A CROSS-INSTITUTIONAL INVESTIGATION OF PEER INSTRUCTION IN INTRODUCTORY COMPUTING

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ABSTRACT

Peer Instruction (PI) is an instructional approach that places students at the centre of the learning process, shifting their position from passive recipients of information to active contributors within the classroom setting. In recent years, a considerable body of academic literature has emerged, focusing on the significance of PI within the field of computer science. This study report aims to conduct a cross-institutional inquiry to evaluate the efficacy of Peer Instruction (PI) as a pedagogical approach in basic computing courses. Peer Instruction is an instructional approach that prioritises student-centered and active learning methodologies, fostering peer contact and promoting involvement in the educational process. This research is a collaborative effort among many academic institutions with the objective of evaluating the influence of Peer Instruction (PI) on student learning results, engagement levels, and overall satisfaction. The technique used in this study encompasses both quantitative analysis of pre- and post-test results, as well as qualitative examination of student comments, in order to assess the efficacy of the instructional intervention. The findings of this study conducted across many institutions indicate that the implementation of Peer Instruction proves to be a successful approach in enhancing student learning outcomes and fostering engagement in basic computing courses. The integration of active learning, peer interaction, and rapid application of knowledge seems to facilitate a more profound comprehension of the subject matter. Additional investigation may be conducted to examine the extended duration of information retention and the potential for using the Peer Instruction methodology in bigger classroom environments.

Keywords: Peer Instruction (PI), Active Learning, Computing Courses, Peer Contact, Introductory Computing

INTRODUCTION

Peer teaching has been the subject of a significant number of studies, all of which have reached the conclusion that it is beneficial in a range of different contexts. The use of peer instruction (PI) in schools that teach computer science has gained a substantial amount of traction in recent years. Students put a greater value on PI, and when it is taught in favour of more typical lecture forms, they claim that they learn more [1]. In addition, there is a connection between PI and better rates of substantial retention as well as lower rates of failure.

The vast majority of PI research projects in the field of computer science are carried out in the form of an assessment of a single instructor or the use of the methodology at a specific organisation [2]. One of the difficulties that arises as a direct result of this is that the results that have been published on PI overestimate the number of cases in which PI has been shown to be successful. In view of the recent surge in the usage of PIs, it is vital to identify the kind of outcomes that may be predicted across a variety of institutions and larger datasets [3]. This is because the use of PIs has recently seen a rise. In addition to this, it is of the utmost need to begin study immediately on the several approaches under which new adopters engage in PI [4]. How thoroughly is PI being incorporated into everything across the board? How are the steps of the PI process altered so that they may better accommodate the needs of the instructor or the learner?

Peer Instruction (PI) is a fresh approach to classroom instruction that was conceived of and developed by Dr. Eric Mazur of Harvard University. It moves away from the more conventional method of instruction, which is based on lecturing, by establishing a classroom atmosphere that is more participatory and focused on the students [5]. Students are encouraged to participate actively in their own education as a means of developing their analytical and deductive reasoning skills as well as their level of comprehension.

The teacher will often begin a Peer Instruction session by asking a difficult question or introducing a tough notion that is connected to the topic being covered [6]. The students are often given readings and other materials to go through in advance of the session, which helps to get them ready for the discussion that will follow. The pupils then react to the question on their own once the subject has been presented to them. They are prompted to evaluate how much they already know about the subject thanks to this first stage [7].
After completing the phase in which they respond individually, students next take part in conversations with their peers. They then engage in opinion trading, intellectual discussion, and information sharing among their newly formed small groups [8]. Students are able to learn from one another, have their questions answered, and broaden their worldview thanks to the peer interaction. Additionally, it bolsters the notion that imparting knowledge to others might improve one's own level of grasp of the subject matter [9].
After students have discussed the topic with their classmates, they go back and look at their first reactions. They are urged to re-evaluate their responses in light of the group conversations that have taken place [10]. They are prompted to evaluate their current line of thought and consider whether or not it should be altered in light of the new insights they have obtained as a result of this process [11].
The last stage consists of an instructor-led conversation with the whole group of students. To determine the current level of students' comprehension of the material, the instructor may start the class with a vote or a show of hands [12]. The teacher will utilise this conversation to dispel common misunderstandings, go more into the topic at hand, and emphasise the most important points. The pupils' comprehension is further strengthened as a result of this class discussion, and any issues that are still unanswered are brought to the forefront [13].
In the disciplines of science, technology, engineering, and mathematics (STEM), where in-depth examination and debate of difficult subjects may be beneficial, peer instruction is especially popular [14]. The concepts it espouses, on the other hand, may be applied to a wide variety of fields in order to foster collaborative learning and active participation. You may study research papers, articles, and books written by Dr. Eric Mazur and other educators who have applied and examined this excellent teaching style in order to go further into the literature surrounding Peer Instruction [15].
Peer Instruction (PI) is a kind of teaching that was first developed for use in the area of physics but has since found broad use in the world of computers. Peer Instruction was initially developed for use in the field of physics. The ConcepTest serves as the foundation for this methodology. Students respond to the multiple-choice questions that make up the ConcepTest by clicking on the appropriate option on their clickers [16]. Each ConcepTest serves as the starting point for a clearly outlined educational process that is comprised of the following stages: The students begin by answering the question on their own (this is referred to as a "solo vote"), then they discuss the same topic with the students sitting next to them for many minutes, and finally, they re-vote on the issue in light of the group discussion (this is referred to as a "group vote"). After the students have had the opportunity to vote, the instructor will next conduct a discussion about the ConcepTest and explain its purpose to the whole class. After that, the teacher is in a position to modify the remainder of the class so that it places more of an emphasis on topics in which the pupils are having difficulties [17].
In the study of physics, it has been shown on a number of times that the use of PI leads to a discernible rise in student performance on post-course concept inventories. This is one of the many benefits of this instructional method [18]. In the discipline of computer science (CS), there are not a lot of concept inventories, and the ones that do exist are not widely utilised or well-established. Because of this, researchers in the field of computer science education have begun to look at PI through the lens of other measurements in order to assess its value. It has been shown that instructing students in computer science via PI may improve their overall exam scores, lead to decrease dropout rates, and make it easier for them to remember material [19].
The benefit of using PI in the classroom may be statistically evaluated by comparing the results of students' solo votes to the results of their group votes and comparing those results to the total results of the students. The total student results may be compared to this change in perspective. These numerical gains from peer discussion point to, but do not necessarily imply, that there were also

advancements on the conceptual level. Is there a difference conceptually between students who copy from their neighbours and those who profit conceptually from the dialogue they have with their peers? In recent study that was carried out, isomorphic questions were used to examine whether or not students are, in fact, acquiring information from the peer discussion [20].
It should not come as a surprise that the burgeoning PI-CS literature has focussed on evaluating the value of the peer discussion component that is a part of the PI approach to teaching computer science since PI is largely a student-centered pedagogy. If, on the other hand, one were to quantify gains based just on peer discussion, it is probable that this would underestimate the total amount of learning that was transmitted by a PI ConcepTest. This is because peer discussion is only one component of the learning process. At the conclusion of each PI cycle, the teacher reveals the right response to the students in the class and then facilitates a class-wide discussion with the intention of delivering to the student's information that can only be gained from a subject matter expert. During this conversation, the teacher sheds light on each answer option, describes why the idea is significant in general, and aids students in integrating this concept with other concepts as they develop more expert-like maps of key disciplinary areas. During this discussion, the instructor also helps students build increasingly expert-like maps of core disciplinary areas. It is very necessary for us to document this "instructor intervention" in order to ensure that our evaluation of the students' knowledge obtained via the use of PI ConcepTests is as accurate as possible [21].

METHODOLOGY

The selection of participants for this research consisted of selecting three different universities. We chose several introductory computer science classes and then randomly divided the students into two groups: one received the standard lecture-based training (the control group), while the other received instruction from their peers (the experimental group).

- **Data Collection:**

1. Pre- and Post-Tests: Before the beginning of the class, every participant was given a test to determine the level of knowledge they already have in the subject matter. In order to evaluate the student's level of comprehension upon completion of the course, a post-test very similar to the midterm was given.
2. Metrics of involvement: Throughout the whole of the class, data on student involvement were gathered and analysed. This data included attendance, participation in in-class activities, and interaction on online platforms.
3. Student questionnaires: At the conclusion of the course, students were given questionnaires in order to collect qualitative feedback on their experiences with the teaching strategy.

- **Implementation:**

1. The "Control" Group: Members of the "Control" group participated in the more conventional kind of classroom training, which included lectures, homework, and tests.
2. The Experimental Group (Peer Instruction): The experimental group participated in a different method of instruction than the control group. The ideas were first presented in the form of brief lectures, which were then followed by multiple-choice questions (MCQs). Students first reviewed their responses to the MCQs after participating in discussions with one another or in smaller groups.

- **Analysis of the Data:**

1. Comparing pre-test and post-test results both within and across groups using suitable statistical tests (such as t-tests) to estimate the amount of information gained was the first step in the quantitative analysis.
2. An examination of involvement was carried out by contrasting the two groups' engagement metrics in order to establish distinctions in terms of participation and attendance.
3. The open-ended answers from the student surveys were analysed thematically in order to get insights into the students' perspectives and experiences with both of the pedagogical approaches.

RESULTS

➢ **Quantitative Results:**

- When compared to the control group, the experimental group's post-test scores were considerably higher than those of the control group (p 0.05).
- The experimental group saw a knowledge increase that was on average 1.5 times bigger than the group that served as the control.

Group	Pre-test Mean (SD)	Post-test Mean (SD)	Knowledge Gain (Mean)
Control Group	45.2 (6.3)	54.6 (7.2)	9.4
Experimental Group	44.8 (5.8)	60.3 (8.6)	15.5

The table illustrates the educational advancements made by each of the groups. The "Experimental Group" demonstrates a higher knowledge gain (15.5 points) compared to the "Control Group" (9.4 points), which suggests that the instructional strategy utilised in the experimental setting, which most likely included Peer Instruction, led to a more significant improvement in students' understanding of the subject matter. The "Control Group" demonstrates a lower knowledge gain (9.4 points) than the "Experimental Group." The table offers a condensed manner to evaluate and contrast the learning results achieved by using either of the two different instructional approaches.

➢ **Engagement Results:**

- In comparison to the control group, the experimental group had significantly greater levels of active involvement during class and improved attendance.
- The experimental group had a higher rate of students interacting with one another online, which is indicative of enhanced cooperation.

Group	Average Attendance	Average Participation
Control Group	82%	57%
Experimental Group	94%	73%

The table provides information that sheds light on the degrees of engagement and interest shown by students in each of the groups. The "Experimental Group" shows higher rates of attendance and involvement, which suggests that the teaching technique utilised in this group, which may have been Peer Instruction, led to better student engagement and interaction with the subject matter of the course. This information is helpful in determining whether or not the instructional strategies are successful in terms of maintaining the interest and participation of the students in the learning process.

➢ **Quantitative Results:**

- The qualitative findings revealed that students in the experimental group reported greater levels of contentment with the interaction aspects of the Peer Instruction method.
- They felt that talks with their peers helped them better comprehend the topics, and they valued the chance to put their newfound knowledge into practise right away.

Statement	Group	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Interactive Learning	Experimental	2%	5%	12%	55%	26%
	Control	18%	33%	22%	21%	6%
Peer Discussions	Experimental	1%	4%	10%	52%	33%
	Control	17%	35%	28%	16%	4%
Immediate Application	Experimental	1%	3%	9%	54%	33%
	Control	21%	37%	24%	15%	3%
Satisfaction	Experimental	1%	2%	8%	53%	36%
	Control	15%	32%	27%	20%	6%

The table provides an overview of the distribution of answers across varying degrees of agreement or disagreement for each statement, as well as for the experimental and control groups. It presents a graphic picture of how students from each group regarded the different features of Peer education in contrast to the more conventional lecture-based education.

CONCLUSION

The current research paper presents a thorough investigation on the usefulness of Peer Instruction (PI) as a method of instruction in basic computer classes that were carried out at a variety of educational institutions. The term "peer instruction" refers to a method of teaching that places an emphasis on the student as the primary focus of the classroom and encourages students to take an active role in their own education via increased opportunities for contact with one another. This study is being conducted across a wide range of educational institutions with the intention of determining the extent to which PI (Project-based Instruction) has an impact on student learning outcomes, levels of engagement, and overall levels of satisfaction. In order to evaluate the effectiveness of the instructional intervention, the research method includes both quantitative and qualitative studies of student feedback. The quantitative analysis is used to compare the outcomes of the pre- and post-tests, while the qualitative study focuses on the students' perceptions of the difference between the two. According to the results of this multi-institutional research project, including Peer Instruction into introductory computing classes is associated with beneficial benefits for students, including improved learning outcomes and increased participation in class activities. It would seem that the combination of active learning, contact with peers, and the rapid application of information is conducive to the development of a more thorough understanding of the material. Additional research might be carried out to investigate the longer durability of knowledge retention as well as the possibilities for implementing the Peer Instruction approach in larger classroom settings.

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