Journal of Engineering Education Transformations,
Volume No 36, January 2023, Special issue, eISSN 2394-1707

10.16920/jeet/2023/v36is2/23035

Peer-to-Peer Learning Process (PPLP) Framework to Enhance Problem Solving Skills

A. M. Abirami, P. Karthikeyan, M. Thangavel
Department of Information Technology, Thiagarajar College of Engineering, Tamil Nadu, India

***Abstract*—Present generation of students give less attention in class. This is a serious issue among college or university-level students. The faculty members have to use active learning strategies to have better student engagement in their classes. The faculty has to carefully design these pedagogical practices in such a way that more than one student gets involved in the activities in groups instead of in solo performances. This article details an innovative teaching-learning practice namely Peer-to-Peer Learning Process (PPLP) framework for improving the problem-solving skills of students. The experimental results show that the use of the PPLP framework in the class would enhance the academic performance of students.**

***Keywords*—Peer-to-Peer Learning Process, Problem Solving Skills, Learning Process, Academic Performance, t-test**

***JEET Category*—Practice**

I. INTRODUCTION

PEER learning is one of the popular learning processes in teaching and learning. Peer assessment is the type of peer learning wherein classmates give and get qualitative feedback from their peers. It is the structured learning model which develops self-learning and lifelong learning attitude among peers. It is an evidence-based, interactive, learner-centric teaching-learning approach developed by Eric Mazur in the 1990s. It involves students in the assessment process and creates a better learning environment where the students exchange their ideas. It saves teachers' time and improves students' understanding of the topic or the learning materials. On the other hand, the students get feedback faster from their peers, as teachers find it difficult to give one-to-one feedback to all students. It helps the students to correct their mistakes and get ready for the next assessment, which improves their meta-cognitive skills.

There are many advantages when peer assessment strategy is adopted in the teaching-learning process: (i) motivates the students to take responsibility for the learning (ii) makes the students give constructive feedback to their peers (iii) enhances the critical thinking of their own (iv) in-depth knowledge in the topic or course (v) mutual understanding between the peers. However, the teachers face issues while implementing peer assessment strategies in their classes. Few students may take free rides, few may not use the rubrics for assessment and validation on their own, and few may not actively participate in the activity. These challenges can be addressed by considering the following aspects: (i) plan for the activity with instructions or guidelines and well-defined rubrics (ii) create awareness among the students about peer assessment activity by clearly stating to them the purpose of the activity, benefits of the activity and the set of guidelines (iii) possibility of having anonymous documents *(single-blind review)* for assessment (iv) educating the students about how to give quality and valuable feedback by using good/bad sample feedbacks (v) set time limit for each in-class and out-class activities (vi) involve students while framing the criteria for assessment which makes the students take ownership (vii) facilitate and guide student teams when required.

Peer assessment strategy can be practiced whenever the teacher wants to focus on a complex topic when students need to spend their effort in understanding the concepts when the class performance is low for a particular topic and so on. The teacher can do some prior analysis, select a suitable topic and find time for practicing this activity. In this paper, the peer-to-peer learning process framework with consistent feedback from the assessors is demonstrated. The article is organized as follows: section 2 describes the related work in this research area and the research question, section 3 explains the methodology, section 4 discusses the results and section 4 concludes the paper with remarks.

II. RELATED WORK

Many educational and psychological researchers studied and explored the possibility of using peer assessment as a teaching-learning practice. Graaf et. al. (2006) used peer assessment instruments for the evaluation of the individual in project-based learning at Delft University of Technology. Bronson et. al. (2007) framed peer assessment proforma for first-year engineering courses wherein the students assessed their peers based on five criteria, which in turn were considered by the faculty members for final evaluation. Chang et. al. (2010) used a peer instruction process for the evaluation of projects and indicated that this process enhanced the critical thinking skills of students as there were continuous

interactions and discussions among them. Kommula et. al. (2010) used a peer assessment instrument for assessing individual contribution in team-based projects. Well-defined peer assessment is a reliable and valid approach for teaching (Chin, 2016).

Alzaid (2017) used peer assessment for student engagement as well as for the evaluation process and demonstrated that the peer assessment well coincided with the teacher's assessment. Tenório et. al. (2017) used a game-based approach for the peer assessment process for the evaluation of essays and claimed that this improved process increased the quality of evaluation and quantity of submission. Dai et. al. (2018) proposed a technology-based peer learning platform through flipped classrooms for larger classrooms at the University of Southern California. It has 5 phases selection of topics, self-study by students, system integrated peer-to-peer interactions, selection of questions by teachers, and in-class interactions. Maya et. al. (2018) studied the effectiveness of peer assessment between online and on-campus learning environments. They indicated that there were more volunteers for peer assessment in the online mode than in the other one, whereas more quality feedback was given by the on-campus students than the online students. Gupta et. al. (2019) used peer assessment for review studies of English as a Second Language or Foreign Language (ESL/EFL) classrooms and strongly recommended adopting this model in English classes. Double et. al. (2020) suggested that peer assessment could be made a formal practice inside the classroom as it improved the academic performance of the students.

Milan et. al. (2021) studied the experience of students in different parameters like their perception of peer assessment, the challenges faced during the activity, and the support extended in the learning process. Chris (2022), in his article, described different strategies for peer learning and said that it is beneficial to both peers. Gong et.al. (2022) discussed peer learning models like focus group discussions, collaborative projects, peer assessment, mentoring, and cascading groups for experiential learning. Yin et. al. (2022) studied the impact of peer assessment and concluded that this assessment would enhance learning among the students. Jeanette et. al. (2022) studied the trustworthiness of peer assessment which in turn enabled the setting up of an inclusive environment for a heterogeneous group of students.

From the literature, it is understood that most of the research focused the peer assessment as a separate process and used one level of assessment. To our knowledge, the feedback from the peers was not used in any of the research. The research questions are framed as follows:

RQ1: Does the peer assessment improve the problem-solving skills of students?

RQ2: Does the peer assessment improve the academic performance of students?

This article focuses on the peer assessment process as well as the feedback from the assessors at different stages, which in turn would improve the learning process by setting up a suitable learning environment.

III. METHODOLOGY

This section explains the proposed Peer-to-Peer Learning Process (PPLP) framework. PPLP is a framework that focuses on peer assessment activities and feedback. The continuous feedback to the students from their peers and the faculty at different stages helps them to improve their coding skills, as shown in Fig.1. The subsequent subsections detail the three different phases of the PPLP framework.

A. Phase 1 - Problem Solving

In this phase, the faculty selects the suitable problem and gives a detailed description with sample inputs and outputs. The faculty has to ensure that the problem is understood by all the students. The students are asked to solve the problem by writing a procedure, drawing a flowchart, and then writing code manually in a notebook. All students are informed about the time limits for each task in advance and the faculty would keep track of the timer.

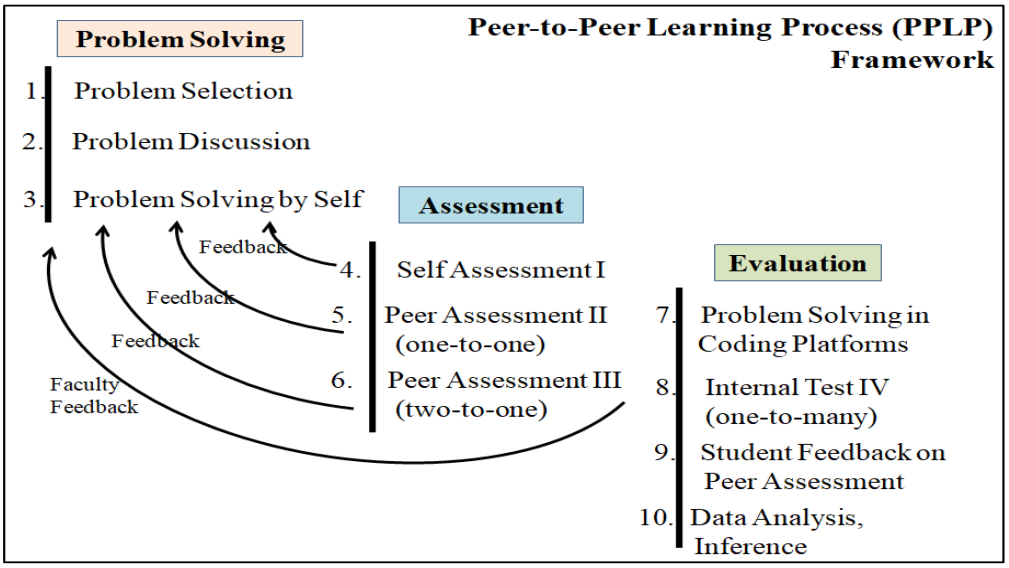

Fig.1 Peer-to-Peer Learning Process (PPLP) Framework

B. Phase 2 - Assessment

In this phase, the solutions suggested by each individual are assessed in three different stages. Initially, the students themselves would revisit their solutions and make any modifications (self-assessment I). Then the solutions are randomly distributed to peers and the faculty would ensure that each student would get a different notebook not their own. Secondly, one-to-one peer assessment takes place. The peer would go through the solution and give detailed comments and their names. After this second assessment (peer assessment II), the notebooks would reach the owners. Each student would go through the comments given by their peers and discuss them with them if needed. Thirdly, the notebooks would be circulated once again. The faculty has to ensure that the notebooks are in different hands. This time, a two-to-one peer assessment is done, where two peers would be reviewing the two notebooks together (peer assessment III). The notebooks would reach the students and they read the comments given by their peers. At this stage, the students would be ready for taking up the challenges in the coding platform. There may be chaos in the classroom and the faculty has to strictly follow the time limit for each task.

C. Phase 3 - Evaluation

This phase happens outside the classroom whereas the other two phases happen inside the classroom. The faculty can set the coding challenge in the platforms like HackerRank, HackerEarth, and the like with time limits. Setting the time limit would restrict the students from copying to some extent. Solving the challenges in these platforms makes the students motivated as they have hidden test cases. Students would keep trying the code until all the test cases are passed. Some students may have discussions with their peers or friends if they face any issues. The faculty has to give necessary instructions beforehand such that the peers should not share their code, instead, they need to teach their fellow peers on demand. The faculty can monitor the students through the leader board and submissions.

TABLE I
ACTIVITIES WITH TIME REQUIREMENT

Task Description	Users	Mode	Required Time (m)
Problem Selection	F	OC	10
Problem Description	F	IC	10
Problem Solving	S	IC	10
Self Assessment I and Feedback	S	IC	3
Peer Assessment II and Feedback	S	IC	5 to 7
Peer Assessment III and Feedback	S	IC	5 to 7
Coding Challenges	F, S	OC	60
Internal Test IV, Evaluation and Feedback	F, S	-	-
Data Analysis and Report	F	-	-

OC – Outside Class, IC – Inside Class, F – Faculty, S - Students

This coding challenge is followed by the internal test where the faculty can evaluate the students by framing one or two questions related to the coding challenges. These questions can be slightly twisted from the original questions. It informs the faculty whether the students utilized the peer assessment activity, peer feedback, and coding challenges in a constructive manner or not. Finally, the feedback on the peer assessment activity is obtained from the students. All data is analyzed and inferred and an improvement plan is prepared for further action. Table I shows the details of activities with time requirements to implement the PPLP framework.

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

The proposed PPLP framework was implemented in the batch of UG Engineering Programme students for the course Python Programming, where 58 students belonged to class 1 *(the control group where PPLP was not used)*and 62 students belonged to class 2 *(an experimental group where PPLP was used)*.

The performance of class 2 in test 1 was alarming to the faculty. In this test, there was question Q1 *"complete the flowchart for the missing symbols and data for the question CheckPrimeNumber"*, which carried 5 marks. Nearly 44% of class 2 got 0 marks in that question. The faculty thought of using a peer instruction approach for improving the problem-solving skills of students. He used the PPLP framework in his class, as detailed in section 3, and studied the class performance in test 2.

The faculty selected the coding challenge IsFibo from the HackerRank Platform and described the problems in detail. IsFibo expects to determine whether the given number is in the Fibonacci sequence. All the students were asked to solve the problem individually by writing a procedure, drawing a flowchart, and then coding. The solutions were shuffled randomly and distributed to peers. Then one-to-one peer assessment and two-to-one peer assessment were carried out with elaborated review comments. On the same day after class hours, the students were asked to solve those HackerRank challenges. All students solved the problem but few students took lesser time, and few students took comparatively more time. Fig. 2 shows the time taken by students to solve the challenge IsFibo in the HackerRank platform by class 2 students.

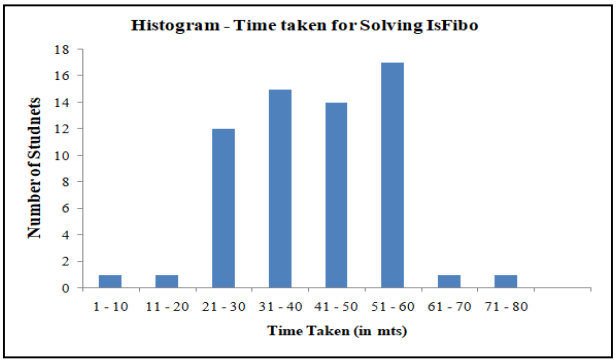

Fig. 2 Histogram – Time taken for solving the challenge

In the subsequent test, one question Q2 regarding the Fibonacci sequence was set with slight changes for 5 marks. The question was "Determine the number of integers lying between the integers X and Y, where X and Y are present in the Fibonacci sequence. Write Python script with suitable Python function(s). Give a suitable error message, if X or Y

does not present in the sequence". This test was common to both class 1 and class 2. Table II shows the performance of both classes for this particular question. The experimental group performed better than the control group.

TABLE II
PERFORMANCE OF BOTH CLASSES

Marks	Class 1	Class 2
Mark = 5	2	18
Mark = 4	3	14
Mark = 3	6	14
Mark = 2	14	6
Mark = 1	7	2
Mark = 0	20	8
Absent	6	0
Total	58	62

Table III shows the performance of class 2 in the problem-solving questions in test 1 (Q1) and test 2 (Q2), before and after implementing PPLP. The performance of class 2 was showing a greater improvement in problem-solving skills.

TABLE III
PERFORMANCE OF CLASS 2 IN TWO TESTS

Marks	Test 1 (Q1)	Test 2 (Q2)
Mark = 5	14	18
Mark = 4	2	14
Mark = 3	4	14
Mark = 2	15	6
Mark = 1	0	2
Mark = 0	27	8
Absent	0	0
Total	62	62

A. Discussions

The proposed PPLP framework experimented with two groups - class 1 (control group) and class 2 (experimental group). The effectiveness of the PPLP framework was evaluated using statistical tests. The Null hypothesis states that the PPLP does not have any effect on the performance of the students. The Alternate hypothesis states that the PPLP does affect the performance of the students. The null hypothesis is rejected, if the p-value is less than the significant level (0.05).

Case 1:

The performance of students of both groups class 1 and class 2 (w.r.t question Q2) was studied using the t-test and the results are shown in Table IV. As the p-value (0.00001) is less than the significant level of 0.05, the null hypothesis can be rejected. The implementation of PPLP has significant and positive effects on the students' performance. The research question RQ1 is addressed by this case, and the peer assessment improves the problem solving skills of students.

Case 2:

The performance of students of class 2 (w.r.t questions Q1, Q2 and test 1 and test 2) were studied using the t-test and the results are shown in Table V.

As the p-value (0.0001) is less than the significant level of 0.05, the null hypothesis can be rejected. The class average also improved. Hence, the implementation of PPLP has significant and positive effects on the student's performance. The research question RQ2 is addressed in this case, and peer assessment improves the academic performance of students in test 2.

TABLE IV
STATISTICAL RESULTS OF CONTROL AND EXPERIMENTAL GROUPS

Statistical Measures	t-Test: Two-Sample Assuming Equal Variances		t-Test: Two-Sample Assuming Unequal Variances	
	Class 1	Class 2	Class 1	Class 2
Mean	1.44	3.26	1.44	3.26
Variance	2.09	2.75	2.09	2.75
Observations	52	62	52	62
Pooled Variance	2.45266			
Hypothesized Mean Difference	0		0	
df	112		112	
t Stat	6.165725		6.240176	
P(T<=t) one-tail	5.69E-09		4E-09	
t Critical one-tail	1.658573		1.658573	
P(T<=t) two-tail	1.14E-08		8.01E-09	
t Critical two-tail	1.981372		1.981372	

TABLE V
STATISTICAL RESULTS OF CLASS 2

Statistical Measures	t-Test: Paired Two Sample for Means (for class 2 - Experimental Group)			
	Before PPLP (Q1)	After PPLP (Q2)	Before PPLP (test 1)	After PPLP (test 2)
Mean	1.94	3.26	25.02	28.63
Variance	4.03	2.75	68.81	85.55
Observations	62	62	62	62
Pearson Correlation	0.039547		0.690422	
Hypothesized Mean Difference	0		0	
df	61		58	
t Stat	-4.07932		-3.98535	
P(T<=t) one-tail	6.66E-05		9.54E-05	
t Critical one-tail	1.670219		1.671553	
P(T<=t) two-tail	0.000133		0.000191	
t Critical two-tail	1.999624		2.001717	

Student feedback was obtained from the class 2 students after this PPLP activity. 54 students responded *to* the feedback and the results are shown in Figures 3, 4, 5, and 6.

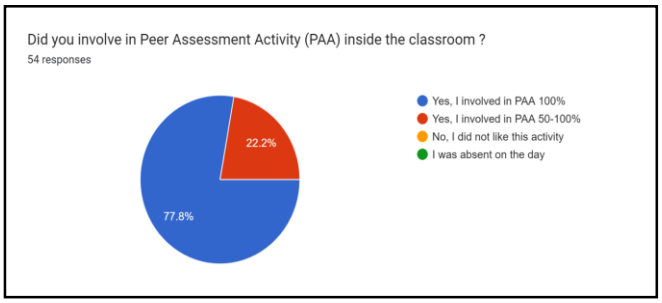

Fig.3. Feedback Responses – Involvement in Peer Assessment Activity

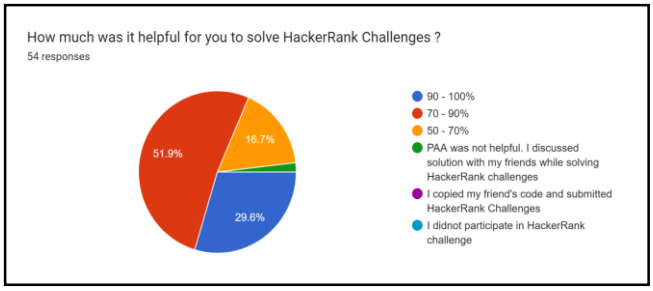

Fig.4. Feedback Responses – Supportive to HackerRank challenges

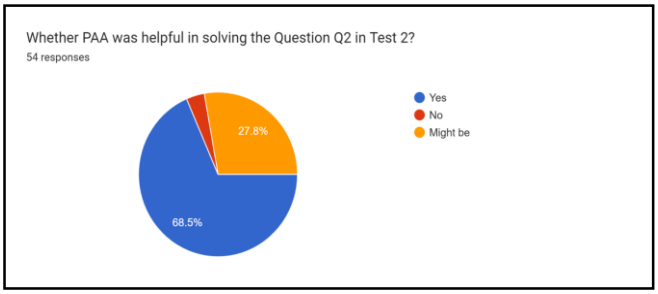

Fig.5. Feedback Responses – Supportive to Test 2

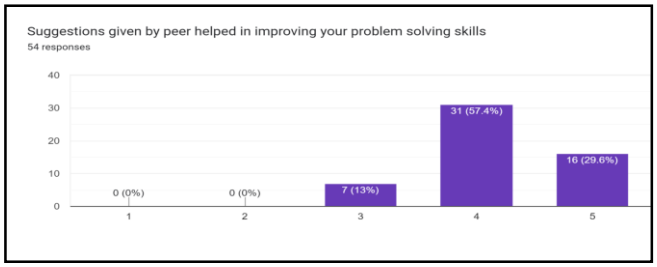

Fig.6. Feedback Responses - Suggestions by peers in Problem Solving Skills

Nearly 87% of the class 2 students said that they actively participated in the Peer Assessment Activity (PAA). In that, 80% of the class said that this PAA helped them in solving HackerRank challenges and test 2; 87% claimed that the suggestions given by their peers improved their problem-solving skills.

V. CONCLUSIONS

Sustaining the academic performance of students is one of the challenging tasks for teachers. Present generations of students are reluctant to give their attention to the classes. They need to be motivated continuously and be given constant support through different innovative teaching and learning practices. This article explained one such practice namely Peer-to-Peer Learning Process (PPLP) framework and its phases. The experimental results, statistical results, and feedback from the students demonstrated that peer instruction and peer learning support the problem-solving skills of students to a greater extent.

ACKNOWLEDGMENT

We thank the Department of Information Technology, Thiagarajar College of Engineering for supporting this work.

REFERENCES

Alzaid, J. (2017). The Effect of Peer Assessment on the Evaluation Process of Students, - International Education Studies, vol. 10, pp. 159-169, DOI: 10.5539/ies.v10n6p159.

Bronson, P., Ng, A. & Wong, K. K. (2007). Design and Implementation of a Peer Assessment Tool for Problem Based Learning in Engineering, in Proceedings of the Australasian Association for Engineering Education (AAEE) Conference, Melbourne.

Chang, C.W., Pearman, C.J., Farha, N. W. (2010). P2P: Assessing a Peer Evaluation Strategy, Journal of Educational Technology Development and Exchange, vol. 3, no. 1, pp. 69-84.

Chin, P. (2016). Peer Assessment, New Directions in the Teaching of Physical Sciences, pp. 13-18, DOI: 10.29311/ndtps.v0i3.410.

Chris, D. (2022). Peer to Peer Learnning – Examples, Benefits & Strategies, https://helpfulprofessor.com/peer-learning/ [accessed on Aug 2022]

Dai, Y., Li, T., Liu, A. & Lu, S. (2018). P2P Platform for Peer Instruction in Flipped Classroom. In Proceedings of 2018 ASEE Annual Conference & Exposition, DOI:10.18260/1-2—30854.

Double, K.S., McGrane, J.A. & Hopfenbeck, T.N. (2020). The Impact of Peer Assessment on Academic Performance: A Meta-analysis of Control Group Studies. Educational Psychology Review, vol. 32, pp. 481-509.

Gong, H.J., Kwon, J. & Brock, M. (2022) Experiential learning through a peer learning assistant model in STEM, Educational Research, DOI:10.1080/00131881.2022.2096092.

Graaff, E., Gillian, S. & Maartje, B. (2007). PEER Assessment and PEER review to support teamwork in engineering education, in Proceedings of 6th ASEE Global Colloquium on Engineering Education, Istanbul, Turkey.

Gupta, S., Abdullah, F., Li, G. Xueshuang, Y. (2019). Peer Assessment in Writing: A Critical Review of Previous Studies, Journal of Advances in Linguistics, vol. 10, DOI: 10.24297/jal.v10i0.7992.

Jeanette, C. H. & Jonas, N. (2022). Students' experience of making and receiving peer assessment: the effect of self-assessed knowledge and trust, Assessment & Evaluation in Higher Education, vol. 47, no. 6, pp. 959-971.

Kommula, V. P., Uziak, J., & Tunde Oladiran, M. (2010). Peer and self-assessment in engineering students' group work. World Transactions on Engineering and Technology Education, vol. 8, no. 1, pp. 56-60.

Maya, U. & Miri, B. (2018). Peer assessment in a project-based engineering course: comparing between on-campus and online learning environments, Assessment & Evaluation in Higher Education, vol. 43, DOI: 10.1080/02602938.2017.1405238.

Milan, S. (2021). Peer assessment as a learning and self-assessment tool: a look inside the black box, Assessment & Evaluation in Higher Education, vol. 46, no. 6, pp. 852-864.

Tenório, T., Bittencourt, I.I., Isotani, S., Pedro, A., Ospina,P., Tenório, D. (2017). A gamified peer assessment model for online learning environments in a competitive context, Computers in Human Behavior, vol. 12, pp. 433-437.

Yin., S., Chen, F. & Chang, H. (2022). Assessment as Learning: How does Peer Assessment function in Students' Learning? Frontiers in Psychology, https://doi.org/10.3389/fpsyg.2022.912568