How Are Effective Combinations of Personal Characteristic types different in Controlled Project-Based Learning Courses?

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Abstract—To improve practical IT education, many universities are implementing project-based learning (PBL). Although researchers have examined the relationship between projects and personality, they have not investigated the type of projects and team construction based on personality. We consider not to construct optimal team for the view of educational effectiveness if we do not understand the difference of each course characteristic. Herein the Five Factor & Stress theory is used to measure personal characteristics and classify students enrolled in two different PBL courses at a university into four types – leadership, management, tugboat, and anchor. Then knowledge and skills questionnaires are used to measure educational effectiveness. The results show that educational effectiveness is highest when a team consists of management and anchor types but not leadership types in the PBL course which teaches system development, and a team without management types is consisted in the PBL course which teaches IT management strategy.

Keywords— Five Factor & Stress Theory (FFS), Project Based Learning (PBL), Personal Characteristic, Education

I. INTRODUCTION (*HEADING 1*)

To improve practical IT education, many universities are implementing project-based learning (PBL) in which students acquire expertise, knowledge, and skills by participating in a group project. PBL is as an effective study method not only in information systems but also in various engineering domains [1]. Many researchers have examined the relationship between projects and personality [8]. For example, it has previously been shown that personality impacts performance and attitude in software engineering [2] [3]. Moreover, other studies which targeted classes or projects at a university [8], have examined the relationship between project success or product and personality.

However, previous studies did not focus on the impact of team composition based on the personality of the team members on a project. Previous our research has quantified personal characteristics and analyzed the relationship between the scatter of personal characteristics in a team and educational effectiveness [5] [6]. Also we research best team composition in one PBL course[15]. However, the studies do not reveal optimal tem combinations in different PBL courses. We hypothesize that the optimal team construction will depend on the target project. In this study, we investigate the impact of team construction in two PBL courses, "Fundamentals of Information Systems Development (C_D)" and "Fundamentals of IT Management (C_M)". C_D teaches the initial stage of system development (e.g., requirement analysis and architectural design) and C_M teaches IT management strategy. Therefore, we consider that the educational effectiveness in team increase if teams include the students who have the required capability of each course. Consequently, if we understand the characteristic of courses, we construct optimal teams to each course. We aim to determine the combination of Five Factor & Stress theory (FFS) types that yields the highest educational effectiveness for two controlled-PBL. Specifically, the following two research questions are examined:

RQ1) Does the educational effectiveness at the individual level have the same dependency on the FFS characteristics for different PBL courses? We examined whether the personal characteristics affect individual educational effectiveness in the two courses.

RQ2) Does the same combination of FFS characteristics result in the same educational effectiveness in different PBL courses or does the highest education effectiveness vary by course? We researched whether a certain combination of

personal characteristics has the same influence on a team's educational effectiveness in the two courses.

This paper makes the following contributions:

•FFS personal characteristics and educational effectiveness are not significantly related for an individual in a PBL course on the initial stage of system development, but are significantly related for an individual in a PBL course on IT management strategies.

•We investigated the optimal team composition by PBL course from ten different team compositions.

II. BACKGROUND

A. Educational Effectiveness

To quantitatively measure the improvement in knowledge and skills by taking the course, we asked the students to complete the same questionnaire before and after the practical course. The questionnaire consisted of 28 questions in C_D, and 40 questions in C_M that refer to the Information-technology Promotion Agency (IPA) common career skill framework [7] which is based on the Skills Framework for the Information Age (SFIA) [14] and is the standard IT framework in Japan. We selected items from the IPA common career skill framework that we expected the students to acquire in this class. The students assessed themselves on a scale of 0 to 5, while the educational effective was expressed on a scale of –140 to 140 in C_D and on a scale of -200 to 200 in C_M. This study uses the following terms:

・Individual educational effectiveness, which is the sum of basic human skills and specific skills, was assessed as the difference between the before and after knowledge and skills questionnaire results.

・Team educational effectiveness is the median individual educational effectiveness by team.

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B. Five Factor & Stress (FFS) Theory

The FFS theory maps personal characteristics in a two-dimensional graph where the X-axis (Y-axis) ranges from receptive to condensable (preservative to diffusible). A receptive person is accepting of new knowledge and skills, while a condensable person imposes his or her own knowledge and skills on others. A diffusible person is assertive, whereas a preservative person is reserved. A questionnaire is used to measure X and Y. The numerical values of X and Y range from –20 to 20. And students were classified into four types: leadership, tugboat, management, and anchor (Table 1). The characteristics of the four types are the expected action in the team.

TABLE I. QUALIFICATIONS AND CHARACTERISTICS OF THE FFS TYPES

Type	Qualification	Characteristic
Leadership (L)	$X \geqq 0$ and $Y > 0$	Good at changing
Tugboat (T)	$X < 0$ and $Y > 0$	Good at realizing ideas
Management (M)	$X < 0$ and $Y \geqq 0$	Good at improving the present situation
Anchor (A)	$X \geqq 0$ and $Y \geqq 0$	Good at maintaining the present situation

III. DESIGN OF THE EXPERIMENT

We analyzed the data from two class at Waseda University called C_D and C_M. In both courses, students work on a realistic project in a classroom setting (controlled PBL). Table 2 shows the detail of both courses. Both classes divide the students into teams composed of four to six members.

To collect data for our research, the students completed two different types of questionnaires: knowledge and skills questionnaires and a FFS theory-based questionnaire. The former measures educational effectiveness, and each student completed it twice (before and after the course), while the latter is used to categorize the students into the FFS four personality types. To maintain the integrity of our research, obviously insincere data about educational effectiveness were removed [e.g., if the same grade was checked in both (before and after) questionnaires]. Table 3 shows the data of the number of students and teams in this research.

TABLE II. DETAIL OF C_D AND C_M

	C_D	C_M
Style	Controlled PBL	Controlled PBL
Content	Requirement analysis and architectural design	IT management strategy
Capability expected to acquire	Business improvement by software system support	Business innovation

TABLE III. NUMBAER OF STUDENTS AND TEAMS

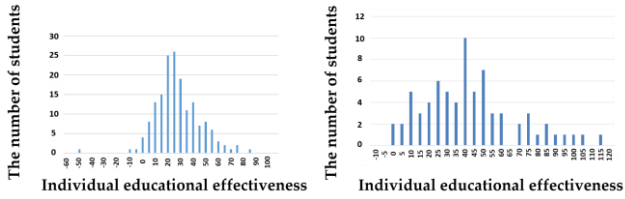| Year	C_D				C_M			
	Number of students		Number of teams		Number of students		Number of teams	
	All	Valid	All	Valid	All	Valid	All	Valid
2011	25	25	6	6	14	14	3	3
2012	17	15	4	2	10	10	3	3
2013	39	38	8	7	15	15	4	4
2014	64	63	12	11	20	16	4	1
2015	28	26	6	5	23	22	5	4
Sum	173	167	36	31	82	77	19	15

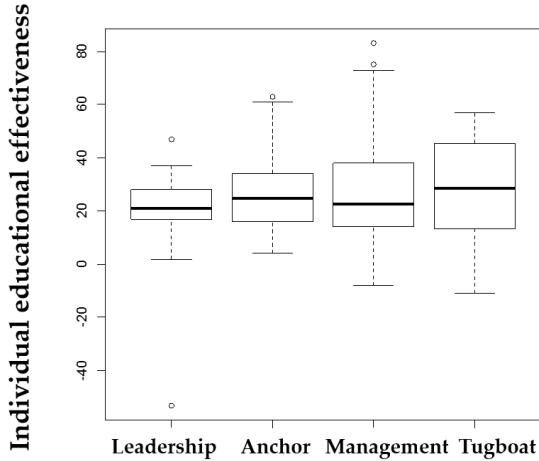Fig. 1. Histogram of individual educational effectiveness for C_D (left) and C_M (right).

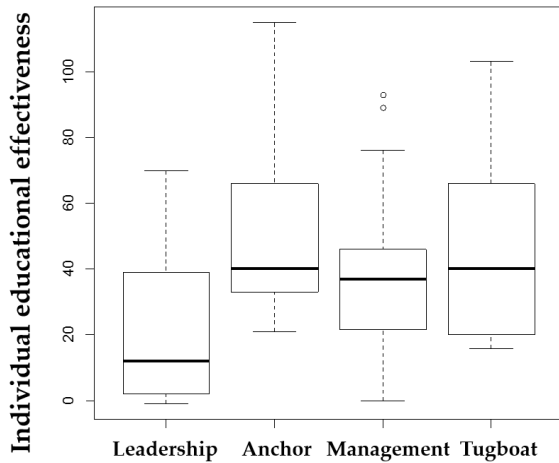Fig. 2. Boxplot between FFS types and individual educational effectiveness for C_D.

Fig. 3. Boxplot between FFS types and individual educational effectiveness for C_M.

IV. RESULT AND ANALYSIS

A. Data for Two Kind of Questionnaires

Figure 1 shows the histogram of the individual educational effectiveness by student for each course. Because the students' educational effectiveness is expected to be scattered by a normal distribution, we used the Kolmogorov-Smirnov test to verify whether the histogram is a normal distribution. In C_D, the personal characteristics of the students were divided as follows: 17 leadership, 66 management, 20 tugboat, and 64 anchors. In C_M, the students were divided as follows: 9 leadership, 32 management, 9 tugboat, and 23 anchors.

B. Personality and Individual

Figure 2 and 3 show the boxplot between the FFS type and educational effectiveness by course. For multiple comparisons, we analyzed the variance. In C_D, a p value of 0.438 (> 0.05) makes it difficult to confirm if there is a significant difference in educational effectiveness by FFS type. However, the p value of 0.023 (< 0.05) confirms that the leadership type make a significant difference in educational effectiveness in C_M.

C. Personality and Team

Table 4 shows the ten different team compositions where the number denotes how many teams had that a particular composition. Figure 4 shows the boxplot of the relationship between the FFS team composition and team educational effectiveness by course. However, a boxplot cannot be used to determine this relationship due to the small sample size. Thus, we used a regression tree to determine which combination has the best educational effectiveness by R. A regression tree divides data into nodes and then determines the best node. Figure 5 shows the regression trees of team educational effectiveness in C_M and C_D. Each node in the tree indicates the average score of the team education effectiveness. In C_M, the highest score (41) of the team educational effectiveness occurs when the management node type is false. On the other hand, the highest score (26.469) in C_D is achieved when the leadership node is false, but the management and tugboat nodes are true.

TABLE IV. TEAM COMPOSITIONS IN THE CLASS FROM 2011 TO 2015

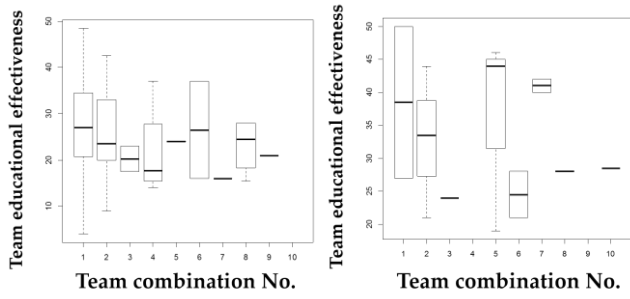| No.	L	A	M	T	Number of teams	
					C_D	C_M
1		✓	✓	✓	7	2
2		✓	✓		9	3
3			✓	✓	2	1
4	✓	✓	✓		4	0
5	✓		✓	✓	1	3
6	✓		✓		2	2
7		✓		✓	1	2
8	✓	✓	✓	✓	4	1
9		✓			1	0
10			✓		0	0

Fig. 4. Boxplot of the team composition and team educational effectiveness for C_D (left) and C_M (right).
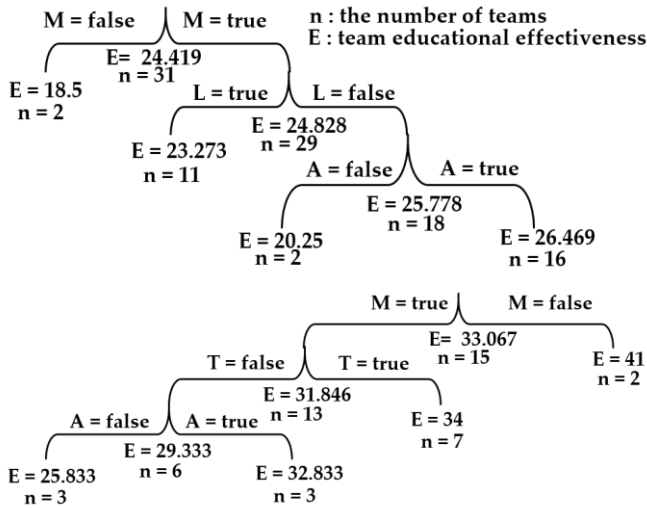

Fig. 5. Regression tree of team educational effectiveness for C_D (top) and C_M (bottom).

V. DISCUSSION

A. Educational Effectiveness on Each Personality Vary by Course (RQ1)

The educational effectiveness at the individual level on FFS characteristics differs between the two PBL courses. Educational effectiveness is unrelated to the FFS type of the student in C_D, whereas leadership-type students have a lower educational effectiveness than other types of students in C_M (Fig. 2 and 3). Because C_M teaches IT management strategies, the ability to generate new ideas, reform business practices, and an entrepreneurial spirit are beneficial in the course. Consequently, leadership-type students in C_M have a low educational effectiveness because they possess these capabilities prior to the course. On the other hand, C_D teaches requirement analysis and architectural design through improving business. Hence, the C_D course can strengthen a weak point for each type of student.

B. Highest Education Effectiveness on Team Vary by Course (RQ2)

For the educational effectiveness at the team level, the combination of FFS characteristics differs between the two courses. In C_D, the highest team educational effectiveness is achieved when a team is composed of management and anchor types without leadership types (Fig 5). In C_D, students develop a system solution for a fictitious company where the course instructor sets the problem. Because FFS management-type (anchor-type) students are good at improving (maintaining) the present situation, they are well suited for the C_D course where the students improve a company from the present situation. This class involves minimal transformations. Hence, the strengths of leadership-type students are not utilized. Consequently, teams consisting of management types without leadership types are the most effective. If the students created the initial ideas, then it is likely that leadership-type students would realize a high educational effectiveness.

In C_M, the highest team educational effectiveness is achieved when a team does not have management-type students (Fig 5). In this course, students suggest IT management strategies for a fictitious company where the course instructor sets the problem. Hence, the characteristic of management-type students is not needed. Therefore, management-type students do not contribute to the educational effectiveness of the team.

C. Threats to Validity

One threat to internal validity is insincere responses because the knowledge and skills questionnaire and the FFS questionnaire are self-check forms. In addition, we currently cannot confirm the precision of the regression tree (Fig. 5) due to the small data size. Because, also, data size of C_D is twice bigger than C_M, it is possible that difference of each data size affect the result of this paper. Moreover, this study only analyzed 10 of the 15 possible combinations for team composition. It is possible that this affected our results.

A threat to external validity is that we cannot guarantee that our results are applicable to other similar practical lectures due to the insufficient data. However, the lectures and courses under examination were developed in collaboration with the IPA as part of a national effort; thus, the results should be similar for equivalent lectures and courses offered at other universities or companies.

D. How to Use These Findinfs

This research assists university teachers by revealing the optimum team composition for certain PBL courses. The findings indicate that teams for a controlled-PBL course on software intensive system development should be formed by classifying students according to the FFS theory and then creating teams with management types but not leadership types. However, if a team contains leadership types, it should also include management types, and either the teacher or a teaching assistant should carefully observe such a team. On the other hand, a controlled-PBL course on IT management strategies should create teams without management types. However, if a team contains management types, it should also include

tugboat or anchor types, and either the teacher or a teaching assistant should carefully observe such teams.

From the result of our research, we consider that when a teacher constructs a team in a controlled-PBL course, he or she needs to consider the compatibility between the characteristics of the PBL course and human personality.

VI. RELATED WORK

Previous research has quantified personal characteristics and analyzed the relationship between the scatter of personal characteristics in a team and educational effectiveness [5] [6]. In this study, we research the types of personal characteristics and analyze the relationship between different combinations of personal characteristics and educational effectiveness.

Many different methods have been used to measure personality [4] [8], including the Five Factor Model (FFM) and the Myers-Briggs Type Indicator (MBTI). The FFM quantifies personality, whereas the MBTI classifies personality. Another study analyzed the personality type of each team member with the goal of determining which member is the best suited for the role of project manager [10]. Due to our objectives, we use the FFS theory to measure personality because FFS theory is better suited to the goal of our study.

Other studies have researched the relationship between personality and product quality or performance [11] [12] [13]. However, it is possible that product quality and performance are related with other factors (e.g., original skills). In our study, we measure the educational effectiveness in a course by having students complete questionnaires before and after the course. This method should remove the influence of the students' original skills, allowing the relationship between personality and educational effectiveness to be assessed directly.

VII. CONCLUSION

We researched the relationship between educational effectiveness of a team in two controlled-PBL courses at Waseda University (C_D and C_M) and the personal characteristics of the team members, which were categorized by the FFS theory. The results show that the optimal team composition depends on the purpose of the course. The knowledge and skills questionnaires revealed that teams should consist of management and abchor-types students without leadership-types students in C_D, and but should not have management-type students in C_M.

In the future, we plan to target classes where teams contain many members using different methods such as the MBTI [8] and Belbin's team role model [9] to categorize personal characteristics. Moreover, we need to increase the sample size for a more precise analysis. Finally, because the knowledge and skills questionnaire is a self-check form, the responses may be insincere. For internal validation, we plan to test to students or use the products developed in the course.

REFERENCES

[1] R. Graham, "UK Approaches to Engineering Project-Based Learning," Bernard M. Gordon-MIT Engineering Leadership Program, Building Engineering Leaders, Cambridge, 2010.

[2] R.Feldt, L.Angelis, R.Torkar, and M.Samuelsson, "Links between the personalities, views and attitudes of software engineers," Information and Software Technology, 52 (6), 2010.

[3] M.V.Kosti, et al., "Personality, emotional intelligence and work preferences in software: engineering: An empirical study," Information and Software Technology, 56 (8), 2014.

[4] N. Salleh, et al., "An Empirical Study of Effects of Personality in Pair Programming using the Five-Factor Model. Empirical Software Engineering and Measurement," ESEM 2009, 2009.

[5] S. Inaga, H. Washizaki, Y. Yoshida, K. Kakehi, Y. Fukazawa, et al., "Team Characteristics for Maximizing the Educational Effectiveness of Practical Lectures on Software Intensive Systems Development," CSEE&T 2013, 2013.

[6] Y. Yamada, S. Inaga, H. Washizaki, K. Kakehi, Y. Fukazawa, et al., "The Impacts of Personal Characteristic on Educational Effectiveness in Controlled-Project Based Learning on Software Intensive Systems Development," CSEE&T 2014, 2014.

[7] Ministry of Economy, Trade and Industry & Information-Technology Promotion Agency, Japan (IPA), "Common career/ skill framework," 2012, http://www.ipa.go.jp/english/humandev/reference.html.

[8] Alan R. Peslak, "The Impact of Personality on Information Technology Team Projects," the 2006 ACM SIGMIS CPR: Forty four years of computer personnel research: achievements, challenges & the future, 2006.

[9] D.Partington and H.Harris, "Team role balance and team performance: an empirical study," Journal of Management Development, 18 (8), 1999.

[10] K. Shirakawa, et al., "Optimal Team Formation for Software Development Exercise," the 9th WSEAS international conference on Applications of computer engineering, 2010.

[11] L. F. Capretz and F. Ahmed, "Making Sense of Software Development and Personality Types", IT Professional, 2010.

[12] J. Karn, and T. Cowling, "A Follow up Study of the Effect of Personality on the Performance of Software Engineering Teams," ISESE '06, 2006.

[13] N. Gorla and Y. W. Lam, "Who Should Work with Whom? BUILDING EFFECTIVE SOFTWARE PROJECT TEAMS", Communications of the ACM, 47 (6), 2004

[14] Brian R. von Konsky, et al., "Visualising Career Progression for ICT Professionals and the implications for ICT Curriculum Design in Higher Education," ACE '14, 2014.

[15] Y. Sunaga, H. Washizaki, K. Kakehi, Y. Fukazawa, S. Yamato, and M. Okubo, "Relation between Combinations of Personal Characteristic Types and Educational Effectiveness for a Controlled Project-based Learning Course," IEEE Transactions on Emerging Topics in Computing, (to be published).