

The Effects of Openness to Experience on Pair Programming in a Higher Education Context

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Abstract

This paper describes a formal experiment carried out to investigate the effect of the personality factor Openness to experience on the academic performance of students who practiced pair programming (PP) in higher education. The experiment was carried out at the University of Auckland, using as subjects undergraduate students attending an introductory software programming course. Our results showed that differences in Openness level could significantly affect academic performance of students who pair programmed. In addition, our results also showed that most students gained higher satisfaction from the PP experience and their confidence level in solving programming exercises was also high.

1. Introduction

Reviews of research evidence report some educational benefits that Pair Programming (PP) has to offer. For instance, that PP improves students' learning [28]; increases satisfaction, enjoyment, and confidence in solving tasks ([16],[19]); and increases retention of students in computer science courses [19]. However, despite these benefits PP, which involves two people working together in solving programming or design tasks, was reported to be problematic most often when pairs are incompatible [16]. Such incompatibility issues might be related to psychosocial aspects such as personality, ethnicity or gender differences [27].

The present study is an extension of our previous work ([25],[26]) where we have investigated the effects of personality from the perspective of the Five-Factor personality model (FFM), with first year undergraduate students practicing PP in an introductory programming course. The main motivation behind that work was to look at the effect of FFM on PP, given that it had not yet been previously investigated at length particularly in teaching or academic settings. The study reported here investigated the possible effects of personality trait "Openness to experience" on the PP's effectiveness (measured by academic success of students practicing PP). Openness to experience is one of the broad personality traits of the FFM that describes intellectual, cultural, or creative interest [7]. Personality research on team settings showed that there is a relationship between team composition based on personality and the team's processes and outcomes ([4],[22],[3]). Thus, our study investigates whether such relationship exists within the context of PP teams.

The objective of our research was to improve the effectiveness of PP as a pedagogical tool for CS/SE education by investigating the effects that Openness to experience of paired students may have on PP's effectiveness. The main contribution of this paper is to add empirical evidence regarding the effects of the Openness personality trait towards paired students' academic performance. This will increase our understanding on the potential effects

of personality towards PP's effectiveness as a pedagogical tool. We also believe that this study would be a useful addition to guide future research in PP team composition.

2. Motivation and related work

Based on our systematic literature review of PP in higher education, we found that personality was one of the most common factors investigated in previous PP studies [24]. Nonetheless, the results from these studies were inconsistent in terms of the effect or influence of personality towards PP's effectiveness [24]. The list of studies investigating personality in PP in higher education context is provided in [24]. The motivation of our research was also driven by the fact that many existing PP studies employed the Myers-Briggs Type Indicator (MBTI) as a personality measurement [24]. Although MBTI was found to be very popular and widely used by researchers in the computing and business domain, there has been a rapid emerging consensus by personality psychologists on the value of the FFM or "big-five" as a parsimonious and comprehensive framework of personality traits [6]. Such a growing acceptance of the FFM has motivated us to employ this framework in our research. The FFM consists of five personality dimensions known as Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to experience [7].

Of the five broad traits proposed in the FFM, the three major traits reported to be important educationally and relevant for higher education are: Conscientiousness, Neuroticism and Openness to experience [8]. Conscientiousness relates to one's achievement orientation where highly conscientious individuals are described as being diligent, hardworking, and organized. The level of Neuroticism determines one's ability to remain calm and composed. People who are emotionally stable (i.e. low Neuroticism) are better able to cope with stress and anxiety [7]. Conscientiousness was studied in our previous study because it is considered to be the most influential trait that can potentially affect academic success as well as team performance as reported in the psychology literature ([8],[22],[3]). In our previous studies, personality traits Conscientiousness and Neuroticism were reported **not** to significantly affect paired students' academic performance ([25],[26]); however results indicate that there is a significant positive correlation between performance and Openness to experience trait when teams comprise pairs [25].

In this study, we focused our investigation on the Openness to experience trait. Openness to experience (also known as Intellect) is the fifth factor of the FFM that relates to an individual's intellectual curiosity, need for variety, and aesthetic sensitivity according to the person's cognitive, affective and behavioral tendencies [7]. Someone who is high in Openness to experience is described as being imaginative, intellectual, receptive to new ideas, and also broad-minded. Those at the opposite end of this spectrum usually show a lack of aesthetic sensibilities, preference for routines, and favouring conservative values ([17],[7]).

Literature in personality psychology reports that Openness to experience facilitates the use of learning strategies, and that students with a relatively high level of Openness are described as being foresighted, intelligent, and resourceful [8]. Within the context of teamwork, research showed that team's performance could be impacted by the team personality composition ([4],[3],[2]). These studies however, were conducted in the context of teams consisting of three to five members. For example, Acuna et al. [2] investigated the relationship between personality, team processes, and team's effectiveness (measured by software quality and team's satisfaction) in students' team practicing Agile and their findings showed a positive correlation between personality and software quality. Therefore, in the context of students practicing PP, personality factor such as Openness to experience may play a role in differentiating students' performance. Different pairing of students practicing PP

according to their Openness trait may result in improved academic performance, poorer performance or have no impact on performance. It may also impact their satisfaction and/or confidence level with practicing PP and/or the programming tasks performed.

3. Research methodology

This Section details the formal experiment conducted during the first semester of 2010 at the University of Auckland. The experiment was conducted in the tutorial labs of an introductory undergraduate course – Principles of Programming (COMPSCI 101), where participants were first year undergraduate students. The teaching component of this course consisted of ten weeks of lectures and nine weeks of compulsory tutorials. The main aim of this course was to provide students with the basic concepts of object-oriented programming development in Java. Lectures were given three times a week, each lasting for an hour; in addition, there was a two-hour tutorial session once per week, run by a tutor and a few teaching assistants. During the tutorials, students worked with their allocated partners; data about the students’ pairing experience was gathered from every tutorial session. Students willing to participate in the experiment were required to sign a consent form to fulfill the ethical requirements of the University of Auckland’s Human Participant Ethics Committee.

3.1. Hypothesis

Personality research on team settings reports that teams composed of highly open to experience members are able to develop more diverse methods or alternatives in problem-solving tasks [17]. In addition, Openness to experience has been shown to be a strong predictor of team performance because the team members who scored high on this trait are more adaptable and capable of handling changes that occur in a dynamic environment [4]. In an academic setting, Openness to experience has been positively correlated with undergraduate academic success, in particular to students’ final grades [10]. The findings from our previous studies also showed a significant positive correlation between Openness to experience and students’ academic achievement in the midterm test and in the final exam ([23],[25]). Given this line of reasoning, we conjecture that paired students’ academic performance may be influenced by their level of Openness to experience. Hence, the following hypothesis was proposed:

H_O: Differences in the level of Openness to experience do not affect the effectiveness of students who pair programmed

which is contrasted by the following alternative hypothesis:

H_A: Differences in the level of Openness to experience affect the effectiveness of students who pair programmed

Table 1 shows the categorization of pairs according to students’ level of Openness to experience. A pair (O_{High} , O_{High}) denotes a pair combination where both students have high levels of Openness to experience. This experiment compared 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.

Table 1. Pair Configuration

Openness to experience level	Pairing groups
High	Pair (O_{High} , O_{High})
Medium	Pair (O_{Med} , O_{Med})
Low	Pair (O_{Low} , O_{Low})

3.2. Variables

In this experiment, PP's effectiveness was measured using students' academic performance in assignments (14%), a midterm test (15%), and final exam (60%). Hence, PP's effectiveness, satisfaction, and confidence were our dependent variables and level of Openness to experience (low, medium, and high) our independent variable. Level of satisfaction and confidence were measured using a questionnaire where all questions employed a five-point Likert-scale. We used the same set of instruments as in our previous experiment [25].

3.3. Instrumentations and Materials

At the start of the academic semester, one of the authors provided the participants with an overview of the experiment (including PP) in one of the course lectures. During that lecture, consent forms and participant information sheets (PIS) were distributed to the students for signing. The PIS described important information regarding the experiment and highlighted its major purpose. Participants' personality traits were measured using a short version of the IPIP-NEO (<http://www.personal.psu.edu/j5j/IPIP/>). The short version of the IPIP-NEO has been reported to measure exactly the same traits and to also present acceptable measurement reliability [15]. It consists of 120 items which descriptions were authored by Johnson [15]. The test produces personality scores in a numerical scale, with 0 being the lowest score, and 99 the highest score for each personality factor, respectively. The grouping of participants per Openness to experience was done based on the distribution of scores for the Openness to experience trait (i.e. low – lowest 15%; medium – middle 20%, high – highest 65%). This was done in order to provide a more balanced number of subjects within each group.

In addition to the personality test, participants were administered with a pre-test questionnaire to gather their demographic information as well as their programming competency level. Short questionnaires were given to the students during each of the PP sessions in order to measure their satisfaction and confidence level working with their partner. The statistical package to generate the results of our analysis was SPSS v. 17.

3.4. Experimental Procedure

We followed the same procedure carried out in our previous experiments ([25],[26]), where each of the tutorial sessions was treated as an independent formal experiment. Students' personality and demographic data were gathered during the first week of the semester. An online version of the IPIP-NEO inventory was used to measure students' personality against the FFM. The results of the personality profiling were then used to allocate partners. For this purpose, the scores on the Openness to experience trait were used to assign paired students in three possible groups: low, medium, and high.

In every tutorial, pairs were allocated randomly within each group (i.e. low, medium or high). A "single factor between-group design" was the research design we employed, allowing each subject to experience only one condition or group [20]. In a particular tutorial, a student was assigned to a pair of low Openness, medium Openness, or high Openness.

Every tutorial lasted for two hours where the first 45 minutes were used by the tutor to explain the topic, and the remaining 75 minutes were allocated for students to solve the programming exercises in pairs. To allow for "pair-jelling", students worked with their partners for an initial period of 30 minutes; and then swapped their roles every 15-20 minutes. Before the end of every tutorial, students provided feedback relating to working with the partner by filling out a questionnaire. The exercises given during the tutorials were graded, thus contributing towards the students' final grade. In addition, assignments and test were also graded, however these were completed individually.

The outcomes measured from the experiment were the students' academic performance in their three assignments, in a midterm test and in a final exam. Since tutorial exercises varied

from week to week, the experiments were designed in such a way as to minimize the confounding factor which might occur due to differences in tasks and level of complexity of exercises. Therefore, the same set of exercises was given throughout a week.

4. Results

In this Section, the results of the formal experiment are presented, followed by a discussion of results and the potential threats to the validity of our findings.

4.1 Subjects

A total of 488 students were enrolled in the COMPSCI 101 course during the first semester of 2010. Of these, 372 (76.2%) were male students, and 116 (23.8%) were female students. The subjects' age ranged from 18 to 55 years old (the mode age = 19 years). Of the 164 students who answered the demographic survey, 138 (84.1%) did not have any work experience; however 55 (33.5%) students indicated that their programming competency was above average. Of the 488 students, 154 (31.6%) students completed the personality test and have consented to participate in the study. Of these 154 students, only 137 students remained enrolled throughout the semester and sat the midterm test and the final exam. Therefore, the sample size used in our analysis was 137 students.

4.2 Data Distribution

Figure 1a shows the distribution of assignment scores according to students' level of Openness to experience. The box represents the middle 50% of the scores, with the upper and lower tails indicating the 75th and 25th percentiles, respectively. The distribution of assignments' scores for the high Openness group was more peaked than that for both low and medium groups. Both low and medium Openness to experience groups showed a similar spread. The highest and lowest medians were shown for the high Openness and medium Openness group, respectively. The outliers indicate cases where the students did not complete some of their assignments.

Figure 1b show the distribution of the midterm test scores for each of the Openness to experience levels. The dispersion of scores and median for both low and medium Openness to experience groups were similar and differed from the high Openness group, which showed a more peaked distribution, and the highest median overall. Figure 1c shows the distribution of scores for the final exam according to students' level of Openness to experience. The dispersion of scores and median for both low and medium Openness to experience groups were similar, and differed from the high Openness group, which showed a more peaked distribution, and the highest median overall.

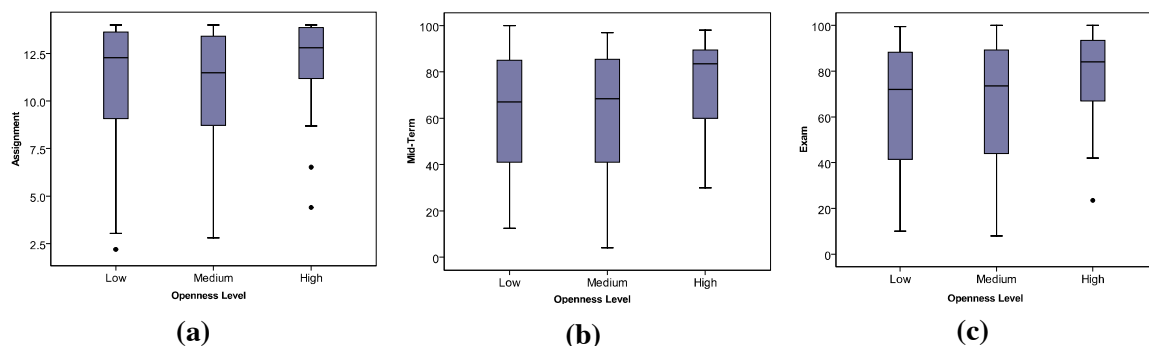


Figure 1. Comparison of academic performance between groups

4.3 Correlation Analysis

A correlation analysis using the Pearson's correlation coefficient ($\alpha = 0.05$) was performed to measure the strength of association between levels of Openness to experience and paired students' academic performance (see Table 2). The results showed a statistically significant positive correlation between Openness to experience and the midterm test ($r(137) = 0.18, p < 0.05$) and between Openness to experience and the final exam ($r(135) = 0.17, p < 0.05$). These findings corroborate the results from our previous experiments [23], [25]. In addition, there was also a significant positive correlation between Conscientiousness and all performance measures ($r(137) = 0.17, p < 0.05$ for assignments; $r(137) = 0.19, p < 0.05$ for the midterm test; $r(135) = 0.18$ for the final exam). These findings were partly consistent with those from our previous experiment [26].

Table 2. Correlation between the academic performance and the FFM (N=137)

	1	2	3	E	A	C	N
1	1						
2	0.68**	1					
3	0.69**	0.89**	1				
E	-0.06	-0.07	-0.07	1			
A	-0.01	0.08	0.08	-0.01	1		
C	0.17*	0.19*	0.18*	0.24**	0.42**	1	
N	0.04	-0.02	-0.00	-0.32**	-0.27**	-0.49**	1
O	0.15	0.18*	0.17*	0.28**	0.07	-0.02	-0.13

1. Assignments 2. Test 3. Exam

(E) Extraversion (A) Agreeableness (C) Conscientiousness (N) Neuroticism (O) Openness

** Correlation is significant at the 0.01 (1-tailed)

* Correlation is significant at the 0.05 (1-tailed)

4.4 Hypothesis Testing

The null hypothesis was tested using the one-way analysis of variance (ANOVA) test to analyze whether there was any significant difference in academic performance between the three levels of Openness to experience (low, medium, and high). ANOVA compares the variance between the groups of low, medium and high Openness and produces the F ratio, which represents the variance between the groups [21].

Table 3 provides the mean and standard deviation values for academic performance for each group. Overall mean values indicate that paired students of high Openness performed better in the assignments, midterm-test and exam than the other groups. The results from the Levene's test for homogeneity of variances indicate that the variances of scores were significantly different for each group of Openness to experience (i.e. $F(2,134) = 5.78, p < 0.05$, for assignments; $F(2,134) = 5.29, p < 0.05$, for midterm; $F(2,132) = 6.88, p < 0.05$ for exam). In this case, the homogeneity of variance assumption was violated and therefore instead of referring to the ordinary ANOVA, the Robust Tests of Equality of Means needed to be consulted using either the Welch or Brown-Forsythe test [21].

Both tests (Welch and Brown-Forsythe) indicate that there was a statistically significant difference between the three levels of Openness to experience relating to the mean scores of paired students' academic performance ($\alpha = 0.05$). Based on the p values, we had evidence to reject the null hypothesis and it can be concluded that at least one of the groups means is significantly different from the others (i.e. $W(2, 87.51) = 4.79, p < 0.05$, for assignments; $W(2, 88.81) = 7.43, p < 0.05$, for the midterm test, and $W(2, 86.72) = 7.65, p < 0.05$, for the final exam).

Post-hoc comparisons were performed to further examine which groups means differed. For this purpose, we applied the Games-Howell procedure because it was reported to be the

appropriate procedure to be used when the assumption of equal variances was violated [20]. The results from applying the Games-Howell test could be summarized as: i) Paired students of high Openness to experience achieved better performance in assignments, midterm test, and final exam when compared with their counterparts ($p < 0.05$). ii) Paired students of lower and medium Openness to experience had comparable performance in assignments, midterm test, and final exam ($p < 0.05$).

Table 3. Mean and Standard Deviation of Paired Students' Academic Performance

Performance Measures	Openness Level	N	Mean	SD
Assignments (Range: 0 to 14)	Low Openness	48	11.02	3.58
	Medium Openness	47	10.24	3.41
	High Openness	42	12.06	2.23
	Total	137	11.07	3.23
Midterm scores (Range: 0 to 100)	Low Openness	48	64.14	22.72
	Medium Openness	47	57.97	26.53
	High Openness	42	75.67	18.89
	Total	137	65.56	24.00
Exam scores (Range: 0 to 100)	Low Openness	48	66.83	26.46
	Medium Openness	45	60.17	28.51
	High Openness	42	79.30	19.35
	Total	135	68.49	26.23

We conducted a post hoc power analysis using the G*Power 3.1.2 to compute the statistical power of the ANOVA test employed in our experiment [11]. A statistical power represents the likelihood that a treatment effect will be observed whenever there is one. High power indicates greater ability to detect a difference between treatments if a true difference exists, when compared with a study with low statistical power [9]. Our analysis indicates that this experiment demonstrates a reasonably high statistical power (between 0.70 and 0.88) with a medium effect size (ranging between 0.24 and 0.30).

5. Results on Satisfaction and Confidence

We analysed paired students' levels of satisfaction and confidence based on data gathered from a PP questionnaire distributed in each tutorial session. Data were gathered starting from the third week onwards to give students ample time to familiarize themselves with PP during the first two weeks of tutorials. The questionnaire's response rate was initially 81.7% when gathered for the first time; however it decreased to 56.9% for the last week of tutorials.

Students indicated their level of satisfaction working with their partner by answering the question "*Please rate how satisfied are you working with your partner*", measured on a scale from 1 (very dissatisfied) to 5 (very satisfied). On average 75 (87.2%), out of an average of 86 students attending the tutorials, were satisfied working with their partner. The Kruskal-Wallis test was used to compare satisfaction levels between groups of different levels of Openness to experience. Table 4a shows the mean satisfaction rank of paired students, where a higher mean rank indicates a higher satisfaction level. The results indicate that there was only one tutorial (i.e. tutorial 4) that showed a significant value ($\chi^2(2, 99) = 7.19, p = 0.03$); therefore, overall our results demonstrated that the satisfaction level of paired students were not affected by students' level of Openness to experience.

Students reported their confidence level by answering the question "*How do you rate your level of confidence solving the exercises with your partner?*", measured on a scale from 1 (very low) to 5 (very high). On average 73 (84.9%), out of an average of 86 students attending tutorials were highly confident in the correctness of their programming solutions when working in pairs. Table 4b presents the mean rank for paired students' confidence level, showing only one tutorial with a statistically significant difference in confidence level across

the three groups (tutorial 4, $\chi^2(2, 99) = 8.78, p=0.01$). Overall findings indicate that paired students' confidence level was not affected by students' Openness to experience level.

Table 4. Mean rank for satisfaction & confidence level

	Openness Level	N	(a) Satisfaction			(b) Confidence		
			Mean Rank	Sig.	(%) Satisfied/ Very Satisfied	Mean Rank	Sig.	(%) High Confidence
Tut. 3 N=112	Low	37	49.27	0.19	87.5	50.15	0.24	83
	Medium	37	59.35			61.91		
	High	38	60.76			57.42		
Tut. 4 N=99	Low	33	48.26	0.03	81.8	49.02	0.01	78.8
	Medium	34	59.16			59.96		
	High	32	42.06			40.44		
Tut. 5 N=97	Low	35	48.44	0.27	86.6	43.97	0.26	86.6
	Medium	34	54.10			54.22		
	High	28	43.50			48.95		
Tut. 6 N=63	Low	18	29.31	0.08	87.3	28.06	0.18	85.7
	Medium	31	29.73			31.19		
	High	14	40.50			38.86		
Tut. 7 N=70	Low	26	34.46	0.84	85.7	32.98	0.68	84.3
	Medium	19	37.58			37.50		
	High	25	35.00			36.60		
Tut. 8 N=84	Low	28	46.95	0.33	95.2	47.82	0.23	91.6
	Medium	29	38.55			38.03		
	High	27	42.13			41.78		
Tut. 9 N=78	Low	26	37.48	0.69	89.7	40.75	0.86	87.2
	Medium	24	42.40			40.10		
	High	28	38.89			37.82		

In addition to measuring the satisfaction and confidence level, students' feedback on the following questions were also gathered: (Q1) "I felt that working with this partner was a productive experience"; (Q2) "I enjoyed working with my partner"; (Q3) "My motivation level increased when working with my partner".

Based on the students' feedback, on average 78 out of 87 students (89.7%) indicated that their pairing experiences was productive (Q1). In terms of enjoyment, 78 out of 87 students (89.7%) agreed that working with partner was an enjoyable experience (Q2). PP also helps increased students' motivation level (Q3). On average 73 out of 87 students (83.9%) agreed with the statement mentioned in Q3.

6. Discussion

The findings from this experiment showed that paired students' academic performance appeared to be significantly affected by students' Openness to experience level. These findings corroborate some existing results reported in the personality-psychology literature. For example, Blickle [5] found Openness to experience to be positively associated with academic performance. His findings indicate that the Openness to experience trait has a crucial effect on the learning strategies, which mediate the relationship between personality trait and performance [5].

Ackerman and Heggestad's meta-analysis [1] revealed a substantial positive correlation between Openness to experience and intelligence, and "knowledge and achievement". Matzler et al. [18] have shown in their study that the acquisition and dissemination of knowledge are greater for teams scoring high on Openness to experience.

In the context of paired programming, students working collaboratively in solving programming tasks can benefit from the elements of Openness to experience by being more willing to engage in learning experiences. Studies' findings report that the mean level of

Openness to experience in team compositions positively influences knowledge sharing among team members ([14],[18]). It means that a team composed of higher aggregate levels of Openness to experience resulted into higher levels of knowledge sharing [14]. LePine [17] stated that *“In a team setting, open individuals should not only make more suggestions, but because they tend to be insightful, enthusiastic, and talkative, they should tend to build on the ideas of other members”* (p. 32).

Openness to experience is considered a better predictor when the situation involves novel or complex tasks [12]. Thus, it is also possible that paired students who are high on Openness to experience were more inquisitive in solving complex issues such as programming problems. This is because open individuals tend to be more creative and receptive to ideas/change and willing to try new thing or learning to do different things ([17],[13]). In our experiment, we found a positive correlation between Openness to experience and paired students' performance in the midterm test and final exam, a result which is consistent with the findings from our previous experiments ([23],[25]). The findings from the present experiment also showed that paired students of high Openness levels outperformed those who have low and medium level Openness, thus confirming our supposition that differences in Openness to experience levels affect the academic performance of students who pair programmed.

There are several potential threats to the validity of our findings. In our experiment, academic performance was used as our dependent variable and a surrogate measure of PP's effectiveness. However, students' academic performance may also be affected by other factors such as learning styles, self-motivation, and programming ability or competency. In spite of being a surrogate measure, students regularly attend the tutorial and practicing PP throughout an entire semester may have had an influence on their learning process which eventually affected their performance in the test and exam.

Due to the limitation in the sample size employed in this study, we are able to account for only a single personality factor (i.e. Openness to experience) and this prevents us from controlling for the effects of other personality factors towards pairing effectiveness or students' academic performance. For instance, students may perform well in this course because of their conscientious behavior regardless of their high level of Openness to experience. We suggest that future replication study should consider controlling the effects of these two major personality factors.

7. Conclusions and Future Work

The findings from the present experiment provide strong support to our alternative hypothesis regarding the effects of the Openness to experience factor on PP's effectiveness (measured by students' academic performance). We found evidence that the level of Openness to experience played a significant role in influencing students' academic performance where paired students of high Openness achieved better performance compared with their counterparts. The satisfaction and confidence level of students who worked in pairs, however, were not affected by their level of Openness to experience. Results showed that on average 87% of students indicated that their satisfaction level was high when working with their partner. Similarly, most students (85%) responded that they had high level of confidence in solving the programming exercises collaboratively with their partner. As part of our future work, we will replicate this experiment to confirm or refute this finding.

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