the students and their teacher. The students have also shown an improvement of the quality of their workmanship in producing products in their project study. In the previous cohort of the project study, the students agreed that their consciousness was formed based on the experiences related to the practical training. Shimada, Moriyama and Matsuura (2006b) examined how a project study – a technology subject in a technical high school – played a critical role for students to form their self-consciousness and found that the students possessed eight types of consciousness gained through product-making activities in the project study. The eight categories of technical students' consciousness in the project study were displayed in Table 1. The eight categories of students' consciousness included: (a) the acquisition knowledge and skills, (b) patience and efforts, (c) cooperation and teamwork, (d) accomplishment of *monozukuri*, (e) planning, (f) enjoyment of *monozukuri,* (g) independence, and (h) reflection.

In an earlier study, Kanda and Matsuura (1999) have examined the students' awareness in the practical training subject – a subject which has similarities to the project study course from the standpoint of making a product. The study found five significant factors that affected students' consciousness in the practical training subject which were: (a) consciousness, (b) safety, (c) values, (d) learning, and (e) self-assessment (see Table 2). In addition, Shimada et al. (2006b) have found that the practical training consciousness structure has affected positively on the development of the students' self-concept. Even though the investigation of Shimada et al. (2006) has determined the categorization of consciousness formed through product-making activities but they have not yet examined its structure. Similarly, although Kanda and Matsuura (1999) examined the structure of consciousness, it focused

only on the practical training. Therefore, there have been no recognized reports that elucidated the structure of consciousness formation based on comprehensive verification of reflections on consciousness developed through the activities of production in a project study. Therefore, in the present study, the authors have decided to focus on the consciousness reflections on the design-and-make of production activities in a project study.

Table 1: The eight types of students' consciousness in the project study

	eight consciousness categories (Shimada et al. 2006)
1	the acquisition of knowledge and skills in project study
2	the importance of patience and efforts in project study
3	the importance of cooperation and teamwork in project study
4	the sense of accomplishment in monozukuri in project study
5	the awareness of the importance in planning in project study
6	the pleasure of monozukuri in project study
7	the awareness of the importance in independence and initiative in project study
8	reflection and self-examination following a misstep in project study

Table 2: Student's consciousness in the practical training subject

	practical training consciousness structure group (Kanda & Matsuura 1999)
F1	positive consciousness of practical training subject
F2	factor regarding safety of practical training subject
F3	factor regarding values of practical training subject
F4	factor regarding learning of practical training subject
F5	factor regarding self-assessment of practical training subject

METHODOLOGY

The purpose of the study was to investigate the structure of consciousness and reflection on the production activities in a project study among Japanese technical high school students. The study used Shimada et al. (2006) and Kanda and Matsuura (1999) models as the underpinning framework to conceptualize the study. Derived from Shimada et al. (2006), eight categories of students' consciousness included: (a) the acquisition knowledge and skills, (b) patience and efforts, (c) cooperation and teamwork, (d) accomplishment of *monozukuri*, (e) planning, (f) enjoyment of *monozukuri,* (g) independence, and (h) reflection were the bases for developing the instrument. In addition, based on Kanda and Matsuura's model, five factors were adopted for the study. There were (a) consciousness, (b) safety, (c) values, (d) learning, and (e) self-assessment.

A survey method was used as the research design. In general, a survey is a research method that collects data from respondents to obtain their perception on certain topics of interest. A sample of 689 12th graders in the technical high schools in Oita, Osaka and Tottori prefectures was selected. The study was designed to identify the students' consciousness structure and reflection regarding their production activities of design-and-make products during the one-year project study activities. Based on the conceptual framework of Shimada et al. (2006b) and Kanda and Matsuura (1999), twenty-one questionnaire items were developed and validated by several experts. In other words, a measuring instrument for the project study consciousness has been developed.

The initial set of questionnaires contained 21 items. For the first category of the acquisition of knowledge and skills, two (2) items were developed. For the second category of the importance of patience and efforts, three (3) items were created. In the third category, two (2) items were developed to measure the importance of cooperation and teamwork. In terms of *monozukuri* (the fourth category),

three (3) items were posited for the sense of accomplishment in *monozukuri*. Similarly, three (3) items were developed for the awareness of the importance in planning (fifth category). For the sixth category, two (2) items were created to measure the pleasure of *monozukuri*. For the seventh and eighth categories, three (3) for the awareness of the importance in independence and initiative and the other three (3) items for reflection and self-examination following a misstep, respectively. Along with these items, the three dominant factors were added to the questionnaire made the total number of items was 25.

The survey was carried out in February of 2015. After the empirical data were gathered, the data analysis was conducted through mainly a factor analysis. As for the consciousness of students in the project study, three factors were extracted by the factor analysis. The factor analysis using the principal factor method and varimax rotation was implemented. Also, GP analysis was implemented in order to confirm the item discriminating powers. The internal consistency of this scale was confirmed by using the Cronbach Alpha coefficient. Furthermore, the mean and the standard deviation (SD) of each factor were calculated for each category of the students' activities for making products.

RESULTS AND DISCUSSION

The purpose of the study was to investigate the structure of consciousness in reflection on the production activities in a project study among Japanese technical high school students. A sample of 689 students was selected to participate in the study. However, only 575 students have returned the questionnaires. Hence, it was 83.5% rate of return.

Structure of consciousness on "Project Study"

After the survey, a simple tabulation was performed on the data and its structure was examined by employing a factor analysis with a major factor method and varimax rotation. For the factor analysis, an explanatory data analysis was performed with the emphasis on the validity of the interpretation by applying the following three analysis criteria: (a) an eigenvalue of 1.00 or greater after rotation (the Kaise-Guttman rule), (b) a commonality after factor extraction of 0.30 or greater, (c) factor loading of 0.40 or greater, and (d) a difference between the factor loading and another factor loading of 0.10 or greater. Finally, the data analysis extracted three factors as the final outcome (Table 3).

The first factor was a content relating to the importance of teamwork and planning, self-reflection with self-examination and knowledge regarding process of production activities. We named this factor as F1 – acquisition of knowing how. The second factor was content relating to the feeling of satisfaction, the recognition of advantages for the future and the acquisition of knowledge and skills. We referred this factor as F2 – the recognition of the values. The third factor was content relating to safety and we named this factor as F3 – consideration of safety.

Based on the factor analysis results, relations were examined between each factor and the categories. F1 – acquisition of knowing how confirmed the relationship among frameworks, with the importance of patience and effort, the importance of cooperation and teamwork, the sense of accomplishment in *monozukuri,* the importance of planning, the importance of independence and activeness, and reflections following a misstep. F2 – the recognition of the importance of values. F2 confirmed the relations regarding consciousness with the acquisition of knowledge and skills, the sense of accomplishment in *monozukuri,* the pleasure (joy) of *monozukuri*, and the values of project study for the future. Finally, F3 – consideration of safety confirmed a relationship with the consciousness of safety.

Judging from these findings, a structure was confirmed by consciousness groups through one-year project study activities, based on the sense of acquiring "knowing-how", which was characterized by the importance of teamwork and planning, accordingly, "knowing-that (values)" was obtained, including the sense of fulfilment in acquiring knowledge directly through activities of project study, advantages for the future and reasons of being actively engaged in the project. The "values" in obtaining knowledge and skills of "knowing-that" were reflected upon. In addition, consciousness of safety during production activities was also critical.

Table 3: A result of factor analysis on "Project Study"

	questionnaire items	F1	F2	F3	Communality
12	Through the project study, I realized that it is important to make a plan and to use time efficiently.	0.760	0.154	0.318	0.702
18	Through the project study, I realized that it is important to think and work actively and independently.	0.753	0.277	0.111	0.657
11	Trough the project study, I realized that it is important to have process planning and procced with the planning.	0.742	0.179	0.296	0.671
17	Through the project study, I realized that it is important to be actively involved in the work.	0.722	0.347	0.125	0.657
10	Through the project study, I realized that it is important to accomplish one thing.	0.659	0.332	0.301	0.635
(16)	Through the project study, I realized that it is important to proceed with things by themselves.	0.643	0.294	0.029	0.501
6	Through the project study, I realized that it is important to cooperate with friends and teachers.	0.624	0.360	0.243	0.579
(13)	Through the project study, I realized that they are required to make a design before an operation, prepare tools and materials and share roles.	0.589	0.216	0.367	0.529
(7)	Through the project study, I realized the importance of teamwork.	0.584	0.351	0.227	0.516
20	I found that they could have worked more efficiently during the project study, in thinking back on it now.	0.519	0.186	0.162	0.330
3	I thought that they were able to make efforts to overcome difficulties when they faced a difficult situation when taking the project study.	0.488	0.361	0.138	0.387
19	I thought that they were able to be aware of their lack of knowledge and insufficient skills due to the project study.	0.486	0.248	0.233	0.352
25	I thought that experiences obtained in project study would be beneficial for their future.	0.317	0.755	0.175	0.702
24	I thought that the project study would be helpful for finding a job.	0.232	0.723	0.256	0.642
1	I thought that they retained technical knowledge and skills by project study.	0.240	0.706	0.114	0.569
8	I thought that project study enables I to feel satisfaction.	0.381	0.569	0.315	0.568
15	I thought that project study is fun.	0.311	0.538	0.262	0.455
22	I thought that they must behave calmly with safety consciousness during project study.	0.281	0.292	0.810	0.821
23	I thought that they must act on the principle of safety first.	0.239	0.252	0.699	0.610
	Eigen value before rotation	11.98	1.09	0.84	
	Coefficient of determination(%)	47.92%	4.37%	3.35%	
	Eigen value after rotation	6.62	5.02	2.27	
	Coefficient of determination(%)	26.47%	20.08%	9.09%	

( ) is an item to be eliminated on discussion N=575

Creation of measurement scale

The measurement scale for consciousness at the completion of a project study course was verified for reorganization, while maintaining the consciousness structure as shown in Table 3. As the number of items corresponding to a category in each factor was intended to be two at most, items which had low factor loading were eliminated (items 7, 13, 16; see Table3). Finally, 16 items were retained. These items were examined by confirmatory factor analysis. Confirming the three-factor structure, the scale of consciousness at the completion of the course was reorganized. Subsequently, discrimination was confirmed using GP analysis and internal consistency for each factor using Cronbach Alpha coefficient (F1: α=0.88, F2: α=0.87, F3: α=0.85). Based on the analysis shown in Table 3, a new model was verified.

Classification of activities for making products

Shimada et al. (2006) have been focusing on project-based learning of production activities in project study, classifying them into four types: (A) making products type, (B) electronic control type, (C) information processing type, and (D) others. The present research also classified the activities according to the method of the classification as shown in Table 3. (A) making products type had 292 students

(examples: producing a vacuum engine, welding, lathe and others), (B) electronic control type had 131 students (examples: microcomputer car, control of an assembly line and others), (C) information processing type had 76 students (examples: LED, 3DCAD and others) and (D) others had 76 students (examples: intellectual property, solar power generation and others).

Differences of students' consciousness in each type

After eliminating the type D (others), analysis was performed in regard to the differences in consciousness among the three groups corresponding to the three types, employing a one-way analysis of variance (ANOVA). The results revealed that significant differences were recognized in the factor of F1 which was the acquisition of knowing how [$F(2, 496) = 7.17$, $p<0.01$] and the factor of F3 which was the consideration of safety [$F(2, 496) = 3.60$, $p<0.01$]. The results of the multiple comparisons were F1: A = B > C (MSe = 0.49, $p<0.05$) and F3: A > C (MSe = 0.81, $p<0.05$). Considering these findings, for F1 which was the acquisition of knowing how, there was a tendency that making products type (A) and electronic control type (B) had high values. In comparison with the information processing type (c), these two types (A and B) were more likely to have planning and operations with liveliness and opportunities of cooperation for making a product. These strategies led to the enhancement in the sense of acquiring knowing how for making products type and electronic control type, as it was assumed. Judging from these differences, effective teaching strategies should be designed for the information processing type (C) of project study, for example, an introduction of a process relating to the acquisition of knowing how, to stimulate consciousness development of students taking this type of course. For F3 which was the consideration for safety, the data showed that the information processing type had lower tendency for safety than the making products type.

This was because making products type had more risks, in reality, dealing with machine tools or laboratory instruments more frequently, which could result in physical hazards. It was inferred that the working conditions led to the formation of intensive consciousness in the students of A type. It was probable that the students of type C who were information processing type, as they worked with computers and digital devices, had rather low risks of physical dangers, and their consciousness in safety was different as compared to the other two types of students. How to capture this consciousness requires a further investigation. Differences of consciousness were not detected in F2 where the values were concerned. The findings showed that the project study was beneficial for certain types of students. Based on the data, the structure of consciousness is dependent on the goals and contents for production activities and the engagement of the students. In sum, having a bird's-eye view toward the results, validity of the model created in the present study was verified.

CONCLUSION

The purpose of the study was to investigate the structure of consciousness in reflection on production activities in a project study among Japanese technical high school students. In this article, we reported the structure of consciousness in technical high school students' reflection after the completion of a project study course regarding production activities of design-and-make products in Japan. The findings of the research pointed out that the varied experiences in the project study have enabled the students to solve the problem, to work independently and to be creative in solving the problem. The project study – a technology subject in a technical high school – played a critical role for students to form their self-consciousness and the previous study has found that the students possessed eight types of consciousness gained through product-making activities. The eight categories of technical students' consciousness in the practical study were: (a) the acquisition knowledge and skills, (b) patience and efforts, (c) cooperation and teamwork, (d) accomplishment of *monozukuri*, (e) planning, (f) enjoyment of *monozukuri,* (g) independence, and (h) reflection. In terms of the structure of consciousness of the practical training, the researchers have selected five (5) factors based on Kanda and Matsuura (1999) model which included: (a) consciousness, (b) safety, (c) values, (d) learning, and (e) self-assessment. However, the present study found that only three significant factors that affected students' consciousness in the project study which were consciousness, safety, and values. In conclusion, the main results indicated that effective teaching strategies should be designed for certain types of students that were involved in this study. Finally, for future studies, it is necessary to investigate the relationship

between students' structure of consciousness in a project study with their future chosen occupations or career pathways.

ACKNOWLEDGMENT

This work was supported by KAKENHI (No. 17K18660) which was the Grant-in-Aid for challenging exploratory research.

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