Practical Consideration of Pair Problem Solving in Computer Literacy Education

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Abstract

Direct instruction to students enrolled in a computer literacy program at the undergraduate level frequently involves difficulties due to varied knowledge levels and skills among the students, as well as an increase in the number of unmotivated students. An available solution is the pair problem solving approach which can prove to be effective as an effective method. This report shares the findings of an investigation regarding the efficacy of pair problem solving, as compared to individual problem solving in computer literacy education. Furthermore, the paired approach analysis was able to extract specific criteria for successful pairs. The research, which included two (paired and individual) 15-minute practical examinations and questionnaires, a test on basic scholastic ability, and a survey on PC experiences, was conducted with approximately 280 students from three universities who were enrolled in a computer literacy program in 2008 and 2009. The results reveal that the overall scores of the pairs exceeded those of the individuals. Moreover, more than 90% of students found pair problem solving to be a positive experience. From the viewpoint of learning effectiveness, it is worth mentioning that the most effective pair combinations included those with a small difference in basic academic ability, a large difference in PC experience, and a partner of the opposite sex.

Keywords: pair problem solving, computer literacy

Introduction

With the advent of declining university enrollments, university instructions are becoming difficult to be followed because of different cognitive and behavioral characteristics observed in students, such as lower academic ability and intellectual curiosity (Figure 1).

The skills needed to operate a computer have diversified and the computer literacy gap has expanded.

Because of this, there have been arguments for the necessity to strictly review educational content and methodology particularly for computer literacy education (Murakami et al., 2008). Given the current situation, interactive and participatory approaches for effective instructions that focus on the student have been taking place. It has been reported that cooperative learning is very effective in research and in practice, particularly for pairs and small groups. Therefore, the expectations from these methods are increasing (Yasunaga, 2008, Tachibana et al., 2010).

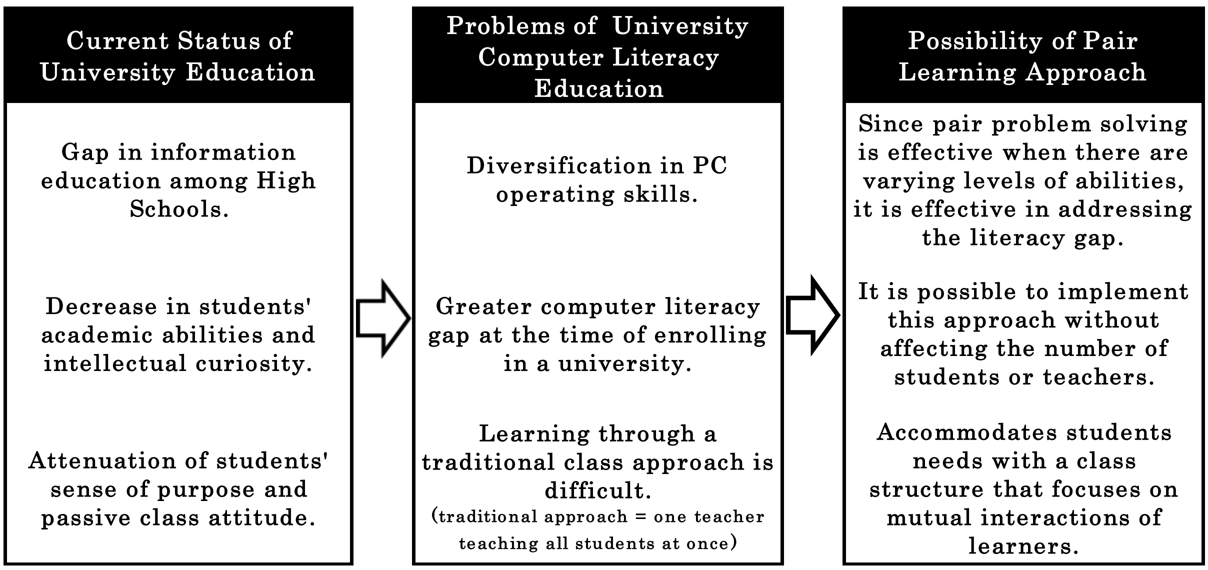

Figure 1 Background of research

The effects of the pair approach within information education suggest possibilities, such as encouraging information literacy, and stimulating students' desire to learn, (Takahashi et al., 2004) as well as improving their ability to complete tasks, solve problems, and learn independently (Terakawa et al., 2005). On the other hand, there are indications that depending on the pair combination, there may not always be an effect on learning or that there might be issues with developing methods to form effective pairs (Kaneko et al., 2007, Takahashi et al., 2010). However, regardless of the numerous reports on the subject, there is a lack of understanding of pair combinations or combination criteria because there are few studies that deal with this issue. Keeping this in mind, the authors of this study introduced a pair approach into university computer literacy education in 2008. They examined the effectiveness of this approach by comparing individual problem solving with pair cooperative problem solving and verifying the effects pair combinations have on the results. Thus far, it is evident that pair cooperative problem solving improved the overall task achievement level and was particularly effective for students with lower grades and with mixed-gender pairs (Uchida et al., 2010). The students' assessment of pair learning was high, indicating that this method was effective in meeting students' needs (Uchida et al., 2010). However, this method also has certain disadvantages such as striking differences observed between pair results and either no or negative effects with certain pair combinations.

This study first reports the problem solving results with pairs from a pair combination criteria perspective based on the results of pair solving approach in class, conducted from 2008 to 2009. It also focuses on the problem-solving process as an index for learners' awareness toward working as pairs as well as the quantitative changes in utterances among pairs, as a means to examine the issues of problem solving for selected pairs. Finally, the study considers the pair learning effect from the amount of utterances and survey results to determine how cooperative problem solving is effective through conversation and student trends.

Methodology

The subjects of this study were enrolled in a computer literacy program in 3 departments of 2 private universities in Aichi Prefecture. A total of 7 classes and 280 students participated each year for 2008 and 2009. In April, students were surveyed on pair combination criteria and in July, experimental classes were held for pair testing (Figure 2).

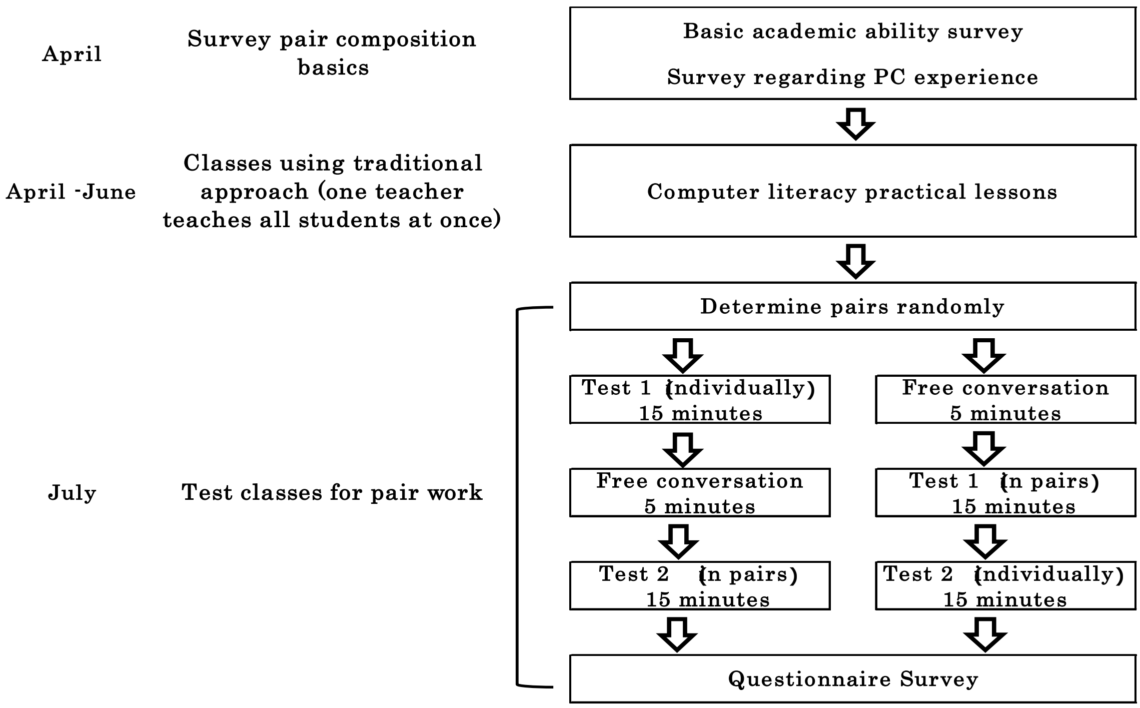

Figure 2 Outline of the study

Pair Combination Criteria

In 2008, students were surveyed on their basic academic ability, computer experience, interest in computers, and typing speed in order to gain basic data regarding the pair combination criteria. Of these four criteria, a prior study has acknowledged the relationship between basic academic ability and scholastic performance of students after enrolling in university, adapting to university education, and scores in the national exams. Three other items reflected computer literacy before university, which is the basic premise for computer literacy education, and were included because objective data on them is relatively easy to obtain.

Given the results of 2008, the 2009 survey focused on 2 indicators; basic academic ability, which implied involvement in problem solving and performance in pairs, and computer experience before university.

The basic academic ability survey consisted of 20 math and *kanji* (Japanese character) problems and used an adjusted difficulty level so that performance would approximate a normal distribution. Math problems were composed of basic math problems developed to measure university students' academic abilities. *Kanji* problems referenced the *kanji* test that measures basic Japanese ability. The survey lasted 20 minutes and surveys were collected individually for each participant.

The survey on computer experience before university had 20 multiple-choice questions about the Internet, software, and computer usage inside and outside the school. In the 2008 survey, there were few questions and the multiple choice answers varied based on the question. The 2009 survey improved on these two issues. The survey time lasted 5 minutes and surveys were collected individually for each participant.

Pair Problem Solving

After 8–10 practical computer literacy classes, students were tested (Test 1 and Test 2) individually and in pairs for 15 minutes (22 questions) based on word-processing proficiency. Pair groupings were randomly selected to determine the effect of pair combination criteria. Then, students in each department were divided without bias per class. Approximately half of the students took Test 1 individually followed by Test 2 in pairs. The remainder of the class took Test 1 in pairs followed by Test 2 individually. In each of the divided groups, almost all students were in the same year of school and from the same academic discipline. Since one teacher taught the same material to both groups, the difference between the groups is presumed to be negligible. During the test, students solved problems in pairs and individually, and the results were collected individually for each participant. According to preliminary investigation, the dispersion for Test 1 and Test 2 was set to a certain level adjusting the difficulty level so that the average variance of correct responses differed by 15 to 20 percent. Furthermore, in order to eliminate the issues with testing order in 2009 and 2008, the tests were conducted in the reverse order (switching Test 1 and Test 2).

Before the pair test, students were given five minutes for free conversation to develop smooth communication for each pair's first encounter. Twenty minutes of conversation was recorded from the time free conversation began to the end of the pair test. After the test, the students took a survey about their method of problem solving in pairs. The 2009 survey improved upon the issues with multiple choice expressions that were apparent during the 2008 study. The survey time lasted 5 minutes and surveys were collected individually for each participant.

Analysis of Results

The analysis of the results employed a standard deviation as a standardized score to comparatively examine the values from Test 1, Test 2, basic academic ability, and computer experience. The amount of utterance was determined by converting the conversations recorded during the pair tests into text. The number of times students spoke was treated as the amount of utterances and the number of characters was treated as the utterance character count. The analysis of the pair results used in this study consists of the values that were calculated by subtracting the individual test scores (standard deviation) from each subject's pair test scores (standard deviation), added according to pairs.

Results and Interpretation

Outline

Looking at the results from the individual and pair practical tests 1 and 2, the pair tests (average standard deviation: 50.65 in 2008 and 51.62 in 2009) surpassed the scores from the individual test (average standard deviation: 49.34 in 2008 and 48.36 in 2009) (ρ = 0.0015 for 2008 and ρ = 0.0001 for 2009). As an overall trend, this indicates that the task achievement level improves through pair problem solving. However, from an individual perspective, there was either no difference between the pair and individual results or the pair results were negative for close to 40% of students. On examining the relationship between pair and individual tests, trends were indicated in which pair problem solving had relatively less effect for students who scored high in the individual test, while students who scored lower improved (Figure 3). Previous research has also extrapolated that working in pairs is more effective for students with lower grades.

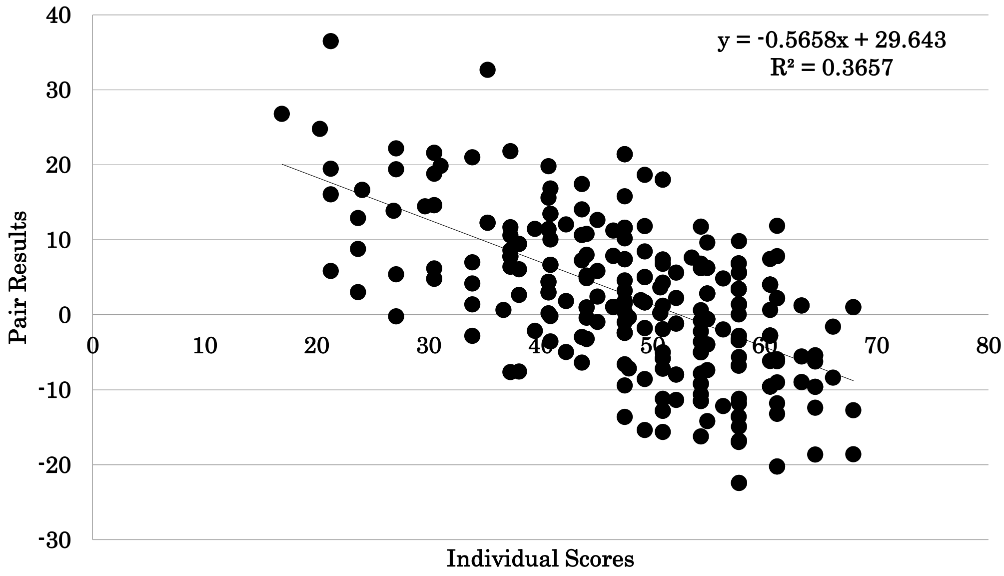

Figure 3 Individual scores and pair results

Criteria for Pair Combination

Table 1 Pair Results and Pair Combination Criteria

Pair Combination Criteria	H (High Pair Results)			L (Low Pair Results)			t value	ρ
	n	m	s.d.	n	m	s.d.		
Basic Academic Ability Difference	92	8.85	6.24	36	14.45	8.29	3.63	0.001 **
Difference in PC Experience	92	8.88	6.81	36	7.17	6.86	1.26	0.211

**ρ<.01

As for the criteria for pair combination, analysis was conducted for two indicators suggested to be effective in the 2008 study, computer experience before university and basic academic ability (Table 1). Group H with a pair score above +10 and Group L with a score below −10 were selected in order to examine the characteristics of the pair learning effect. A comparison of groups H and L indicated that the basic academic ability gap was small. The reason for this is that the gap in basic academic ability reflects the level of high school that students came from, the academic discipline, desire to learn, and class attitude. It is possible that these disparities affect the amount and quality of communication in pair testing. On the other hand, trends indicated that the gap in computer experience was greater in Group H and lesser in Group L, although the difference between the two was insignificant. The idea was that students with richer experience taught the students who lacked experience, which made the pairs more effective. However, the hypothesis is that for pairs with a lower computer experience, students would get stuck or need help in the same places, and although they consulted each other, they could not solve the problems.

Table 2 Pair Results by Gender and Amount of Conversational Utterance

	Pair Gender	Pair Results	Amount of Conversational Utterance
Male	same	0.85	2138.3
	mixed	6.3	2114.8
Female	same	1.68	2200.1
	mixed	4.3	2127.4

In addition to the two indicators—basic academic ability and computer experience before university—it was clear that gender was a factor in problem solving and performance. Males uttered less overall and male gender pairs were less effective, while mixed-gender pairs were more effective (Table 2). On the other hand, females overall were more vocal, although the result was that females vocalized more with same gender pairs as opposed to mixed-gender pairs. However, females achieved greater results with mixed-gender pairs as opposed to same gender pairs. Furthermore, there was a high correlation between the amount of utterances and the pair results with females than with males. The outcome determined that mixed-gender pairs are more effective, followed by female pairs with male pairs being the least effective.

From the above results, it can be concluded that the most effective pair combinations have a small gap in basic academic ability, a large gap in computer experience, and a partner of the opposite sex.

Pair Learning Effect and the Amount of Utterances

The vocal data (roughly 100 per year) collected during the pair test was converted into text. The conversation was analyzed by the amount of utterances and the character count of the utterance.

There was a strong correlation ($r = 0.98$, $y = 19.3x$) between the amount of utterances and utterance character count. The average number of times students uttered during the 15 minute, 22 question (Q1–Q22) pair test was 106.0 and the average utterance character count was 2107. In other words, it was evident that there were 7 conversational exchanges every minute and they spoke roughly 20 characters at a time. Moreover, depending on each pair, the utterance character count was disproportionate (highest was 4733 characters and lowest was 83 characters) and there was a large difference between the test results. Examination of the relationship between the overall utterance and pair results showed that vocal pairs were more effective (Figure 4, $r = 0.42$).

Looking at utterances for each question, there was more utterance for Q2 (insert a page number in the center of footer) in Test 2, which had a character count of 342, than Q9 (create an autoshape, and insert characters) in Test 1, which had a character count of 188. From these results, we can conclude that depending on the pair, there was a communication gap and a significant increase in utterances for problems with functions including a lot of steps or functions that were used less frequently during the class.

Looking at the changes in utterances over time, utterances increased in the latter half of Test 1, which had a higher average score, and the utterance was particularly high for Q13–Q18. In contrast, Test 2 had higher utterances for Q1–Q11 with significant reduction in the latter half. Furthermore, there was a difference between Test 1 and Test 2 for the pair learning effect by problem.

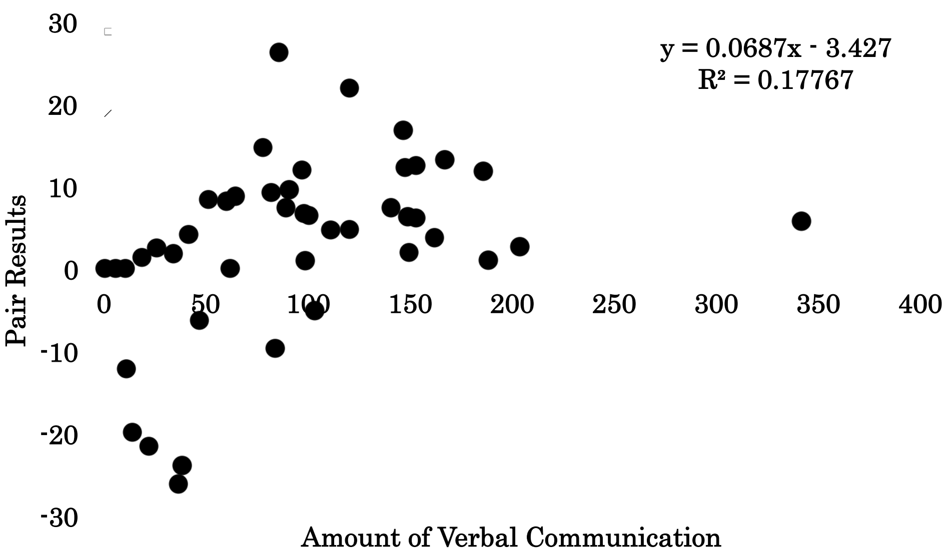

Figure 4 Relationship between pair results and amount of conversational utterance

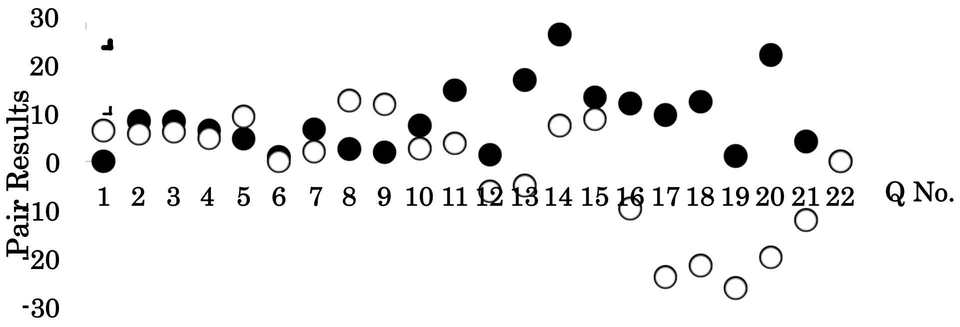

Figure 5 Pair results by each question（● –Test1 ○ –Test2）

While it was more effective in questions Q13–Q18 for Test 1, Test 2 indicated negative values for Q16–Q21, which was lower than individual scores (Figure 5). Compared to Test 1, the difficulty level for Test 2 was slightly higher. This led students to spend more time communicating during the pair test, leaving less time for them to solve problems in the latter half of the test.

As demonstrated above, the amount of utterances changed during problem solving for each pair depending on the difficulty level of the problem and their time management skills, suggesting that it impacted the positive effect of working in pairs.

Learner Awareness for the Pair Test

Judging from the results of the survey conducted after the pair test, a relationship between the effectiveness of pairs and a trend toward awareness of the pair test was considered. In 2008, the survey included 10 items in 2008, whereas it comprised 11 items in 2009.

Table 3 Survey Items with Significant Differences from Pair Results

Survey Item	Pair Result	n	m	ρ	Judgement
Easier to solve as a pair than individually	H	174	2.41	0.0001	**
	L	86	1.99		
Consulted during the pair test	H	174	2.54	0.0017	**
	L	86	2.25		
A free conversation time before the pair test is necessary	H	98	2.33	0.0028	**
	L	42	2.66		
There was sufficient time for the pair test	H	76	0.28	0.0053	**
	L	44	0.07		
Communication during the pair test was usef	H	174	2.69	0.0174	*
	L	86	2.52		

Analysis of the significant difference between Group H, which was highly effective in terms of the pair learning effect, and Group L, which was less effective, was conducted with respect to these questionnaire items. The results of the common items from 2008 and 2009 were totaled together.

First, Table 3 shows the items that pointed the significant differences. These results infer a willingness to solve problems cooperatively and communicate with each other, and whether or not they had sufficient time determined how effective pair learning was. As such, a positive attitude and increasing participation awareness of cooperative problem solving, expanding the ability to communicate, and improving time management skills are essential to promoting effective pairs.

We can interpret from the survey items (Table 4) where there was no significant difference between confidence in the class and students' interest toward computers, and these items are unrelated to the effect. Free conversation time beforehand, the pair testing evaluation, and students' interactions that were high across the board, are useful suggestions for setting up pair approach classes.

Table 4 Survey Items with No Significant Difference with Pair Results

Survey Item	Pair Result	n	m	ρ	Judgement
Pair works were easy to understand	H	76	1.47	0.3193	
	L	44	1.41		
Free conversation time was sufficient	H	98	2.72	0.2808	
	L	42	2.66		
Pair work approach works well	H	98	2.65	0.2677	
	L	42	2.60		
Interest in computers	H	76	1.82	0.2673	
	L	44	1.72		
Friendly interaction with partner	H	98	2.50	0.2096	
	L	42	2.60		

Conclusion

The results from the two-year experimental classes with pair testing provided the following findings within computer literacy education at university.

1) Pair problem solving was higher than individual problem solving and it confirmed that pair task achievement was higher overall. On the other hand, from an individual perspective, working in pairs was ineffective or less effective for nearly 40% students.

2) The study inferred that the combination of criteria such as mixed-gender pairs with similar academic ability and differing computer experience was highly effective.

3) The study discovered characteristics such as a greater discrepancy in the amount of utterances for certain pairs and remarkable increase in utterances for questions involving functions with more process steps or functions that were used less frequently in class.

4) Amount of utterances changed depending on the difficulty level of the problem or their time management skills, indicating an impact on the effect of working in pairs.

5) The study suggested that it is possible to improve pair learning results by improving students' participation awareness and positive attitude toward cooperative learning, as well as improving their ability to communicate and time management skills.

Further detailed analysis of the issues related to the pair learning approach will be conducted to resolve factors that affect the positive effect of pair learning. In addition, this study captured the pair learning effect through short-term experimental classes and consideration of further long-term application is necessary.

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