Analyzing Effect of Team Composition on Education in Practical Lecture of Information Systems Development

Shota INAGA, Student, Waseda University
Hironori WASHIZAKI, Waseda University
Yusuke YOSHIDA, Waseda University
Yoshiaki FUKAZAWA, Waseda University
Kazuhiko KAKEHI, Waseda University
Shoso YAMATO, University of Tsukuba
Masashi OKUBO, NEC Learning, Ltd.
Teruhiko KUME, NEC Learning, Ltd.
Manabu TAMAKI NEC Learning, Ltd.
Toshikazu KANOU, NEC Corporation

Abstract

Over the past few years, there has been a problem in training IT professionals in both universities and the industrial world. Therefore, practical lectures performed as controlled project-based learning, which teach practical skills based on system acquisition and supply and project management are being given at various universities in Japan.

In many cases, the business of acquiring and supplying information systems is carried out as a team-based activity. Therefore, to teach business concepts, students must perform their task as part of a team. However, in practical lectures, we do not know what kind of personal characteristics and team composition are most beneficial to obtain the highest educational effectiveness.

Thus, we propose a framework for analyzing the effect of the personal characteristics of a team composition on education effectiveness. We also apply the framework to two actual practical lectures.

As a result, it is expected that in similar practical lectures, we can also obtain the educational effectiveness that we want if we can compose a team with suitable characteristics the basis of our findings. Moreover, the results may be applied to company trainings because the contents of the lectures are similar to those of company training programs.

Keywords & Phrases: Team Management, Educational Effect, Project-Based Learning (PBL), Information Systems, Personal Characteristics, Five Factors and Stress (FFS) Theory

1. Introduction

Over the past few years, there has been a problem in training IT professionals in both universities and the industrial world. Therefore, practical lectures performed as controlled project-based learning (PBL), which teach practical skills based on system acquisition and supply and project management are being implemented in various universities in Japan [1].

For example, two lectures were given at Waseda University from 2010 in cooperation with the Ministry of Economy, Trade and Industry, IPA, and NEC-NEC learning. The two lectures are “The Basic Project for IT Management”, which teaches practical planning and the use of the information system from a viewpoint of acquisition and “The Basic Project for System Development”, which teaches the management of an information system development project from the viewpoint of supply [2].

In many cases, the business of acquiring and supplying information systems is carried out as a team-based activity. Therefore, to teach business concepts, students must perform their task as part of a team.

In developing information systems, members with different personalities composing a moderately blended team lead to a reduction in the risk of the project concerned [3]. Moreover, in businesses other than those of information systems, a team consisting not of random members but of complementary members mutually leads to an increase in productivity [4]. However, in practical lectures, we do not know what kind of personal characteristics and team composition are most beneficial to obtain the highest educational effectiveness. Students do not have business experience.

Thus, we measure knowledge before and after lecture enforcement, the liveliness of the exercise in lecture enforcement, and the personal characteristics independent of experience in actual business, and analyze the relationships between them. After that, we identify the tendency common to the highest-educational-effectiveness team. We also show the result of student feedback for controlled project-based learning (PBL).

The rest of the paper is organized in the following order: PBL, the problem, our solution and the result of analysis.

2. Controlled PBL

To help students acquire knowledge and skills about the planning and development of information systems, PBL is used as an ideal education method. In PBL, the teacher does not teach students but only support them, and students challenge themselves autonomously to identify and solve real problems.

PBL is a way of making students acquire expertise, knowledge, and skills by participating a project of a certain fixed period. PBL is recognized as an effective study method not only in information systems but in various engineering domains [5].

In Waseda University, both the above-mentioned lectures are given in the form of controlled PBL, which provides a short experience of a similar real project in a classroom setting.

3. Problem of education effect analysis in practical lecture

As mentioned above, the effect team composition setting education effectiveness in a practical lecture on information system development in a university setting is not yet sufficiently clarified. Here we list three problems (P1)-(P3) that we should solve to clarify education effectiveness.

(P1) Obscurity of education effectiveness

In many cases, the education effectiveness of lectures in the university is measured by the quality of the product obtained during enforcement, and the subsequent questionnaire and test results. However, this method of measurement does not reflect the student's knowledge or skills before the lecture.

(P2) Difficulties in grasping dynamism in team exercise

To clarify the effect of team composition on education effectiveness, it is desirable that the contribution and attitude of individual students in an exercise be elucidated. However, since exercises by a team are advanced through discussions and cooperation between team members, it is complicated and thus it is difficult to surmise the dynamism of what from products. As a trial to measure an individual's contribution, a way of recording all utterances in an activity is developed [6]. However, it is costly and unrealistic.

(P3) Difficulty in characteristic quantification

To clarify the influence on the education effectiveness of team composition, it is desirable to quantitatively measure the characteristics and education effect of team composition. Furthermore, it is desirable to analyze the relations between measured values. To clarify the constitutional characteristic of a team, it is necessary to measure each member's personal characteristics quantitatively. However, few quantification studies of the various personal characteristics of a university student without experience in business domains have been reported.

4. Influence analysis framework for team composition

To solve the above-mentioned problems (P1)-(P3), we design a framework for influence analysis that consists of ideas of the following solutions (S1)-(S3).

An image of the framework is shown in Figure 1. Figure 1 shows a process of outputting some products through exercises, and in this case, the input includes given requirements. Furthermore, it shows a process of outputting the same team that has the same knowledge and skills, by considering each team as an input.

(S1) Knowledge and skill questionnaire evaluation before and after practical lecture

We use questionnaires of the same questions of questionnaire before and after practical lectures and ask the students to answer them. Thus, the difference in knowledge and skills between before and after practical lectures is measured quantitatively and the education effectiveness is precisely clarified as a result. Doing this, we can solve the problem (P1). A knowledge and skill questionnaire is designed with about 40 questions that refer to the educational target and common career skill framework of each lecture [7]. Each attending student evaluates the questions by himself and answers them in six steps. The following degrees of what are also used: 0: I do not know, 3: I can perform, 5: I can evaluate. In the business of acquiring and supplying information systems, both foundation human skills and specific knowledge and skills are required. Thus, we classify the questionnaires into foundation and specific parts.

We show an example of the questionnaire in the practical lecture "The Basic Project for IT Management" in Table 1.

(S2) Measurement of number of member's utterances per unit time

We measure the number of utterances per unit time in an exercise for each individual. We assumed that each individual's utterance is not partially performed within the exercise time. By doing this, we solve (P2).

(S3) Quantification of personal characteristic using FFS theory

To quantify the various personal characteristics, the Herrmann model [8] and Five Factors and Stress (FFS) theory [4] are proposed because they can be applied to a university student with no experience in business. In this study, we use the FFS theory because characteristics can be quantified by answering only 30 questions. The FFS theory can find four characteristics (preservative, receptive, diffusible, and condensable). In this paper, the FFS theory has two aspects: the directivity about condensable and receptive (X), and the directivity about diffusible and preservative (Y). Using X and Y, the FFS theory can classify individuals into four types (Figure 2).

● Leadership type: Expansion and reform
● Anchor type: Defense and thoroughness
● Tugboat type: Scouting and leadership
● Management type: Management and adjustments

We use the averages and standard deviations of X and Y, which indicate personal characteristics when we express the characteristics of team composition. Thus, we solve (P3). We show the results of having plotted the member characteristics for the maximum and minimum teams with a standard deviation of X in Figure 3.

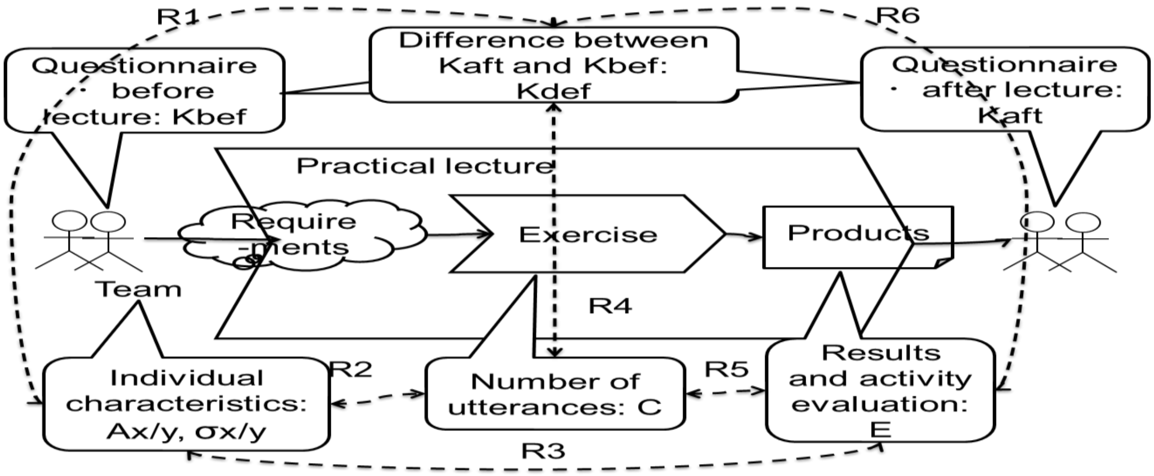

Figure 1. Framework of the analysis of team composition

Knowledge and skills	**Category**
Planning	Foundation
Presentation	Foundation
Communication	Foundation
Requirement analysis	Specific
Risk management	Specific
Best practice	Specific
Bench marking	Specific

Table 1. Some question items in knowledge and skill questionnaire

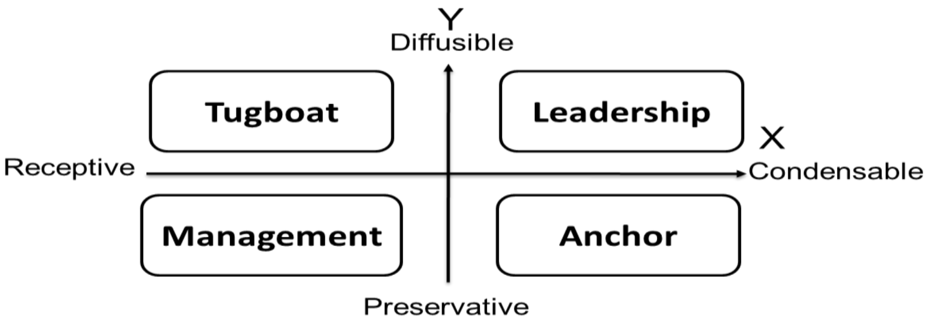

Figure 2. Types and directivities in FFS theory

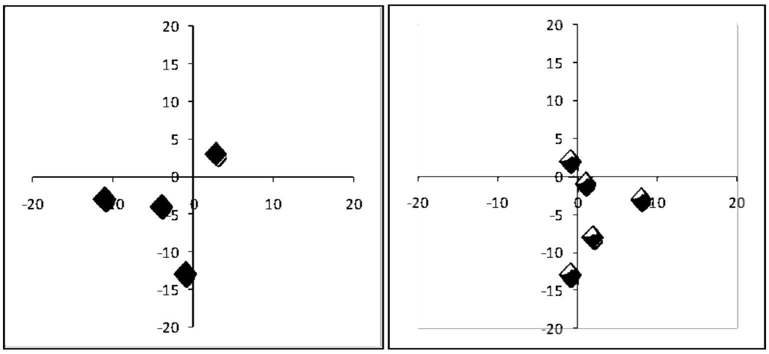

Figure 3. Member characteristics for maximum (left side)
and minimum (right side) teams with a standard deviation of X

5. Analysis of the influence that team composition brings

On the basis of the designed framework, we analyzed each of the relations R1-R6 connected between the measured values in Figure 1 for the two lectures in 2011. The procedure used and result obtained are described below.

5.1 Object

We show the two controlled PBL lectures that were given at Waseda University in cooperation with the Ministry of Economy, Trade and Industry, IPA, and NEC-NEC learning.

● Basic Project for IT Management (L1)

This lecture consisted of three lectures per day for five days, 15 students took this lecture. Three teams were formed randomly regardless of personal characteristics, each team had five students.

● Basic Project for System Development (L2)

This lecture consisted of three lectures per day for five days, 26 students took this lecture. Six teams were formed randomly regardless of personal characteristics, each team had four or five students.

These two lectures also partially exhibit with the characteristics generally assumed for the original PBL as follows. Therefore, it is thought that similar education effect can be acquired without losing the original characteristic of PBLs.

● It undergoes four phases: purpose, planning, execution, and judgment [9]: In Controlled PBL, three phases except purpose are carried out within five days. A teacher sets up the purpose.

● Students work autonomously [9]: In Controlled PBL, students work autonomously for five days. In the morning, a teacher explains the technology that should be used on the day. In the afternoon, except in the case where a question is asked during an afternoon exercise, the teacher does not participate actively.

● An activity leads to a final product [5]: In Controlled PBL, students are engaged in the manufacture of products, such as the planning of an information systems, and design specifications. However, the actual construction of an information system is not carried out in the end.

● A real problem is dealt with [10]: In Controlled PBL, a teacher with much experience in information system planning and development sets up problems similar to a real problem from his own experience. Students challenge themselves in solving the problem for five days. Moreover, teachers conduct a role play (customer, and CEO, etc.) and demand some requirements and evaluate the result. This leads to an experience of a realistic environment or process.

We show below a list of the measured values obtained for the team and their definitions.

● Ax: Average team value of the personal characteristic X obtained using FFS questionnaire.

● Ay: Average team value of the personal characteristic Y obtained using FFS questionnaire.

● σx: Standard deviation of team value of the personal characteristic X obtained using FFS questionnaire.

● σy: Standard deviation of team value of the personal characteristic Y obtained using FFS questionnaire.

● Kbef: The average team knowledge and skill questionnaire result before lecture. Kbef (foundation) and Kbef (specialty) each point out the average of only the foundation in an evaluation result, and the application. Below, Kaft and Kdef are the same.

● Kaft: Average team knowledge and skill questionnaire result after lecture.

● Kdef: Average team difference in knowledge and skill questionnaire result, Kdef=Kaft-Kbef.

● C: Average team sum total of the number of utterances per unit time throughout the entire lecture.

● E: Evaluation for obtaining the result and activity of a team.

5.2 Analytic method and expectation

We analyzed the relations (R1)-(R6) in Figure 1 with the following expectations.

(R1) For both L1 and L2, each team is expected in the beginning of an exercise to discuss and to output various opinions, and after the middle stage to complete their discussion and collect products (proposal and system design specifications, etc.). We expect that for the team that has with the largest difference in terms of characteristics, each member plays their desired part, and they can acquire knowledge and skill as a result. Then, after checking that there is no strong correlation between σx and σy, we apply the regression analysis using σx and σy as the explanatory variable and Kdef the response variable. We expect that the results of the knowledge and skill obtained after the lecture and the variations in personal characteristics will also be related, and we analyze them.

(R2) We expect that, in the team which has most different characteristic member, they will have active discussion for the same reason as (R1). Then, we conduct regression analysis using σx and σy as the explanatory variables and C as the response variable.

(R3) We expect that, in the team which has most different characteristic member, they will make better products and their evaluation will be better for the same reason as (R1). Then, we apply regression analysis using σx and σy as the explanatory variables and E as the response variable.

(R4) We expect to realize the expectations in (R1) and (R2). We also expect that, if the team's utterance is active, the team members will acquire more knowledge and skill. Then, we calculate the correlation coefficient of C and Kdef.

(R5) We expect that, if the team's utterance is active, they will make better products and their evaluation will be better because the lecture is advanced, using exercises accompanied by discussion. Then, we calculate the correlation coefficient of C and E. However, since all the utterances are not directly connected to a product or activity evaluation, we assume a weak correlation here.

(R6) Knowledge and skills are required in manufacturing products. Thus, we expected that the team that produces good products will have acquired more knowledge and skills. Then, we calculate the correlation coefficient of E and Kdef.

5.3 Analysis result and consideration

The results analyzed for (R1)-(R6) are shown below.

(R1) A strong correlation in which the correlation coefficient of σx and σy is as large as -0.75 is seen in L1. As a result of applying regression analysis to all combinations that use σx and σy as the explanatory variables and Kdef as the response variable, all that adjusted coefficients of determination become negative, and an effective regression cannot be obtained. We consider that this is the reason that we have only three datasets and it is not enough. When an explanatory variable is changed into Ax or Ay, and when a response variable is changed into Kbef or Kaft, the results are the same.

On the other hand, the correlation coefficient of σx and σy is as small as 0.22 in L2, and we find that there is no strong correlation between both. As a result of applying regression analysis to all combinations that use σx and σy as the explanatory variables and Kdef, Kbef and Kaft as the response variables, the adjusted contribution reached the maximum (0.67) for the regression obtained by the simple regression analysis that uses only σy as the explanatory variable and Kaft (specialty) as the response variable; the correlation coefficient is as large as 0.86. The scatter diagram and regression Kaft (specialty) = 1.36σy + 16.64 are shown in Figure 4 (left side).

As mentioned above, in L2, we can find that the team that has varied characteristics in terms of diffusible and preservative acquires more technical knowledge and skills after the lecture. This is the same as our earlier expectation. In the exercise of system development that needs both the emission and convergence of an opinion, it is hard to acquire technical knowledge and skills for the team that has similar diffusible and preservative directivities. No remarkable relation was observed regarding the directivities of condensable and receptive.

For the Kdef difference between before and after acquisition of knowledge and skill, no relation showing a variation in personal characteristics was observed. As a possible reason for this, it can be considered that there is little room for knowledge and skills to be extended for students whose knowledge and skills have already been mastered to some extent regardless of team composition.

(R2) For L1, we cannot find an effective relation like (R1). On the other hand, for L2, as a result of applying regression analysis to all combinations that use σx and σy as the explanatory variables and C as the response variable, the adjusted contribution reached maximum (0.56) for the regression obtained by the simple regression analysis that uses only σy as the explanatory variable; the correlation coefficient is as large as 0.80. The scatter diagram and regression equation $C = -4.24\sigma y + 50.04$ are shown in Figure 4 (right side).

From this result, contrary to our expectation in L2, the team whose members have similar characteristics in terms of diffusible and preservative directivities has active discussion. In addition, concerning the directivities of condensable and receptive, no remarkable relation like (R1) was observed.

(R3) The effective regression of L1 and L2 was not obtained. From this result, no relation between team composition and product or activity evaluation was found. This is because product or activity evaluation is only part of the effort measuring the team’s dynamism (not all activities).

(R4) A strong correlation (correlation coefficient, 0.76) is seen between C and Kdef for L1. However, since there is little data, it is not a reliable result.

On the other hand for L2, the correlation was weak (correlation coefficient 0.18). No relation is found to express the differences in knowledge and skills or the number of utterances. This result is considered to be due to the fact that students can also acquire knowledge and skills through individual work or individual thinking as well as study but for discuss.

(R5) For L1, although the correlation coefficient is 0.44, it is unreliable because of the small amount of data. The correlation coefficient is -0.63.

Contrary to our expectation, the tendency for product evaluation to give slightly low levels was observed for the team with a more active discussion (Figure 5). As the reason for this, it is considered that all the utterances are not directly connected to product or activity evaluation. The product manufactured efficiently in the case in which the plan was set at an early stage and each member began doing on individual task.

(R6) The correlation coefficient is as low as 0.21 for L1, there is also little data, and no clear relation is observed. The correlation coefficient is -0.32 for L2.

Contrary to our expectation, the team with the higher level of product evaluation tended to show a smaller difference in knowledge and skills among members. This is the reason the product evaluation only checks a small part of the knowledge and skills acquired during the entire lecture.

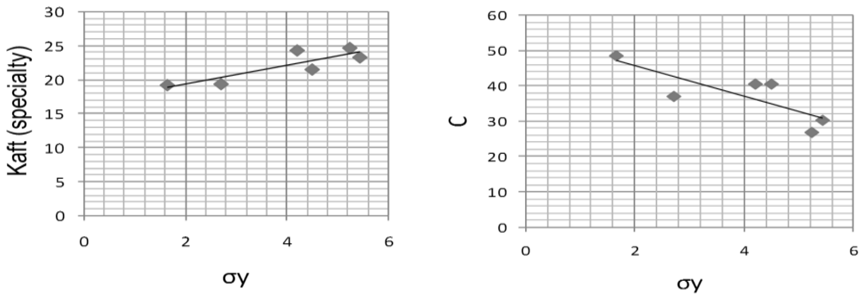

Figure 4. Scatter diagram of σy and Kaft (specialty) (left side), and σy and C (right side).

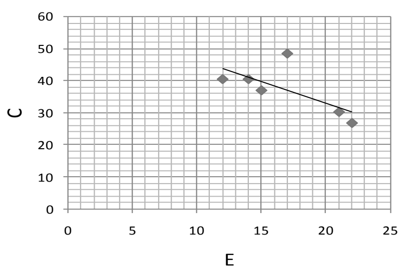

Figure 5. Scatter diagram of E and C for L2

5.4 Consideration from results

The consideration obtained from the foregoing paragraph is summarized below.

(1) Regarding "The Basic Project for IT Management", there are few teams (three) and we cannot clearly identify the influence of team composition on education effect.

(2) Regarding "The Basic Project for System Development", for the team that has different diffusible and preservative directivities, arguments tend to minimal although the team has much more technical knowledge and skills after the lecture.

As a result, we find that if we expect students to acquire technical knowledge and skills, it is preferable to form teams with members who have both characteristically different diffusibles and preservatives. Moreover, if we expect to let students make more active discussions, it is preferable to form teams with members who have similar diffusibles and preservatives. However, summarizing an opinion may take much time and it may lead to a decrease in product level evaluation the fall of evaluation, and to the acquisition of less technical knowledge and skills.

5.5 Validity evaluation

One assistant is in charge of measuring the number of utterances of all the teams, without using sound or video recording devices, such as a recorder. Therefore, the number of utterances has a lower reliability than the other measured values, which can be a threat to inner validity. Next, we treat a similar practical lecture, but we use recording equipment and increase the number of assistants.

Knowledge and skill questionnaire evaluations are based on self- valuation. Therefore, a reply different from the actual condition may be obtained. This can also be a threat to inner validity.

There is no guarantee that these results can apply to a similar practical lecture in other universities or to the training of new employees of a company, because there is little data gathered and only ten teams are used in this study. However, the lectures are not focused on special knowledge, environments, or a process of planning or developing information systems. Since lectures are developed under the IPA enterprise, it is thought that results may conform to those of similar lectures in other universities. Moreover, the results may be applied to company trainings because the contents of the lectures are similar to those of company training programs.

5.6 Student feedback about controlled PBL

We asked students to answering a questionnaire about the two lectures on the final day of lecture in 2011. We show the result in Figure 6 (the result for L2 is almost the same.).

Many students were satisfied with the contents of each lecture, and they said that they would like to recommend lectures to their juniors. Moreover, some students gave their own opinions; "I now have a concrete image of actual work.", "I realized the importance of group work." and "I acquired skills in system development and IT management.".

As a result, it turned out that these lectures provided good opportunities to learn the planning and development of information systems, teamwork, and the importance and difficulty in communication through exercises under instruction from a professional. Therefore, we can state that Controlled PBL functions effectively in the domain of planning and developing information systems.

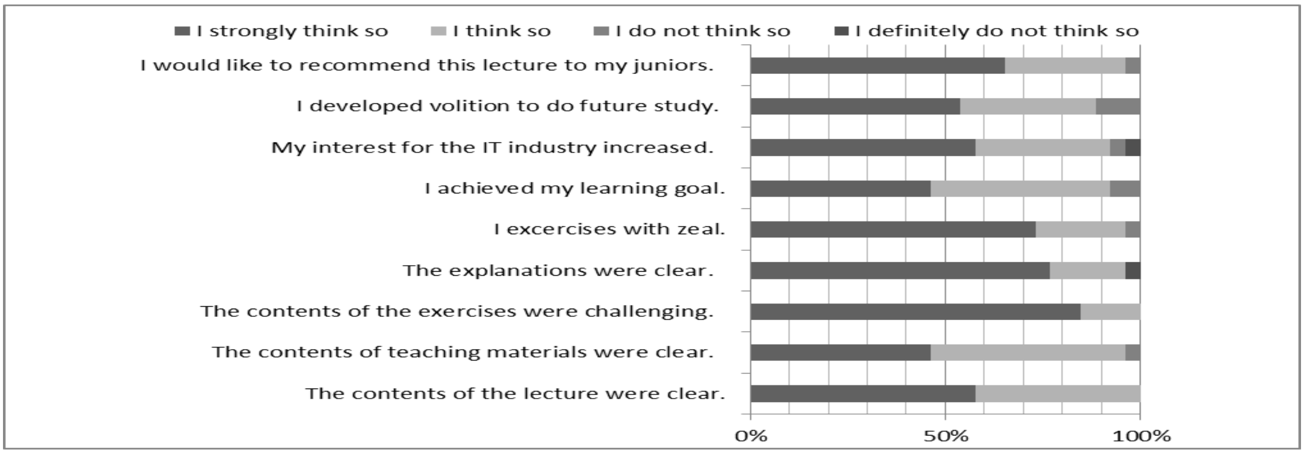

Figure 6. Result of student evaluation using questionnaire for L1 (N=12)

6. Related research

There is an activity that analyzes the type of each member as a project manager and elects the optimal member as a project manager [11]. However, this activity only mentions the role of the project manager.

On the other hand, our framework does not elect an individual for a managerial role but only mentions the directive variation of the member in a team.

7. Conclusion

We propose a framework for analyzing the effect of the personal characteristics of a team on the effectiveness of education, and apply the framework to two actual practical lectures. By analyzing the application result, the variation in the member's personal characteristic in a team clearly showed an effect on education. Moreover, we also show that Controlled PBL functions effectively for students.

In a future work, we will measure the threat mentioned in Section 5.5, analyze individual units, verify the generality and validity of results through the application of what to the same lectures or other related lectures in 2012 at Waseda University. We still need to msure and compare the education effect in an intentionally constituted team so that we can increase education effectiveness.

Acknowledgement

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