

# Pair-Programming in Online Programming Learning Environment

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## Abstract

We know that pair-programming is more effective individual programming. Then, pair-programming allows not only having more elaborate and high program score but also learning the programming more effectively, easily and funny. To begin with, we have described the design of the system for online pair-programming. The system has been considered both cases of synchronous pair-programming at the real-time and asynchronous pair-programming at the non real-time. Then we experimented to make sure of the usefulness of pair-programming in online environment for novice. We compared the learning efficiency between online and offline synchronous pair-programming using Nebraska of Squeak that is educational programming language for novice. The experiments have led to an effect and a possibility of the online pair-programming as well as offline pair-programming. Our findings will help educators to design the system for the online pair-programming effectively.

## 1. Introduction

The revolution in information technology (IT) and computer has resulted in innovations that are having increasingly visible affects on the human life. There is high interest for the computer education in K-12 curriculum and growing a size of investment for that. We need right methods and tools for teaching a content of computer education, including programming which is essential part of the CS curriculum.

We expect that learners learn the education programming language more easily and they can program and simulate what they want. This point of view, Pair-programming is noted for the method in collaborative learning. It first suggested that commercial programmers could

develop an application efficiently and effectively.

The Pair-programming is widely acknowledged as a more effective method than developing individually by extreme programming (XP) developers and researchers. The important fact is that the pair-programming allows not only having more elaborate and high program score but also learning the programming more effectively, easily and funny. Therefore, the pair-programming could be a useful and effective method for a programming education.

Especially, we need to present more various learning environments on the pair-programming. That is why a collaborative learning environment can make feasibility effective learning among learners of different place, age and various characters over the temporal and spatial limit.

The goal of our study is making an experiment on feasible of online pair-programming and designing a system adequate to the pair-programming for the distance-learning environment.

In this paper, we describe on features and researches of the pair-programming. We make an experiment on comparing a co-located pair-programming with a distributed pair-programming.

Moreover, we propose a pair-programming system for online programming environment. The system makes the learners program in on-line with features of established pair-programming keeping. In design of this system, we consider both cases of a synchronous statue at real-time programming learning and an asynchronous statue at non real-time programming learning in online.

## 2. Background

### 2.1 Pair-programming

Pair-programming is a style of programming in which two programmers work side by side at one computer, continuously collaborating on the same design, algorithm, code, or test [1].

Pair-programming could be used in classroom with several synergistic behaviors. Students put a positive form of pressure on each other. It allows pair negotiation, reviews and debugging to get the best solution together. Knowledge is constantly being passed between partners. Students feel fun with Pair-programming than working alone [7].

### 2.2 Related Works

There have been many research studies on the pair-programming. They found that for a development-time cost of about 15%, pair-programming improves design quality, reduces defects, reduces staffing risk, enhances

technical skills, improves team communication and is considered more enjoyable at statistically significant levels than students who programmed independently [2, 4, 6].

Moreover, the result of an experiment indicated that distributed pair-programming is a feasible and efficient method for dealing with team projects [1], and showed that internet-based real-time collaborative programming allows physically dispersed programmers to concurrently and collaboratively design, code, test, debug and document the same program [5].

## 3. Online Pair-programming System

In this section, we propose the system for an online pair-programming. Even if an asynchronous pair-programming is slightly inefficient, we present not only a synchronous pair-programming system but also an asynchronous pair-programming system.

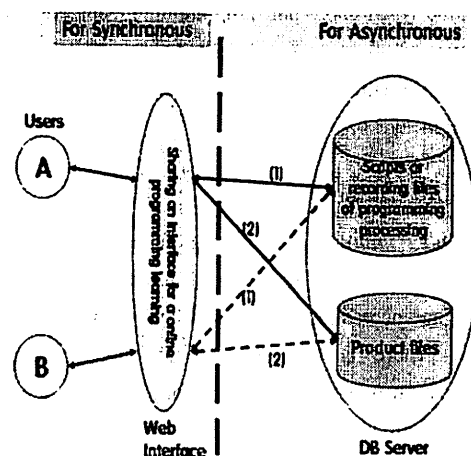


Fig. 1 Pair-programming for Synchronous and Asynchronous in online programming learning environment

Firstly, in case of the synchronous situation that distributed learners A and B program on real-time, the learner A and B can perform an assignment at the same time by a rule. At that time, the system

must allow to program at the same time with sharing their working interface and support various communication devices for communicating smoothly like internet chatting applications, white board and web board. In addition, while one user works, it is necessary to control so that others and a user cannot work.

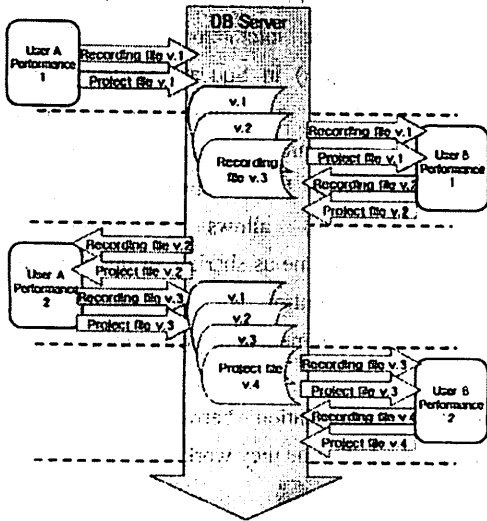
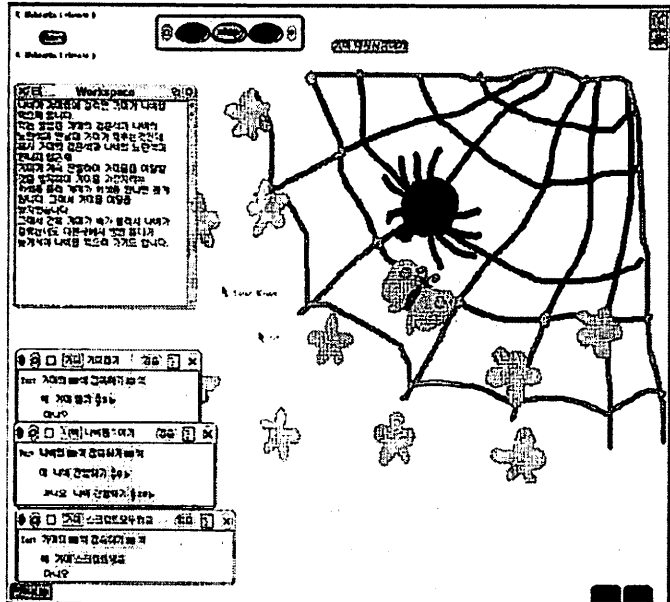


Fig. 2 Learning Processing for Asynchronous Pair-programming

Second is the asynchronous situation that distributed learners A and B program on non real-time. A program is constructed by the system which exchanges the authority for carrying out a subject after students have deliberations to a subject with putting in order. The learner programs for a set time then the system store a file recoded or scripts included all of programming process. When learner A finishes to program, the system stores a final programming product as well.

Fig.3 Interface of Server side using Squeak Nebraska →



In the same way, the learner B can connect after the learner performs. When the learner B connects, the system applies the stored files recoded or scripts included all of programming process of the A. Next the learner B looks at the programming processing, he programs taking over to the product file loading from the DB server.

As they repeat the process like that, the learners A and B could get an effect of pair-programming in the asynchronous learning environment as well.

### 3.1 Experiment

As we have seen, existing researches have presented an effect of the pair-programming in off-line or on-line environment for commercial programming. Therefore, this paper makes an experiment on a possibility of the online pair-programming for novice. We assume that the learning effect of the online pair-programming would be similar to that of the offline pair-programming.

In the experiment, we only compared a learning effect between a co-located pair-programming team and a distributed pair-programming team. It

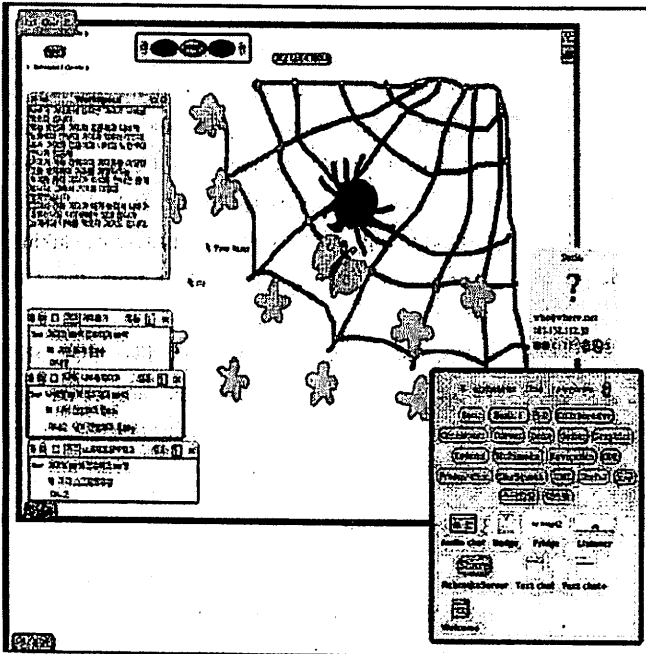


Fig. 3 interface of Client side using Squeak Nebraska

### 3.2 Method

This experimentation was performed during five weeks, for 3rd grade students (N=68) of National University of Education during May ~ June, 2006. The students were a novice on the programming. Therefore, they performed assignments of four varieties during four weeks with pair-programming above and beyond assignments for basic programming skills. Then we had an individual final test at the last week. We supposed that their learning ability and interest area was equivalent as students of same university and same department (dep. of art education). The main feature and the learning environment of these two groups in this experiment are as follows.

#### 1. Distributed team (17 groups)

The second set is a distributed team group. After the students paired, they performed programming assignment with interface sharing using each computer at the remote situation. At this time, we allowed to chat with text and phone (they can use a messenger with headset) for

is for this reason that the pair-programming is much more effective than the individual pair-programming.

Especially, we had an experiment with Squeak using a Nebraska for the distributed pair-programming.

Nebraska is a toolkit for building remote interactions with morphic (object) in Squeak. Students could share a mouse or keyboard interaction in same contents of screen [3]. "Nebraska" of Squeak (e-toy) allows performing on real-time as sharing an interface and a control for the programming assignment at the same time.

smooth communication between each other during the whole time they worked.



Fig. 5 Distribute team

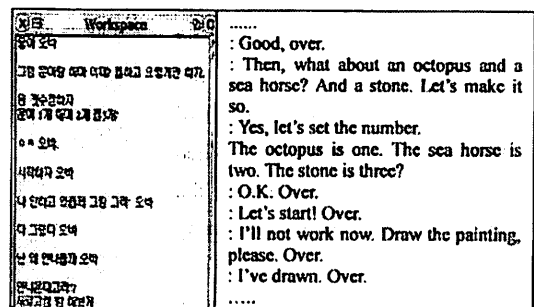


Fig. 6 Example of chatting

## 2. Co-located team (17 groups)

The first set is a co-located team group. After the students paired, they performed the programming assignment side by side using one computer in the same space. There were no special conditions on the system. They programmed by turns with an established rule and time.

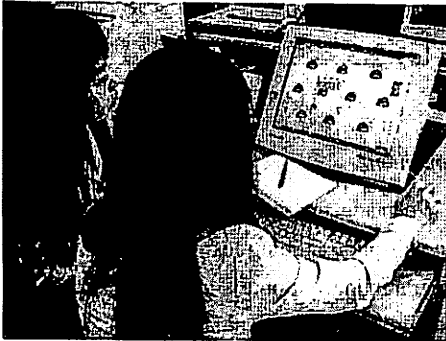


Fig. 7 Co-located team

## 3.3 Experimental Results

We, as was suggested above, made learners learn the basic skill and presented assignments that the team can solve together. Then, at the final week, we examined all of them individually.

We estimated a *program score* as productivity of the assignment and a *creative idea* as Quality. Then we compared the result between two groups.

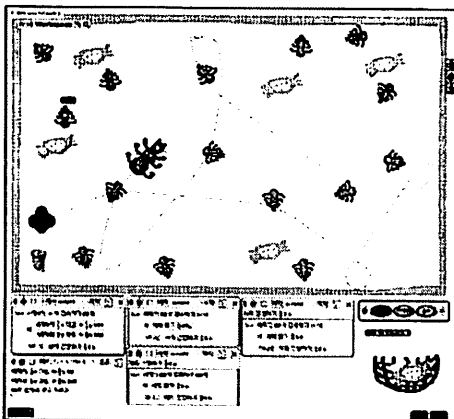


Fig. 8 4th assignment using Squeak: An application of a conditional

## The program score

Learning the programming language effectively means that the learner can solve completely and elaborately conditions of the assignment. Accordingly in this experimentation, we scored the program score of assignment as detail items like a naming of objects and scripts, a using a variable and a conditional sentence, a control button and conditions on each assignment that the learners solved. The scores in two classes were compared using T-test. The result of the two groups on the program score is as follows.

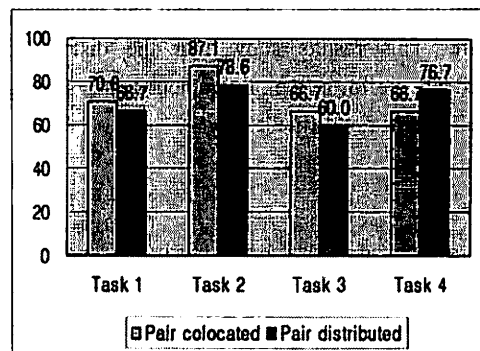


Fig. 9 The program scores (%)

From Fig. 9, the program score of the initial assignments can be seen that pair distributed team has lower scores than pair co-located team. This small difference, however, was not statistically significant with  $p > .05$ . This finding suggests that learners can learn with pair-programming not only in online learning environment but also in offline learning environment.

## The creative idea

Another condition of effective programming learning is a quality of the completed program. With a program making together, at once learners can make a bid for a new idea and add some other scripts or functions. The creative idea is making new algorithms or ways from adding

various ideas besides an idea (of an algorithm) that the teacher present at first.

For example, when students make drive a car on the motor-racing track, students can use differently a number of sensors and a color of the track (or the background) or they can have the other ideas like making some defenses, having acceleration about specific conditions.

In conclusion, with the assignments performing, it is evident that learners encourage each other and communicate smoothly.

Fig. 10 shows that both the teams had various ideas as time passed. Especially, pair distributed team had more creative idea than pair collocated team. This results show that the distributed students perform the assignment with sharing their idea is not difficult as well.

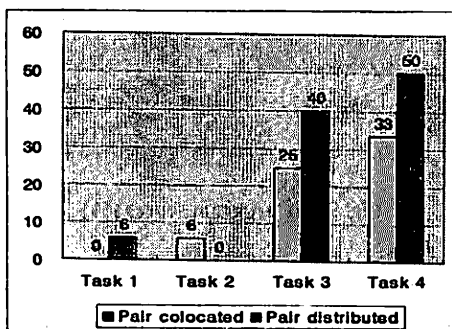


Fig. 10 The creative idea (%)

*Final Test*

Then we presented a final test assignment. The programming assignment included all functions learners had learned. The result is as follows.

Though it shows that the pair distributed team has lower scores than the pair co-located team, the score also was not statistically significant with  $p > .05$ . Thus it appears that the online pair-programming is very effective for novice programming learning as well.

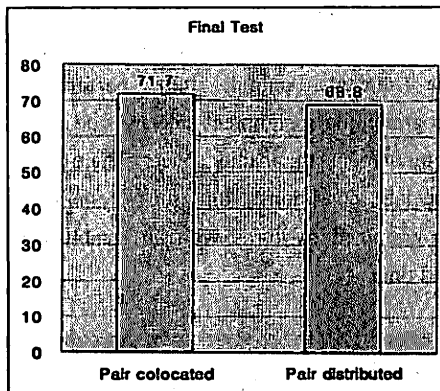


Fig. 11 The final test scores

*Sentiment*

We made the students note a sentiment about the pair-programming learning after they finish up programming. Some students of the pair distributed teams noted about the online pair-programming as follows.

*"Although we used a chatting, a communication is not easy. But sharing this interface and input device (mouse, keyboard) together, I think that it will be good if we use to a collaborative drawing learning."*

*"Because of performing together, the good idea smote me."*

*"Because of distance-programming, though we didn't locate together, it was nice that we could cooperate."*

From the results of the test and the observation on instruction, the following suggestions were obtained.

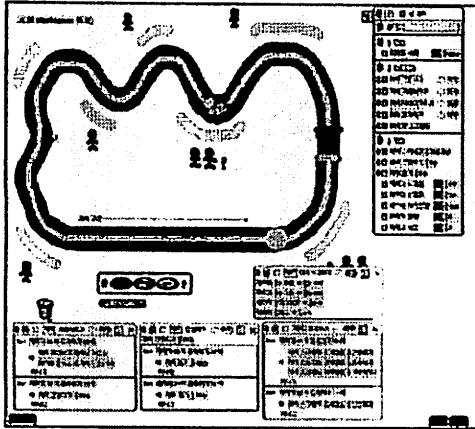


Fig. 42 The final test's assignment

- *A communication:*

The pair co-located team could use not only fundamental communication but also various communications like a body language and a dawning a plan or flowchart.

Because the pair distributed team, however, is restricted to the communication, there is a limit to affect effectively each other on sharing the idea and learning the functions. The distributed learners will be able to share more ideas and apply to program as well, if the system supports more convenient communication.

Consequently, providing various chatting systems and white board for the smooth communication between the learners, the educators have to support to share each other's ideas effectively.

- *A authority control:*

The pair co-located team may be difficult the controlling on an authority for influencing directly each other. Therefore of the two the learner who is more positive or capable of programming can perform the assignment, or they didn't perform together by an individual inclination and tend to program each one.

On the other hand, because Nebraska of Squeak

could be input at the same time by two learners, the pair distributed team could interrupt each other. However, the feature of Nebraska is suppliable a partner's work without a large obstacle. There is also an advantage that the same interesting cooperative work is possible like a drawing together.

Therefore, while the user who did works, it is necessary to offer the authority control function which was for other users preventing from working.

Moreover, since students have fair study time, the timer function which can check each other working hours is also required.

- *An Inner compulsion:*

In pair co-located team, they showed in part the tendency which is going to solve individually and it is going to submit without solving a subject together. With comparing this, since pair distributed team had to be connected with each other on the network in order to solve a subject, almost all teams submitted it according to team.

Thus, we can say that an inner compulsion of online pair-programming is larger than that of the existing offline pair-programming.

#### 4. Conclusion

We remain optimistic that pair-programming can be used effectively in online programming learning environment. The students with the distributed pair-programming were able to complete the programming assignment high quality as the co-located pair-programming. Therefore, our experiment is important in the way that distributed pair-programming is feasible and efficient method for programming learning.

For the diffusion of distance learning such as an e-learning, we need the various and individual leaning methods like the on-line pair programming. For this reason, we can say this experiment is useful for promotion of the computer education. Ultimately, we believe more

computer science educator will attempt to embrace pair-programming as part of programming in computer science of K-12 curriculum.

In addition, we need to research on being feasible and efficient of the asynchronous pair-programming as well as the synchronous pair-programming.

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