

Relationship Between the Five Factor Model Personality and Learning Effectiveness of Teams in Three Information Systems Education Courses

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Abstract— Although working in teams is an effective method for students to learn skills necessary for information systems, the optimal combination of team members to maximize the learning effectiveness has yet to be clarified. This study investigates the relationship between the combination of students' personality characteristics and learning effectiveness in three information system lecture courses. Two Five Factor Model (FFM) questionnaires were used to determine each student's personality characteristic. For each course, which has different styles, several different relationships are found. This study should assist educators in maximizing students' learning effectiveness in information systems courses involving teamwork.

Keywords— component; information system education; communication; coordination; five factor model; software engineering education; personality characteristics; problem-based learning

I. INTRODUCTION

Working in a team is an important learning method in an education course. For example, project-based-learning (PBL), where students work on a project, is an effective way to learn needed skills [1] [2]. Because it is almost impossible for one student to solve the tasks in PBL, students work in teams. Teamwork is the driver of success in software projects [3]. The variables directly affecting teamwork in software development include communication, coordination, balance of member contributions, mutual support, effort, and team cohesion [4]. As a team, students learn specific information system skills, communication, coordination, and other fundamental skills more effectively.

A moderately diverse team where members have different personalities reduces risks when developing software intensive business systems [5]. In software engineering, personal characteristics impact performance and attitude [6] [7]. Therefore, the combination of the each team member should also be important for information system development. However, the optimal composition in a team of students in academic education is unclear. In our previous study, we researched the relationship between student

personality characteristics and learning effectiveness using the Five Factor and Stress theory (FFS) [8] [9]. Unfortunately, FFS is a minor theory. Consequently, this survey uses the Five Factor Model, which is a major personality characteristic model [10].

This study focuses on the following research questions:

- **RQ1:**) Are individual student's personality characteristics related to learning effectiveness?
- **RQ2:**) Are the team personality characteristics related to learning effectiveness?
- **RQ3:**) Is there a similar relationship between team personality characteristics and learning effectiveness in different information system lecture courses?
- **RQ4:**) Does the relationship between team personality characteristics and learning effectiveness depend on the format or country of the information system lecture course?

To investigate these RQs, we analyzed three actual lecture courses. Two courses titled, "System development project Course (SC)" and "IT Management project course (IC)" are open courses by Waseda University in Japan. The other is an open course by the State University of New York (US). In these courses, students work in teams on a real project in a classroom setting. To measure the student's personality characteristic and learning effectiveness, we employ the FFM questionnaire and the knowledge and skill questionnaire.

This paper contributes to academic education in several countries and several courses. Specifically, we study the relationship between character and learning effectiveness.

The remainder of this paper organized as follows. Section 2 explains the relevant information about FFM and learning effectiveness. Section 3 describes our research methods. Sections 4 and 5 report and evaluate the results, respectively. Section 6 discusses related works. Finally, Section 7 concludes this paper.

II. BACKGROUND

A. Five Factor Model

The five-factor model of personality is a hierarchical organization of personality traits in terms of five basic dimensions: Neuroticism (N), Extraversion (E), Openness to experience (O), Agreeableness (A), and Conscientiousness (C). Studies using both natural language adjectives and theoretically based personality questionnaires support the comprehensiveness of the model and its applicability across observers and cultures [10]. Many types of questionnaires have been developed to measure these five factor dimensions. In this paper, we use two questionnaires entitled, “Revised NEO Personality Inventory (NEO-PI-R)” and “International Personality Item Pool (IPIP)”.

NEO-PI-R is one of the most famous methods to measure the Big 5. It is a measure of the five factor dimensions of personality characteristics in healthy adults [11]. It has 240 question items and five scales to measure the following dimensions:

1) *Neuroticism (N)*: Neuroticism contains the degree of stress reaction. A high score indicates that a person tends to have unrealistic thinking, cannot control anger, and has difficulty dealing with stress.

2) *Extraversion (E)*: An extroverted personality is friendly and out-going. On the other hand, a non-extroverted personality does not mean unfriendly and shy, but means modest and humble. These differences are attributed to the degree of curiosity [12].

3) *Openness (O)*: A highly open personality means a non-traditional and positive toward new ideas. This relates to intelligence of creative and diffusion thinking, but it is not the same as intelligence.

4) *Agreeableness (A)*: A highly agreeable personality means altruistic and kind. A high value is often good in a team, except in several cases. For example, highly agreeable people tend to avoid discussing matters lively.

5) *Conscientiousness (C)*: A conscientious person has a purpose and is strong-willed. They are firm and trustworthy. On the other hand, a unconscientious person tends to be unreliable.

IPIP is the same as NEO-PI-R in term of measuring Big 5. It is just a little less reliable than NEO-PI-R. However, it is easy to use for free. IPIP has 50 question items ranked on a five-point scale. The IPIP scales that represent the NEO-PI-R were created by identifying items that correlate highly with Costa and McCrae's NEO PI-R [13]. Although each of the five dimensions are similarly measured, instead of Openness, IPIP uses Intelligence. The average of the correlation value between NEO-PI-R and IPIP is about 0.65~0.75 [14].

To use these questionnaires in Japan, they must be translated into Japanese. In the case of NEO-PI-R, we use NEO-PI-R for the Japanese version published by Tokyo Shinri Co., which assures validity. [11]. In the case of IPIP, we use a Japanese Translation questionnaire [15].

B. Learning Effectiveness

Learning effectiveness is an improvement in knowledge and skills as defined by the Information-technology Promotion Agency (IPA) common career skill framework based on the Skills Framework for the Information Age (SFIA), which is the standard IT framework in Japan [16] [17]. To measure this quantitatively, we asked the students to complete the same questionnaire before and after the courses on a six-point scale in SC and IC. However, students were asked to answer the FC only after the course. This questionnaire contained 28 questions about for SC and FC, and 40 questions for IC. Table 1 shows actual questions

TABLE I. QUESTIONNAIRE ITEMS COMMON TO ALL COURSES TO MEASURE TEAM KNOWLEDGE AND SKILLS

No	Knowledge and skill
Q1	Planning
Q2	Preparing a presentation
Q3	Presenting
Q4	Communicating
Q5	Practical speaking
Q6	Asking relevant questions
Q7	Sharing information with the team
Q8	Applying problem-solving methods
Q9	Being independent
Q10	Involving others
Q11	Setting goal and actions
Q12	Analyzing the present situation and revealing goals or problems
Q13	Revealing processes for problem-solving
Q14	Being innovative
Q15	Clearly sharing ideas
Q16	Listening to others' ideas
Q17	Understanding different ideas or situations
Q18	Understanding the relationship between people or matter
Q19	Illustrating as an explanation
Q20	Requirements analysis
Q21	Requirements definition
Q22	Functional design
Q23	Discussion of business processes
Q24	Project planning
Q25	Project management
Q26	Development process
Q27	User interface development
Q28	Database development

common to all courses. The first 19 questions measure the knowledge and skills of team management. The remaining questions measure the specific information system knowledge and skills of each course.

We defined the learning effectiveness as the improvement in the questionnaire results according to the difference in the before and after questionnaires in SC and IC. In FC, we defined it as the post knowledge and skills in the questionnaire results according to the value of after questionnaires. The mean of each team member’s learning effectiveness is used as the learning effectiveness of the team.

III. METHOD

This experiment targets three actual academic lecture courses: SC, IC, and US.

SC teaches management of software-intensive business systems development projects from the viewpoint of the provider. Students primarily learn about upper processes, (e.g., requirements analysis and architectural design) by working on a real project in a classroom setting. IC teaches knowledge and skills of IT management from the viewpoint of IT section personnel. Students primarily learn knowledge and techniques to develop management strategies, IT strategies, etc. from an experienced guest lecturer. In FC, students work in six different teams, which are “Requirements”, “Engine”, “User Interface”, “Database”, “Quality”, “Assurance”, and “Usability”, on the same project. All teams work together to produce a major software product using SCRUM. Students determine the features, release plans, and progress themselves under the mentorship of the instructor.

SC and IC met for five consecutive days involved three 90-minute sessions at Waseda University in the each year. We gathered the data three times from 2014 to 2016. US took place over the course of 15 weeks in Spring 2016 at the State University of New York at Oswego. When we extract the valid data (removing no-responder of questionnaires or the teams with 3 or less students), SC divided 113 undergraduate computer science and engineering majors into 23 teams. IC divided 61 undergraduate computer science and engineering students into 13 teams. US divided 21 undergraduate Computer Science or Software Engineering majors and graduate Human-computer Interaction majors into 4 teams. Each team had 4-6 students.

The students in US used PBL, whereas students in SC and IC worked on a controlled project in a classroom setting (controlled PBL). However, SC and IC are offered at two Japanese governmental bodies (MEXT and IPA) as well as two IT companies (NEC and NEC Learning) in cooperation with Waseda University.

Table 2 shows the features of each course. In SC, although students receive the detail function article, skills, and roles, students only create the deliverables of the upper process (no programming). In IC, students receive the rough skills and instructions in the classroom learning. Then, they must propose an IT management strategy as a team. In US, although students are divided into several teams, they work as on large unit to develop an actual application.

TABLE II. FEATURES OF EACH COURSE

Item	SC	IC	US
Date	5 consecutive days	5 consecutive days	15 weeks
Student	113 undergrads	61 undergrads	21 undergrads and grads
Team	23 teams	13 teams	4 teams
Form	Almost all practice	Classroom learning, practice, and presentation	Almost all exercises
Contents	Upper process of system development	IT business strategy consultant	Application development

IV. RESULTS AND DISCUSSION

A. NEO-PI-R and IPIP

Several students in SC and IC answered both questionnaires NEO-PI-R and IPIP. Table 3 shows the correlation value between the NEO-PI-R’s dimension value and IPIP’s dimension value. Accordingly, we can compare the NEO-PI-R data and the IPIP data.

TABLE III. CORRELATION VALUE BETWEEN THE NEO-PI-R AND IPIP DIMENSIONS (N=39)

Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness
0.297 (p=0.066)	0.713 (p<0.001)	0.485 (p=0.002)	0.393 (p=0.013)	0.647 (p<0.001)

B. Individual Learning effectiveness (RQ1)

Table 4 shows the correlation between the five dimensions and learning effectiveness for individual students. Not all courses show a strong correlation. In a previous work [9], individual values are not correlated to the learning effectiveness. Thus, we focus the combination of personal characteristics within the team.

C. Team Learning effectiveness (RQ2,3,4)

Table 5 shows the correlation of the teams between the FFM dimension value of the average or variance and the learning effectiveness. There is only a weak correlation, but some findings are interesting.

1) Neuroticism

Neuroticism (N) contains the degree of the stress reaction. Generally, a low value of N indicates high ability to handle stress. Figure 1 plots the average (left) or various (right) N value of the teams and learning effectiveness for SC (top), IC (middle), and US (bottom). In SC and IC, teams with a low variance in the N value represent a good team, suggesting that teams with the same level of Neuroticism are good for team cooperation in a discussion lecture. On the other hand, FP does not show a correlation, which may be due to two reasons. First, the course focuses on an exercise and not discussions; teams comprised of individuals with similar N values are good for discussions. In US, team’s work products only partly relied on group discussion, but mainly on code completion and feature addition under time pressure. This may have raised reported Neuroticism levels while at the

TABLE IV. INDIVIDUAL CORRELATION VALUE BETWEEN PERSONAL CHARACTER AND LEARNING EFFECTIVENESS

Course	FFM data	cor. value	p value
SC	N	0.042	0.665
	E	0.035	0.720
	O	0.063	0.516
	A	-0.152	0.115
	C	0.129	0.180
IC	N	-0.132	0.344
	E	0.167	0.232
	O	0.175	0.209
	A	0.130	0.352
	C	0.102	0.467
US	N	-0.115	0.585
	E	-0.189	0.364
	O	-0.109	0.604
	A	-0.129	0.538
	C	-0.267	0.197

ITEM	FFM	cor. value	p value
	A	-0.326	0.277
	C	-0.423	0.150
US_AVE	N	-0.353	0.647
	E	-0.309	0.691
	O	0.136	0.864
	A	0.232	0.768
	C	-0.657	0.343
US_VAR	N	0.492	0.508
	E	-0.970	0.030
	O	0.763	0.237
	A	-0.367	0.633
	C	-0.950	0.051

TABLE V. TEAM CORRELATION VALUE BETWEEN THE PERSONAL CHARACTER AND LEARNING EFFECTIVENESS

ITEM	FFM	cor. value	p value
SC_AVE	N	0.116	0.612
	E	0.019	0.931
	O	0.029	0.894
	A	0.177	0.420
	C	-0.171	0.435
SC_VAR	N	-0.212	0.333
	E	-0.038	0.865
	O	-0.007	0.976
	A	-0.171	0.435
	C	-0.135	0.538
IC_AVE	N	-0.110	0.721
	E	-0.370	0.213
	O	-0.226	0.459
	A	0.342	0.253
	C	-0.053	0.862
IC_VAR	N	-0.522	0.067
	E	-0.339	0.258
	O	0.093	0.763

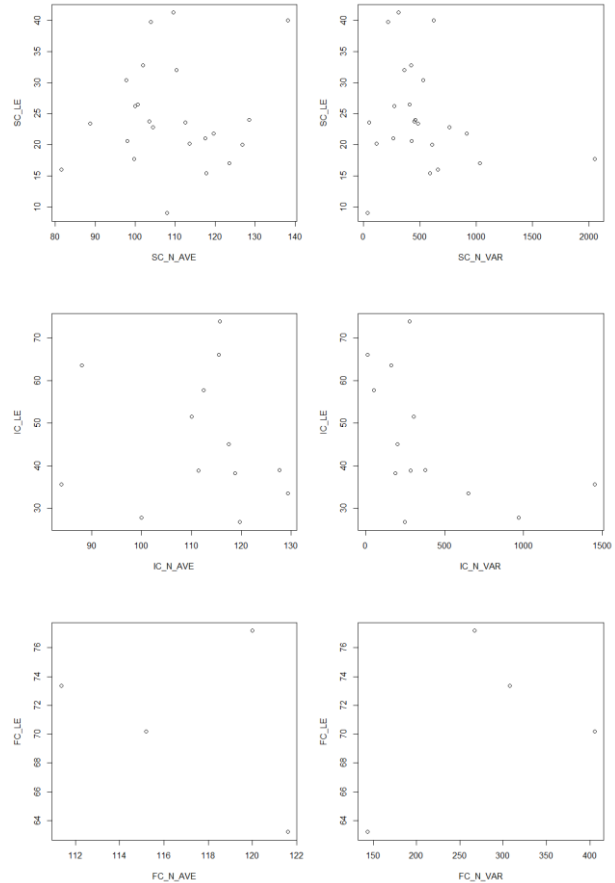


Figure 1. Plot of the N value and learning effectiveness of the teams

same time, yielded learning effectiveness in some individuals. Second, there may be a cultural difference between students in Japan and the United States as previously reported in [22] and confirmed herein.

2) Extraversion

An extroverted personality (E) is out-going and seeking interaction with others. Figure 2 plots the average (left) or various (right) E value of the teams and learning effectiveness in SC (top), IC (middle), and US (bottom). In previous studies [9] [20], when the variance is high, the team is good. However, this finding does not hold for US. In previous studies, a high variation in E may help facilitate discussions. Like in the previous section on Neuroticism, this may be explained by the purpose of the class: in US, the purpose was to develop incremental artifacts of a sellable product. In the instructor's experience, it frequently happens that very extroverted individuals take charge within their team, becoming a leader, and making discussions for the team. In these cases, the knowledge discovery process may have been hindered in some other individuals. Contrastingly in SC and IC, both courses encouraged discussion and thought exchange, thereby allowing other students to learn from discussion leaders.

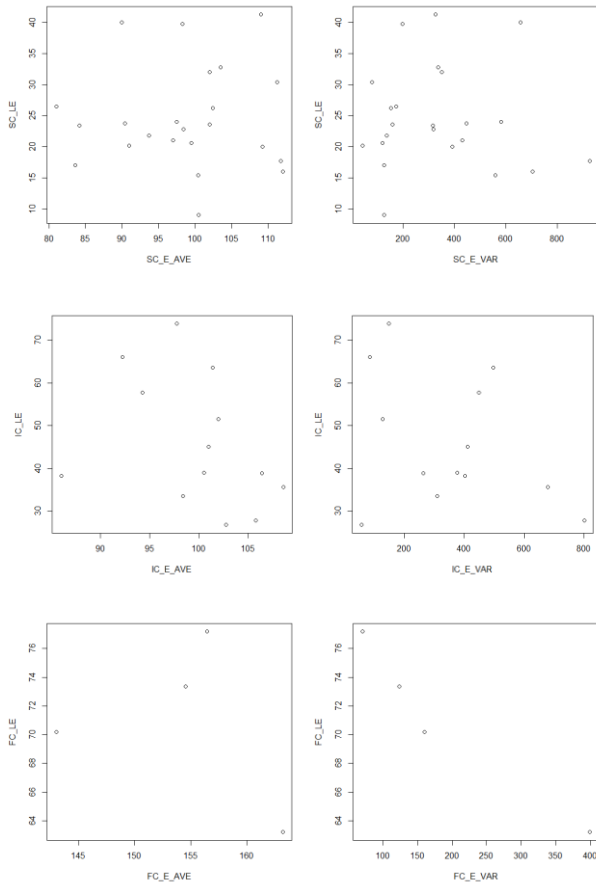


Figure 2. Plot of the E value and learning effectiveness of the teams

3) Openness

A high openness means nontraditional, accepting of new ideas, and the rich of novel ideas. Figure 3 plots the average (left) or various (right) O value of the teams and learning effectiveness in SC (top), IC (middle), and US (bottom). In

SC, the high value of openness indicates a high level of learning effectiveness. This is indicative of the relevance for openness personality characteristic for early-stage development processes such as requirements analysis, architecture design, etc. In other word, early-stage development may need the openness of new ideas. In IC, the high variance in O improves learning effectiveness because this course has 3 various lecture form (classroom lecture, practice, and exercise). It may be that a low value of O is needed in a classroom lecture and high value of O is needed in a practice and exercise. In US, the correlation of the average value of O within the team with learning effectiveness was low, however the variance between O and learning effectiveness was high. These results strongly suggests that a high degree of variance in openness within the team increased the team's learning effectiveness in the development task. This may be due to the need to conceive, communicate, and decide upon design choices.

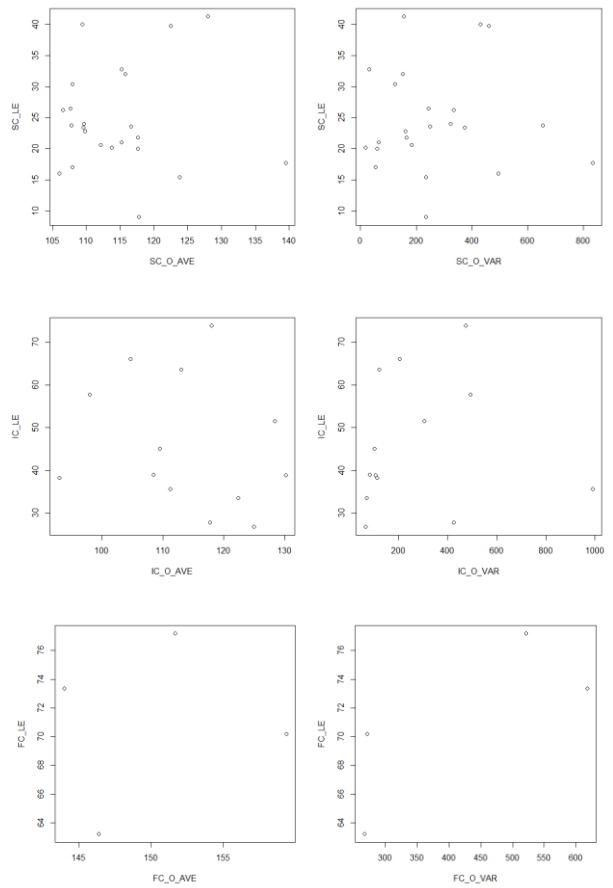


Figure 3. Plot of the O value and learning effectiveness of the teams

4) Agreeableness

The agreeableness personality characteristic (A) describes an individual's degree of altruism and kindness towards others. However, being too agreeable is usually indicative of people avoiding discussion. Figure 4 shows the plot of the average (left) or various (right) A value of the teams and learning effectiveness of the team in SC (top), IC

(middle), and US (bottom). In IC, when the team value of A is near about 105, that team reported high learning effectiveness.. In a case study of this course, when students were asked to develop the management strategy, students were able to acquire management skills through discussion with one another, as detailed instructions weren't provided. This suggest that a low level of A increases debate, and thereby learning. On the other hand, in SC, the team has higher value of A, the team reports higher levels of learning effectiveness, despite the absence of strong correlations (see Table 5). In this course, when students make the deliverables of system development, students were provided with a role and the skills pertaining thereto. Therefore, this course may need more agreeableness to achieve higher performance than other courses. Finally, in US, the a similar correlation between average and within-team variance of agreeableness and learning effectiveness as in IC was found. This seems to suggest that agreeableness impacts learning effectiveness in development teams in a similar manner as in IT strategists. This may be due to the fact that milestones, sprints, and requirements were discussed in class and therefore involved mediation by the instructor. This means that typically, agreement by the entire class was sought regarding the next milestone before development continues. Like an IT strategy team, implementation hence proceeded according to the direction outlined by the team, thereby yielding a similar impact on learning effectiveness.

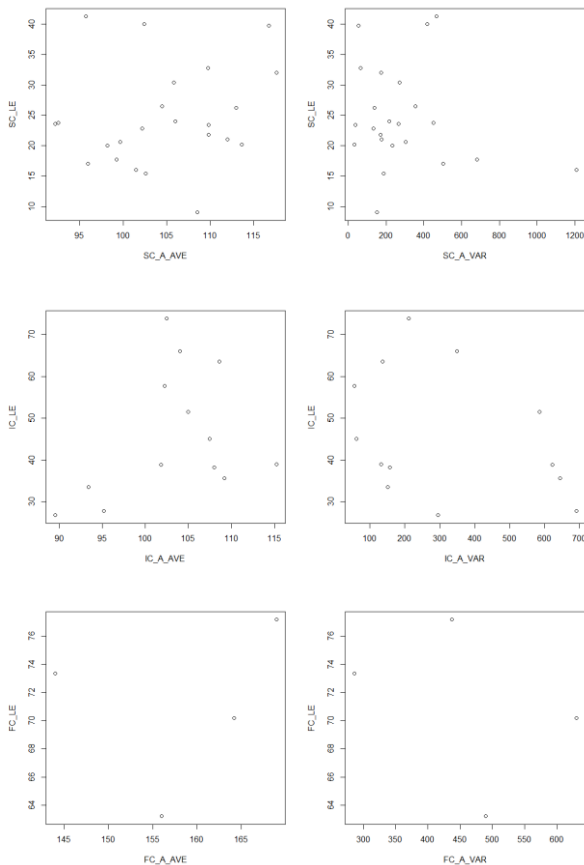


Figure 4. Plot of the A value and learning effectiveness of the teams

5) Conscientiousness

Conscientious people have a sense of purpose and are strong-willed. On the other hand, unconscientious people tend to be unreliable. Figure 5 plots the average (left) and various (right) C value of the teams and learning effectiveness in SC (top), IC (middle), and US (bottom). In SC, there is not a clear relation. However, in IC, a team C value around 95 indicates a good team. Similar to agreeableness, students in SC receive detailed skills, whereas students in IC receive rough instructions. The amount of effort required by lecture course may depend on the degree of detailed skills or instruction. Meanwhile, in FP, when the team variance value of C is low, the team is good. Because FP is an exercise-centered lecture, the burden on students is larger than that on the students in the other courses. Therefore, the similar values of conscientiousness may distribute the burden fairly among team members, realizing a better team.

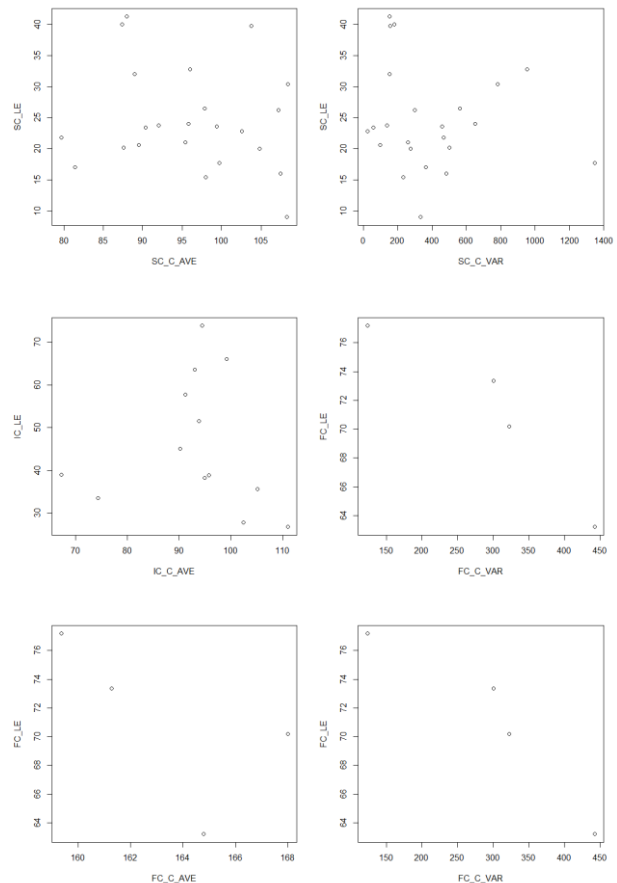


Figure 5. Plot of the C value and learning effectiveness of the teams

D. Threats to Validity

This research data were acquired using questionnaires, which were subjectively answered by students. Thus, spurious estimations and insincere responses are the threats to the internal validity. To resolve this, more quantitative

methods that do not burden educators and students are necessary. Another threat to the internal validity is sample dataset. Because we just began collecting data, it is currently impossible to verify whether the results are time specific or universal. In the future, additional data should be acquired and analyzed.

A threat to the external validity is that we do not have sufficient evidence to apply these results to other similar practical lectures. However, the courses used in this research have been developed as the part of a nationwide effort in collaboration. Therefore, we deduce that similar courses should yield comparable findings.

V. RELATED WORK

Because various factors influence software projects, many researchers have examined the relationship between a project and personality [18] [19].

A. Five Factor and Stress Theory (FFS)

In our previous study, we researched the relationship between student personality characteristics and learning effectiveness using the Five Factor and Stress theory (FFS) [8] in SC and IC. FFS theory emphasizes the personality characteristics in the team by mapping a person's personality onto a two-dimensional graph where the X-axis ranges from receptive to condensable, while the Y-axis ranges from 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. The previous study revealed that teams with a larger dispersion on the X-axis have a higher learning effectiveness [20]. One drawback of this study is that the FFS is not a major theory. Therefore, we use FFM in this paper. In this experiment, when we compared students' responses in the questionnaire about FFS to those about FFM, there is a correlation between the X- and Y-axes of FFS and several dimensions to FFM, lending credence to the significance of FFS.

B. FFM and Academic Performance in a Pair Programming Course

In previous work, Salleh et al. researched the relationship between student performance and personality of FFM during pairing activities [21]. The results showed a positive correlation between conscientiousness and assignments' scores. Additionally, students' test performance was positively correlated with openness to experience.

On the other hand, we researched the relationship between the team (4~6 people) FFM combination and the learning effectiveness (not performance).

VI. CONCLUSION

We examined the relation between the student's personality characteristics according to FFM and the learning effectiveness in the three team-activity lecture courses. The results show that although individual characteristics are not strongly correlated to learning effectiveness, there are a few strong team correlations. The interesting aspects of the team

correlations may be related to the course style (discussion, practice, or exercise).

In the future, we plan to acquire more data to remove the threats to validity. In this study, we focused on the impact of an individual personality dimension on the learning effectiveness and each personality dimension. In the future, we plan to focus on combined personality dimensions (for example, low Extraversion and high Openness) to evaluate learning effectiveness of a team.

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