Team Characteristics for Maximizing the Educational Effectiveness of Practical Lectures on Software Intensive Systems Development

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Abstract

In practical lectures on software intensive business systems, we do not yet have an established method for determining what kind of personal characteristics and team compositions are most beneficial to obtaining the maximal educational effectiveness. Here, we propose a framework for analyzing the effects of personal characteristics of team members on educational effectiveness. We also apply the framework to an actual practical lecture. As a result, we find that it is better for a team to have members with a similar degree of tendency of conservative for acquiring more knowledge and skills and the team members have similar characteristics of progressive or conservative. It is expected that in similar practical lectures, we can also obtain the desired educational effectiveness if we can compose a team with the suitable characteristics as based on our findings.

1. Introduction

In order to improve the training of IT professionals, practical lectures in the form of controlled project-based learning (PBL), which teach practical skills for systems acquisition and provisioning and for project management, are being implemented in various universities in Japan. For example, a course has been offered at Waseda University since 2010 in cooperation with the Japanese governmental bodies (MEXT and IPA) and IT companies (NEC and NEC Learning). This course is "Fundamentals of Information Systems Development", which teaches the management of software intensive business systems development projects from the viewpoint of the provider. In this course, students mainly learn about upper process such as requirements analysis and architectural design. This course is provided in the form of an experience similar to a real project in a classroom setting (controlled-PBL). In many cases, the business of acquiring and providing software intensive business 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 software intensive business systems, having members with different personalities compose a moderately blended team lead to a reduction in risk [1]. Moreover, in businesses other than those of software intensive business systems, a team consisting not of random members but of complementary members mutually leads to an increase in productivity [2]. However, in practical lectures, there have been no studies on what kind of personal characteristics and team composition are most beneficial to obtain the highest

educational effectiveness.

In this study, we measure the students' knowledge before and after the course, the liveliness of the students during course exercises, and the personal characteristics of the students independent of experience in actual business, and analyze the relationships between them. Our research question is to identify the common characteristics of the teams in which the educational effectiveness of the course was high.

2. Problem of analyzing educational effectiveness in practical lectures

As mentioned above, the effective team composition in a practical lecture on software intensive business systems development in a university setting is not yet sufficiently clarified. Here we list three problems P1-P3 that we should solve to clarify educational effectiveness.

P1) Obscurity of educational effectiveness: In many cases, the educational effectiveness of a course in the university is measured by the quality of the products obtained during the course, and the subsequent questionnaire and examination results. However, this method of measurement does not take into account the student's knowledge or skills before the course.

P2) Difficulty in grasping team dynamism: To clarify the effect of team composition on educational effectiveness, it is desirable that the contribution and attitude of individual students in a team exercise be elucidated. However, this is a complicated matter because team exercises are advanced through discussions and cooperation between team members, and it is difficult to assess the team dynamism from the products of the exercises. As an attempt to measure an individual's contribution, a method of recording all utterances in an activity has been developed [3], but it is costly and unrealistic.

P3) Difficulty in quantifying personal characteristics: To elucidate the influence of the compositional characteristics of a team on educational effectiveness, it is desirable to quantitatively measure both the compositional characteristics and educational effectiveness, and to analyze the relationship between them. To determine the compositional characteristics of a team, it is necessary to measure each member's personal characteristics quantitatively. However, to the best of our knowledge, no studies of the various personal characteristics of a university student without experience in business domains have been reported.

3. Influence analysis framework for team composition

To solve the above-mentioned problems, we design a framework for influence analysis based on the following solutions S1-S3. The overall structure of the framework is shown in Figure 1. Within the practical lecture, the input is some system requirements and the output product is some requirements specifications and architectural design created by the team

S1) Questionnaire evaluation of knowledge and skills before and after practical lecture: We ask the students to fill out the same questionnaire before and after the practical lecture to quantitatively measure the improvement in their knowledge and skills before and after practical lecture, thus solving problem P1. The questionnaire consists of about 40 questions that refer to the educational goal and common career skill framework of the lecture [4]. In the business of acquiring and providing software intensive business systems, both basic human skills and specific knowledge and skills for software intensive business systems development are required. Therefore, we classify the questions into basic or specific. For example, questions regarding communication and information sharing would be considered basic, while questions regarding requirement analysis and functional design would be specific.

S2) Measurement of number of utterances per unit time: Instead of recording all utterances, we measure the number of utterances two or three times for five minutes in each exercise for

each individual team member. We assume that each individual's utterances are completed within the time of the exercise. By doing this, we mitigate P2.

S3) Quantification of personal characteristics using FFS theory: The Herrmann model [5] and Five Factors and Stress (FFS) theory [2] can be applied to university students with no experience in business to quantify their personal characteristics. In this study, we use the FFS theory because the exercise time is limited, and characteristics can be quantified by answering only 30 questions. For example, students are asked if they say things as they come to mind, or if they get tired easily. The FFS theory maps a person's personality onto a two-dimensional graph based on four characteristics (Preservative: tend to be conservative, Receptive: tend to accept of new knowledge and skills, Diffusible: tend to self-assert, and Condensable: impose own knowledge and skills on others). The X axis ranges from receptive to condensable, and the Y axis ranges from preservative to diffusible (Figure 2). The value of X and Y is from -20 to 20. We use the averages and standard deviations of X and Y to quantify the compositional characteristics of a team, thus solving P3. A sample plot of the member characteristics of a team is shown in Figure 3. We see that all points have similar Y values, or that all team members are preservative to a similar degree.

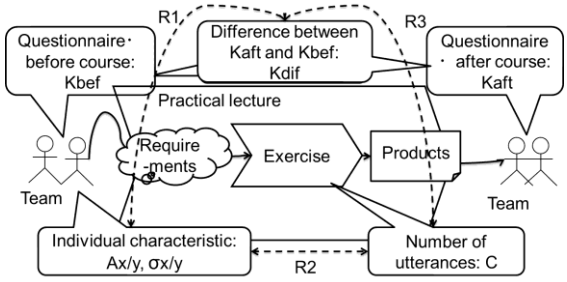

Figure 1. Framework for the analysis of team composition

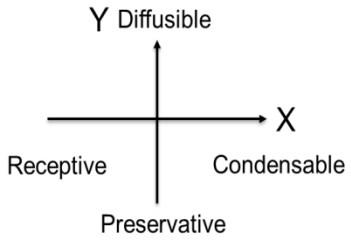

Figure 2. Two-dimensional graph in FFS theory

4. Analysis of the influence of team composition

Using the framework that we designed, we analyzed each of the relations R1-R3 between certain measured values as shown in Figure 1 for a course in 2011 and 2012 at Waseda University. The procedure and results are described below.

4.1. Object

Fundamentals of Information Systems Development: Students learn about the management of software intensive business systems development project from the viewpoint of the system provider. Students mainly learn upper processes. This course consists of three lectures per day for five days. The number of students that took this course was 26 in 2011 (L1) and 17 in 2012 (L2). Teams of four to five students were formed randomly regardless of personal characteristics. (The number of teams formed was six and four for L1 and L2, respectively.) In L1 and L2, the following were measured for each team.

- Ax (Ay): Team average of value of personal characteristic X (Y) obtained using FFS.
- σx (σy): Team standard deviation of value of personal characteristic X (Y) obtained using FFS.
- C: Team average of number of utterances during a five-minute period.
- Kbef: Team average of knowledge and skills questionnaire results before lecture. Kbef (basic) and Kbef (specific) are the averages of only the basic questions and the specific questions, respectively. This also applies to Kaft and Kdif below.

● Kaft: Team average of knowledge and skills questionnaire results after lecture.
● Kdif: Team average difference in knowledge and skill questionnaire results before and after lecture; Kdif=Kaft-Kbef.

4.2. Analytic method and analysis results

The procedure and results of our analysis for R1-R3 are shown below.

R1) In L1, the correlation coefficient of Ax and Ay is as small as 0.22, and σx and σy is as small as 0.02. In L2, the correlation coefficient of Ax and Ay is as small as -0.28. Therefore, there is no strong correlation between them (In L2, the correlation coefficient of σx and σy is as large as -0.95). Upon applying regression analysis to all combinations that use σx and σy or Ax and Ay as the explanatory variables and Kdif as the response variables, the adjusted contribution reached the maximum (L1: 0.50, L2: 0.98) for the regression obtained by the multiple regression analysis that uses Ax and Ay as the explanatory variable, and Kdif (basic) as the response variable; the correlation coefficient is as large as 0.84 in L1 and 0.99 in L2. The regression equations are *Kdif (basic) = 5.08Ax -0.74Ay +22.68* (L1), and *Kdif (basic) = -1.48Ax -1.32Ay +10.34* (L2). With regard to personal characteristics as described by the FFS theory in Figure 2, in L1, we find that the more condensable and preservative a team is, the more basic knowledge and skills it acquires through the course. In L2, we find that the more receptive and preservative a team is, the more basic knowledge and skills it acquires through the course. From these findings, we can deduce that if we want students to acquire more basic knowledge and skills through the course, it is preferable to form teams with members who are strongly preservative. In fact, the team in Figure 3 has the highest point of Ay and the highest score of Kdif (basic).

R2) For L1and 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 a maximum (L1:0.56, L2: 0.75) 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 (L1) and 0.91 (L2). The scatter diagram and regression equations $C = -4.24\sigma y + 50.04$ (L1) and $C = -3.44\sigma y + 42.2$(L2) are shown in Figure 4. From these findings, we can deduce that if we want students to hold highly active discussions, it is preferable to form teams with members who are similar in how diffusible or preservative they are. Unlike for R1, no remarkable relations were found concerning the condensable and receptive directivities. In fact, the team in Figure 3 has the lowest point of σy and the highest score of C.

R3) For L1and L2, we found the correlation to be weak because; the correlation coefficients were 0.18 for L1 and 0.17 for L2. No relation is found between the amount of knowledge and skills acquired (Kdif) and the number of utterances. We believe this is due to the fact that students can also acquire knowledge and skills through individual work or individual thinking in addition to the team discussions.

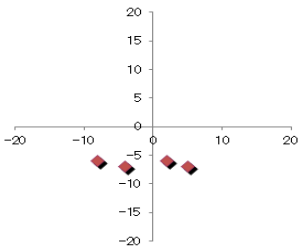

Figure 3. Example of team member's characteristics (2012)

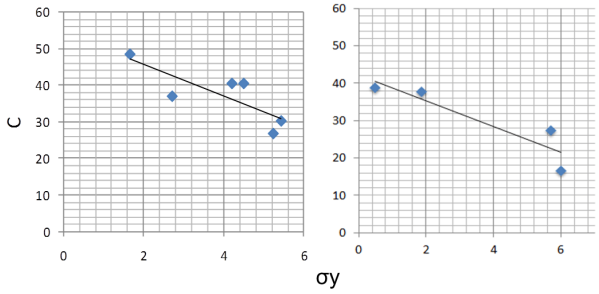

Figure 4. Scatter diagram of σy and C (left: 2011, right: 2012)

4.3. Summary of findings

Finally, we find that if we form a team with members who are strongly preservative, and each member's preservative directivities are very close to each other, the team acquires more basic knowledge and skills through the course, and they hold more active discussions. In this course, it is better for students do to work conservatively or steadily than diffuse their ideas, because the requirements which need for making requirements specifications and architectural design of software intensive business systems were provided by the instructor.

4.4. Threats to validity

One assistant was in charge of measuring the number of utterances of all the teams, without using any sound or video recording devices. Therefore, the measured number of utterances is less accurate than the other measured values, which can be a threat to inner validity. In the future, we need to increase the number of assistants or use recording equipment. Knowledge and skills questionnaire evaluations are based on self-valuation. Therefore, the response may not accurately reflect the students' actual knowledge and skills. This can also be a threat to inner validity.

There is no guarantee that our results can be applied to a similar practical lecture, because there is little data gathered. However, since the lectures and courses under examination were developed in collaboration with IPA as part of a national effort, the results will most likely be similar for the equivalent lectures and courses offered in other universities or companies.

5. Related work

There is a study that analyzes the personality type of each member as a project manager, and the optimal member is elected as a project manager [6]. However, this study only examines project manager. Our framework is not used to elect an individual for a managerial role, and only mentions the directive variation of the individual as a team member.

6. Conclusion

We propose a framework for analyzing the effect of the personal characteristics of a team on the effectiveness of education. By analyzing the results, we clearly see that variations in the team members' personal characteristics have an affect on educational effectiveness. For future work, we will collect more data at Waseda University in 2013. We will also take measures to eliminate the threats mentioned in Section 4.4, analyze each individual not as a team, use new quantification method of personal characteristic such as Herrmann model [5]. Moreover, we will consider the relevance about Kbef and Kaft.

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