Chen, W. et al. (Eds.) (2017). Proceedings of the 25th International Conference on Computers in Education.
New Zealand: Asia-Pacific Society for Computers in Education

Effects of Peer Interaction on Web-Based Computer Programming Learning

Nuttaphat ARUNOPRAYOCH[a*], Chih-Hung LAI[a], Pham-Duc THO[a] & Jing-San LIANG[b]
[a]*Department of Computer Science and Information Engineering, National Dong Hwa University, Hualien, Taiwan, Republic of China*
[b]*Taipei Municipal Sanxing Elementary School, Taipei, Taiwan, Republic of China*
*nuttaphat.aruno@gmail.com

Abstract: This paper aimed to investigate an effectiveness of peer-interaction strategies on web-based computer programming. Totally, thirty-three computer science students participated in the programming course. The learning achievement was compared by using an e-learning system and a peer-interaction system. Moreover, the correlations between peer-interaction functions and their students' learning achievement, and the students' attitudes toward the new system were examined. The results demonstrated that there is no significant difference between using traditional e-learning system and the peer-interaction system. Furthermore, peer-interaction functions had a positive relationship with their learning achievement. Ultimately, it is found that students had positive attitudes toward the peer-interaction system.

Keywords: peer-interaction, peer assessment, computer programming, online learning system

1. Introduction

Computer programming has become a must-learnt subject since the world has already entered digital era. Thus, Introduction to Computer Science is a required fundamental course that students must take as a first course (Flores, Barron-Cedeno, Moreno, & Rosso, 2015). Learning computer programming language is not an easy task because of its challenges, for example, problem-solving ability, the idea of mathematics, and computer proficiency (Flores et al., 2015).

To make learning computer programming more interesting and efficient, a considerable amount of research has been conducted by using different strategies such as peer-assisted learning, question generating, source code reusing, web-based learning, unidirectional and reciprocal teaching, and online annotations (Altintas, Gunes, & Sayan, 2016; Flores et al., 2015; Kalelioglu, 2015; Luxton-Reilly, Denny, Plimmer, & Bertinshaw, 2011; Shadiev et al., 2014; K. Topping, 1998). Some research clarified that learning with peers plays an important role in today's education to improve students' understanding of the central concepts of a subject. Moreover, it helps promote social skills which are needed in society; therefore, such strategy shall be applied to computer programming learning (Altintas et al., 2016; K. J. Topping, 1996; Yeh, Hung, & Chiang, 2017).The results from the previous research showed that students had an outstanding academic performance by using the strategies mentioned above (Altintas et al., 2016; Flores et al., 2015; K. Topping, 1998; K. J. Topping, 1996; Yeung & Nguyen-Hoang, 2016).

Interestingly, there is one strategy that stands out of others; it is called peer-interaction strategies which allow students to interact with their peers to complete given tasks. In this study, the researchers proposed the use of Peer-interaction Programming Learning System (PIPLS) to support computer science students in learning computer programming language. The study investigated three research questions listed as follow:

- Does the use of PIPLS improve students' academic performance?
- Are there any correlations between provided peer comments and learning performance?
- Are there any correlations between quality of received peer votes and learning achievement?
- What are students' attitudes toward the peer interaction learning system?

2. Literature Review

Peer interaction is significant in a class (Yu & Wu, 2012). Yu and Wu (2012) found that learners who were using a system based on peer-interaction context tend to use both learning strategies and deep learning approaches; students chose different techniques applied to each given task in order to have it successfully answered (Russell, Van Horne, Ward, Bettis, & Gikonyo, 2017). Indeed, there are prior studies have provided evidence supporting the claim that involving peers in learning is essential (Altintas et al., 2016; Flores et al., 2015; K. Topping, 1998). Topping (1996 and 1998) examined the effectiveness of using peer tutoring and assessment in higher education; he found that these methods promoted students' understanding and academic achievement; therefore, further research should focus on these approaches accompanied with using future technology.

In 2011, StudySieve was introduced by a group of researchers at The University of Auckland to evaluate higher-order thinking and their perception toward StudySieve (Luxton-Reilly et al., 2011), it is a system that allows students to generate multiple-choice questions. Its capabilities are intriguing seeing that the system can provide an environment allowing students to answer and comment others' questions and answers. The results showed that students were active to learn contents deeply by creating questions and answering others' questions during the system-used courses.

However, its limitation, which is clearly seen, was that besides multiple-choice questions; other types of questions such as essay, fill-in-the-blank, and especially coding with auto-grade function were not included. To tackle those limitations, a system that has a variety of questions types must be developed. Consequently, PIPLS has been developed by Tho Pham-Duc and his team under the guidance of Prof. Lai Chih-Hung (Lai & Tho, 2016).

3. Methods

3.1 Research Design

This study was carried out in a simple design by using quantitative approaches. It was conducted in pre-test/post-test comparison between Test 1 (E-learning) and Test 2 (PIPLS). The independent variable of this study was a group of participants. The dependent variables of the study were the test scores from two different teaching methods: traditional e-learning and PIPLS. The participants' perceptions toward the system were examined during a final test phase as shown in Figure 1.

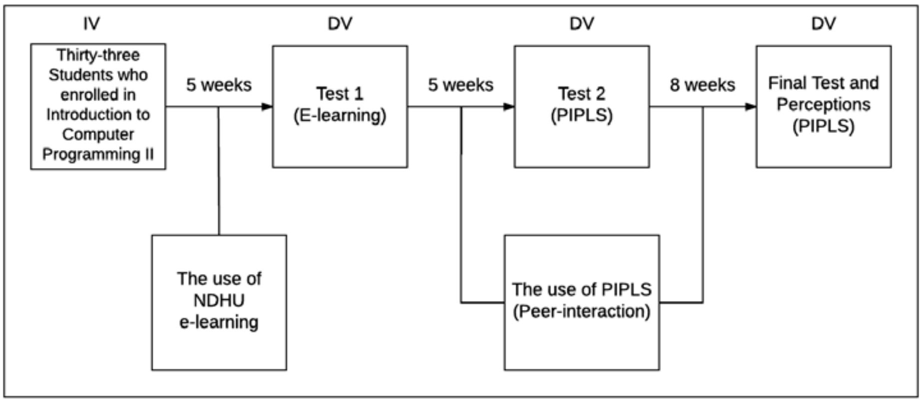

Figure 1. Research framework

3.2 Participants

A sample of thirty-three undergraduate students of Computer Science and Information Engineering who enrolled in Introduction to Computer Programming II were selected; in other words, every student in the class was asked to participate. There were 25 males and 8 females. All students were approximately aged 20 years old.

3.3 Learning Contents

The class, Introduction to Computer Programming II, was taught separately as a 3-hour lecture and a 3-hour laboratory per week, using an e-learning system and PIPLS as mediators:

- During the use of e-learning, for the 3-hour lecture, the content was introduced with PowerPoint to explain the main concept of each lesson; in the 3-hour laboratory class, students were asked to use a compiler to complete given tasks, then submit a code file on e-learning system.
- During the use of PIPLS, even if PowerPoint was still used to introduce the main concept to students, the 3-hour laboratory was conducted with PIPLS allowing students to interact with their peers inside and outside the classroom to resolve assignments.

3.3.1 Peer-Interaction Programming Learning System (PIPLS)

It is a web-based learning system based on the open source Question2Answer system (Lai & Tho, 2016) modified with further development and in-depth web programming customization which allows an instructor to create a class on the system, PIPLS's interface as seen in Figure 2. It has been designed; the user interface, to provide question generating and peer interaction functions such as:

- Question generation types: essay, multiple-choice, short answer, true-false, fill-in-the-blank, and coding with both an automatic and a semi-automatic assessment from staff or peers.
- Peer-interaction functions: peer assessment (comment) allows the student to give sophisticated suggestions to peers' questions and answers, chat room, asking for help (letting peers know that help is needed), voting function (up-vote and down-vote) which allows students to assess the quality of questions and answers, and providing open comment.
- Others: questionnaire, leaderboard, and achievement trophies.

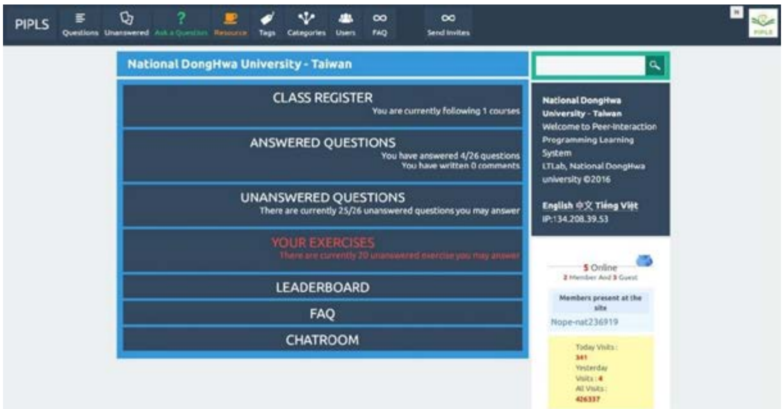

Figure 2. The PIPLS's main page

3.4 Experimental Procedures

This study was carried out in three phases. Students were assigned to take a computer programming proficiency test at the end of each phase. During phase 1 students received a traditional lecture by using PowerPoint as a teaching material, and used an e-learning system to submit assignments. On the other hand, in phase 2 and 3 students were still taught by a traditional method, but were asked to use PIPLS as a tool to complete assignments by using peer-interaction functions provided. The first two phases continued for a period of five weeks, and the last phase continued for a period of eight weeks; therefore, this study had been conducted for 18 weeks consecutively started from the beginning of the 2016 spring semester. The questionnaire concerning perceptions was digitally provided, along with the final test, at the end of the 18-week experimental period.

3.5 Data Collection and Instrument

In this study, PIPLS was used as a data collection tool in order to bring answers to research questions. Creating an account to be used as an identification accessing to the system was essential. An account contains a student's information. Furthermore, PIPLS collects every data from an account in the form of database powered by MySQL, the frequencies of functions usage, the time spent on the system, answered questions, call for help, comments, voting, etc. Thus, the collected data derived from the database were statistically analysed.

The students' attitudes toward the system were measured by using 5-Likert scales (1 = *strongly disagree* and 5 = *strongly agree*) questionnaire provided in the system. The questionnaire, based on Koorsse's research (Koorsse, 2012) according to the information appeared in programming assistance tools (Luxton-Reilly et al., 2011), consisted 16 questions regarding the students' preference between an e-learning and PIPLS.

3.6 Data Analysis

To reveal whether there was an academic difference between pre-test and post-test or not, paired-samples t test was statistically calculated with the data collected from PIPLS's database using SPSS. To test whether there was a relationship between the use of peer-interaction functions (e.g., comment and voting) and final scores, Pearson's correlation and simple regression were calculated. In addition, the students' attitude toward PIPLS were explained by descriptive statistics. It should be noted that 5% had been determined as the significance level.

4. Results and Discussion

To investigate the effects of PIPLS on exams, paired-samples t test was applied. Thus, the null hypothesis which there is no statistically significant difference between the means of Test 1 (e-learning) and Test 2 (PIPLS) regarding their academic exam scores was tested.

As seen from Table 1, there is no statistically significant difference between the means of Test 1 (*M* = 80.95, *SD* = 29.71) and Test 2 (*M* = 83.68, *SD* = 18.22) regarding exam scores at the .05 level of significance (*t* = -.44, *df* = 32, *n* = 33, *p* = .66). However, on average students' scores after using PIPLS were higher than their previous scores according to the difference of means. It should be noted that there was a violation found in paired-samples correlation.

According to t-test results, learning programming via PIPLS did not cause any differences from using e-learning regarding test scores. There, only, were slight increases in the means of Test 1 and Test 2's scores. Even if PIPLS's mean was higher than e-learning's mean, the occurred violation should be noted. More importantly, the results may be caused by the number of participants which were only 33 students involved and the different difficulties of the concerned exams. Similarly, the results from the research using peer-assisted learning showed that there was no statistically significant difference between the means of the experimental group applied peer-assisted learning and the control group applied traditional teaching methods regarding their academic scores (Altintas et al., 2016).

Table 1: Results of Paired-samples t test and Descriptive Statistics for Test 1 (e-learning) and Test 2 (PIPLS).

			Test 1 (e-learning)		Test 2 (PIPLS)			
Outcome	*n*	*df*	*M*	*SD*	*M*	*SD*	*t*	*p*
Score	33	32	80.95	29.71	83.68	18.22	-.44	.66

To answer the questions that whether the frequency use of peer-interaction functions (e.g., comment and voting) improve students' final score or not, correlation and regression analysis was statistically performed.

Table 2 demonstrates relationships between peer-interaction functions and the final scores. The results showed that students, who had a high amount of comments toward peers' questions and answers, successfully achieved higher final scores compared to those who did not (*r* = .35, *df* = 31, *p* = .049). It was also found that students whose answers were upvoted, which means received good feedback for the most informatively-useful answers, by their peers performed significantly better than those who did not receive (*r* = .36, *df* = 31, *p* = .039).

Table 2: Results of Pearson's Correlations for comment and receiving up-vote on final scores.

			Comment		Receiving up-vote	
Correlation	*n*	*df*	Pearsons's (*r*)	*p*	Pearsons's (*r*)	*p*
Final score	33	31	.35	.049*	.36	.039*

*$p < .05$

The results in this experiment showed that students benefit from peer interactions in terms of learning. Even though there was no significant difference regarding their final scores, it can clearly be noticeable that peer-interaction functions in PIPLS (e.g., comment and voting) had positive relationships.

Furthermore, the predictive powers of the frequency use of peer-interaction functions on the students' final scores by using simple regression analysis were presented in Table 3. The results showed that giving peers comments was a significant predictor of final scores, $\beta = .35$, $t(31) = 2.05$, $p = .049$, $R^2 = .12$. Moreover, it demonstrated that receiving up-vote was a significant predictor of final scores, $\beta = .36$, $t(31) = 2.15$, $p = .039$, $R^2 = .13$. It can be said that giving peers comments and receiving up-votes could be a factor that affects students' academic achievements regarding their final scores in this case.

Table 3: Results of Simple Regression for comment and receiving up-vote on final scores.

			Comment			Receiving up-vote		
Coefficients	*n*	*df*	β	R^2	*p*	β	R^2	*p*
Final score	33	31	.35	.12	.049*	.36	.13	.039*

*$p < .05$

The mentioned results are similar to prior research, for example: peer instruction (PI) applied to calculus and algebra-based introductory physic course indicated that students mastered in both conceptual reasoning and problem-solving skills upon the implementation (Crouch & Mazur, 2001), and involving peers in learning process as reciprocal teaching indicated a significant result of better improvements (Shadiev et al., 2014; Yeh et al., 2017).

Another finding of this study was that students had good perceptions and preferences toward using PIPLS compared to using e-learning ($N = 33$, $M = 3.95$), it should be noted that 5-Likert scales were used; 0 indicates '*strong disagree*' and 5 indicates '*strongly agree*'. The questions were made to explore the students' thoughts toward PIPLS and their motivation for future use. The examples from the questions as follow:

- The function of viewing others comments helps me learn better.
- The function of viewing others comments motivated me to use the system.

According to the results of attitude toward PIPLS, most students agreed that using PIPLS was useful for learning programming compared to an e-learning system described by interpreting $M = 3.95$ which was statistically close to 4 indicated '*agree*'. Students mentioned that explaining and providing suggestions to peers could help them to learn program concept deeper and, to find some mistakes in their codes.

5. Conclusion

The main purpose of this study was to explore the effects of peer interaction on web-based programming language learning system. The main conclusions of this study are summarised as follows. Firstly, the slight improvement was found after students used PIPLS in terms of their second test scores, however statistically there was no significant difference between two sets of scores. Secondly, frequently using peer-interaction functions provided by PIPLS did affect students' final scores. Lastly, most of the students perceived that peer-interaction methods supported by PIPLS were more useful for learning computer programming languages compared to an ordinary e-learning.

To be informed, this study is primarily limited by its sample size and experimental methodologies; therefore, a larger sample size would have benefited the results of the study to conduct the comparison of a control group and an experimental group, and the implementation could have been longer. Other teaching methods would have been more useful than conducting only traditional methods (i.e., using Powerpoint's slides and teacher-centered) to deliver knowledge (Matthíasdóttir, 2006). Moreover, the differences between genders: male and female, and the time spent on the system might be critical factors as well.

In a nutshell, peer interaction helps students not only to promote their understanding of programming concepts but also improve their academic achievements. Thus, the contribution of such methods based on web-based programming learning along with engaging students to frequently use peer-interaction functions should be further investigated for future research.

Acknowledgements

This study is supported in part by the Ministry of Science and Technology of the Republic of China under contact number: MOST 105-2511-S-259-004-MY3.

References

Altintas, T., Gunes, A., & Sayan, H. (2016). A peer-assisted learning experience in computer programming language learning and developing computer programming skills. *Innovations in Education and Teaching International, 53*(3), 329-337. doi:10.1080/14703297.2014.993418

Crouch, C. H., & Mazur, E. (2001). Peer Instruction: Ten years of experience and results. *American Journal of Physics, 69*(9), 970-977. doi:10.1119/1.1374249

Flores, E., Barron-Cedeno, A., Moreno, L., & Rosso, P. (2015). Uncovering Source Code Reuse in Large-Scale Academic Environments. *Computer Applications in Engineering Education, 23*(3), 383-390. doi:10.1002/cae.21608

Kalelioglu, F. (2015). A new way of teaching programming skills to K-12 students: Code.org. *Computers in Human Behavior, 52*, 200-210. doi:10.1016/j.chb.2015.05.047

Koorsse, M. (2012). *An Evaluation of Programming Assistance Tools to Support the Learning of IT Programming: A Case Study in South African Secondary Schools.* (Philosophiae Doctor), the Nelson Mandela Metropolitan University.

Lai, C.-H., & Tho, P.-D. (2016). *Development of a Programming Learning System Based on a Question Generated Strategy.* Paper presented at the the 24th International Conference on Computers in Education, India.

Luxton-Reilly, A., Denny, P., Plimmer, B., & Bertinshaw, D. (2011). *Supporting Student-generated Free-response Questions*. Paper presented at the NACCQ/CITRENZ Conference, New Zealand.

Matthíasdóttir, Á. (2006). *How to teach programming languages to novice students? Lecturing or not?* Paper presented at the International Conference on Computer Systems and Technologies - CompSysTech'06.

Russell, J., Van Horne, S., Ward, A. S., Bettis, E. A., & Gikonyo, J. (2017). Variability in students' evaluating processes in peer assessment with calibrated peer review. *Journal of Computer Assisted Learning, 33*(2), 178-190. doi:10.1111/jcal.12176

Shadiev, R., Hwang, W.-Y., Yeh, S.-C., Yang, S. J. H., Wang, J.-L., Han, L., & Hsu, G.-L. (2014). Effects of Unidirectional vs. Reciprocal Teaching Strategies on Web-Based Computer Programming Learning. *Journal of Educational Computing Research, 50*(1), 67-95. doi:doi:10.2190/EC.50.1.d

Topping, K. (1998). Peer assessment between students in colleges and universities. *Review of Educational Research, 68*(3), 249-276. doi:10.2307/1170598

Topping, K. J. (1996). The effectiveness of peer tutoring in further and higher education: A typology and review of the literature. *Higher Education, 32*(3), 321-345. doi:10.1007/bf00138870

Yeh, H. C., Hung, H. T., & Chiang, Y. H. (2017). The use of online annotations in reading instruction and its impact on students' reading progress and processes. *Recall, 29*(1), 22-38. doi:10.1017/s0958344016000021

Yeung, R., & Nguyen-Hoang, P. (2016). Endogenous peer effects: Fact or fiction? *The Journal of Educational Research, 109*(1), 37-49. doi:10.1080/00220671.2014.918528

Yu, F.-Y., & Wu, C.-P. (2012). Student Question-Generation: The Learning Process Invovlved and Their Relationships with Students' Perceived Value. *Education Science, 57*(4), 135-162.