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INVESTIGATION OF STUDENT'S PERSONALITY ON PAIR PROGRAMMING TO ENHANCE THE LEARNING ACTIVITY IN THE ACADEMIA

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ABSTRACT

Agile Software development is now a global phenomenon and is rapidly becoming organizations' most preferred IT process. Extreme Programming (XP) is one of the Agile Methods and Collaborative Pair Programming (CPP) is one of the very important practices of eXtreme Programming. Agile focuses team work which is very important in the field of software development. The software industry has practiced CPP, where two programmers working side by side on one computer on the same problem with great success. Similar experiments have been conducted in academia and pair programming has been shown to be beneficial for both students and teaching staff in university courses. In this study, we conducted some set of experiments about the "human" aspect of the CPP; in particular the effects that personality attributes may have on pair programmer's effectiveness as a pedagogical tool. A formal experiment has been conducted during 2012-13 odd semester at the PSG College of Technology, India to investigate the influence of personality differences among paired students using the five-factor model as a personality measurement framework. The aim of this research is to improve the implementation of CPP as a pedagogical tool to the academic setup through understanding the impact of the variation in the personality profile of paired students towards their academic performance.

Keyword: Pair Programming, Extreme Programming Five Factor Model

I. INTRODUCTION

Agile software development focuses on team work and is important in the field of software development. Collaborative Pair programming is a style of programming that is associated with agile development-although it can be used in a non-Agile projects-in which two programmers occupy their chair side by side at one computer continually collaborating on the same problem and its system design, algorithm, software code, test. One of the pair member, the driver, is typing at the computer or design a document. The next person, called the navigator, has several duties, including monitoring and reviewing the work of the driver on the lookout for both syntax and strategic errors. Strategic errors occur during the wrong path selection of the driver.

This study presents the results of CPP experiment conducted at PSG College of Technology, during the odd semester of 2012-13. It involved 132 students who will learn computer based programming subjects which investigated the human aspects of CPP in which the effectiveness of pair programmers, affects the personality attributes using the pedagogical tool. It investigated the influence of personality difference among students those who pair programmed. Investigating the personality difference is done using as a personality measurement framework called five factor model. The personality effects can be measured by academic performance, i.e., Lab exercises, Programming assignments, objective type test.

In this study, a formal experiment has been conducted to investigate the influence of personality differences among paired students. The aim is to improve the implementation of CPP as a pedagogical

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tool through understanding the impact the variation in the personality profile of paired students has towards their academic performance.

The subjects involved in the formal experiment were undergraduates of 54 students of first year BE Metallurgical Engineering and 60 students of second year BE EEE and 18 postgraduate students of first year ME control systems who has completed the personality test International Personality Item Pool Representation (IPIP) based questionnaire. By using the personality test scores and academic performance, the effectiveness has been found out. Based on evidence from this systematic review of the CPP in higher education, we found that personality was the most common factor which influences the performance of pair programming. Research evidence suggests that developers' personality is one of CPP's most critical success factor because of teamwork. So, our aim of this study was to conduct some set of tests to improve the implementation of the CPP practice as a pedagogical tool by focusing on personality traits and demonstrate CPP experiments to the academic environment for good learning and knowledge transfer.

2. MOTIVATION RELATED TO WORK

Collaborative Pair programming is the practice where two programmers work together on the same programming task using one computer and one keyboard and mouse. The direct way of collaborating in pair programming might intensify both the benefits and problems of small group collaboration in general. This raises issues concerning the interaction between the individuals in a pair that influences particular forms of interaction among people are expected to occur, which would trigger learning mechanisms but actually there is no guarantee that the expected interactions will occur. So, there is a general concern is to develop ways to increase the probability that some types of interaction occur; Personality has been a subject of interest in the context of programming and software engineering for some time (Hannay and Arisholm, 2010). The **Fig. 1** shows the collaborative process model of product which insist team work.

Pair members must give some attention to the subject of personality should make substantial contributions to increased programmer performance. Schneiderman in his book Software Psychology states: "Personality variables play a Critical role in determining the interaction among programmers and in the work style of individual programmers and there is a lack of strong evidence on the impact of personality on performance: "Personality tests have not been used successfully for selecting programmers who will become good programmers"; "Unfortunately too little is known about the impact of personality factors" (Williams and Kessler, 2000; Hannay and Arisholm, 2010). There are many types of personality models are available and any given model may have several alternative operations, which give rise to the actual tests that are administered to measure a person's personality according to that model. Generally, personality tests are used in governmental, recruitment and career counseling agencies and the military. This study sought to identify and investigate various human personality factors towards academic setup within the student groups. This is to verify a situation in which psychological research; many of them are simplified or altered over time for specific purposes with little or no scientific control.

For example, pairs may work for shorter or longer periods of time, partners may rotate and the driver and navigator roles may, or may not be adhered to. On the one hand, CPP inspires a particularly close form of collaboration which might intensify group dynamics, while, on the other hand, short sessions may not allow more inert group dynamics to manifest themselves (Barrick *et al*., 2001). In any event, it is of interest to investigate factors that may affect the interaction that occurs in CPP (Cockburn, 2001). These factors include personality, gender, expertise, attitudes, motivation and preferences. However, since performance, e.g., in terms of time and quality, is often the ultimate criterion variable in software engineering, such factors have mostly been studied in terms of how much they directly influence performance, or in some cases, satisfaction. This means that the nature of collaboration in terms of how pairs interact has mainly been treated in a black-box manner, with a few exceptions (Walle and Hannay, 2009). We have found that students are compatible with partners whom they perceive of similar skill, although instructors cannot proactively manage this perception (Katira *et al*., 2005). The **Fig. 2** shows the Pair Collaboration as a mediator variable which indicates the success of pair depends on the personality types and Pair Collaboration Process.

When it comes to personality, the direct impact of personality on performance has been found to be modest in several areas of research, including software engineering. However, even though direct effects on performance are disappointing, it is not unreasonable to expect that personality might have a more substantial impact on how pairs collaborate. How to pair collaborate might then be used to predict performance; Pair collaboration is based on Participation + negotiation + critical dialogue +critical reflection (Buchanan *et al*., 2005).

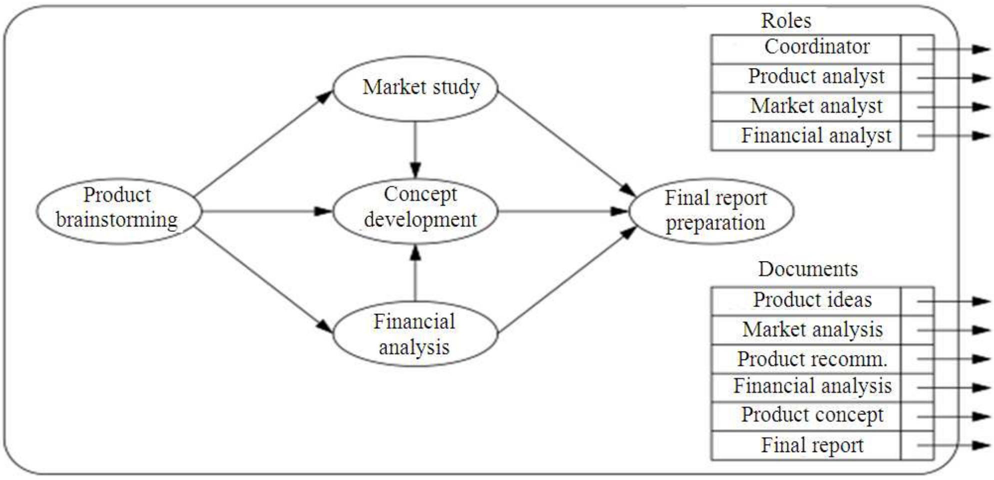

Fig. 1. Collaborative process model of product

Fig. 2. Pair Collaboration as a mediator variable

3. FIVE-FACTOR MODEL

The Five Factor Model is a theory of personality assessment and measurement which was founded in factor analysis. There exist several models of personality with several alternative tests (usually questionnaires) that are administered to measure a person's personality. A model that in recent years has dominated the academic scene consist of five factors and goes under the name of the Big Five (Barrick *et al*., 2001). The **Fig. 3** shows the various factors of Big-Five personality.

Extraversion (E)-means a person is, talkative, social and assertive. Agreeableness (A)-means a person is good natured, co-operative and trusting. Conscientiousness (C)-means a person is responsible, orderly and dependable. Neuroticism (N)-means a person is anxious, prone to depression and worries a lot. Openness (O)-means a person is imaginative, independent minded and has divergent thinking. The **Fig. 4** shows the Five-Factor Model which influences the personality traits in CPP.

Personality Traits are consistent patterns of thoughts, feelings, or actions that distinguish people from one another. Traits are basis tendencies that remain stable across the life span, but characteristic behavior can change considerably through adaptive processes. A trait is an internal characteristic that corresponds to an extreme position on a behavioral dimension.

In this research we focus on Conscientiousness which is one of five super-ordinate traits in the model of Big Five personality traits, the other factors are openness, agreeableness, extraversion and neuroticism The Big Five posits that the most important personality differences in people's lives will become encoded as terms in their natural language, the so called Lexical Hypothesis (Walle and Hannay, 2009).

This study focuses on the first part of this relationship, which consist of two issues: (1) The definition of the construct of the pair's collaboration and (2) the relationship between personality and pair collaboration; for example, whether extroverts talk more, whether conscientious people have more task-focused conversation and whether people with low emotional stability have more conflicts in collaboration. For (1), to avoid confounding of constructs, it is important to define the construct of the pair's collaboration before relating this construct to performance: Good and bad pair collaboration should not merely be defined to be whatever gives good and bad performance. If we were to do that, we would not gain insight into collaboration and pair collaboration as a mediator variable would add nothing to the model that is the part of the relationship that concerns the effect of pair collaboration.

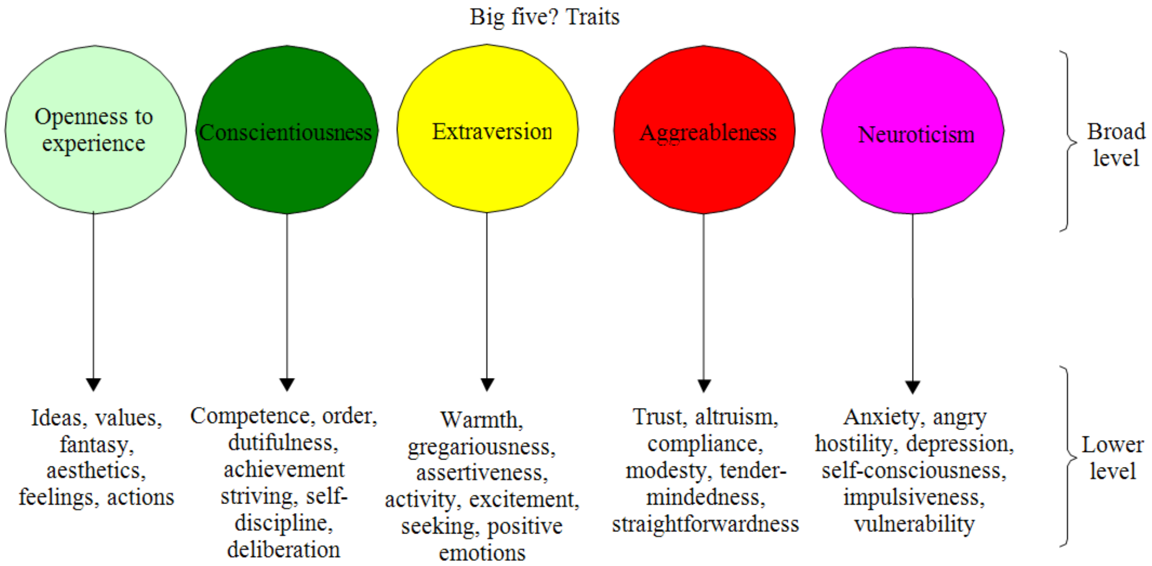

Fig. 3. Big five factors

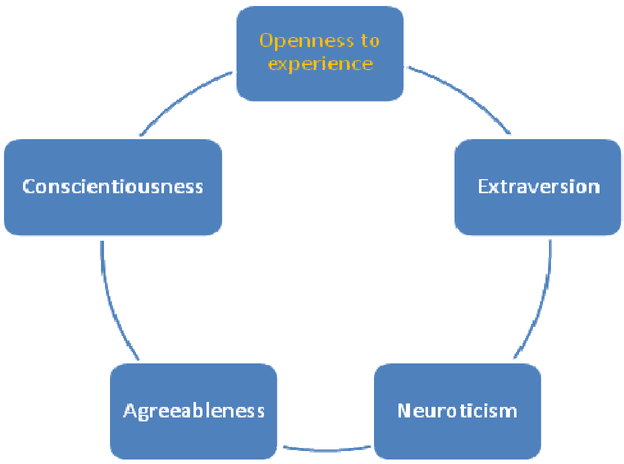

Fig. 4. Five-factor model

4. RESEARCH METHOD

This section describes the formal experiment conducted during 2012-13 odd semester at PSG College of Technology with 132 student participants. Then we present the hypothesis, we aimed to study for these experiments.

4.1. Research Objectives

The objective of this work was to improve the effecitiveness pair programming as a tool for computer science education. This objectives were outlined using the Goal/Question Metric (GQM) framework (Basili *et al*., 1999). The GQM definition is shown in **Table 1** and the detailed goal definition of the formal experiment is as follows:

In this study a formal experiment was conducted using solo, pair lab exercise, assignments and tests as per the experiments conducted by Venkatesan and Sankar (2010) for accessing the personality of students. In order to judge the problem solving skills of the students we put them to a simple test where they were provided with a problem statement and were asked to answer certain questions on the respective domains.

Table 1. GQM definition

Goal(s)	Question(s)	Metric(s)
To test the effect of conscientiousness towards a successful pair configuration	Do differences in conscientiousness level within a pair affect the pair's academic performance?	Students' academic performance measured by assignments, internal test scores
To test the level of satisfaction and confidence of paired students.	Were students satisfied and did they feel confident working in pairs?	CPP questionnaire on satisfaction and confidence level

4.2. Hypotheses

The previous studies showed that conscientiousness to consistently predict educational success. This is the main personality factor for our research setting. So, the pairs can be formed based on personality differences with students, different levels of conscientiousness and it can be two levels that are high and low. Low conscientiousness possesses to unorganized and unprepared whereas high conscientiousness tends to be organized and achiever. Thus, this factor is believed to affect CPP's effectiveness. Hence, in order to investigate the above hypotheses, more specific hypotheses were developed.

The team members may have the diversity or heterogeneity of personality. The study is to find the performance of student those who paired with their matching personality. The difference in personality on the CPP's effectiveness is investigated by the following hypothesis:

H0: The effectiveness of students who pair programmed do not affect the difference in personality traits
H1: The effectiveness of students who pair programmed do affect the difference in personality traits

4.3. Variables

The personality traits were our independent variables and CPP's effectiveness and satisfaction were our dependent variables. Pair effectiveness was measured using assignments and test scores and satisfaction was measured using a questionnaire where all questions employed a nine-point like scale. The dependent variables were measures of the students' assignments and test scores based on the percentage of time allocated to a category and relative to the total length. The **Fig. 5** shows the relationship between the variables.

4.4. Experimental Procedure

Each of the tests was treated as an independent experiment. The test hypothesis were investigated using a "single factor between-group design" as the experimental design. This design allows each subject to experience only one condition or group, which means, in a specific tutorial, one student was assigned either to a pair of similar personality or to a pair of mixed personality (Salleh *et al*., 2009) (controlled group = similar personality, experimental group = mixed personality). Therefore, before the first test, student's personality data were gathered using questionnaire similar to the online IPIP test (Raad and Schouwenburg, 1996). The results of the personality test were used to allocate right partners. Due to this purpose, the personality scores of conscientiousness were used to assign students between two different groups of similar or mixed personality (Salleh *et al*., 2009) (e.g., A student with the highest score on conscientiousness was paired with someone with low scores on conscientiousness to form a pair of mixed personality). **Table 2** shows the categorization of pairs according to students' level of Conscientiousness to experience. A pair (C_{High}, C_{High}) denotes a pair combination where both students have high levels of experiences coming under Conscientiousness. It is used to compare the performance of students in these groups based on their academic achievement in the course. Our experiment also looked into the association between each student's personality score with their academic performance, level of satisfaction and confidence when working in pairs. It also shows the categorization of pairs according to personality differences using as basis the conscientiousness factor.

The experiment is based on students who have Laboratory subjects such as Programming Languages (C, C++, Java, Data Structures). First, they were supposed to adopt solo programming for an hour. A problem solving question has given to all students to solo programming. When they finish the problem the completion time has been noted down on each and every student. Considering their performance in solving the problem and time they took to complete the problem, they were paired with students for CPP. Another problem solving question has given to every pair.

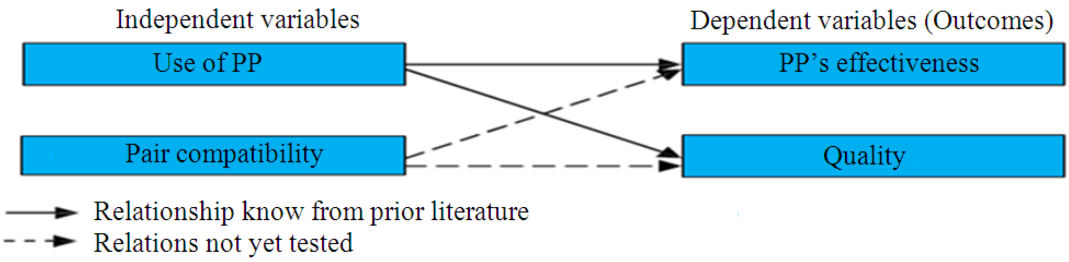

Fig. 5. Relationships between variables

Table 2. Personality differences

Similar personality	Mixed personality
Pair (C Low, C Low)	Pair (C Low, C Med)
Pair (C Med, C Med)	Pair (C Med, C High)
Pair (C High, C High)	Pair (C Low, C High)

Table 3. Personality scores level

Internal test scores	Lowest 30%	Middle 40%	Highest 50%
Level	Low	Average	High

As in solo programming session the CPP session also the completion time noted for each pair (Venkatesan and Sankar, 2010). The personality traits were classified into low, average or high based on the range of scores shown in **Table 3**.

Every test lasted for a one and half an hour. In the beginning a small introduction was given about CPP and explained a test topic for about 10 min, followed by exercises for the remaining 80 min. The students were allowed to program in C/C++. To allow for "pair-jelling", students worked with their partners, for an initial period of 30 min; and then swapped their roles every 15-20 min. Before the end of the test, students provided feedback working with the partner by filling out a questionnaire about their view on the personality analysis of the partners. The exercises given during the test were graded, thus contributing towards the student's final grade. In addition, assignments and test were also graded, but completed individually.

4.5. Analysis Procedure

The analysis procedure can be processed by testing our null hypothesis, here we used a single factor Multivariate Analysis of Variance (MANOVA) to analyze the difference in academic performance between the controlled and experimental groups; MANOVA is regarded as a complex statistic that linearly combines several dependent variables in a single analysis, where variables need to be correlated at a low to moderate level.

Herein, assignments and test scores were analyzed simultaneously using the General Linear Model program in SPSS. The statistical package to generate the results of our analysis was SPSS v. 17. The bivariate Pearson correlation is used to measuring the association between variables.

5. SCREEN RECORDING TOOL

In order to supervise the student solo and pair programming sessions, a tool has been created using Java. This tool record all the screen activities after the student asked to program. This tends to know how the students program in visually. This helps in knowing the completion time of student and no need in note down manually for every student. When the test starts with students asked to start the recording tool and after completing the coding after compiling and validating they have to stop recording the tool in order to know the time taken by a student get to know easily. The **Fig. 6** shows the Screen recording tool using Java.

This tool has been created using the Java Media Framework (JMF) API. This framework is included in AWT-Abstract Window Toolkit. There are different Classes are there in JMF. The outcomes measured from the experiment where the student's academic performance in their test and assignments. Since the experiments were designed in such a way to minimize the confounding factor which might occur due to differences in various activities/tasks and level of complexity of exercises assigned to the group students. So that, the activity/tasks and exercises remained the same for all the students.

Fig. 6. Screen recording tool using Java

6. RESULTS

We discussed about the results from the formal experiment are presented, followed by the summary of threats to the validity of our findings.

6.1. Subjects

The subjects involved in the formal experiment were undergraduates of 54 first year BE Metallurgical Engineering students and 60 sec year BE EEE students. 18 postgraduate students of first year ME Control systems and in total 132 students who has completed the personality test. The study was conducted for both the postgraduate and undergraduate students of PSG College of Technology.

We have categorized the students on the basis of individual and pair programming. Under instructor supervision, they were introduced to pair programming concepts and groups were formed likewise. To judge the testing skills of the students we put them to a simple test where they were provided with a problem statement and were asked to answer certain questions. The findings pointed out towards some important miss out in our classrooms and provide broad suggestions some of which have been implemented by the authors.

6.2. Assignments

The students were given a problem solving assignment to do and they need to fill up the five-factor questionnaire to find their model.

6.3. Tests

Based on personality scores they could be paired up with students who are low, medium and high, students are categorized. Then they had to do a programming experiments using a C/C++ program similar to the experiments conducted in the paper (Venkatesan and Sankar, 2010). In those experiments, there was no consideration of the personality, but this test was conducted based on student's individual personality factors.

6.4. Correlation Between Personality Traits and Academic Performance

In order to assess the relationship between variables, one can measure the strength of a relationship using a correlation test. We are categorizing the groups with similar and mixed personality pairs. The test scores between these two groups were somewhat same, but mostly same personality group pairs obtained somewhat lower marks than mixed personality students. **Table 4** shows the mean and standard deviation.

There is no significant difference between students between two groups. The correlation between personality factors and academic performance gives the results that Conscientiousness and openness to experience were the two traits that showed a positive correlation with students' performance, but the results were mixed. Conscientiousness showed a positive association with assignments' scores, but no correlation with test scores.

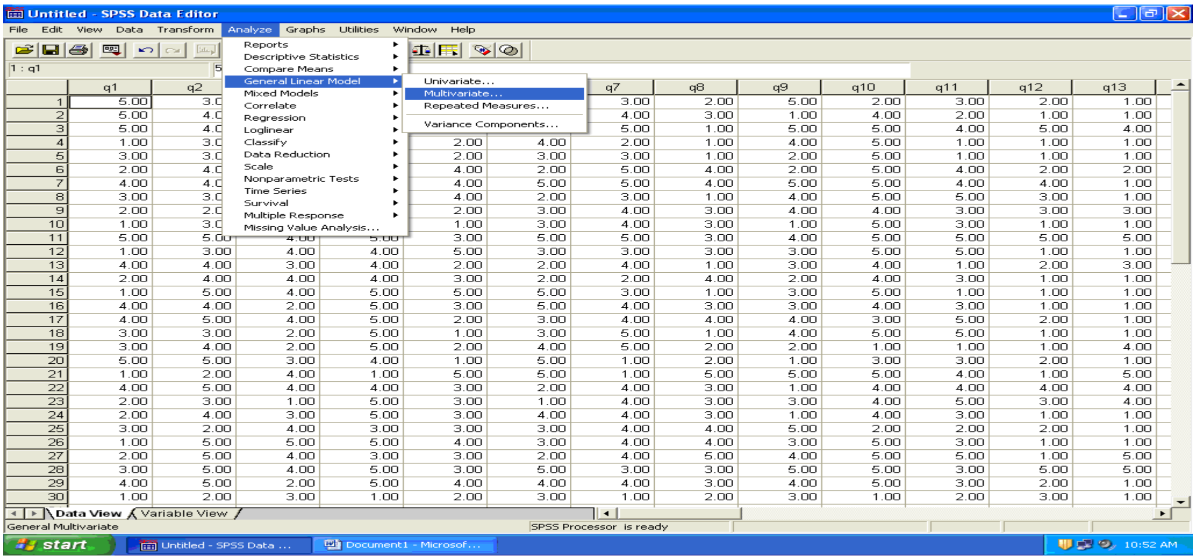

Fig. 7. SPSS data editor

Table 4. Mean and standard deviation of similar and mixed personality of paired students

	Personality type	Mean	SD	N
Assignments	Same personality	12.30	3.62	66
	Mixed personality	11.99	3.02	66
	Total (Average)	12.15	3.30	132
Internal test scores	Same personality	75.57	21.33	66
	Mixed personality	83.52	16.39	66
	Total (Average)	78.04	19.61	132

6.5. Hypotheses Testing

We used a single factor Multivariate Analysis Of Variance (MANOVA) which is a complex statistic that linearly combines several dependent variables in a single analysis using the General Linear Model program in SPSS. The statistical package SPSS was used to find the mean and standard deviation for academic performance (assignments and test scores). Multivariate test has been performed for finding the level of significance. The level of confidence and satisfaction was found out by the questionnaire given to fill up after the tests were finished about their pairing experience.

The questionnaire gives result in within the same group and between the groups. It also gives some good satisfaction and confidence between pair programmers. The **Fig. 7** shows the SPSS data editor.

Pairs of similar level of competency were effective and 89.1% of students responded that CPP made them work better with others based on their feedback. Their exam scores were higher compared with those from previous semesters. The students had a preference to pair with a student of similar actual skill (based on CGPA scores). Skill level appeared to have a strong influence in the success of CPP sessions. The skill level gap between the partners should not be too broad. Differences in Conscientiousness level did not significantly affect the academic performance of paired students.

7. CONCLUSION

Our study has confirmed that most students are attracted by the concept of CPP. When comparing similar and mixed personality pairs, the test scores between these two groups were somewhat same, but mostly a mixed personality group pairs obtained higher marks than same personality students. The performance of students who engaged in CPP during laboratory sessions with those who worked solo were recorded and compared. Similarly, most of the students responded that their confidence level increased when working in pairs. There is significant quality learning by using CPP. The evidence from this study suggests that regardless of the variation in students' personality disposition, CPP not only caused the increase of satisfaction and confidence level, but also brought enjoyment to the class and enhanced students' learning motivation. Furthermore, the majority of students enjoyed the experience and would like to have collaborative programming in the future.

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