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Imparting effective Teaching Learning Methodsfor teaching C programming course to First YearNon-IT Students

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***Abstract*— Nowadays, Computers are the dominant technology of the twenty-first century. Thus, programming and the development of software are fundamental activities in which many people across the globe are involved. As a result, programming courses are part of the curriculum. The course is introduced to all first-year IT and Non-IT students who have either no or less expertise in computer programming. The main purpose to select these techniques for non-IT students is to prepare them to work with IT specialists at their future jobs by instilling in them a constant knowledge of technical fundamentals. But as compared to IT students, learning of C programming becomesdifficult for non-IT students due to this their passing rate is low. Students lose their interest in programming due to their having less computer programming knowledge which leads to a gap in technical competency require by the IT sector. Taking this into consideration activities like quizzes, debugging tests, and usage of a virtual lab for students were implemented. These activities enhanced students' way of thinking, problem-solving ability, programming, and debugging skills. The idea of using PBL teaching methods, Think-Pair-Share, and E-Learning may improve the effect of C language teaching, and promote the student's learning initiative. The main focus of this study is to enlighten different teaching approaches and methodologies forfirst-year non-IT students.**

***Keywords*— Coding standard, E-Learning, Programming Language, PBL Teaching, Problem-solving, Non-IT, Virtual Lab.**

I. INTRODUCTION

Information technology has recently advanced quickly and has become quite important to modern living. This function is crucial both at home and at work or school. Students must therefore master a variety of computing abilities to feel confident, be prepared for the future, and be able to contribute effectively to the IT world.

According to ERUM MEHMOOD (2020), the programming course is introduced to all first-year students who have either no or less expertise in computer programming. The programming is challenging for novices right away. First, there are some language issues. Any programming language has a syntax that is extremely dissimilar from a normal language. Simple grammatical mistakes might produce cryptic error messages that are challenging to deciphering. Additionally, the students run into semantic challenges.

It is challenging to forecast the precise outcome of a programmed code because it is difficult to accurately understand the operational semantics of programming language features. In consequence, this makes writing programs challenging. Second, solving problems is challenging regardless of the complexity of the programming language used. For beginners, language difficulty matters more than problem-solving.

For undergraduate students to apply their newly acquired knowledge to real-world situations rather than just writing code, they must possess problem-solving abilities as per Vidya S. Handur (2015). They ought to be able to create and enhance a system using quantitative and qualitative evaluations of its performance, functionality, and usability. They should be aware that there are various answers to a certain issue and that choosing one of them is not merely a technical task because these solutions will affect people's lives. Graduates should also be able to explain their solution to others, including the rationale behind it, the steps it takes to resolve the issue, and any presumptions that were made.

The most effective approach to learning is activity-based learning. The teacher facilitates the learning of the students through a variety of activities. The independence of the learner is prioritized above everything else, which produces the optimal learning environment. The information and materials required to help the students concentrate and think critically are made available to them. Activity-based learning can be implemented using a variety of activities, depending on the teacher's skills, the student's abilities, the time available, etc. Teachers can employ many types of exercises to make their lessons entertaining, which is helpful.

Therefore, the primary goal of modern computer education for students who do not major in IT is to prepare them to always be knowledgeable about technological foundations and be able to communicate effectively with IT specialists at their future workplaces. This paper focused on, how to combine PBL and E-Learning to teach the fundamentals of programming to non-

IT students who are new to the subject as per Margarita Zambrano (2021).

The remainder of this paper is as follows: Section II is based on the related literature analysis. Problem description and problem analysis in Section III. Improvement in C language teaching in Section IV. The concluding remarks are described in Section V.

II. LITERATURE REVIEW

This section explores, existing strategies in teaching and learning programming courses for undergraduates.

The implementation of a Web-based e-learning platform and the accompanying teaching strategies in a very large class of first-semester mechanical engineering are presented in this paper as the author's learned experiences. Around 1400 students were enrolled at Technische University München (TUM). The focus was on giving students the chance to practice programming and modeling languages online and to assess their use for potential future research on the associated learning mechanisms. This paper covers the benefits for the instructor during various course phases and provides an outline of how e-learning relates to other course components as per Rehberger, S (2013).

LIU Shukun (2013), One of the foundational courses for computer majors in many colleges is C programming. One of the most crucial classes for computer majors is this one because it is a prerequisite for courses like data structures, analysis and design of algorithms, system software, and object-oriented technology. Because of this, all computer science educators are aware of its importance during the educational process. Define Learning Goals, Increase Learning Interest, and Improve Study Motivation are all part of the C language teaching program's overview. Select the appropriate textbook, change the teaching style, place more emphasis on various topics by the learning objectives, improve student interaction, modify the lesson plan, and reassign the hours of theoretical and practical instruction, the practical teaching approach, task organization, and strengthened practical ability testing. The authors found that implementing newer teaching techniques had a positive impact on students' academic performance.

According to the Budny, D. Lund (2002) experience teaching C programming, students struggle to comprehend the concepts of arrays, pointers, and structures. They also struggle to deal with the syntax of the language, plan the organization of the program, and comprehend the concepts of function calls and flow control statements like looping and branching. Due to the nature of the language, the instructor of a normal C programming course must address each of these issues simultaneously. The author's split the many concepts to address this issue and used distinct software applications to introduce each notion separately. Explanations of the idea of an array, matrix operations, and data input, for instance, have all been done using EXCEL. Additionally, the built-in functions give the learner a variety of helpful resources. HTML is a great way to introduce the idea of building a program, and MATLAB is a great way to introduce the idea of control, such as looping and branching, without many of the syntactical error issues that C has. Once the students are comfortable using EXCEL, UNIX, HTML, and MATLAB, introducing C to them is a lot simpler for them to comprehend.

The author Greg Michaelson of this paper are attempting to develop a problem-driven pedagogy for programming. The authors presumptively define computational thinking (CT) as algorithms, abstraction, patterns, and decomposition. A CT is not a method; it is a framework. The elements of CT interact and overlap with one another. There are simply no distinct steps of decomposition, abstraction, patterns, or algorithms. Finding these are a creative, iterative process in and of itself. And also, the solution as information and computation. The authors advise to begin with specific examples of the problem scenario and letting the information organize the computation. As with all education, consider the students' active participants and make an effort to base practice on resolving significant issues related to their real-world experiences and articulating in a manner they are likely to find relatable and interesting.

The goal of this study is to improve student learning in a course on programming for undergraduates by combining a straightforward active learning technique with the ideas of cognitive psychology. The investigation was carried out for a C++ first-year course. Quantitative studies were specifically conducted on a class of about 120 students who were taught the material utilizing the intervention and reinforcement-based active learning method. These two techniques' two main tenets are (a) teaching topics through hands-on programming, and (b) practicing group debugging. The students are able to recall the knowledge and do well on the examinations thanks to the active learning technique (group debugging activity) and cognitive psychology principles. Particularly, the pupils excelled in the portion of the course that involved easier topics in the beginning as per Seshasai Srinivasan.

This article reviews two active learning techniques that are already being used in introductory programming classes and suggests methods to make them even better. They concentrate on a group of assignments that can help transition live coding activities from instructor-led to student-led and turn the former into a true active learning pedagogy. Then, without the disadvantages typically associated with this type of programming competition framework, they suggest utilizing test-driven development methodologies through projects designed to engage students in competitive learning. The novel activities have been tried out in classes taught at the University of South Florida, and observations of their effects are examined in relation to constructivist educational approaches, pair programming/test-driven procedures, and constructive alignment theory as per Alessio Gaspar (2007).

M. Ercan et. Al (2020), analyze challenges in teaching programming course to electrical and electronics engineering students. To overcome these challenges and to increase engagement of students in programming authors used

evidence-based technique for teaching computer. The approach entails integrating a number of tried-and-true teaching best practices with a reflective tool for the instructor to use while developing and delivering the course.

Hu Lin et. Al (2012), examine approaches currently used to teach C programming and finds out whether these approaches failed to generate enthusiasm, and creativity in students. Because of these approaches students remain in a passive learning state. So authors recommended the idea of using the PBL method to teach C programming to develop active learning in students.

III. PROBLEM DESCRIPTION

The widely used computer programming language C, which contains many numbers of operators and expressions as well as the qualities of flexible statements and portability, are used to communicate between people and computers. At first interaction with the C language, it would be challenging to comprehend the issue. For instance, complex expressions and operations with priority rules, according to the algorithm in C language procedures, such as increment, decrement, comma, and the concept of the ternary operator. But to finish the task, the majority of teachers use experimental "teaching based" teaching models, classroom lectures, tasks, and a very big lesson information capacity. The teachers are the center of the classroom, emphasizing fundamental education and initiative while disregarding the majority of the students in favor of "teaching." Students are always in a passive position when using the teaching strategy "I tell you to listen, I teach you to learn" which results in a lack of interaction between professors and students. Additionally, professors just communicate knowledge to students, which is not conducive to igniting their excitement or encouraging initiative on their behalf.

With the ongoing advancement of high education reform and the extensive use of multimedia technology, a variety of teaching methods were reversed type are integrated and used in the classroom by many teachers, to varying degrees, to make up for the absence of conventional teaching methods and to improve the teaching outcome. However, there is still a lack of widespread stimulation for students' independent learning and passion, they are still in a state of passive learning.

IV. IMPROVEMENT IN C LANGUAGE TEACHING

Following effective techniques, we have implemented for improvement in C language teaching:

1. Problem Based Learning (PBL)

In the so-called "problem-based learning (PBL)" method, which is focused on real-world examples for the screenplay, students go through case studies to "find, analyze, and solve problems" while being guided by teachers. Students can do their information searches and acquire the essential knowledge while resolving issues Problem Based Learning Method.
In the so-called "problem-based learning (PBL)" method, which is focused on real-world examples for the screenplay, students go through case studies to "find, analyze, and solve problems" while being guided by teachers. Students can do their information searches and acquire essential knowledge while resolving issues. The knowledge the students have learned in this method is amazing and has a long-term memory. With "problem-based learning," which is learner-centered, the learner should determine the learning objective based on the problem, and self-learning should be used to solve problems and gain understanding. With this kind of instruction, students can develop their capacity for self-learning and develop into lifelong learners as per Wen Xiangmin (2012).

- **Application of the PBL method in C language teaching:**

  - **PBL MODEL BUILDING:**

The students can finish writing source code and talk about the benefits of the code through the five steps of "questions, assumptions constructing, data gathering, argument assuming, and summary." The ideas for algorithm design can be developed, and actual programming skills can be trained, by strengthening the algorithm and weakening the language. The named course lasts for one semester and students have two hours of lecture and 4 hours of practical weekly. Usually, the whole class is divided into 3 batches and each batch size is 20 students; this number annually depends on the total number of the matriculated student.

  - **TEACHING ORGANIZATION OF PBL MODE:**

The "theoretical courses, practical courses, and extra curricular instruction" organizational structure are used in the classroom, and the students are taught in groups. At thebeginning of the semester, groups are formed based on the student's program design aptitude, with benefits and drawbacks and 6–8 students in each group, with a team leader in charge of the group's implementation. The teacher merely assigns assignments for each group, leaving the leader in charge of the group member's completion of the relevant work and daily practical difficulties. Emphasis is placed on self-directed learning and cooperative learning groups in this manner so that students can develop their social interaction and teamwork abilities.

  - **TEACHING EVALUATION OF PBL MODE:**

The "C Programming Language" PBL teaching mode places more attention on practical training to improve students abilities, and it prevents students from being inert, plagiarizing, or just not doing. It also establishes acomprehensive evaluation system that includes written tests,programming, operation, and other things. Three categories of routine procedures are distinguished: Problem-solution, exercises in a notebook that needed to be handed in, and a program title that can be copied by U disc or sent to the teacher via the network are the first three requirements. Eachpoint of knowledge is explained, and then corresponding operations are delivered. There will also be arbitrary questions asked in class, and the group being

questioned must explain how they solved their problems.

Following figure 1 shows a sample flowchart design by the student using the Raptor tool. Students can visualize the execution step of the program using the Raptor tool which will help to develop a solution for the given problem statements.

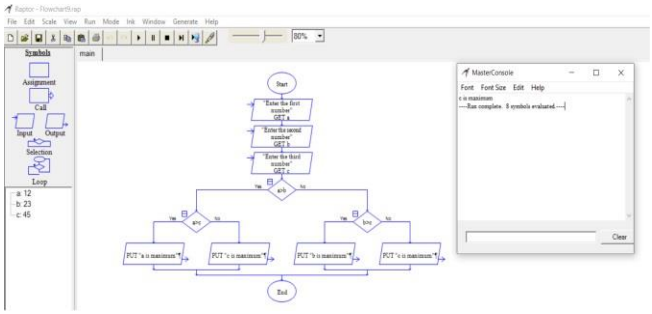


Fig. 1 Design a Flowchart using Raptor

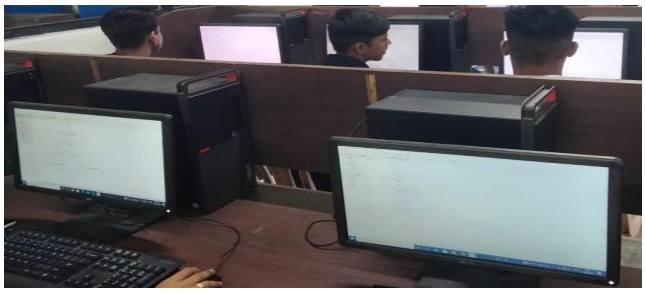


Fig. 2 Utilization of The Raptor tool for designing a flowchart

For the programming for problem-solving (C) first-year course, we use the Raptor tool during lab sessions for experiment no. 1 to increase the interest of students in this course. Figure 2 shows students designing a flowchart for a given problem statement during a lab session.

2. E-Learning Method

You can train yourself whenever and wherever you want because you have access to the internet constantly. It is a highly practical and adaptable choice, and most of all, you are independent in every way. You can train yourself not only during the week but also on the weekends or whenever you have free time. There is no absolute law. You can communicate with others online and get any questions answered through discussion boards and chats. If you don't happen to understand the subject the first time around, you can go back and watch and listen to the video tutorials that are offered for audio and video learning. The Moodle e-learning environment is a very efficient learning technology that supports blended learning and promotes student interest in the course and motivation for learning activities, therefore fostering a culture of learning.

- **Application of the E-Learning method in the C language teaching:**

  - **Moodle:**

A free software program called MOODLE was created to assist professors and students in developing high-quality instruction. Modular Object-Oriented Dynamic Learning Environment is also known as MOODLE.
The primary purpose of Moodle is to exchange course materials. The lecture slides, documents in any format (PDF, HTML, DOC, etc.), movies, audio, animations, images, and other content can all be included in the class notes as per Olga Mironova (2016).
We can arrange the content either topically or according to the class schedule, depending on the format selected. Different sub-titles for content, such as introduction, overview, survey, graphics, animations, conversations, etc., are possible. Discussion boards can be included to increase student and teacher interaction, which is a requirement for an efficient e-learning system. Teachers can encourage students to ask questions online, post questions for discussion, and answer questions online. Teachers can create and assign quizzes using MOODLE as per Dr. Dharmendra Chourishi.
In every learning setting, assessments play several important functions in providing feedback to the student on where they stand with the subject objectives and the class as a whole, as well as to the tutor on the quality of the instruction.
Assignments can be defined in moodle with a deadline and a maximum grade. The server where the assignments are stored allows students to upload them in any file type with a date stamp.

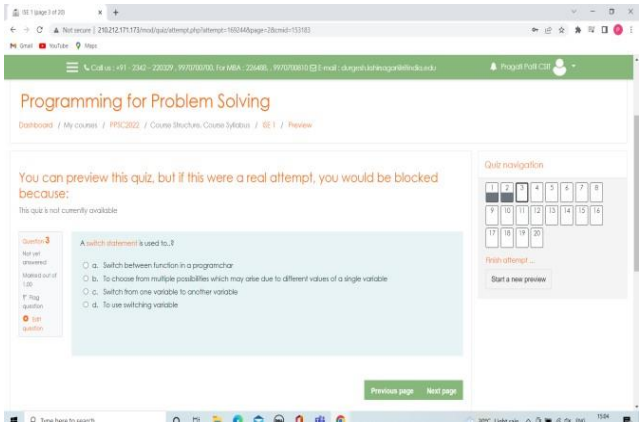


Fig. 3 Conduction of quiz on moodle

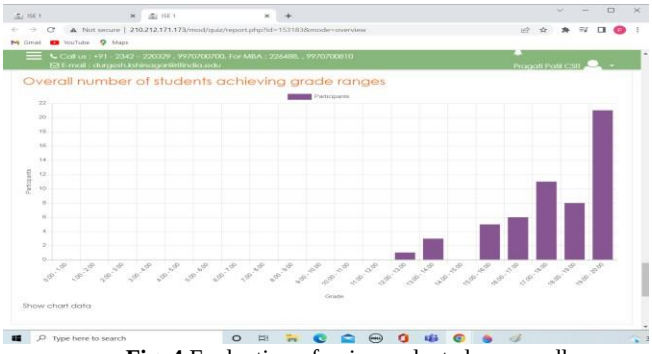


Fig. 4 Evaluation of quiz conducted on moodle

The above Figures 3 and 4 show the usage of moodle for conducting online quizzes and debugging tests to evaluate the student's performance.

- **Virtual Labs:**

A virtual teaching and learning environment designed to improve students' laboratory skills is referred to as a virtual lab. They rank among the most significant e-learning resources. In contrast to the limitations of actual labs, they are located online, where students can conduct a variety of experiments at any time and without regard to location or schedule.
Additionally, virtual laboratories offer the teacher several benefits. Teachers can arrange experiments without having to travel to the lab at specific times or set up in different locations thanks to virtual labs. This accomplishes one of the main purposes of online learning, which is to savetime and effort. Students and teachers can use the most recent technologies in virtual labs. Teachers have the chance to monitor and evaluate students electronically thanks to virtual labs. Additionally, Virtual Lab offers pre-test and post-test options to gauge students' comprehension of that particular exercise. In a virtual lab, students view and interact with system-generated objects, data, or phenomena to achieve the learning goals of a lab experience.
We have used the existing virtual lab of programming for the problem-solving course(C) to develop the interest, engagement level, and programming skills of non-IT students. This existing available virtual lab contains a pretest, procedure, simulation, post-test, etc. and with the help of pretest and posttest marks course teachers can get an idea of the depth of understanding of particular concepts by students. Figure 5 and figure 6 shows the utilization of existing available virtual lab by students for this course.

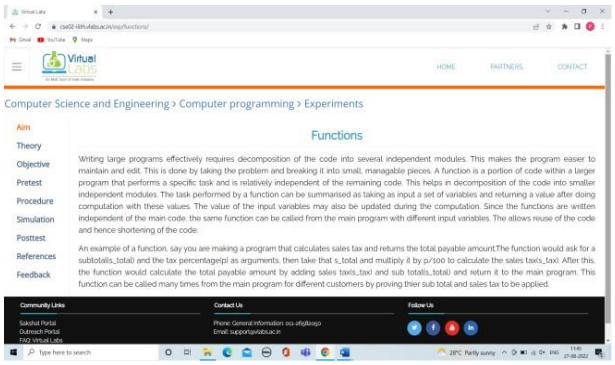


Fig. 5 Use of existing available Virtual Lab

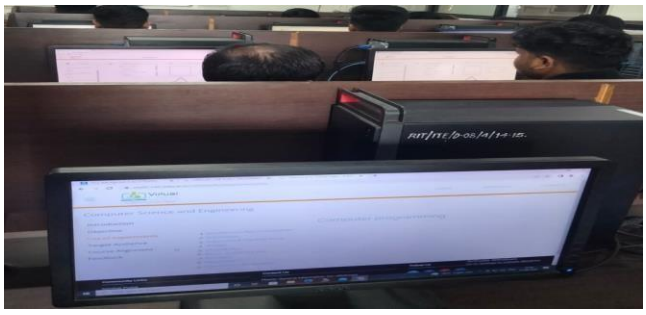


Fig. 6 Utilization of Existing virtual lab

3. THINK-PAIR-SHARE

To keep engaging students in the teaching-learning process it is important to make the normal learning process more attractive and dynamic as per Olga Mironova (2016).

In a class, we can see two types of learners:

Active Learners: Who prefer to work out things and work in groups.
Reflective Learners: They prefer thinking things through and to work alone or with a familiar partner.

For example, Data Type is the topic where students get confused to understand and know the differences between each of them. Once the topic is delivered, we may ask questions to the students and make them think and share the ideas with the paired neighbor, so they may get clarity with the topic.

- **Think-Pair-Share Implementation:**

To implement this activity, we have formed pairs of students. 30 pairs were formed out of 60 students and each pair have one reflective and one active learner. Some questions were assigned to each pair, and they were asked to discuss among themselves to solve the assigned questions.

Below Table 1 is the Sample Activity plan for conducting the Think-Pair-Share Activity for the topic Basics of C-Programming:

Table 1: Sample Activity Plan of Think-Pair-Share

Sr. No.	Topic	Activity
1	Algorithms and Flowchart Time Duration: **12 min**	1. Pose the question on basic data types and differences between themto ask the learner group to think individually (3 min) (Think) 2. Now Students are divided into 30 teams, each team consisting of one active and one reflective learner (3 min) (Pair) 3. Share their ideas and come up with the solutions (3 min) (Share) 4. Discuss in the classroom (3 min)

After discussing the Data types concepts, a few questionswere posed to the learner group. 60% of the students were giving the

answers (most of them were reflective learners), then I ask them to form the pair and share their ideas. Students discussed with the paired neighbor and were ready to answer the questions. The questions were repeated with slightmodifications on the same topic, and almost 95% of the students answered them.

V. FEEDBACK ANALYSIS

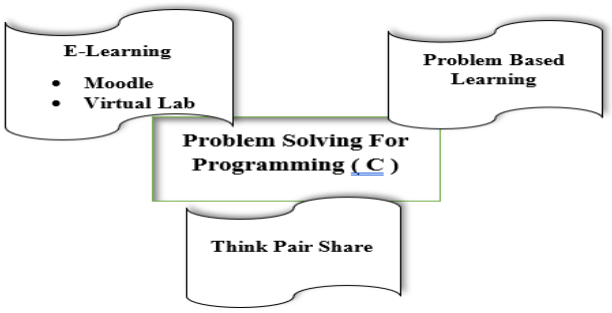


Fig. 7 Active Teaching Learning Practices

After implementing the above innovative teaching-learning methodology we had taken feedback surveys from first-year non-IT students through a google form. The feedback survey of students regarding the implementation of PBL think pair share, E-learning, etc. are as follows:

Table 2: Feedback survey

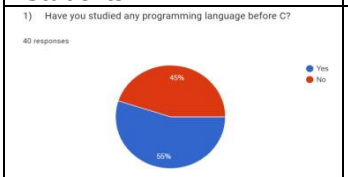
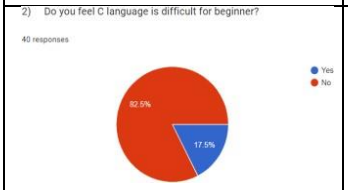
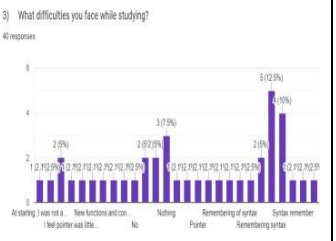
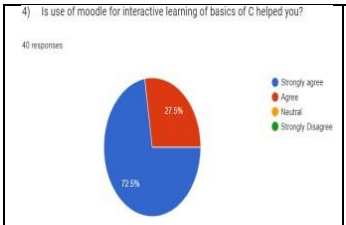
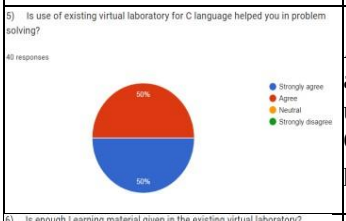
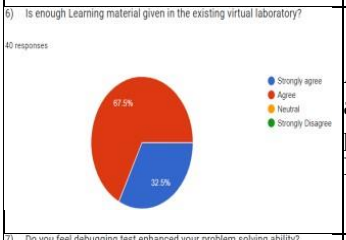
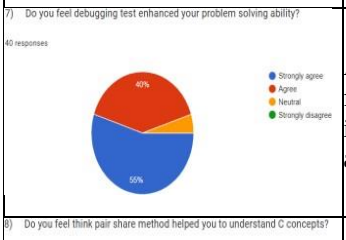
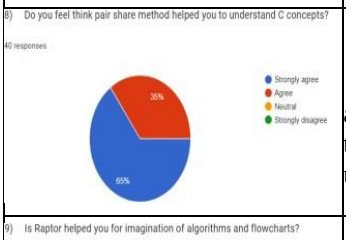
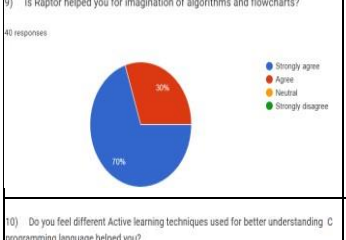
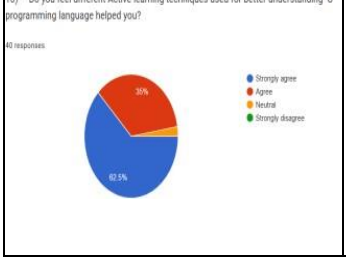
Questionnaires and responses were given by Students	**Analytical Remarks**
	About 55% of students learned programming language before C language.
	About 82% of students face difficulties to learn C Language.
	Students feel difficulties in syntax remembering, pointer concepts, etc.
	About 72% of students strongly agree and 27% agree that the use of Moodle for learning the basics of C helped them.
	About 50% of students strongly agree and 50% agree that the use of the existing virtual lab of C language helped them in problem-solving.
	About 67% of students strongly agree that sufficient material is present in the existing virtual Lab of C language.
	About 55% of students strongly feel that debugging test improves problem-solving ability.
	About 65% of students strongly agree and 35% agree that the think-pair-share method is useful to understand C concepts.
	About 70% of students strongly agree and 30% agree on the use of Raptor tools for the understanding of algorithms and drawing the flowchart.
	About 65% of students feel that different active learning techniques are effective to understand C concepts.

Table 2, is a feedback survey we had taken from the student and it shows students are satisfied and involved in various teaching-learning methodologies conducted throughout the semester and is reflected in their results.

After completion of all activities, feedback from all 70 students have been taken on the scale of 0 to 10. Above figure shows the comparative feedback received from the students on each

activity. It has been observed by the graph that PBL and E-Learning tools are appreciated by many of the students, while think-pair-share is moderately appreciated by the students.

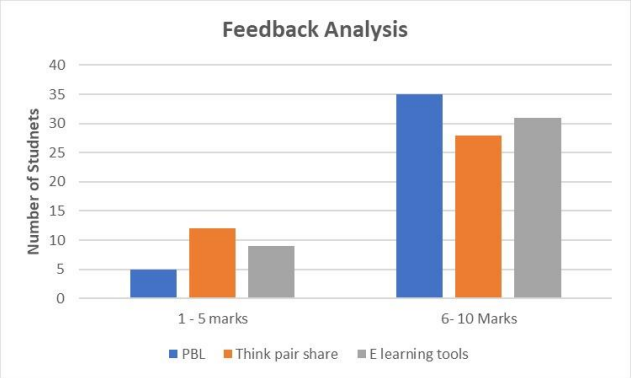


Fig. 7 Feedback Analysis Graph

Observations noted by feedback:

- The majority of the students agreed that C language is difficult for beginners due to difficulty in remembering syntax, pointer concepts, etc.
- To overcome the above difficulties, we used different active learning techniques.
- 72.5% of students feel the usage of moodle for interactive learning of basic C helped them.
- Approximately 67.5% of students are agreeing that the contents of the existing virtual lab are helpful for a better understating of the topic and helpful for the conduction of the experiment of C Lab.
- 70% of students are strongly agreeing (30% agreed) that the raptor tool helped them with their imagination of the algorithm and flowchart.
- The majority of students feel the implementation of different active learning techniques used for a better understanding of C concepts helped them.

VI. CONCLUSION

Traditional teaching methods have their advantages and disadvantages. It has been observed that teaching programming courses using the traditional method is not suitable for especially non-IT students. Learning C programming requires several abilities such as programmers – learning language features, and developing problem and programming skills. To fulfill the above requirements, we use different teaching-learning practices like problem-based learning, debugging tests, Think-pair- share, and virtual lab for a better understanding of laboratory experiments. With the inclusion of these activities in the curriculum, students may easily embrace industry standards and develop effective software for their careers. From the feedback collected from the students, it has been observed that there is a need to conduct programming logic development activities more effectively by the teacher.

REFERENCES

Margarita Zambrano, César Villacís, David Alvarado, Diego Pérez, Verónica Carvajal, Johana Guijarro “Active Learning of Programming as a Complex Technology Applying Problem Solving, Programming Case Study and Online GDB Compiler”, 2021 10th International Conference on Educational and Information Technology.

ERUM MEHMOOD, NAEEM A. NAWAZ , "Curriculum, Teaching and Learning, and Assessments for Introductory Programming Course”, IEEE Access- Volume 8, July 2020.

Olga Mironova, Irina Amitan, Jüri Vilipõld, and Merike Saar, “ACTIVE LEARNING METHODS IN PROGRAMMING FOR NON-IT STUDENTS”, International Conference e-Learning 2016.

Vidya S. Handur 1, Priyadarshini D. Kalwad 2, Nagaratna Yaligar 3, Vishwanath G. Garagad 4, Manjula K.Pawar 5,” An Activity Based Learning: C Programming”, 2015 IEEE 3rd International Conference on MOOCs, Innovation, and Technology in Education (MITE).

Rehberger, S.,Munchen, Frank, T., Vogel-Heuser B." Benefit of e-learning teaching C-programming and software engineering in a very large mechanical engineering beginners class”, Global Engineering Education Conference(EDUCON), 2013 IEEE.

LIU Shukun, CHEN Zhen, TANG Jinpeng Department of Information Science and Technology, “The Improved Methods of Teaching Practice Based on C Language Programming”,© 2013. The authors - Published by Atlantis Press.

Wen Xiangmin1 , Hu Lin2, “Research of PBL teaching in the non-computer science C language teaching”, 2012 2nd International Conference on Consumer Electronics, Communications and Networks (CECNet).

Budny, D. Lund, L.; Vipperman, J.; Patzer, J.L.I.I.I., “Four steps to teaching C Programming”, Frontiers in Education, 2002. 32nd Annual, F1G-18 - F1G-22 vol.2 ,2002.

Greg Michaelson “Teaching Programming with Computational and Informational Thinking Greg Michaelson”, Journal of Pedagogic Development Volume 5, Issue 1.

Dr. Dharmendra Chourishi, Dr. Chanchal Kumar Buttan “Effective E-Learning through Moodle”, International Journal of Advance Technology & Engineering Research (IJATER).

Seshasai Srinivasan, School of Engineering Practice & Technology, Hamilton, Canada Dan Centea School of Engineering Practice & Technology, Hamilton, Canada, ” An Active Learning Strategy for Programming Courses”.

Alessio Gaspar, Sarah Langevin University of South Florida, 3334 Winter Lake Road, 33803 Lakeland, FL, USA [alessio | sarah] @ softice.lakeland.usf.edu, “Active learning in introductory programming courses through Student-led “live coding” and test-driven pair

programming", Gaspar, Alessio & Langevin-Gaspar, Sarah. (2007).

M. F. Ercan and D. Sale, "Teaching programming: An evidence based and reflective approach," 2020 IEEE REGION 10 CONFERENCE (TENCON), 2020, pp. 997-1001.

W. Xiangmin and H. Lin, "Research of PBL teaching in the non computer science C language teaching", 2012 2nd International Conference on Consumer Electronics, Communications and Networks (CECNet), 2012, pp. 490-492