ENHANCING ACTIVE LEARNING THROUGH CHATBOTS: A QUASI-EXPERIMENTAL STUDY USING ChatGPT AT UNDERGRADUATE LEVEL

By

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NATIONAL UNIVERSITY OF MODERN LANGUAGES ISLAMABAD

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December, 2024

THESIS AND DEFENSE APPROVAL FORM

The undersigned certify that they have read the following thesis, examined the defense, are satisfied with the overall exam performance, and recommend the thesis to the Faculty of Social Sciences for acceptance:

Thesis Title: Enhancing Active Learning through Chatbots: A Quasi-Experimental Study using ChatGPT at Undergraduate Level

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Candidate of **Master of Philosophy** at the National University of Modern Languages do hereby declare that the thesis **"Enhancing Active Learning through Chatbots: A Quasi-Experimental Study using ChatGPT at Undergraduate Level"** submitted by me in partial fulfillment of MPhil degree, is my original work, and has not been submitted or published earlier. I also solemnly declare that it shall not, in future, be submitted by me for obtaining any other degree from this or any other university or institution.

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Shamsuddin Qureshi

DEDICATION

Dedicated to my beloved guardian angels in the boundless skies, whose enduring presence has illuminated my path through life's journey. To my late revered spiritual father, Haji Khair Muhammad Abbasi, whose wisdom and guidance continue to inspire and uplift my soul. To my late cherished grandmother, whose unwavering love and nurturing embrace was a source of strength and solace in times of uncertainty. And to my late dear uncle Khalid Mehmood Awan, whose boundless kindness and unwavering support was a beacon of light in the darkest of hours. Your spirits reside eternally within me, guiding me with every step, and for that, I am forever grateful.

ABSTRACT

Thesis Title: Enhancing Active Learning Through Chatbots: A Quasi-Experimental Study using ChatGPT at Undergraduate Level

This study was aimed to investigate the effect of using ChatGPT on active learning of undergraduate students. The study was targeted on undergraduate students studying in colleges and investigated the effect of using ChatGPT on affective reaction and utility judgment of students in an active learning environment. It also assessed the effect of ChatGPT on quality of learning of students at understanding level and applying level of revised Bloom's taxonomy. By employing mixed methods, for quantitative analysis, a quasi-experiment with non-equivalent but matching groups was conducted with pre-tests and post-tests of control group and experimental group to assess learning, and through questionnaire to measure their reactions, and for the qualitative analysis, content analysis of conversations of students carried out through ChatGPT was conducted. Through purposive sampling, undergraduate students of a BSCS class studying the course of Problem Solving and Programming were selected of an Islamabad Model College (Ex-FG college). The results of pre-tests and post-tests were analyzed using independent samples t-test and Mann-Whitney U test, and means were calculated for the questionnaire. The results of the study indicated that ChatGPT has positive effect on both reaction and learning of students in an active learning classroom of programming course at undergraduate level. It was recommended that ChatGPT may be used as a learning aid in an active learning classroom. Moreover, an active learning strategy that was used in this study to implement active learning to teach computer science students using ChatGPT was recommended to be used when designing lesson for an active learning classrooms.

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LIST OF ABBREVIATIONS

Abbreviation	Term
HEC	Higher Education Commission
TEL	Technology-enhanced learning
AI	Artificial Intelligence
TEAL	Technology-enhanced active learning / Technology-enabled active learning
ICT	Information and Communication Technology
MIT	Massachusetts Institute of Technology
POGIL	Process Oriented Guided Inquiry Learning
LLM	Large Language Model
HSSC	Higher Secondary School Certificate
UNESCO	United Nations Educational, Scientific and Cultural Organization
AIED	Artificial Intelligence in Education

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CHAPTER 1

INTRODUCTION

"If we teach today's students as we taught yesterday's, we rob them of tomorrow."

-John Dewey-

Learning occurs in every stage of life. All the human development that exists today is the result of learning that has happened before in human history. There has been wide research of how learning occurs in different human beings at different times and in different contexts. Unfortunately, the education industry in Pakistan still follows the traditional modes of teaching and learning at large where the classrooms are teacher-centered, and the students are considered as empty vessels who passively receive knowledge (Freire, 1970). This traditional mode of teaching and learning has not only caused the country to be left behind in economic development but is also the reason why educational institutions fail to develop contributing members of the society. Apart from that, according to Munna and Kalam (2021), this traditional mode of teaching leads to absenteeism among students and high dropout rates (Taylor and Wilding, 2009).

One of the alternatives to the traditional mode of teaching and learning can be active learning that involves active engagement of the participants in the learning process. Active learning has received widespread attention by the educationists and the researchers for developing students' learning capacity, increasing students' self-confidence and self-reliance, and cognitive development by enhancing their competencies, and improving their skills. The same has been recommended in the policies of different nations, references of the studies claiming that were mentioned in the

review conducted by Hartikainen, Rintala, Pylväs, and Nokelainen (2019). Furthermore, the Higher Education Commission (HEC) in Pakistan also recommends active learning through project-based learning, practicals, and experimentation in its curriculum (HEC, 2023).

According to Hartikainen et al. (2019), active learning refers to an instructional approach that emphasizes on engaging students in instructor-led activities and methods that prioritize student-centered learning. It is a constructivism-based learning paradigm which states that learners construct their understanding by being actively engaged in the learning process (Angraini, Kania, & Gürbüz, 2024). It criticizes the traditional concept of learning in which the external sources like teachers are considered as the only medium of providing knowledge to the students. It focuses on the idea of understanding rather than memorizing.

One of the types of active learning is technology-enhanced active learning. Technology-enhanced learning, TEL, is a type of teaching and learning approach that uses technology including artificial intelligence (AI). This integration of technology in teaching and learning can help learner build their knowledge and develop competencies. This technology-enhanced learning combined with the concept of active learning is called technology-enhanced active learning, TEAL, which is the use of information and communication technology (ICT) for the purpose of students' learning, which could be included in the phases of tutoring, instruction, and assessment (IBE, UNESCO). Borodzhieva, Tsvetkova, and Dimitrov (2021) stated in their study that TEAL was pioneered by Massachusetts Institute of Technology (MIT) as an alternative to the conventional lecture hall format, Technology-Enabled Active Learning (TEAL) is now

being adopted at several prestigious institutions, including North Carolina State University, University of Colorado, Harvard University, and the University of Maryland. (Dominguez, Alarcón, & García-Peñalvo, 2019; Misseyanni, Lytras, Papadopoulou, & Marouli, 2018).

Active learning can be implemented in many different forms and TEAL can utilize different types of information and communication technology. Technology that has recently gained widespread attention in the past decade and is causing revolution in the field of ICT is Artificial Intelligence. Recent advancements in AI has led to the development of generative AI models, known as chatbots, which are trained on vast amount of data to generate similar data based on that data; latest examples of which include ChatGPT and other similar technologies of OpenAI like ImageGPT, and DALL-E.

Chatbots are one of the most common applications of AI in today's world. A chatbot is an artificial intelligence application that is programmed to mimic human-like conversation through text or voice interactions. Chatbots can be found in various industries, including customer service, healthcare, and finance. They are used to automate tasks such as answering frequently asked questions, making reservations, and providing personalized recommendations. With the help of AI and machine learning, chatbots can learn from interactions with humans and become smarter over time, making them a powerful tool for active learning.

ChatGPT, a chatbot designed and developed by OpenAI, was launched for public in November, 2022. It was based on GPT-3.5 which stands for Generative Pre-trained

Transformer version 3.5. It gets a query in the form of text and uses neural network to perform variety of text generation tasks. It was trained on massive dataset which is used to generate its responses with remarkable accuracy and even make predictions on new, unseen data. As of the time of writing the synopsis of this study, ChatGPT had surpassed one billion visitors to its website through which the users can access the service: chat.openai.com (SimilarWeb, 2023).

ChatGPT based on GPT-3.5 is freely available, and has enormous potential to be used for the purpose of helping its users in teaching and learning activities. It can answer students' questions regarding any subject; they can use it to understand complex concepts by getting detailed systematic explanation (Baidoo-Anu & Ansah, 2023).

As students can learn by themselves using ChatGPT, and the same is the objective of active learning, this study aimed to study through an experimental design how active learning can be enhanced with the use of ChatGPT in a classroom setting.

1.2 RATIONALE OF THE STUDY

The rationale behind choosing this study for research included both personal interest and curiosity of the researcher as well as the studies pointing to this direction. The researcher had observed that the current generation studying in schools and colleges had experience with the digital technology from an early age compared to his generation and past generations. Same was pointed out in the studies of Rideout, Peebles, Mann, and Robb (2022), and Munawar, Ahmed, and Abbasi (2020), which were conducted on the children in America and Pakistan respectively. Hence encouraging students to use technology in the classrooms and integrating the same in everyday classes should not be a

problem and could enhance engagement and cognitive development (Ní Shé, Ní Fhloinn, & Mac an Bhaird, 2023).

Since the current generation has had early access to digital technology, they have become accustomed to perform multiple tasks at the same time (Rideout et al., 2022). Studies suggest that this could lead to the development of lesser attention spans for a single activity or inability to focus on the task at hand. In their 2014 study, Rosen, Lim, Felt, Carrier, Cheever, Lara-Ruiz, Mendoza, and Rokkum documented how the use of technology has led to attention-related issues like the inability to focus and lesser attention time spans. Students of this generation that actually possess this lesser attention span would not be able to focus while sitting passively or being least engaged in activities in traditional classrooms of longer duration.

In public schools and colleges in Pakistan, access to computers is only available to students in the period of laboratories. The teaching in such institutions does not commonly involve active participation of students and is generally dominated by the traditional methods. Numerous studies have highlighted the drawbacks of conventional teaching methods, which include students failing to progress at their individual pace, insufficient student engagement leading to absenteeism, and ultimately, high rates of student dropouts. Arshad-Ayaz (2010) in his study states that in educational institutions, hands-on approach to teaching and learning is required where students can use computers for learning by and for themselves; and that technology can be used to engage students to reduce high drop-out rates.

Another reason for choosing this study was the constructivist philosophy of the researcher that learners actively play their part in constructing their understanding (Angraini et al., 2024). The researcher himself has spent the past six years in teaching; and has always encouraged and tried to involve his students to participate in the learning process. Though, he had always felt a disconnection in the teaching and learning process when students had to go to the laboratory to practice what was taught in the class. This motivated the researcher to adopt a teaching-learning methodology of active learning that combines learning and practice together.

Furthermore, Lazar's (2015) study highlights the significance of educational technology in facilitating teaching and learning by demonstrating that the use of technology allows students to make individual progress in mastering educational content; they can define and choose the pace of work, and repeat the learning process for the topic that was not sufficiently clear to them or needs improvement; that after they perform practice exercises or tests, they can promptly receive feedback on their performance and keep track of their progress. Apart from that, in the recent times, the use of artificial intelligence (AI) has become an emerging trend in the field of education. The recent release and popularity of ChatGPT encouraged the researcher to integrate the use of ChatGPT in his practice which led to the question of what effects could it have on the learning of students.

1.3 STATEMENT OF THE PROBLEM

In recent years, there has been a growing trend of utilizing Artificial Intelligence (AI), specifically generative AI, in the field of education. The release of ChatGPT and its popularity has made the researchers focus their attention on exploring how powerful and

useful could it be in different contexts and significant research has explored its applications and impact in educational contexts. The use of ChatGPT in education is a promising area of research, as it offers the possibility of enhancing student engagement and learning outcomes. This study contributes to the growing body of research by examining the potential of generative AI to transform education.

Active learning, which emphasizes student-centered teaching approaches and interactive classroom environments, has been shown to be effective in promoting deeper learning and critical thinking skills. By leveraging the capabilities of ChatGPT in an active learning context, we can create a more personalized and engaging learning experience for students.

Although the use of ChatGPT in education offers potential benefits, there is currently a lack of empirical research on its efficacy in promoting active learning in higher education. Therefore, this study was aimed to investigate the effect of using ChatGPT on active learning of undergraduate students from colleges.

1.4 RESEARCH OBJECTIVES

Following were the objectives of this study.

1. To investigate the effect of using ChatGPT on active learning of students at undergraduate level.
    1a. To investigate the effect of using ChatGPT on students' reaction in terms of affective reaction and utility judgment of experimental group at undergraduate level.

1b. To investigate the effect of using ChatGPT on students' learning at Understanding and Applying Level of Revised Bloom's Taxonomy at undergraduate level.

1b(i). To assess the difference in students' learning in pre-test at Understanding Level of Revised Bloom's taxonomy of control group and experimental group.

1b(ii). To assess the difference in students' learning in post-test at Understanding Level of Revised Bloom's taxonomy of control group and experimental group.

1b(iii). To assess the difference in students' learning in post-test at Applying Level of Revised Bloom's taxonomy of control group and experimental group.

1.5 RESEARCH QUESTION

The overarching question for this study was:

Q1: How can ChatGPT be used for enhancing active learning at undergraduate level?

1.6 NULL HYPOTHESES

Following null hypotheses were formulated for this study.

$H_0$1: There is statistically no significant effect of using ChatGPT on active learning of students at undergraduate level.

$H_0$1a: There is statistically no significant effect of using ChatGPT on students' reaction of experimental group at undergraduate level.

$H_0$1a(i): There is statistically no significant effect of using ChatGPT on students' affective reaction of experimental group at undergraduate level.

$H_0$1a(ii): There is statistically no significant effect of using ChatGPT on students' utility judgment of experimental group at undergraduate level.

$H_0$1b: There is statistically no significant effect of using ChatGPT on students' learning at undergraduate level.

$H_0$1b(i): There is statistically no significant difference in students' learning in pre-test at Understanding Level of Revised Bloom's taxonomy of control group and experimental group.

$H_0$1b(ii): There is statistically no significant difference in students' learning in post-test at Understanding Level of Revised Bloom's taxonomy of control group and experimental group.

$H_0$1b(iii): There is statistically no significant difference in students' learning in post-test at Applying Level of Revised Bloom's taxonomy of control group and experimental group.

1.7 CONCEPTUAL FRAMAEWORK

This study was based on the learning theory of Constructivism and Kirkpatrick's model. Constructivism proposes that individuals engage in the active process of constructing their own understanding and knowledge of the world by means of their experiences and interactions with their environment (Piaget, 1973). In other words,

people create their own understanding of the world by their experiences and their interpretation of those experiences.

Constructivists believe that knowledge is not a mere transfer of information from a teacher or a textbook to a learner; rather it is something that is actively constructed in the learner's mind through their experiences and interactions with the world around them. This implies that learners are not simply passive receivers of knowledge, but instead, they actively engage in the learning process as participants.

Kirkpatrick’s model is a model that has stood the test of time as one of the most widely recognized and applied course evaluation frameworks. It was first introduced by Donald Kirkpatrick in 1959 in an article titled "Techniques for Evaluating Training Programs" that appeared in the Journal of the American Society of Training Directors. Over the years, the model has been refined and expanded by Kirkpatrick himself and other researchers. For example, in 1976, Kirkpatrick published an article titled "Evaluation of Training," which further elaborated on the four levels of evaluation and provided guidance on how to implement them in practice (Kirkpatrick, 1976).

The Kirkpatrick’s model offers a framework for identifying the types of inquiries that should be posed during evaluation and the standards that may be suitable for assessment. This framework is based on four levels: reaction, learning, behavior, and results which are described below according to Kirkpatrick and Kirkpatrick (2006).

The Level 1 of Kirkpatrick's model assesses the degree of satisfaction of participants or how they feel about training program. At this level, the evaluators can

gauge participants' engagement, contributions, and responses to understand how well the program was perceived by them.

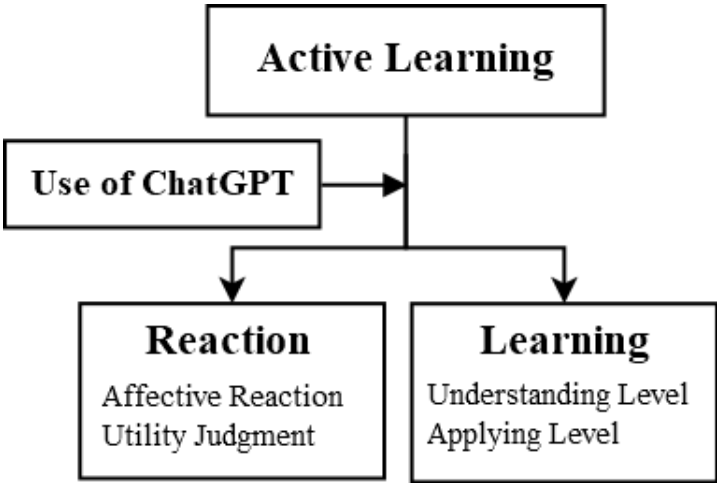
The Level 2 of Kirkpatrick's model focuses on measuring the knowledge, skills, and values acquired by the participants during the training by using quantifiable indicators. This level determines whether knowledge of the participants and/or their skills had improved as a result of the training. This level also assesses participants' confidence in performing the changed behavior that the training had targeted, their assurance of being able to perform it, and their motivation for doing it.

The Level 3 of Kirkpatrick's model evaluates the changes in the behavior of the participants at their workplace resulting from the training. This level involves measurement for changes in behavior which spans over several weeks or months after the training of the participants.

The last level, i.e., the Level 4 of Kirkpatrick's model evaluates the institutional outcomes that can be attributed to the training program and demonstrate a positive return on investment.

Figure 1.1

Effect of ChatGPT on Active Learning measured through Kirkpatrick's Model



As this study was delimited to the evaluation of the first two levels of Kirkpatrick's model, the studies of Praslova (2010) and Ruiz and Snoeck (2018) were used as the basis to define how each level can be measured.

Table 1.1

Adaptation of First 2 Levels of Kirkpatrick's Model into Higher Education and TEL

Level of Kirkpatrick's Model	Definition in the context of higher education (Praslova, 2010)	Definition in the context of TEL (Ruiz & Snoeck, 2018)
Reaction	Students' affective reactions and utility judgments	Students' reaction to the computer-assisted learning tool
Learning	learning outcomes that are obtained through methods such as knowledge exams, performance-based assignments, or other forms of graded work	the extent and quality of learning that occurred during the course

The definitions of the levels for the purpose of this research were:

Reaction: this level measures affective reaction and utility judgment of the instruction and the computer-assisted learning tool used during the instruction. It is measured through students' evaluation of instruction and the computer-assisted learning tool used in terms of satisfaction (affective reaction) and their self-assessments of perceived educational gains from the instruction and their perceived usefulness of the computer-assisted learning tool used during the course (utility judgments).

Learning: this level measures the achievement of learning outcomes, in terms of the levels of revised Bloom's taxonomy, as the result of instruction (Krathwohl, 2002). It measures the extent and quality of learning that occurred during the course. For the purpose of this study only Understanding level and Applying level were targeted to assess learning.

1.8 SIGNIFICANCE OF THE STUDY

As this study was based on evaluating the effect related to active learning, this study could be beneficial for the students in increasing their engagement and active participation in the classroom. This active participation and increased engagement could have a positive effect on students' satisfaction about their learning experience. Furthermore, this study could lead to better achievement of the learning outcomes by improving the learning that occurs in class with the help of technology use in class.

This study could be significant for the teachers as the results of this study could provide insights to the teachers of how to integrate the use of technology in particular the use of ChatGPT in their everyday classes to enhance the teaching and learning experience for both students and teachers.

This study could provide valuable suggestions to the policy makers to combine active learning activities with artificial intelligence to provide a learning experience to students where they can construct their own knowledge through practice and immediate feedback and suggestions where required. Furthermore, based on the evidence found in the study, the policy makers can determine the resources needed for successful implementation of technology-enhanced active learning.

This study could be helpful for the administration of educational institutions to make decision based on the results of this study to promote the use of ChatGPT and active learning in their institutions and support teachers in their practices towards active learning.

1.9 METHODOLOGY

A summary of research methodology used in this research is presented below.

1.9.1 Approach

A mixed method approach was used to analyze the data using statistical techniques.

1.9.2 Design

The research design of this study was explanatory sequential design. It was divided into three levels. The level 1 involved non-equivalent control group, experimental group pretest-posttest quasi-experimental design to measure one variable under investigation, i.e., Learning, while the level 2 and level 3 were descriptive. The level 2 involved questionnaire to measure the other variable, i.e., Reaction. Finally, the

level 3 involved analysis of ChatGPT conversation history to validate the findings of first two levels and draw conclusions about the usage of ChatGPT for active learning.

1.9.3 Population

The study was delimited to the undergraduate students in Islamabad Model Colleges (Ex-Federal Government Colleges) in Islamabad. Specifically, for the purpose of experimental study on active learning, the undergraduate students pursuing the degree of BS Computer Science (BSCS) in Islamabad Model Colleges were the target population.

1.9.4 Selection of the Site

The study was conducted at Islamabad Model College for Boys H-9, chosen for its offering of HEC's accredited BSCS degree courses conducive to active learning experimentation, the researcher's familiarity with its social and cultural environment, and the convenience of access and data collection**.**

1.9.5 Sampling Technique

The sampling technique selected for this study was purposive sampling.

1.9.6 Sample Size

The sample size for this study was 60 students which was the total size of one class of undergraduate students in the institution.

1.9.7 Inclusion Criteria

Students enrolled in the program of BSCS were selected for this study. In particular, the students of first semester studying the introductory level programming course of Problem Solving and Programming of 4(3+1) credit hours was selected, which means these students were spending 3 hours of time on attending class lectures and 3 hours were dedicated for their practice in the computer laboratory.

1.9.8 Lesson Plans

Weekly lesson plans were constructed for an active learning environment in computer science education, incorporating Fink (2003) and Felder & Brent's (2009) active learning concepts and Hazzan, Lapidot, and Ragonis's (2020) teaching model comprising trigger, activity, discussion, and summary stages. Following Bowen's (2017) Backward Design Template, each week consisted of a total of 6 hours of active learning and lab work, with students grouped into teams of 3 for collaborative activities and discussions in a computer lab equipped with resources such as computer systems, multimedia projectors, whiteboards, and internet access, with each group having a ChatGPT account for learning purposes.

1.9.9 Research Instruments

The instruments that were designed and adapted from the literature for data collection for the level 1: reaction and level 2: learning of Kirkpatrick's model under investigation in this study were an adaptation of questionnaire to measure perceived usefulness for learning (Ruiz & Snoeck, 2018) to measure affective reaction of participants and their utility judgment regarding the use of ChatGPT in terms of learning

of students at understanding level and applying level of Revised Bloom's taxonomy, and two tests: one that included multiple choice questions to assess understanding of students and another with coding exercises to assess students learning at applying level of revised Bloom's taxonomy.

1.9.10 Verification of the Instruments

To ensure the robustness and validity of the research tools employed in this study, a comprehensive process of expert validation was meticulously undertaken that involved online and in-person interactions with seasoned experts in the field. Feedback regarding tools and recommendations for improvement received from experts were incorporated into the tools to enhance content, clarity, and relevance, resulting in validated instruments aligned with research objectives. The collaborative effort between the researcher and experts emphasized a commitment to conducting a reliable study, ensuring that the refined tools met specific research needs and enhanced data collection quality. Furthermore, to ensure the reliability of the instrument pilot testing was conducted and the results of it were analyzed through IBM SPSS Statistics version 26.

1.9.11 Data Collection

Data collection encompassed several phases: initially, students underwent pre-tests that were designed to assess their learning at understanding level of revised Bloom's taxonomy to gauge their existing knowledge, followed by grouping of students in control group and experimental group based on their competency levels determined through pretests and their history of studying computer science at HSSC level. The experimental group received instructions on utilizing ChatGPT during the time of their learning. Both

control group and experimental group underwent post-tests to evaluate learning outcomes. Interactions with ChatGPT were recorded for qualitative analysis. A questionnaire was also provided in the end to the students of experimental group to gauge their affective reaction and their usage of ChatGPT, with responses analyzed quantitatively to assess the effect of the computer-assisted learning tool, i.e. ChatGPT in an active learning environment.

1.9.12 Data Analysis

Data analysis was conducted using IBM SPSS Statistics version 26, employing both descriptive statistics and content analysis. Descriptive statistics, such as mean calculation, frequency, and tests including t-tests and Mann-Whitney U tests, were employed with 5% level of significance to test the hypotheses and to fulfill study objectives.

Specifically, for objective 1a, data from the close-ended questionnaire was summarized and analyzed to assess students' affective reactions and utility judgments regarding the instruction and ChatGPT usage.

For objective 1b(i), means of pre-test scores for both control and experimental groups were calculated, and independent samples t-tests were used to compare the initial difference in students learning at understanding level of revised Bloom’s taxonomy.

For objective 1b(ii), means of post-test scores for both control and experimental groups were calculated, and independent samples t-tests were used to analyze the differences in learning outcomes at understanding level of revised Bloom’s taxonomy.

For objective 1b(iii), means of post-test scores for both control and experimental groups were calculated, and non-parametric tests, i.e. Mann-Whitney U tests were used to analyze differences in learning outcomes at applying level of revised Bloom's taxonomy as the assumptions to conduct t-test could not be met.

Additionally, content analysis was conducted on the history of conversations made by students of the experimental group from the accounts that were provided to them. This involved coding and categorizing data into themes to identify common patterns, and provide interpretations regarding the research question of the study. Recommendations were made based on conclusions drawn from the study.

1.10 DELIMITATIONS

This study was constrained to the following conditions due to limited time and resources:

1. This study was delimited to one college in Islamabad region.
2. The study was delimited to the undergraduate students studying BS Computer Science.
3. The study was delimited to the students studying the introductory level programming courses of Problem-solving and Programming (theory and lab course).
4. The researcher used non-equivalent control group, experimental group pretest-posttest quasi-experimental design.
5. The number of participants were delimited to maximum of 60 students.

6. The study was further delimited to only those students of the class who will provide informed consent to be included in the quasi-experimental study.
7. The duration of the experiment in the experimental study was six weeks.
8. Pretest was only conducted at understanding level to ensure control and experimental groups were equivalent in terms of their existing knowledge.
9. The researcher utilized his intellectual ability and professional experience along with the studies he referred during the course of this study to create the active learning environment for the purpose of experimental study.
10. The researcher delimited the study to evaluate only the Level 1 and Level 2 of Kirkpatrick's model.
11. The study was delimited to assessing the learning based on understanding and applying level of revised Bloom's taxonomy.

1.11 OPERATIONAL DEFINITIONS

Active learning

Active learning refers to an approach to teaching and learning that involves the use of the technology of artificial intelligence like chatbots to actively engage students to participate in the learning process to enhance their leaning experience and promote critical thinking, problem-solving, and collaboration.

ChatGPT

ChatGPT is an AI-powered chatbot designed to provide human-like conversation and respond to questions and requests from users. It is a language model that has been trained on vast amounts of text data and can provide information on a wide range of

topics. By ChatGPT in this study, it means the free version of ChatGPT based on GPT-3.5 that is currently available for public use.

Learning

Learning refers to the level of Kirkpatrick's model that measures the achievement of learning outcomes, in terms of the Understanding and Applying levels of revised Bloom's taxonomy, as the result of instruction. It measures the extent and quality of learning that occurred during the course.

Reaction

Reaction refers to the level of Kirkpatrick's model that measures affective reaction and utility judgment of the instruction and the computer-assisted learning tool used during the instruction. It is measured through students' evaluation of instruction and the computer-assisted learning tool used in terms of satisfaction (affective reactions) and their self-assessments of perceived educational gains from the instruction and their perceived usefulness of the computer-assisted learning tool used during the course (utility judgments).

CHAPTER 2

REVIEW OF RELATED LITERATURE

"You cannot teach a man anything; you can only help him to find it within himself."

- Galileo Galilei

This chapter provides a comprehensive literature of the major themes that are important for this research study. It starts with the introduction of active learning and the philosophy of constructivism and moves further into the perspective of technology, particularly focusing on artificial intelligence. This chapter also provides a detailed literature on active learning techniques used under the domain of computer science teaching and learning and design framework. Moreover, this chapter covers numerous models for evaluation of programs and courses specifically targeting the Kirkpatrick's model that has been used in this study, and a brief description of the revised Bloom's taxonomy. In the end of this chapter, a literature review based on previous related research is presented to connect it with the current study.

2.1 ACTIVE LEARNING

Active learning is a pedagogical approach that emphasizes the active engagement of students in the learning process. Though the term 'active learning' was not explicitly used by John Dewey in his original works, Dewey is considered a foundational figure in the development of student-centered instructional methods that emphasize learning through active participation. Dewey (1910) suggested that students needed to be active participants in their own learning, instead of being passive recipients of information. He recommended an educational approach that emphasized hands-on, experiential learning,

in which students actively engaged with the subject matter and construct their own understanding of concepts. Dewey proposed an educational model which was based on engaging students through the methods of discovery, inquiry, and problem-solving (Dewey, 1997 as cited by Altinyelken, 2011).

In the decades following Dewey's work, educational researchers and theorists began to explore the concept of active learning in more detail. Scholars such as Benjamin Bloom (1956) in his work Taxonomy of educational objectives: The classification of educational goals and Jerome Bruner (1960) in The Process of Education developed cognitive learning theories that emphasized the importance of active engagement in the learning process.

Bloom's work was one of the most influential models of active learning developed in that period. Bloom's taxonomy identified a hierarchy of cognitive skills, ranging from lower-order thinking skills such as remembering and understanding to higher-order thinking skills such as analysis, synthesis, and evaluation. The taxonomy emphasized the importance of active engagement in the learning process, with higher-order thinking skills requiring more active engagement and deeper understanding of the subject matter (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956).

Jerome Bruner, a psychologist and cognitive theorist, also played an instrumental role in developing the concept of active learning. Bruner in his book argued that learners should be actively involved in the process of constructing their own knowledge. He proposed a model of discovery learning in which learners were encouraged to explore and experiment with ideas and concepts instead of being told what to think or memorize.

He also emphasized the importance of scaffolding, i.e., providing learners with appropriate levels of support and guidance as they engage in more complex learning tasks (Bruner, 1960).

The term active learning as we know it today was first defined by Bonwell and Eison in 1991. In their report "Active Learning: Creating Excitement in the Classroom," Bonwell and Eison defined active learning as "anything that involves students in doing things and thinking about what they are doing". They were of the opinion that active learning strategies, such as discussion, problem-solving, and group work, are far more effective in promoting student learning than traditional, passive forms of instruction. Fink (2003) expanded on this definition by describing active learning being comprised of three key elements:

1. Communication of information and ideas mainly involving students receiving information through methods such as reading, direct instruction, etc.
2. Experiences; further categorized into two types: doing, i.e., hands-on experiences, where students actively participate in a task or activity, and observing, where students observe something relevant to the topic being studied.
3. Reflection, that involves giving students the chance to reflect on their learning individually or in group discussions.

Since then, active learning has become an increasingly popular approach in both K-12 and higher education settings. There are many different strategies and techniques associated with active learning, including group work, problem-based learning, case studies, and inquiry-based learning.

2.2 CONSTRUCTIVISM

The origin of constructivism can be traced back to the time of Socrates who advocated a collaborative approach between teachers and students to engage with each other in conversation by asking questions to construct hidden knowledge and make interpretations (Hilav, 1990 as cited by Amineh & Asl, 2015). The word constructivism is believed to be derived from the works of Jean Piaget and Jerome Bruner (Gruber & Vonèche, 1977). Constructivism is a prominent learning theory today. It proposes that individuals engage in the active process of constructing their own understanding and knowledge of the world by means of their experiences and interactions with their environment (Piaget, 1973). In other words, people create their own understanding of the world by their experiences and their interpretation of those experiences.

Constructivists believe that knowledge is not a mere transfer of information from a teacher or a textbook to a learner; rather it is something that is actively constructed in the learner's mind. This implies that learners are not simply passive receivers of knowledge, but instead, they actively engage in the learning process as participants and construct new knowledge based on their previous knowledge (Mayer, 2004).

There are two major dimensions within the constructivist perspective: Cognitive Constructivism and Social Constructivism. Cognitive Constructivism is the traditional constructivist perspective from the cognitive point of view while Social Constructivism is from the social-cultural point of view (Kanselaar, 2002). Jean Piaget was a proponent of the cognitive perspective who primarily emphasized the individuality of the learner and how individuals construct knowledge through their experiences. Lev Vygotsky (1978) advocated the socio-cultural perspective. He asserted that the process of acquisition of

knowledge is influenced by other individuals and is mediated by the community and the culture. Vygotsky in his theory emphasized social interaction and collaboration as integral components of knowledge acquisition (Kalina & Powell, 2009). He further emphasized the idea that people are more likely to acquire knowledge effectively in a cooperative setting compared to individual learning. According to Vygotsky, when individuals work in a group, they can achieve a deeper understanding through scaffolding. Collaborative learning involves each participant contributing to the construction of knowledge, enabling individuals to progress from one level to the next through shared knowledge building. This approach to learning has a profound influence on learners, influencing both their learning process and the content they absorb.

2.3 BENEFITS OF ACTIVE LEARNING

Today, active learning is widely recognized as an effective way to promote student engagement, motivation, and deep learning. Research has shown that active learning approaches can lead to improved learning outcomes, greater retention of knowledge, and increased student satisfaction with the learning experience. Aykan and Dursun (2022) in their experimental study concluded that active learning practices had a positive effect on students' academic performance and their knowledge retention. Nabors (2012) in her PhD dissertation gave references of the studies from nurse education of Johnson and Romanello (2005) and Williams and Calvillo (2002) and stated that educational formats and methods that encourage active learning prioritize student-centered approaches, thereby fostering greater student engagement, self-directed learning, critical thinking, problem-solving abilities, and deep learning. In her study she also highlighted the work of Phillips (2005) and asserted that active learning approaches foster

social engagement among students while also catering to a range of learning styles, particularly those who prefer visual, auditory, and kinesthetic modes of learning. Krajcik and Blumenfeld (2006) and Yazedjian and Kolkhorst (2007) suggest that the use of active learning strategies by educators can help in promoting the growth of students' critical thinking skills and enhancing their comprehension of complex concepts, and an increase in their attendance and confidence. A meta-analysis performed by Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, and Wenderoth (2014) found active learning approaches to be associated with higher exam scores and lower failure rates in comparison to traditional lecture-based approaches.

2.4 TECHNOLOGY IN TEACHING AND LEARNING

Over the past few decades, technology has become an increasingly important part of education. The use of mobile and smart computing technology in classrooms, provision of internet at the campuses of schools and colleges, and the to the utilization of multimedia devices has transformed the way we teach and learn. Technology has become an asset for students and teachers for seeking information or presenting the teaching and learning material in the form of videos, animations, presentations, and simulations. This technological revolution combined with the need for engaging students in the learning process led the researchers to develop advanced teaching methodologies that integrate technology in the teaching learning process. This integration of technology in the learning process is called technology-enhanced learning, TEL (Bourdeau & Balacheff, 2014).

In a TEL classroom, with the help of technology teachers are able to create more engaging and interactive learning experiences for their students. By utilizing multimedia

tools, the teachers can illustrate complex concepts and make learning more visual and interactive. Online discussion forums and social media platforms have also enabled students to collaborate with each other and connect with experts from around the world. Yet another benefit of technology in the field of education is its ability to support the personalized experience of learning for students. Pogorskiy in his study conducted in 2015 stated, “ICT and communications technology can be a powerful tool for personalized learning as it allows learners access to research and information, and provides a mechanism for communication, debate, and recording learning achievements”. With the help of adaptive learning technologies and machine learning algorithms, it has become possible to analyze the performance data of students and offer them personalized feedback and support to students where they require further assistance, and tailor the content and learning activities to their individual needs and interests.

2.5 TECHNOLOGY-ENHANCED ACTIVE LEARNING

Technology-enhanced active learning is a type of learning that specifically focuses on using technology to promote active learning in the classrooms. It involves designing of learning experiences that will engage students in hands-on, interactive, and collaborative learning activities to promote critical thinking and problem-solving among students. The International Bureau of Education, UNESCO has defined TEAL as the use of ICT as intermediary tools to aid in students' learning, including their teaching and evaluation. Borodzhieva et al. (2021) describe the origin of TEAL in their study that TEAL was pioneered by Massachusetts Institute of Technology (MIT) as an alternative to the conventional lecture hall format, which is now being adopted at several prestigious institutions, including North Carolina State University, University of Colorado, Harvard

University, and the University of Maryland. (Dominguez, Alarcón, & García-Peñalvo, 2019; Misseyanni, Lytras, Papadopoulou, & Marouli, 2018). Belcher in his study (2001) described that the key objective of TEAL at that time was to provide a platform for students to encourage them to explore deeper into the study of physics and technology-related topics to ensure the development of more comprehensive conceptual and analytical understanding of the material at hand. Breslow (2010) further elaborated the framework of TEAL that incorporates lectures, problem-solving, and practical laboratory activities.

Technology has the potential to enhance active learning by providing tools and resources that encourage and support interactive, collaborative, and personalized learning experiences. By leveraging technology, the educators can create more engaging and effective learning environments for students that ensures their success in learning outcomes. In 2012, Shieh conducted an experimental study on TEAL; he concluded that the implementation of TEAL in his experiment led to increased motivation among students to attend physics classes and participate in extracurricular science activities. Furthermore, the teachers became more enthusiastic and confident in their abilities to help students in strengthening their understanding of the concepts in physics.

2.6 ARTIFICIAL INTELLIGENCE IN TEACHING AND LEARNING

In recent times we have witnessed that artificial intelligence is a rapidly evolving field that has been revolutionizing many industries, including education. AI in education refers to the use of machine learning algorithms, natural language processing, and other AI techniques to support teaching and learning in the form of adaptive and personalized learning. Melo (2023) in his study also highlighted the potential of AI to offer

personalized learning experiences for students. Today, there are many online adaptive learning platforms that provide personalized e-learning experience to students like Knewton, Smart Sparrow, Dreambox Learning, etc. These adaptive learning technologies have the capability to analyze students' data, enabling the identification of areas where they require additional support and to provide personalized feedback and recommendations for further learning based on their characteristics and history of usage. The implementation of such technologies by teachers in their classrooms and utilization of such technologies by students for their learning can result in increased students' engagement, motivation, and academic achievement.

AI can also provide real-time feedback to teachers and students in the form of dialog. For example, chatbots like ChatGPT can be used to answer queries made by students and provide them guidance related to their coursework, freeing up teachers' time by reducing the number of queries they need to address for students so that they can focus on more complex tasks instead. Similarly, the AI-powered assessment tools can analyze student work to provide immediate feedback on their performance, enabling students to quickly identify areas where they need to improve instead of waiting for their teacher for feedback.

With the recent advancements in technology and in the field of natural language processing and neural networks, AI is poised to revolutionize education and provide new opportunities for personalized, engaging, and meaningful learning experiences.

2.7 CHATGPT IN TEACHING AND LEARNING

ChatGPT is a general-purpose conversation chatbot which was launched for public in November, 2022. It gets a query in the form of text and uses neural network to perform variety of text generation tasks. Constructed using OpenAI's GPT-3 language models, ChatGPT has been fine-tuned utilizing both supervised and reinforcement learning techniques. It was trained on massive dataset which is used to generate its responses with remarkable accuracy and even make predictions on new, unseen data. In contrast to search engines like Google, Bing, and Baidu, ChatGPT does not scour the internet for up-to-date information and is limited to the knowledge it acquired before the year 2021. As of the time of writing the synopsis of this research study, ChatGPT had surpassed one billion visitors to its website through which the users can access the service: chat.openai.com (SimilarWeb, 2023).

ChatGPT based on GPT-3.5 is freely available, and has enormous potential to be used for the purpose of helping its users in teaching and learning activities. It can answer students' questions regarding any subject; they can use it to understand complex concepts by getting detailed systematic explanation (Baidoo-Anu & Ansah, 2023).

Biswas (2023) in his study pointed out the capabilities of ChatGPT in computer programming. He described that ChatGPT was a robust tool for computer programming that could be used to perform the following programming related tasks: code completion and correction, code snippet prediction and suggestion, automatic syntax error fixing, code optimization and refactoring suggestions, missing code generation, document generation, chatbot development, text-to-code generation, and providing technical answers.

2.8 ACTIVE LEARNING TECHNIQUES USED IN COMPUTER SCIENCE EDUCATION AND TEACHING PROGRAMMING

A substantial body of research has explored the application of active learning techniques across various contexts and subject domains. Specifically, within the domain of computer science education and the teaching of programming, a number of scholars have made significant contributions. To provide an overview of these contributions in this section, a selective literature review was undertaken to specifically examine active learning techniques in the context of computer science education and the teaching of programming. Ericson (2023) in her study has discussed four ways to incorporate active learning techniques into computing courses which include Interactive e-books, Peer-instruction, Mixed-up Code (Parsons) Problems, and POGIL (Process Oriented Guided Inquiry Learning). Srinivasan and Centea (2019) in their study discussed active learning strategy in undergraduate programming course which involved hands-on programming exercises during class lessons and group debugging activities. Brown (2020) in his doctoral dissertation also suggested peer-code review as an active learning strategy to improve students' understanding of programming and software engineering concepts. In their book, Hazzan, Lapidot, and Ragonis (2020) presented different active learning-based teaching methods that can be used in computer science education which include Pedagogical games, the CS-Unplugged approach, rich tasks, concept maps, classification of objects and phenomena from life, and metaphors; and the following active learning-based teaching methods that are specific to be employed in a computer lab: lab-first teaching, visualization and animation, and using the internet. Another study conducted by Gehringer (2007) highlighted active and collaborative learning techniques that can be used for teaching programming which include pair programming, collaborative code,

scaffolding, error hunt, mystery program readings, sequential programming assignments and others.

A comprehensive literature review aimed at identifying research studies exploring various pedagogical techniques used to foster active learning in the context of teaching and learning computer programming was conducted by Berssanette and de Francisco (2021). In their study, the authors discussed that the following active learning techniques have been used by different researchers in their studies: flipped classroom, project-based learning, peer instruction, blended learning, collaborative learning, problem-based learning, game-based learning, pair programming, undetermined, gamification, hands-on, inquiry-based learning, living code, peer-teaching with videos, POGIL, team-based learning, and think-pair-share.

2.9 ACTIVE LEARNING DESIGN

Choosing an active learning technique itself is not enough to effectively create an active learning environment based on the idea of constructivism. Therefore, the researcher studied on how to design active learning environment for the students. According to Fink (2003), an active learning design is comprised of three key elements:

1. Communication of information and ideas mainly involving students receiving information through methods such as reading, direct instruction, etc.
2. Experiences; further categorized into two types: doing, i.e., hands-on experiences, where students actively participate in a task or activity, and observing, where students observe something relevant to the topic being studied.

3. Reflection, that involves giving students the chance to reflect on their learning individually or in group discussions.

Similarly, Felder & Brent (2009) outlined three fundamental steps in the structure of basic active learning:

1. Instruct students to form groups of 2-4 and designate a recorder randomly if writing is necessary.
2. Present a challenging question or problem, providing ample time for most groups to either complete it or make significant progress. The problem can be broken down into smaller steps, treating each step as a distinct activity.
3. Invite several individuals or groups to share their responses, followed by a discussion of the responses.

In the book, Hazzan et al. (2020) described active learning-based teaching model in the context of computer science education comprising of four stages: trigger, activity, discussion, and summary.

Stage 1

In this first stage, referred to as the trigger stage, student teachers are encountered with a challenging active-learning-based stimulus, which is typically an unfamiliar open-ended activity. This trigger aims to stimulate meaningful learning by eliciting a diverse range of questions, dilemmas, attitudes, and perceptions. The complexity and relevance of the trigger is critical for effective learning at this stage. Depending on the trigger's objectives, students may engage in the activity individually, in pairs, or in small groups. The primary goal of this stage is to ensure student teachers can navigate open-ended and

unfamiliar situations, prevalent in computer science education, by providing multiple reaction options. A well-designed trigger exposes students to various aspects of computer science and pedagogy, fostering discussion, refinement, and reorganization of ideas throughout the other stages.

Stage 2

In the second stage, i.e., the activity, students actively work on the trigger that was presented in the first stage, for the duration which depends on the complexity of the trigger and educational goals that need to be achieved.

Stage 3

After the activity stage, the third stage is discussion. It involves gathering the entire class to present and discuss products, topics, and thoughts that emerged during the activity stage. At this stage, the understanding of students is further refined, and the instructor emphasizes key ideas that emerge during the discussion without passing any judgment. Every student at this stage is encouraged to express their opinion and make constructive criticism.

Stage 4

The final stage is the summary. It is different from the first three stages in a manner that this stage is shorter in the time duration, and the instructor is the one who leads in wrapping up the teaching-learning session by summarizing the topic, highlighting the main concepts and ideas that were developed during the previous stages. Students may also take the forefront with the guidance of the teacher in expressing the

summary in various forms such as framework formulations, concept maps, or listing connections between the discussed topic and others.

The role of teacher is also discussed in the book (Hazzan et al., 2020). The instructor plays a pivotal role in establishing a conducive intellectual environment that promotes active engagement throughout the entire class session.

During the initial Trigger stage, the instructor introduces the trigger to student teachers.

In the second Activity stage, the instructor actively engages with various groups, attentively listening to individual opinions, being receptive to their thoughts, and encouraging deeper reflection. While offering guidance in discussions, the instructor should promote alternative thinking approaches without imposing any particular stance.

In the third Discussion stage, the instructor adopts the role of a keen listener, paying attention to key points raised by students. It is essential for the instructor to prompt students to describe the rationale behind their suggestions, explore diverse options, and foster reflective processes—all without passing judgment on their opinions. In this stage the teacher emphasizes important aspects of everyone's opinion, facilitates in building connections between different ideas.

In the final Summary stage, the instructor consolidates the ideas discussed in previous stages. This summary underscores the key points explored, with the instructor possibly introducing any new ideas and providing clarifications that may not have been proposed by the students themselves in the discussion stage.

2.10 MODELS FOR EVALUATION OF PROGRAMS/COURSES

There have been numerous studies in the field of education and professional training focusing on enhancing the effectiveness of courses and their evaluation regarding achievement of learning outcomes. Evaluation of the impact of the educational programs is a critical process that allows educators, trainers, and organizations to assess whether their efforts align with the planned objectives and produce desired results. For this purpose, various researchers from different domains have developed course/training evaluation models that offer unique perspectives for assessing their effectiveness. This section provides details of such course evaluation models focusing primarily on Kirkpatrick's model.

Before going into the core of this section that introduces the Kirkpatrick's model, it is important to explore several alternative evaluation models. Not only these models offer valuable insights into different aspects for the purpose of assessment of learning in courses and training, they have also been utilized across diverse educational and organizational settings.

Among the notable models deserving mention are CIPP Evaluation Model, CIRO Model, and Brinkerhoff's Success Case Method. Kaufman's also proposed his Five Levels of Evaluation calling it more practical than Kirkpatrick's model. Each one of them is briefly discussed below.

2.10.1 CIPP Evaluation Model

The CIPP Evaluation Model was developed in late 1960s by Daniel L. Stufflebeam as a comprehensive and holistic approach to evaluation, helping

organizations make informed decisions about the design, implementation, and improvement of their programs (Stufflebeam, 2000). In alignment with the CIPP acronym, the fundamental principles of this model encompass the evaluation of context, input, process, and product. Each of them is concisely elaborated next.

Context Evaluation This phase involves understanding the environment or context in which the program operates. It looks at the needs, assets, and challenges of the target population, as well as the broader social, political, and economic factors that might influence the program.

Input Evaluation This next phase focuses on the resources allocated to the program. It assesses the design that was selected, planning that was made, and the resources that were provided before the implementation phase. This phase could include examining the curriculum, materials, staff training, and any other inputs necessary for the program.

Process Evaluation This third phase is about assessing the program implementation. This phase evaluates the actual delivery of the program, i.e., whether it is being carried out as it was planned, if there are any deviations from the plan, and how well the activities are being executed.

Product Evaluation This last phase is also known as outcome evaluation. In this phase, the end results of the program are assessed which includes the intended and unintended outcomes, impacts of the program, and its overall effectiveness.

2.10.2 CIRO Model

The CIRO Model was developed by Peter Warr, Michael Bird, and Neil Rackham and introduced in their 1970 publication "Evaluation of Management Training,". It offers a structured approach for gauging the efficacy of management training programs. This model provides organizations with a valuable tool to assess the requirements of their management training and their outcomes.

The acronym 'CIRO' in the name of this model corresponds to the four levels that are integral parts of it: context, input, reaction, and output. This model follows a hierarchical structure; the analysis begins with Context, followed by Input evaluation, assessment of Reaction, and lastly the measurement of resulting Output. A brief explanation of each level of this model is presented below.

1. Context Evaluation At this level, the operational context of the business is evaluated. The information obtained is critical in planning for training and development. This comprehensive analysis of the needs of training leads to the development of three types of training objectives:

Ultimate Objective, addressing specific gaps and deficiencies,

Intermediate Objective, fostering behavioral change in employees to achieve the ultimate objective, and

Immediate Objective, covering skills, knowledge gaps, as well as attitudes of employees and their behaviors.

2. Input Evaluation At this level, data regarding various methods and techniques is collected to select the most suitable approach for training. This level focuses on the design, organization, supervision, and execution of training programs. An examination of available and accessible resources at this level ensures their efficient and effective utilization.

3. Reaction Evaluation At this level, the feedback regarding the provided training is received from the participants for its evaluation. This obtained feedback is important for improvement of the training programs and rectification of any deficiencies that were pointed out. During the data collection at this stage, the participants are encouraged to share their thoughts on program content, value augmentation, and methodology.

4. Output At this last level of the CIRO model, the outcomes achieved after the training program are evaluated in the form of achievements and consequences. These outcomes are evaluated based on the direct impacts of the training, assessed across four levels: individual learner, workplace, team or department, and organizational.

2.10.3 Brinkerhoff's Success Case Method

Brinkerhoff's Success Case Method was developed by Dr. Robert O. Brinkerhoff and was introduced in his book "Success Case Method: Find Out Quickly What's Working and What's Not" published in 2003. It was a response to the need for more targeted and practical evaluation approaches, particularly in the realm of training and development programs. In this model, Brinkerhoff outlined his methodology for evaluation of the impact of training programs within organizations.

The model became popular in organizations and researchers because it emphasized on identifying and understanding success stories within a program, providing a valuable alternative to traditional evaluation methods that often relies on aggregate data. Brinkerhoff's approach is particularly useful in situations where there is an explicit need for the identification of elements contributing to success of the program and apply those insights to make further improvements in the program.

The key steps in the Brinkerhoff's Success Case Method are described below.

Identification of Success Cases This model begins with the identification of the individuals or cases within the program who have achieved notable success. These cases are the ones that represent positive outcomes of the program or their exceptional performance after the program.

In-Depth Analysis Once the success cases have been identified, the next step is the detailed analysis of those cases to examine the specific actions, strategies, or conditions that contributed to their success. This involves gathering qualitative data through interviews, observations, or other relevant methods.

Learning and Application In this third step, the insights gained from the success cases in the previous step are used to improve the program. By understanding what works well, organizations can replicate successful practices and make targeted enhancements to areas that may require improvement.

Continuous Improvement The final step in Brinkerhoff's Success Case Method promotes a continuous improvement cycle. It encourages organizations to regularly

revisit and reassess success cases, ensuring that the program keeps evolving based on ongoing feedback and learning.

2.10.4 Kaufman Model

In 1994, Dr. Roger Kaufman and John M. Keller published a pivotal work titled "Levels of Evaluation: Beyond Kirkpatrick" in the Human Resource Development Quarterly. This work is commonly known as Kaufman's Five Levels of Evaluation or Kaufman's Learning Evaluation Model. Kaufman's model is a model among several learning evaluation frameworks that extends beyond Kirkpatrick's Model. The main difference in Kaufman's model is that it offers a comprehensive framework for evaluating learning programs, placing a strong emphasis on the wider organizational and societal implications of training and development.

Derived from Kirkpatrick's model, Kaufman's Five Levels of Evaluation can be summarized as follows:

Level 1a: Input This component of the first level is related to the materials utilized in training, including digital resources utilized to support training or coaching.

Level 1b: Process The second component of the initial level gauges the acceptability and efficiency of the training process, specifically focusing on the actual delivery of the learning experience.

Level 2: Acquisition The second level delves into the benefits for individuals and small groups. It primarily examines the acquisition of knowledge and its practical application by learners in their roles.

Level 3: Application The third level assesses the effective application of acquired knowledge and skills by participants in their day-to-day job performance.

Level 4: Organizational Payoffs The fourth level scrutinizes the returns and benefits for the organization as a whole. Here, the 'macro-level client' typically represents the business or entity undergoing the evaluation. This level encompasses performance improvement evaluations and cost-benefit or cost-consequence analyses.

Level 5: Societal Outcomes The final level, in line with Kaufman's perspective, focuses on 'mega-level clients,' which can encompass a business's customer base or society at large. It explores the broader societal impacts and outcomes of the learning initiatives.

2.10.5 Kirkpatrick’s Model

At the heart of this section lies the exploration of Kirkpatrick's Model. Kirkpatrick’s model was first introduced by Donald Kirkpatrick in 1959 in an article titled "Techniques for Evaluating Training Programs" that appeared in the Journal of the American Society of Training Directors. This model has stood the test of time as one of the most widely recognized and applied course evaluation frameworks.

The Kirkpatrick’s model offers a framework for identifying the types of inquiries that should be posed during evaluation and the standards that may be suitable for assessment. With its multi-dimensional approach, this model strives to assess the effectiveness of educational programs at multiple levels: reaction, learning, behavior, and results which are described below according to Kirkpatrick and Kirkpatrick (2006).

The Level 1 of Kirkpatrick's model assesses the degree of satisfaction of participants or how they feel about training program. At this level, the evaluators can gauge participants' engagement, contributions, and responses to understand how well the program was perceived by them.

The Level 2 of Kirkpatrick's model focuses on measuring the knowledge, skills, and values acquired by the participants during the training by using quantifiable indicators. This level determines whether knowledge of the participants and/or their skills had improved as a result of the training. This level also assesses participants' confidence in performing the changed behavior that the training had targeted, their assurance of being able to perform it, and their motivation for doing it.

The Level 3 of Kirkpatrick's model evaluates the changes in the behavior of the participants at their workplace resulting from the training. This level involves measurement for changes in behavior which spans over several weeks or months after the training of the participants.

The last level, i.e., the Level 4 of Kirkpatrick's model evaluates the institutional outcomes that can be attributed to the training program and demonstrate a positive return on investment.

2.11 Revised Bloom's Taxonomy

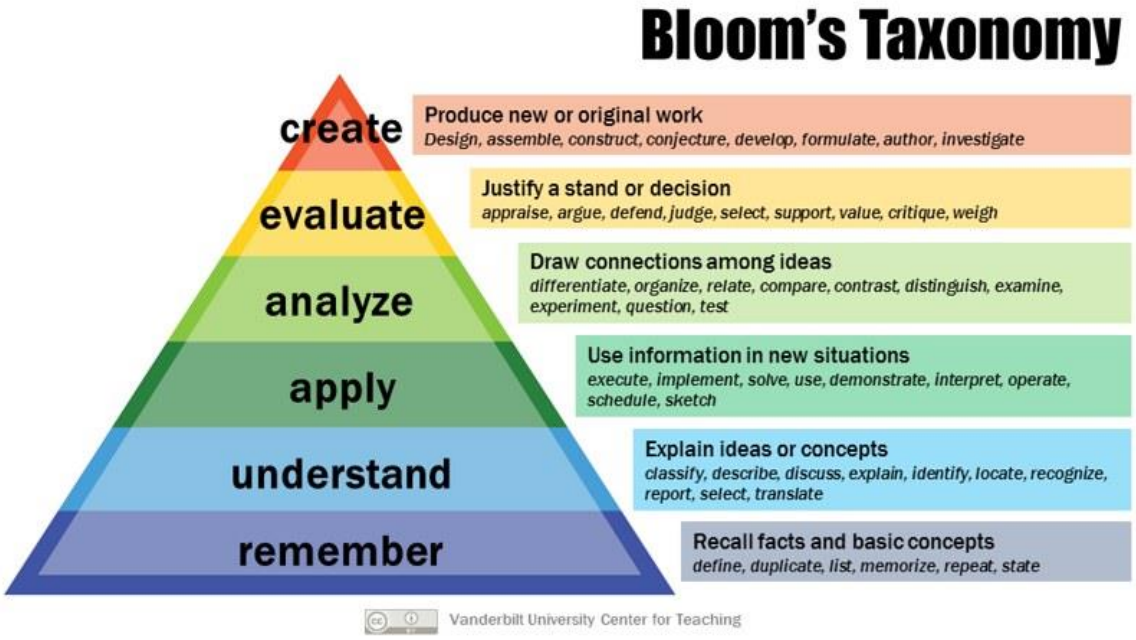
Since this study uses Revised Bloom's taxonomy to assess learning level of the Kirkpatrick's Model, this section of literature review would be incomplete without the description of the revised Bloom's taxonomy. Bloom's taxonomy, initially published in 1956 in the book Taxonomy of educational objectives: The classification of educational

goals, provided detailed definitions and classification of various learning stages based on goals from remembering the facts to creation of new ideas based on the acquired knowledge in the process. Bloom argued in his work that learning is a consecutive process and while learning we move from one stage to the next, going higher in complexity in each stage; and these stages can be found in literature in the form of the pyramid which depicts how the lower levels form the foundation for the higher levels in the pyramid. The purpose of Bloom's framework was to provide teachers with the common vocabulary to facilitate communication to discuss curricular and evaluation problems with greater precision across various subjects and grade levels. The framework not only provided guidance to teachers in planning learning activities or during evaluation of learning but was also a handy guide for curriculum developers.

The original work of Benjamin Bloom was updated by Lorin Anderson and David Krathwohl and published in the year 2001 in which the names of three categories were replaced and the names of the remaining categories that were previously described as nouns were changed into verbs to clearly reflect on the cognitive process that was carried out by the learner at each stage (Krathwohl, 2002). Furthermore, the order of the highest two categories was interchanged. The image of Vanderbilt University Center for Teaching presented below depicts the levels of the revised Bloom's taxonomy.

Figure 2.1

Revised Bloom's Taxonomy



2.12 RELATED RESEARCH

Kengam's (2020) conducted a study in which he described the integration of Artificial Intelligence in education. Highlighted in the 21st International Conference on Artificial Intelligence in Education held in 2020, Artificial Intelligence in Education (AIED) has become an emerging discipline under the umbrella of educational technology. The author observed that the application of AI in the field of education was still an uncharted territory for educators. There were lot of questions that needed to be answered and lot of blanks that needed to be filled regarding its implementation and effect on teaching and learning in higher education. In his study, Kengam has discussed

both the advantages and disadvantages of AI in education, and has suggested a methodology for its implementation.

In a 2019 study, van der Vorst and Jelicic explored the transformative potential of Artificial Intelligence (AI) applications in education, specifically focusing on personalized learning. This study extended Bloom's (1984) discoveries, which emphasized on one-on-one tutoring compared to traditional educational methods for considerable advantage in performance. However, personalized one-on-one learning presents a notable challenge due to limitations in teacher availability and associated costs. The researchers propose that the advancements in machine learning present promising avenues to tackle this challenge, positioning AI as a potential ‘holy grail’ for unlocking the advantages of personalized learning and facilitating tailored education for each student.

In this study, the authors have highlighted the key aspects of an AI system, including its capability to provide feedback to students, tailor the curricula according to individual student needs and evaluate their skill levels. AI serves as a conduit for delivering subject knowledge to students and facilitating them in the acquisition of specific competencies, while accommodating both traditional classroom-style education and newer, more flexible educational paradigms, such as blended learning.

In their study, the authors have further described the impact of AI which extends beyond the student population. They advised that instructors in educational institutions need to be prepared to undergo substantial shifts in their roles as AI assumes certain

teaching tasks, amplifies the importance of others, and introduces entirely new responsibilities as it becomes more deeply integrated into the educational landscape.

In a 2019 study, Jain and Jain investigated the practical application of artificial intelligence in higher education and the effects of its integration. The authors emphasized the importance of AI in higher education based on the results of this study which revealed a noteworthy improvement in students' learning capabilities within higher education institutions through the incorporation of AI. The authors also highlighted the fact regarding the adoption of artificial intelligence in higher education that developing countries in contrast to the developed countries are still in the early stages for its adoption. There are various obstacles that impede the progress of AI adoption in these regions which include inadequate infrastructure, restricted access to information, insufficient support from educational institutions, scarcity of necessary resources, and deficiency in technological proficiencies. These challenges present substantial hurdles for developing countries that are targeting towards leveraging the capabilities of artificial intelligence for higher education.

In his 2023 study on ChatGPT, Biswas described the capabilities of ChatGPT in revolutionizing education and learning. He stated that using ChatGPT can provide enhanced interactive learning experience to students thereby increasing their engagement and motivation to learn. With the personalized support and feedback that ChatGPT can provide to self-directed learners, their performance can be improved and their self-learning skills can be enhanced making them more independent in the process.

In a review study conducted in 2023, Nurtayeva, Salim, Basheer, and Khalilov highlighted the massive influence of ChatGPT and other AI tools on one’s academic

uplift. To illustrate this point, the authors emphasized that ChatGPT has the ability to provide interactive learning settings in which students engage with virtual instructors who can respond to their queries and illustrate a variety of subjects in an expert manner. Citing to a previous study (Nurtayeva & Muhammad Al-Kassab, 2022), the authors were in favor of ChatGPT to analyze student's writing and responses providing individual feedback and proposing alternatives that are compatible with the specific needs of every student. Providing these facts, the authors emphasized that additional empirical study was needed to be carried out in the future to fully understand the impact of ChatGPT and AI tools on academic performance.

Han, Battaglia, Udaiyar, Fooks, and Terlecky noted in their exploratory study of 2023 on the use of ChatGPT in a medical school setting that contemporary teaching methods require active participation by students meaning that they have to do a lot of studying on their own. The ability of students to identify their shortcoming and grapple with uncertainties they have is important for effective utilization of ChatGPT. Furthermore, the authors praised ChatGPT as an expert help which can be accessed by learners whenever and wherever needed. It could be argued that communicating with ChatGPT is like questioning an expert teacher; it does not involve the possibility of them making wrong answers or feeling anxious about being unready or humiliated.

In their 2023 use-case study of ChatGPT within a flipped classroom environment for a medical terminology course, Sangzin Ahn investigated the integration of large language models (LLMs) like ChatGPT into learning activities. The investigation revealed that incorporating LLMs into education yields substantial benefits, fostering active learning environments and amplifying student engagement. These advantages

signify a transformative potential that could significantly impact the educational landscape.

The study undertaken by a consortium of academics, scientists, distinguished researchers, and engineers explored the transformative impact of ChatGPT on contemporary education (Gill, Xu, Patros, Wu, Kaur, Kaur, Fuller, Singh, Arora, Parlikad, Stankovski, Abraham, Ghosh, Lutfiyya, Kanhere, Bahsoon, Rana, Dustdar, Sakellariou, Uhlig, & Buyya, 2024). It described ChatGPT's capacities as perceived by educators, students, and within various learning environments. ChatGPT demonstrates its potential to assist educators by generating instructional materials, providing guidance, and functioning as a virtual tutor for learners, answering queries, revolutionizing education through smartphone and IoT integration, and fostering collaborative group work. Moreover, the authors outline ChatGPT's role as a virtual instructor, aiding learners in web-based independent research through responsive interactions and enhancing collaboration by suggesting frameworks for debates and offering immediate feedback.

Bruneau, Wang, Cao, and Truong (2023) conducted a study exploring ChatGPT's potential to enrich physics education within Vietnamese high schools. The results revealed the dual role that ChatGPT can play for both educators and learners. Students can utilize ChatGPT as their virtual tutor or study partner which could provide them tailored explanations to concepts and answers to questions at an instant. It holds the potential to provide step-by-step guidance to help students navigate intricate physics problems, fostering independent learning and honing problem-solving abilities. Additionally, ChatGPT can be used by students to generate practice exercises and quizzes by themselves to self-assess themselves and to ensure reinforcement of concepts. By

facilitating a personalized learning journey, ChatGPT empowers students to delve into physics at their preferred pace and attain a deeper mastery of the subject.

The authors concluded that integrating ChatGPT into physics education can make the learning experience more dynamic, interactive, and accessible for students. It can help students develop profound conceptual understanding, enhance critical thinking, and improve their problem-solving skills. Moreover, ChatGPT provides a collaborative learning environment that stimulates student engagement and autonomy.

Kwan Lo (2023) conducted a rapid literature review to highlight the strength of ChatGPT's capabilities across different subject areas, its potential applications in education, and the preliminary concerns raised by researchers during its initial release period (December 2022 to February 2023). The review indicated ChatGPT's varying performance across subject domains, ranging from exceptional (e.g., economics) and satisfactory (e.g., programming) to subpar (e.g., mathematics).

While ChatGPT proved to be promising as an aid for instructors (e.g., generating course materials, offering suggestions) and as a virtual tutor for students (e.g., answering questions, facilitating collaboration), challenges had emerged regarding its usage, such as the generation of inaccurate or fabricated information and circumvention of plagiarism detection systems. Immediate action was recommended to revise assessment methods and institutional policies in educational settings. Furthermore, training for instructors and education for students was deemed crucial to navigate the implications of ChatGPT's impact on the educational landscape. Additionally, ChatGPT holds potential in enhancing active learning methodologies. Citing the works of Nisar and Aslam (2023), and Kasneci, Sessler, Küchemann, Bannert, Dementieva, Fischer, Gasser, Groh, Günnemann,

Hüllermeier, Krusche, Kutyniok, Michaeli, Nerdel, Pfeffer, Poquet, Sailer, Schmidt, Seidel, Stadler, Weller, Kuhn, and Kasneci (2023)., the author noted ChatGPT's role as a virtual tutor, assisting students in online independent study by addressing queries and improving group dynamics by suggesting discussion structures and providing immediate feedback.

Chapter 3

RESEARCH METHODOLOGY

"Tell me and I forget, teach me and I may remember, involve me and I learn."

-Benjamin Franklin-

3.1 INTRODUCTION

In this pivotal chapter, the intricacies of the research methodology are meticulously elucidated. Delving into the core of the study's framework, this section encapsulates a thorough examination of various facets crucial to the research process. From delineating the chosen research approach and design to navigating through the intricacies of population selection and site determination, each element is meticulously explored. The chapter unfolds a meticulous discussion encompassing sampling techniques, sample size considerations, participant selection criteria, and the formulation of lesson plans. Furthermore, this chapter provides the details of the instruments used in this study for the purpose of data collection and it also delves into the process of assessing the validity and reliability of the instruments and pilot testing to ensure their efficacy in data collection. Later in this chapter the procedure of data collection and data analysis is elaborated which is further discussed in the next chapter in detail. This chapter also elaborates about the ethical considerations that were made for the purpose of this research endeavor, to uphold the integrity and respect of all the stakeholders that were involved. Lastly, the section of delimitations sheds light on the boundaries and constraints that were defined for the conduct of this study.

3.2 RESEARCH APPROACH

A research approach can be defined as the strategy adopted by the researchers to investigate the chosen research problem, and to collect, analyze, and interpret data in a systematic manner to address a specific research question or objective (Creswell, 2014). It is comprised of the overall framework guiding the research process, which includes the theoretical perspective, methods for data collection, and analytical techniques to analyze that data to achieve research goals. In this study, mixed methods research was adopted to evaluate the effect of using ChatGPT of undergraduate students on active learning. The mixed methods research incorporates gathering data through both quantitative and qualitative approaches. The reason for the selection of this research approach was based on the objectives of this study, which required the utilization of both quantitative and qualitative approaches.

3.3 RESEARCH DESIGN

Research design encompasses the comprehensive blueprint detailing how a researcher plans to carry out a study, specifying the methods, procedures, and techniques to gather and analyze data (Creswell, 2014). It encompasses decisions about the research's goals, the type of data to be collected, and the strategies for its analysis and interpretation. The research design of this study was explanatory sequential design and it was divided into three levels. The level 1 involved non-equivalent control group and experimental group pretest-posttest quasi-experimental design to measure one variable under investigation, i.e., Learning, while the level 2 and level 3 were descriptive. The level 2 involved questionnaire to measure the other variable, i.e., Reaction. Finally, the level 3 involved analysis of ChatGPT conversation history to validate the findings of first

two levels, answer the overarching research question, and draw conclusions about the usage of ChatGPT for active learning.

Level 1

A pre-test was initially conducted to assess the initial learning of students before the conduct of experiment. The results of the pre-test were analyzed using IBM SPSS Statistics version 26 and based on the results of the pre-test, students were divided into two matching groups: one for control group, another for experimental group. Furthermore, students in each group were subdivided into sub-groups comprising of 3 students in each group who were going to be working together during the experimental period. Furthermore, there were two types of students based on their academic background: those who had the background of studying computer science at their intermediate level, and those who had no background of studying computer science. It was ensured that each group had equal number of participants of both types.

In the next step a six-week long experimental study was conducted in which each group of students collaboratively participated in an active learning classroom for control group, and with the addition of the use of ChatGPT for students learning for the experimental group.

In the final step, students were given two post-tests: one to assess learning outcomes at understanding level of revised Bloom's taxonomy and the other to measure the learning outcomes at applying level which were administered in the similar manner as pre-test. The results of pre-tests and post-tests for understanding level were analyzed of both groups by applying independent samples t-test in IBM SPSS Statistics version 26

while the results of the post-tests for applying level were analyzed of both groups by applying Mann-Whitney U test in IBM SPSS Statistics version 26 as the assumptions to conduct t-test could not be met for the data sets.

Level 2

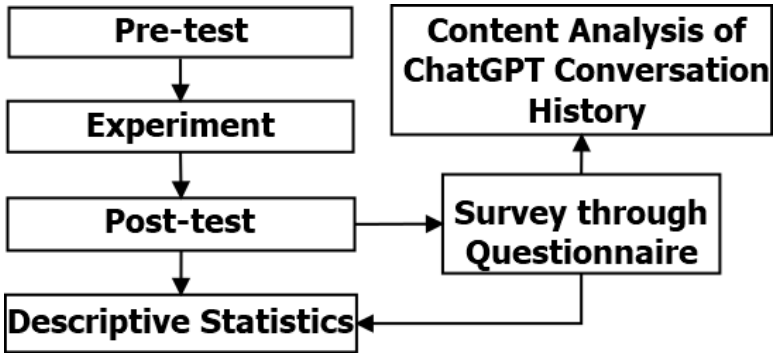
For the assessment of another objective, i.e., to measure reaction of students, the students of the experimental group were given a close-ended questionnaire to fill after the conduct of post-test. The results of this questionnaire were analyzed through IBM SPSS Statistics version 26 by calculating the frequencies and means of their responses to assess students' affective reaction and utility judgment.

Level 3

To enhance the credibility of this research and to improve the validity of the quantitative results, and to answer the overarching research question of this study, a content analysis was conducted of the conversation history made in the ChatGPT accounts of the participants of the experimental group during the course of their learning.

Figure 2.1

Mixed Method Approach Protocol



3.4 POPULATION

In a research study, the population denotes the entirety of individuals, items, or phenomena sharing specific characteristics and deemed relevant to the researcher (Babbie, 2015). It represents the group about which conclusions are being made based on the study's findings. The population of this study was the undergraduate students in Islamabad Model Colleges (Ex-Federal Government Colleges) in Islamabad. Specifically, for the purpose of experimental study on active learning, the undergraduate students pursuing the degree of BS Computer Science (BSCS) in Islamabad Model Colleges were the target population as the degree program offered technical courses which were best suited for active learning.

There were total of 02 Islamabad Model Colleges that were offering the degree of BSCS: one for boys located in H-9 and the other for girls in G-10/4, Islamabad. The number of undergraduate students as per colleges' records in the above colleges at the time of conducting this research study were 315 in total; out of which 147 were boys and 168 were girls.

3.5 SELECTION OF THE SITE

The selection of site is important for the purpose of conducting a quasi-experimental study. It should be done carefully to ensure that the site is appropriate for the study and that the results can be generalizable to other similar settings or populations. Factors such as the size and characteristics of the population, resource availability, the cultural and social context of the site, and the feasibility of data collection should be considered when selecting a site for a quasi-experimental study.

Therefore, the site that was selected for this study was Islamabad Model College for Boys H-9, Islamabad. The reason behind was it was the only college for boys that was offering the degree course in BSCS which included technical courses that were well suited for an experimental study based on active learning. Another reason was being the familiarity of the researcher with the social and cultural environment in the institution, and the feasibility in terms of access to the site and data collection for the researcher for being the employee of the institution and residing in its vicinity. Furthermore, as the college had been offering the graduate level courses of 04-year degree program since 2019 and was the only accredited college by HEC for the said degree program, its results could be generalized to other Islamabad Model Colleges.

3.6 SAMPLING TECHNIQUE

A sampling technique is a method that is used by the researcher to select a representative subset of a population for the conduct of a study. The sampling technique selected for this study was purposive sampling. As the researcher was conducting a quasi-experimental study, he chose the college where he was currently employed for the

research study. The reason for that was because it was easier for him to get all the formal permissions from the head of the institution compared to any other institution, and that he did not have to worry about getting leave from his workplace for the purpose of conducting research. Furthermore, as the researcher was conducting the experiment himself, it was better if he conducted the study in an environment to which he was familiar with and convenient.

3.7 SAMPLE SIZE

The sample size for this study was the total size of one class of undergraduate students in the institution. The maximum size of undergraduate students in one class in the college were 60 students.

3.8 INCLUSION CRITERIA

Students enrolled in the program of BSCS were selected for this study. In particular, the students of first semester studying the introductory level programming course of Problem-solving and Programming of 4(3+1) credit hours were selected. The reason for selecting the students of first semester was that they had little to no background of computer programming and its concepts, and this particular course was that it was focused on fundamentals of programming and core programming skills by introducing students with various programming concept and their application. Since learning of concepts and their application through hands-on practice are core activities that can be effectively implemented through and enhanced by active learning and AI to engage students, this course was chosen to evaluate active learning in our context. According to HEC's policy guidelines for implementation of uniform semester systems,

one credit hour for a course of theory needs the student to spend one hour per week for learning throughout the semester while one credit hour for laboratory requires the student to have three contact hours in the lab per week. Since the above course was of 3+1 credit hours, it means for this particular course, the students were spending 03 hours of time in learning the theoretical part of the course and 03 hours were dedicated for their practice in the computer laboratory each week.

3.9 FORMATION OF GROUPS

For the purpose of this experimental study, the students were initially divided into two groups: one for control group another for experimental group. These groups were further divided into smaller sub-groups; each group comprising of three students to work collaboratively together for active learning. Multiple criteria were used for the formation of diverse and balanced groups, i.e., pre-test results and previous experience of studying computer science at HSSC level. The detail of group formation in steps is elaborated below.

1. Students were divided into performance bands based on the average pre-test scores of understanding level of revised Bloom's taxonomy.
2. Students who had prior experience of studying computer science at HSSC level were identified. Out of 60 students, 32 students had studied computer science at HSSC level while 28 students had no background of studying computer science at HSSC level.
3. Classification was made based on the combination of above factors which resulted in forming the following groups:

Group A: Above average-performing students with previous computer science experience.

Group B: Above average-performing students without previous computer science experience.

Group C: Average-performing students with previous computer science experience.

Group D: Average-performing students without previous computer science experience.

Group E: Below average-performing students with previous computer science experience.

Group F: Below average-performing students without previous computer science experience.

4. Maintaing a balance between pre-test performance and previous computer science knowledge, final group formation for the teaching-learning session was ensured to have equivalent representation of each of the above category.

The table below represents the results of the above strategy for the formulation of groups.

Table 3.1

Groups Formation (total participants = 60)

Scores Category	Range of Scores	Categories of Students based on Previous Experience of Studying Computer Science	Number of Participants
Above Average	13-29	studied computer science at HSSC level	22
		not studied computer science at HSSC level	02
Average	12	studied computer science at HSSC level	02
		not studied computer science at HSSC level	00
Below Average	5-11	studied computer science at HSSC level	08
		not studied computer science at HSSC level	26

Based on the above strategy two matching groups were formed for the purpose of this study, each of which comprised of 30 students. Both control group and experimental group had 12, 01 and 16 students who performed above average, average, and below average in the pre-test respectively.

3.10 LESSON PLANS

For the construction of lesson plans tailored for an active learning classroom environment, the conceptualization of active learning from Fink (2003) and Felder & Brent (2009) was fundamental. The lesson plans were designed following the active learning-based teaching model specific to computer science education, delineated into

four key stages: trigger, activity, discussion, and summary (Hazzan et al., 2020). The framework guiding the construction of these plans was the Backward Design Template presented by Bowen in 2017.

The weekly lesson plans (appendix I) were designed which included active learning classroom and lab work which compensated for 03 hours of theory and 03 hours of lab for a 4(3+1) credit hours course as per the requirements of the course by HEC. For each lesson, students were divided into group of 03 students to work collaboratively together during activity phase and have discussion and reflection. Furthermore, lab activities were designed for each week that students had to perform to ensure further practice of the concepts learned.

All the classes were planned to be held in the computer lab where the resources include computer systems, multimedia projector, white board, and internet connectivity. Each student's group was given access to a computer system that had active internet connectivity, and ChatGPT account logged in for that particular group for the purpose of their learning.

3.11 RESEARCH INSTRUMENTS

The instruments that were designed and adapted from the literature for data collection for each level of Kirkpatrick's model under investigation in this study are described in table 3.2 given below.

Table 3.2

Instrumentation

Level of Kirkpatrick's Model	Activity	Instrument
Level 1	Measurement of affective reaction and utility judgments regarding the use of ChatGPT for learning	Adaptation of Questionnaire to measure perceived usefulness for learning (Ruiz & Snoeck, 2018)
Level 2	Evaluation of quality of learning	Experiment with pre-test and post-test

3.12 VERIFICATION OF THE TOOLS

To ensure the robustness and validity of the research tools employed in this study, a comprehensive process of expert validation was meticulously undertaken. This validation process comprised of two essential phases: online validation through email and in-person interactions during meetings. This expert validation was an invaluable step in refining and enhancing the tools, ensuring their suitability for the research objectives of this study.

In the first stage of expert validation, a select group of seasoned experts in the field of computer science were contacted via email and were requested to validate the research instruments for the purpose of this study. On their approval, the research instruments which included tests that were designed to assess learning of students at understanding level and applying level, and the questionnaire that was formulated to assess their reactions were separately shared with each expert on their emails. Their diverse and specialized perspectives were crucial in assessing the tools' content, clarity,

and relevance to the research objectives. Subsequently, multiple in-person meetings with each expert were held individually at their convenience to receive further feedback and recommendations to make further improvements in the research instruments.

All recommended changes and suggestions provided by the experts that could be feasibly implemented were meticulously incorporated into the research tools. These refinements aimed to enhance the tools' comprehensibility and efficacy for data collection while aligning them more closely with the research context. The revision of the tools was then thoughtfully presented to those experts, who once again contributed their insights and provided their valuable endorsement.

Upon careful consideration of the experts' feedback, the research instruments were ultimately refined and validated to an extent that experts expressed confidence in their suitability for data collection. Validity certificates were officially issued, signifying the tools' alignment with the research objectives and the rigor with which they had been assessed and refined.

This rigorous process of expert validation not only strengthened the research tools but also underscored the commitment to conducting a robust and reliable study. The collaborative efforts between the researcher and the experts ensured that the instruments were finely tuned to meet the specific needs of the research, enhancing the overall quality of data collection.

3.13 PILOT TESTING

For the purpose of pilot testing, the researcher undertook a one day workshop of 55 students of HSSC level to teach the basics of C++ programming language offering the

use of ChatGPT during their learning. At the end of the session, the researcher handed them the questionnaires to assess their reaction which were later analyzed using IBM SPSS Statistics version 26. All the ethical guidelines were ensured during the pilot testing phase.

3.14 RELIABILITY OF THE INSTRUMENT

The results of the pilot testing were analyzed using IBM SPSS Statistics version 26 to assess the strength and to ensure the reliability of the questionnaire to evaluate the reaction of the participants. For this purpose, the Cronbach alpha, item-total correlation, and intersection correlation were calculated of the data collected through pilot testing.

Table 3.3

Cronbach Alpha of the Questionnaire to Assess the Reaction of Students (N=55)

Scale	Major Dimensions	Items	Cronbach Alpha Reliability
Questionnaire to assess Reaction of students		13	.837
	Utility Judgment (Understanding Level)	05	.805
	Utility Judgment (Applying Level)	04	.761
	Affective Reaction	04	.749

Table 3.3 shows the results of computed Cronbach Alpha for the questionnaire to assess reaction of students and its major dimensions. The results indicated that the Cronbach Alpha value for the overall questionnaire was 0.837 while the values of

Cronbach Alpha for its major dimensions, i.e., Utility Judgment (understanding level), Utility Judgment (applying level), and Affective Reaction were 0.805, 0.761, and 0.749 respectively. All of the values of the Cronbach Alpha from the results of the pretest were near to 01, hence it can be interpreted that the questionnaire was highly reliable to measure the reaction of students for this study.

Table 3.4

Item-total Correlation of the Questionnaire to Assess the Reaction of Students (N=55)

Codes of Items	R	Codes of Items	R	Codes of Items	R
UU1	.727**	UA1	.619**	AR1	.681**
UU2	.673**	UA2	.702**	AR2	.498**
UU3	.517**	UA3	.575**	AR3	.644**
UU4	.614**	UA4	.441**	AR4	.443**
UU5	.492**				

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

The above table shows item-total correlation for the questionnaire to assess reaction of students. According to the results illustrated in table 3.4, the highest item-total correlation was of the item UU1 (0.727) and the lowest item-total correlation was of the item UA4 (0.441).

Table 3.5

Intersection Correlation of the Questionnaire to assess the Reaction of Students (N=55)

	Reaction	Utility Judgment (Understanding Level)	Utility Judgment (Applying Level)	Affective Reaction
Reaction	1			
Utility Judgment (Understanding Level)	.803**	1		
Utility Judgment (Applying Level)	.752**	.333*	1	
Affective Reaction	.753**	.407**	.445**	1

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

The above table depicts intersection correlation for the questionnaire to assess reaction of students. According to the results presented in table 3.5, the highest intersection correlation existed between Utility Judgment (understanding level) and Reaction questionnaire (0.803), and the lowest correlation was among Utility Judgment (understanding level) and Utility Judgment (Applying Level) (0.333).

3.15 DATA COLLECTION

The data was collected using the instruments designed for this study in the period of conduct of experiment. It was collected in different phases which included before introduction of the intervention, during the time of intervention (through ChatGPT), and after a sufficient time of the introduction of the intervention that was at the end of the experiment.

Data collection involved the following steps.

- Prior to the course, students attempted a pre-test assess their learning at understanding level of revised Bloom's taxonomy to gauge their existing knowledge.
- Based on their educational background in terms of studying the subject of computer science at HSSC level, and their current level of knowledge determined through pre-test, students were divided into matching control group and experimental group. Furthermore, these groups were divided into sub-groups of 3 students for each ensuring each group had members of equivalent category.
- After formation of groups, students of experimental group were given a basic overview of how ChatGPT works and how they should make queries with it to communicate and get effective results. For example, students were told to include phrases like "in programming" or "in C++" to delimit the answers generated by ChatGPT in a particular domain only. In similar manner they were taught to communicate with ChatGPT just as they would ask a teacher or an expert for an advice or answer to a question. They were instructed to talk with ChatGPT in second person and make queries as detailed as possible so that best responses can be generated. Furthermore, the participants were instructed to start a new conversation each time they have a new question or query, and make follow-up responses in case they want details regarding current conversation for the purpose of easier logical analysis of their conversations.
- After the course, students of both control group and experimental group attempted post-tests, on to assess their learning at understanding level, and the other to

assess their achievement of learning outcomes at applying level of revised Bloom's taxonomy.

- Students' interaction with ChatGPT was recorded in the accounts of their respective groups in the form of conversation history for qualitative analysis.
- Students of experimental group were asked to complete a questionnaire after the course to assess their reactions to the instruction (affective reaction) and the use of computer-assisted learning tool, i.e., ChatGPT during the instruction (utility judgment). The questionnaire only included close-ended questions with response options that were later analyzed quantitatively to assess the effect of ChatGPT in an active learning environment.

3.16 DATA ANALYSIS

Data analysis was conducted through IBM SPSS Statistics version 26. The data analysis involved both descriptive statistics and content analysis. To achieve objectives of this study, descriptive statistics were made. The descriptive statistics involved methods to calculate mean and frequency. The independent samples t-test, and Mann-Whitney U tests, were employed with 5% level of significance to test the hypotheses and to fulfill study objectives. Lastly, to answer the research question under investigation, content analysis was conducted.

- To achieve objective 1a, the data from the close-ended questionnaire was summarized and analyzed by calculating frequency of the students' responses and their mean. The responses were analyzed to determine their affective reactions

and utility judgments regarding the instruction and the use of ChatGPT during the instruction.

- For objective 1b(i), means of pre-test scores for both control and experimental groups were calculated, and independent samples t-tests were used to compare the initial difference in students learning at understanding level of revised Bloom's taxonomy.
- For objective 1b(ii), means of post-test scores for both control and experimental groups were calculated, and independent samples t-tests were used to analyze the differences in learning outcomes at understanding level of revised Bloom's taxonomy.
- For objective 1b(iii), means of post-test scores for both control and experimental groups were calculated, and non-parametric tests, i.e., Mann-Whitney U tests were used to analyze differences in learning outcomes at applying level of revised Bloom's taxonomy. Initially, the independent samples t-test was planned to be used to measure the difference in the learning of students at both understanding and applying level but since the assumptions to run t-test at applying level could not be met, it was later replaced with Mann-Whitney U test which was used to analyze the post-test scores of the groups to determine if there was a significant difference in learning outcomes at applying level of Revised Bloom's taxonomy..
- Content analysis was conducted on the history of conversations made by the students from the accounts that were provided to them. The data was coded and categorized into themes to identify common patterns; and interpretations were made regarding the research question of this study.

The data collected and analyzed in each level was integrated to provide a comprehensive analysis of the effect of ChatGPT on active learning of students in the classroom, including their reactions to the tool and the extent and quality of learning that occurred during the course.

3.17 RESEARCH ETHICS

For a researcher, ethical principles are very important to conduct a sound research study. In this study, to ensure the integrity of the researcher himself and this research, ethical principles were strictly followed in every stage of the research methodology. Furthermore, the research approach that was adopted not only adhered to ethical standards but also ensured profound respect for the rights and well-being of the research participants and anyone else directly and indirectly involved in this research. This section outlines the specific ethical considerations, including informed consent, non-coercion, confidentiality, anonymity, and institutional permissions, that were integral to the conduct of this study.

Informed Consent

During this research, informed consent was obtained from all of the participants. They were provided a comprehensive explanation of the research goals and procedures which elaborated their roles as participants, along with a disclosure of any potential risks, benefits, or inconveniences associated with their participation. Participants were also given the opportunity to ask questions about the research study and seek any clarification as and if needed. Initially it was planned that verbal consent would be obtained from each participant, or their legal guardians in case of minors however since there were no minors

involved among the participants only the verbal consent of the participants was received. Furthermore, it was ensured that the participants were aware of their right to withdraw from this study at any time without facing any adverse consequences.

Non-coercion and Voluntary Participation

During the conduct of experiment for the purpose of this study, the principle of non-coercion was upheld to ensure that the participants became the part of experimental study voluntarily and without any undue pressure or manipulation of any kind. In every stage of their participation, there was no any kind of coercion, inducement, or undue influence that might compromise their autonomy. The participants of this study were consistently informed of the voluntary nature of their participation and were rightly reminded of their right to withdraw at any stage if the want. It was ensured that every participant had their right to decline or discontinue participation without facing adverse repercussions.

Confidentiality and Anonymity

Every possible attempt was made to protect the privacy and confidentiality of research participants. Any personal information and the data collected during the study was carefully safeguarded. Coded or anonymized identifiers were planned to be used to ensure the anonymity of participants for recording of data collected. Participants were explicitly communicated regarding how any information related to them that would be collected will be handled and how their confidentiality will be ensured for reporting of data.

Formal Permission from the Head of the Institution

Formal permission from the head of the institution is required before the research could commence, particularly when the research involves the organization, its employees, or its resources. Official approval from the institutional authority was sought and obtained by meeting with the head of the institution in his office and elaborating him of the purpose of this research and the procedures to undertake the research study at the institution and the timeframe and resources that would be required for it. Furthermore, the benefits that the research study could have for the institution and for the overall educational landscape were described.

3.18 DELIMITATIONS OF THE RESEARCH STUDY

This study was constrained to the following conditions due to limited time and resources:

1. This study was delimited to one college in Islamabad region.
2. The study was delimited to the undergraduate students studying BS Computer Science.
3. The study was delimited to the students studying the introductory level programming courses of Problem-solving and Programming (theory and lab course).
4. The researcher used non-equivalent control group, experimental group pretest-posttest quasi-experimental design.
5. The number of participants were delimited to maximum of 60 students.
6. The study was further delimited to only those students of the class who will provide informed consent to be included in the quasi-experimental study.

7. The duration of the experiment in the experimental study was six weeks.
8. Pretest was only conducted at understanding level to ensure control and experimental groups were equivalent in terms of their existing knowledge.
9. The researcher utilized his intellectual ability and professional experience along with the studies he referred during the course of this study to create the active learning environment for the purpose of experimental study.
10. The researcher delimited the study to evaluate only the Level 1 and Level 2 of Kirkpatrick's model.
11. The study was delimited to assessing the learning based on understanding and applying level of revised Bloom's taxonomy.

Chapter 4

ANALYSIS AND INTERPRETATION OF THE DATA

"The art of teaching is the art of assisting discovery."

-Mark Van Doren-

This chapter delves into the analysis and interpretation of the data, presenting the methodology utilized by the researcher to interpret the findings of the study. This chapter is divided into two parts: one for quantitative analysis and the other for qualitative analysis. Part one contains description of all the data analysis that was conducted to achieve objective 1a, 1b(i), 1b(ii), and 1b(iii) of this research study while part two includes content analysis which was conducted to reflect on the findings in part one and to answer the overarching research question Q1 of this study.

Moreover in part one to achieve objective 1a, the researcher has used a questionnaire (attached as annex-F) to assess the reaction of students which includes their affective reaction and utility judgment. To achieve objective 1b(i), a pre-test was conducted to evaluate learning of students at understanding level of revised Bloom's taxonomy. (attached as annex-D). To achieve objective 1b(ii) and 1b(iii), post-tests were conducted to evaluate learning of students at understanding level and applying level of revised Bloom's taxonomy. (attached as annex-D and annex-E respectively)

The current study was experimental in nature hence pre-test was conducted initially to form two distinct but matching groups as control group and experimental group. The data set of both groups were analyzed and checked for assumptions and

appropriate tests were applied accordingly. To measure the understanding level of revised Bloom's taxonomy, independent samples t-test was used and for the applying level Mann-Whitney U test was applied. In part two, content analysis was carried out on the conversation history in ChatGPT accounts of the participants and inferences were made by comparing the results with the results of the quantitative part.

PART ONE: QUANTITATIVE DATA ANALYSIS

4.1 Objective 1a – Reaction

Students of experimental group were asked to complete a questionnaire after the course to assess their reactions to the instruction and the use of computer-assisted learning tool, i.e., ChatGPT during the instruction. The questionnaire was divided into three categories, one to evaluate students' affective reaction, and the other two to evaluate students' utility judgment related to their learning at understanding level and applying level of revised Bloom's taxonomy, and it only included close-ended questions with response options. The category-wise result of the quantitative analysis of each item is presented in the tables below.

Affective Reaction The affective reaction of students was assessed using 04 items in the questionnaire. The detail of the results of quantitative analysis is presented in table 4.1.

Table 4.1 represents 04 items in the questionnaire that assessed the affective reaction of students by inquiring of whether they would use ChatGPT to learn more about programming if they get a chance in future (AR1) shows that the responses of students ranged from agree to strongly agree out of which 50% lies in the range of agree and the

other 50% in strongly agree, whether they would prefer using ChatGPT in classroom in the future (AR2) shows that the responses of students ranged from agree to strongly agree out of which approx. 36.7% lies in the range of agree and 63.3% in strongly agree, whether they were enthusiastic about using ChatGPT in their learning (AR3) shows that the responses of students ranged from neutral to strongly agree out of which 3.3% lies in the range of neutral and 13.3% in strongly agree, and whether using ChatGPT to learn programming was a positive experience (AR4) shows that the responses of students ranged from agree to strongly agree out of which 50% lies within each range.

According to the above table, the mean of the responses for each item according to the cut-off range falls within 6.17 to 7.0 which indicates that students strongly agree with each item in the category.

Utility Judgment The utility judgment of students at understanding level was assessed based on 05 items in the questionnaire and at applying level was assessed based on 04 items in the questionnaire. The detail of the results of quantitative analysis is presented in table 4.2.

Table 4.1

Reaction of the Participants – Affective Reaction (N = 30)

Variable	Sub-variable	Frequency							Mean Total
Reaction	Affective Reaction	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree	
	AR1	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	15 (50.0%)	15 (50.0%)	6.50
	AR2	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	11 (36.7%)	19 (63.3%)	6.63
	AR3	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (3.3%)	8 (26.7%)	17 (56.7%)	4 (13.3%)	5.80
	AR4	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	15 (50.0%)	15 (50.0%)	6.50
	Mean of means								6.36

Table 4.2

Reaction of the Participants – Utility Judgment (N=10)

Variable	Sub-variable	Frequency							Mean Total
Reaction	Utility Judgment (Understanding Level)	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree	
	UK1	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (10.0%)	17 (56.7%)	10 (33.3%)	6.23
	UK2	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (13.3%)	20 (66.7%)	6 (20.0%)	6.07
	UK3	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (10.0%)	22 (73.3%)	5 (16.7%)	6.07
	UK4	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (6.7%)	14 (46.7%)	14 (46.7%)	6.40
	UK5	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (20.0%)	13 (43.3%)	11 (36.7%)	6.17
	Mean of means								6.19
	Utility Judgment (Applying Level)								
	UA1	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	11 (36.7%)	19 (63.3%)	6.63
	UA2	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	13 (43.3%)	17 (56.7%)	6.57
	UA3	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	16 (53.3%)	14 (46.7%)	6.47
	UA4	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	13 (43.3%)	17 (56.7%)	5.57
	Mean of means								6.31

Table 4.2 represents 05 items in the questionnaire that assessed the utility judgment of students at understanding level and 04 items in the questionnaire that assessed the utility judgment of students at applying level. Utility judgment at understanding level was assessed by inquiring of whether using ChatGPT improved understanding of the topics covered in this course (UK1) shows that the responses of students ranged from somewhat agree to strongly agree out of which 10% lies in the range of somewhat agree and 33% in strongly agree, whether using ChatGPT helped in understanding the topics much faster (UK2) shows that the responses of students ranged from somewhat agree to strongly agree out of which 13.3% lies in the range of somewhat agree and 20% in strongly agree, whether using ChatGPT helped in learning programming concepts more easily (UK3) shows that the responses of students ranged from somewhat agree to strongly agree out of which 10% lies in the range of somewhat agree and 16.7% in strongly agree, whether students used ChatGPT to explain concepts that they were feeling difficulty to comprehend (UK4) shows that the responses of students ranged from slightly agree to strongly agree out of which 6.7% lies in the range of slightly agree and 46.7% in strongly agree, and whether students used ChatGPT to generate examples of code to understand the concepts that they were feeling difficult to comprehend (UK5) shows that the responses of students ranged from slightly agree to strongly agree out of which 20% lies in the range of slightly agree and 36.7% in strongly agree.

According to the above table, the mean of the responses for items UK2 and UK3 according to the cut-off range falls within 5.31 to 6.16 which indicates that students agree with each of these items while the item UK1, UK4, and UK5 falls within the cut-off range of 6.17 to 7.0 which indicates that students strongly agreed with these items.

Utility judgment at applying level was assessed by inquiring of whether using ChatGPT students were able to develop programs with less difficulty (UA1) shows that the responses of students ranged from agree to strongly agree out of which 36.7% lies in the range of agree and 63.3% in strongly agree, whether students used ChatGPT to explain code to them that they were feeling difficult to understand (UA2) shows that the responses of students ranged from agree to strongly agree out of which 43.3% lies in the range of agree and 56.7% in strongly agree, whether students used ChatGPT to identify and correct errors that they made in programming (UA3) shows that the responses of students ranged from agree to strongly agree out of which 53.3% lies in the range of agree and 46.7% in strongly agree, and whether students used ChatGPT to generate equivalent and more optimized code (UA4) shows that the responses of students ranged from agree to strongly agree out of which 43.3% lies in the range of agree and 56.7% in strongly agree.

According to the table presented above, the mean of responses for UA1, UA2, and UA3 according to the cut-off range falls within 6.17 to 7.0 which indicates that students strongly agree regarding the utility judgment of ChatGPT based on those items in the questionnaire while the mean of responses for UA4 falls within the cut-off range of 5.31 to 6.16 which indicates that students agree regarding the utility judgment of ChatGPT based on this item.

The reaction of the participants by computing the overall mean of each category is presented in the table below.

Table 4.3

Reaction of the Participants (category-wise)

Variable	Mean
Affective Reaction	6.36
Utility Judgment (Understanding level)	6.19
Utility Judgment (Applying level)	6.31

4.1.1 Sub-hypothesis 1 – Affective Reaction According the table 4.43 presented above, the mean result of the affective reaction of the participants is 6.36, which falls under the cut-off range of 6.17 to 7.0. It can be interpreted that the students strongly agree that the use of ChatGPT had positive effect on affective reaction of students. This quantitative analysis reveals that the students had the overall positive affective reaction hence the null hypothesis that there is statistically no significant effect of using ChatGPT on students' affective reaction at undergraduate level is rejected.

4.1.2 Sub-hypothesis 2 – Utility Judgment (Understanding and Applying)

According the table 4.3 presented above, the mean result of the utility judgment of the participants is 6.19 and 6.31, which falls under the cut-off range of 6.17 to 7.0. This quantitative analysis indicated that the students had strongly agreed regarding the utility judgment of the use of ChatGPT for learning at both understanding level and applying level of revised Bloom's taxonomy. Hence the null hypotheses that there is statistically no significant effect of using ChatGPT on students' utility judgment in understanding level of revised Bloom's taxonomy at undergraduate level and that there is statistically no significant effect of using

ChatGPT on students' utility judgment in applying level of revised Bloom's taxonomy at undergraduate level have been rejected.

4.2 Objective 1b – Learning

For the quantitative data analysis, the dataset was divided into two segments based on the competencies of the students which was evident from the results of their pre-test and grouping strategy that was elaborated before. Henceforth, each segment comprised of 17 below average performing students for each control group and experimental group, and 13 average and above average performing students in each control group and experimental group.

4.2.1 Objective 1b – Understanding Level The researcher employed an independent samples t-test to compare the mean scores of the test for understanding level of revised Bloom's taxonomy of the control group and the experimental group before and after six-week intervention. The detail of data analysis for pretest is mentioned below which is followed by detail of post-test analysis.

Objective 1b(i): Pre-test Analysis Assumptions necessary for conducting the independent samples t-test were tested, comprising five distinct criteria. The process and outcomes of assumption testing are outlined below.

Assumptions for Conducting Independent Samples t-test

• **Continuity of Dependent Variable** In this study, the dependent variable was students' learning, quantified by their raw scores on tests. As these scores represent a continuous variable, the data satisfies the initial requirement for conducting an independent samples t-test.

• **Independence of Observations** The control and experimental groups in this study were treated as distinct entities since participants in one group were not affiliated with the other. Furthermore, each student's observations were taken independently, meeting the requirement of the second assumption for running an independent samples t-test.

• **Approximate Normal Distribution of the Dependent Variable** To evaluate the normality of the data, the researcher performed a Shapiro-Wilk test using IBM SPSS Statistics version 26 on the datasets independently for both the control and experimental groups as it is suitable for smaller data sets. Details on conducting this test are presented in the tables below.

Table 4.4

Shapiro-Wilk Test for Checking Normality of Data of Control Group & Experimental Group – Understanding Level – Pretest

	Shapiro-Wilk		
	Statistic	df	Sig.
ControlGroup – Understanding Level – Below Avg Std	0.92	17	0.12
ExperimentalGroup – Understanding Level – Below Avg Std	0.92	17	0.18
ControlGroup – Understanding Level –Avg and Above Avg Std	0.94	13	0.49
ExperimentalGroup – Understanding Level - Avg and Above Avg Std	0.94	13	0.49

According to the above table, the significance values or p-values exceeding 0.05 suggests that the datasets follow a normal distribution which implies that there is no significant deviation from normality within the research dataset.

To further assess the normality of the dependent variable, Normal Q-Q Plots were also generated using IBM SPSS Statistics version 26 for both the control group and experimental group which indicated that the data points closely align with the reference line, suggesting approximate normal distribution rather than perfect normality. Consequently, the data meets the third assumption required for conducting the independent samples t-test (appendix K and appendix L).

- **No Outliers in the Dependent Variable** To verify the assumption that the dependent variable does not contain any outliers, Box plots were generated using IBM SPSS Statistics version 26 to assess the presence of outliers in the dependent variable. Details of this process are outlined below.

Figure 4.1

Outliers in Data of Control Group – Understanding Level – Below Average Students – Pretest

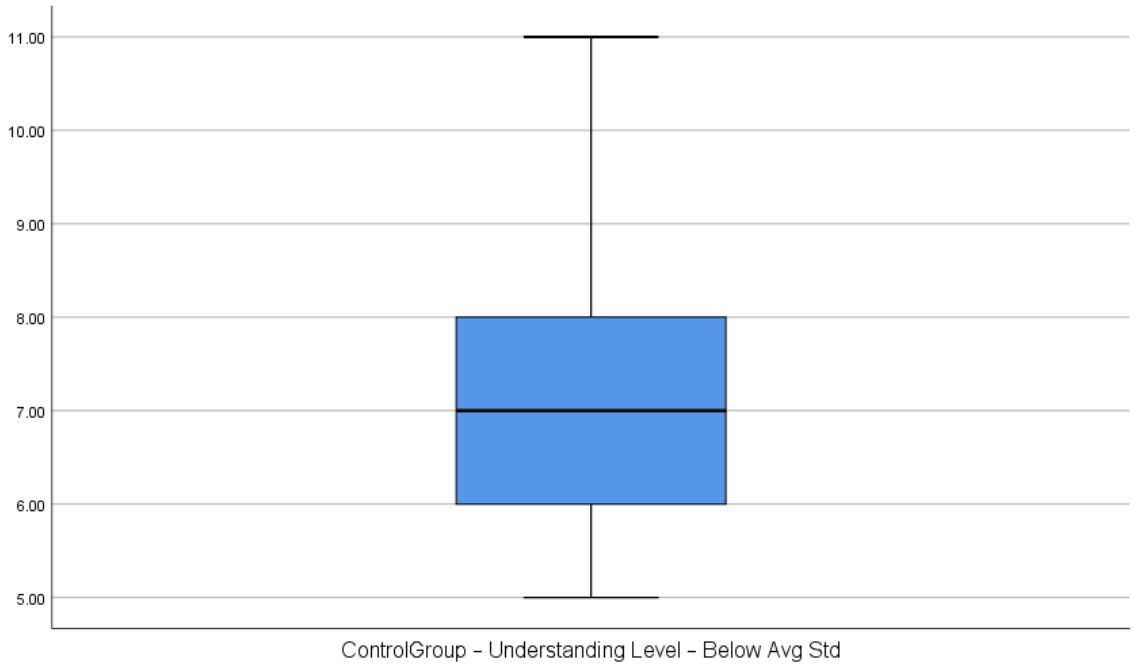


Figure 4.2

Outliers in Data of Experimental Group – Understanding Level – Below Average Students – Pretest

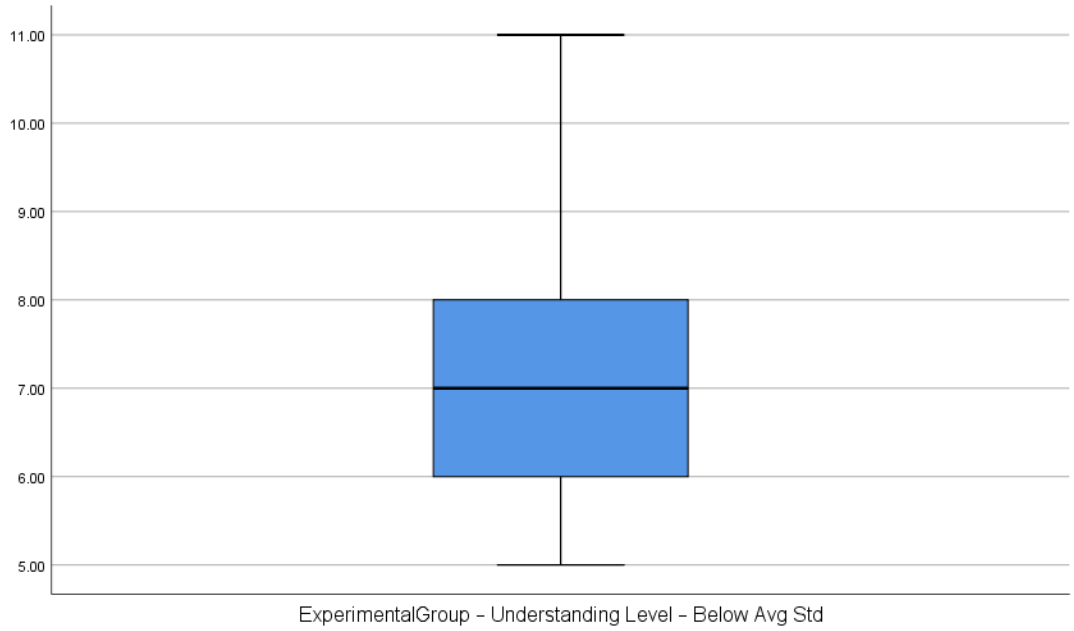


Figure 4.3

Outliers in Data of Control Group – Understanding Level – Average and Above Average Students – Pretest

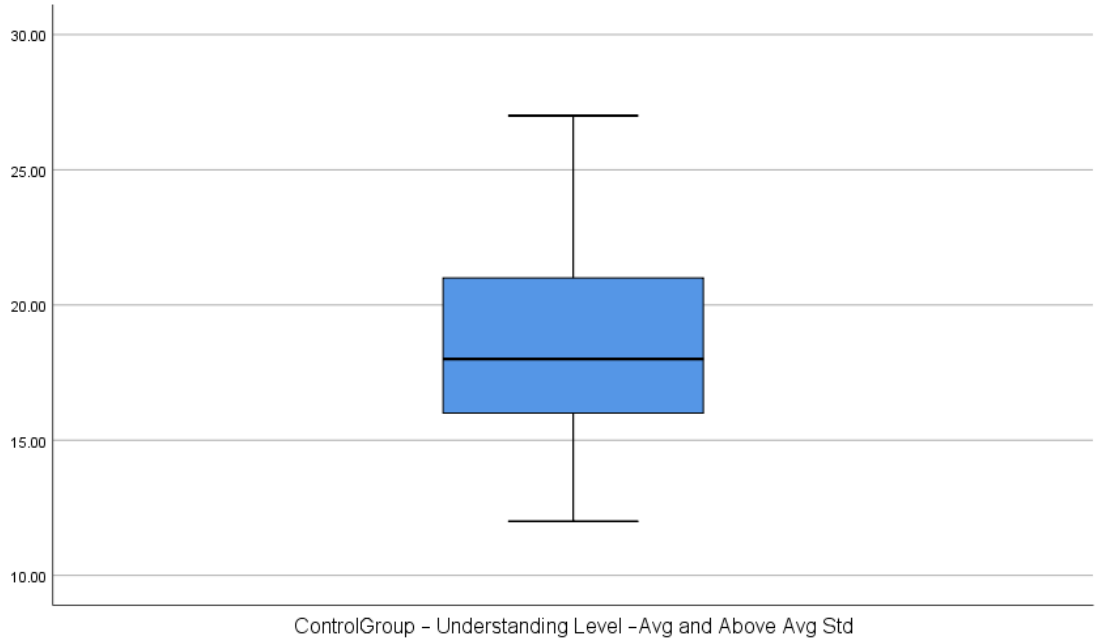
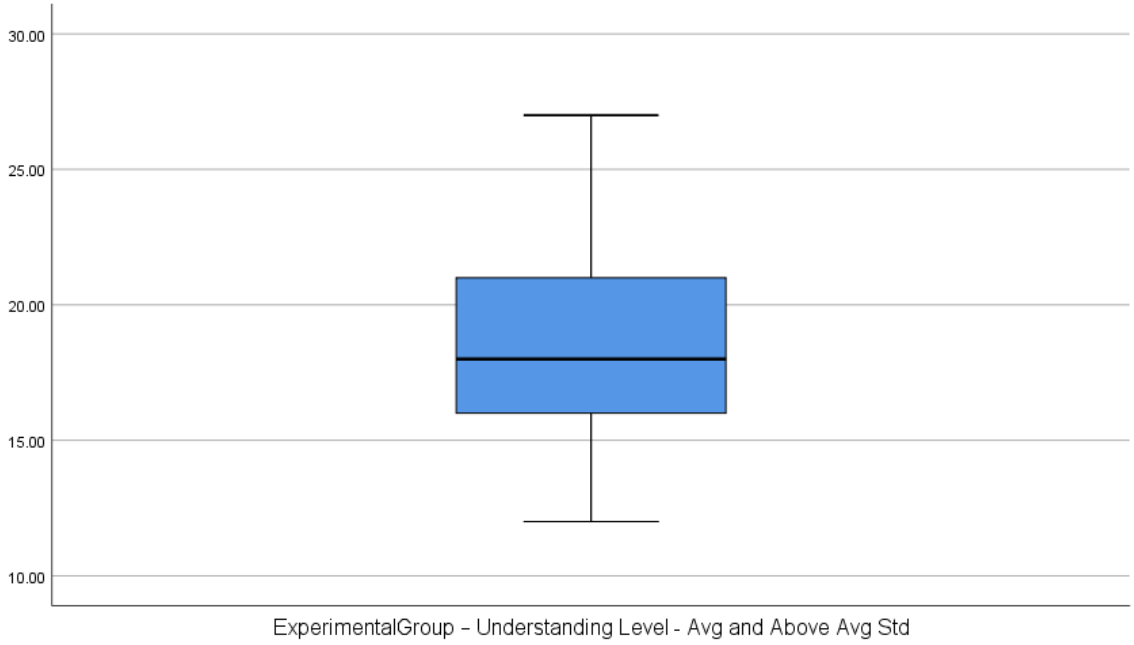


Figure 4.4

Outliers in Data of Experimental Group – Understanding Level – Average and Above Average Students – Pretest



The figures above illustrate that the values in the datasets in both control group and experimental group range from 05 to 11 in below-average performing students and from 12 to 27 in average and above-average performing students. Furthermore, there are no data points beyond the upper and lower whiskers in both figures, indicating the absence of outliers in the datasets. Consequently, the data satisfies the fourth assumption necessary for employing the independent samples t-test, which the researcher has utilized for conducting comparisons between the control and experimental group.

- **Homogeneity of Variance.** To assess the homogeneity of variance among the samples or groups, the researcher conducted Levene's test using IBM SPSS Statistics version 26. This test examined whether there was a significant difference in variance

between the segments of control and experimental groups. The results are outlined below.

Table 4.5

Levene's Test for Checking Homogeneity of Variance – Understanding Level – Below Average Students – Pretest

F	df1	df2	Sig.
0.096	1	32	0.76

Table 4.6

Levene's Test for Checking Homogeneity of Variance – Understanding Level – Average and Above Average Students – Pretest

F	df1	df2	Sig.
0.007	1	24	0.93

The significant values in the above provided tables are 0.76 and 0.93, exceeding the p-value of 0.05, suggesting that the variability between the two groups is not significantly different. In other words, there is no significant variance difference between the groups. Consequently, the dataset fulfills the fifth assumption required for conducting an independent samples t-test. Based on these findings, the researcher employed an independent t-test for the current study.

4.2.1.1 Independent Samples t-test of Results based on Understating Level. To evaluate the difference in the level of learning of students prior to conduct of experiment for the purpose of this study, the researcher conducted an independent

samples t-test to make comparison between the control group and the experimental group groups The researcher analyzed the pre-test scores of understanding level of Revised Bloom's taxonomy of both the groups using independent samples t-test via IBM SPSS Statistics version 26. The ensuing results are detailed below.

Table 4.7

Independent Samples t-test Results of Students Learning at Understanding Level – Below Average – Pretest

Variable	**N**	**Mean**	**df**	**t-value**	**P**
Control group	17	7.0	32	-0.31	0.76
Experimental group	17	7.18			

Table 4.8

Independent Samples t-test Results of Students Learning at Understanding Level – Average and Above Average – Pretest

Variable	**N**	**Mean**	**df**	**t-value**	**P**
Control group	13	18.69	24	-0.12	0.9
Experimental group	13	18.92			

In both of the tables provided above, the mean scores in the pre-test of the control group and experimental group are almost equal. The below average performing students in the control group and experimental group exhibited a mean score of M=7.0 and 7.18 respectively, while the average and above average performing students in the control group and experimental group exhibited a mean score of M=18.69 and 18.92 respectively Furthermore, with p-values of 0.76 and 0.9

or $p>0.05$, it is evident that prior to the conduct of experiment, there is no significant difference in the control group and experimental group with regards to students' learning in terms of understanding level of revised Bloom's Taxonomy hence we fail to reject the null hypothesis $H_0$1b(i) which states that there is statistically no significant difference in students' learning in pre-test at Understanding Level of Revised Bloom's taxonomy of control group and experimental group.

Objective 1b(ii): Post-test Analysis The researcher employed an independent samples t-test to compare the mean scores of the test for understanding level of revised Bloom's taxonomy of the control group and the experimental group after six-week intervention. The detail of data analysis for post-test is mentioned below.

Assumptions necessary for conducting the independent samples t-test were tested, comprising five distinct criteria. The process and outcomes of assumption testing are outlined below.

Assumptions for Conducting Independent Samples t-test

• **Continuity of Dependent Variable** In this study, the dependent variable was students' learning, quantified by their raw scores on tests. As these scores represent a continuous variable, the data satisfies the initial requirement for conducting an independent samples t-test.

• **Independence of Observations** The control and experimental groups in this study were treated as distinct entities since participants in one group were not affiliated with the other. Furthermore, although students worked collaboratively in groups, each student's observations were taken independently, meeting the requirement of the second assumption for running an independent samples t-test.

• **Approximate Normal Distribution of the Dependent Variable** To evaluate the normality of the data, the researcher performed a Shapiro-Wilk test using IBM SPSS Statistics version 26 on the datasets independently for both the control and experimental groups as it is suitable for smaller data sets. Details on conducting this test are presented in the tables below.

Table 4.9

Shapiro-Wilk Test for Checking Normality of Data of Control Group & Experimental Group – Understanding Level – Posttest

	Shapiro-Wilk		
	Statistic	df	Sig.
ControlGroup – Understanding Level – Below Avg Std	0.92	17	0.17
ExperimentalGroup – Understanding Level – Below Avg Std	0.9	17	0.08
ControlGroup – Understanding Level –Avg and Above Avg Std	0.92	13	0.27
ExperimentalGroup – Understanding Level - Avg and Above Avg Std	0.92	13	0.25

According to the tables above, the significance values or p-values exceeding 0.05 suggests that the datasets follow a normal distribution which implies that there is no significant deviation from normality within the research dataset.

Furthermore, to assess the normality of the dependent variable, Normal Q-Q Plots were also generated using IBM SPSS Statistics version 26 for both the control group and experimental group which indicated that the data points closely align with the reference line, suggesting approximate normal distribution rather than perfect normality. Consequently, the data meets the third assumption required for conducting the independent samples t-test (appendix M and appendix N).

• **No Outliers in the Dependent Variable** To verify the assumption that the dependent variable does not contain any outliers, Box plots were generated using IBM SPSS Statistics version 26 to assess the presence of outliers in the dependent variable. Details of this process are outlined below.

Figure 4.5

Outliers in Data of Control Group – Understanding Level – Below Average Students – Posttest

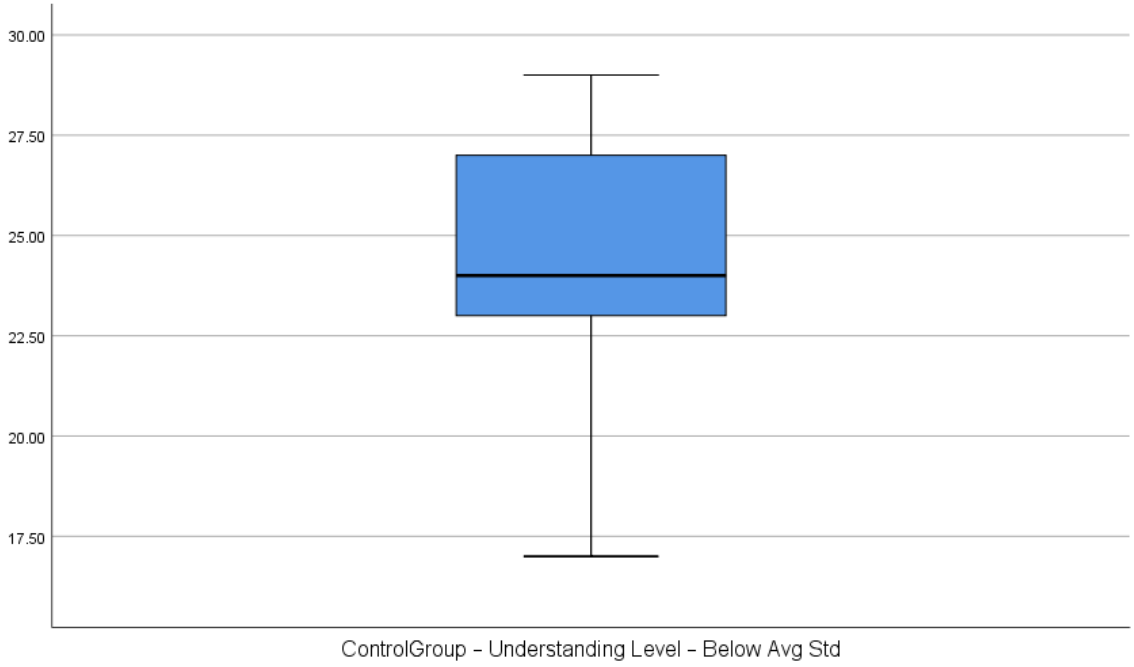


Figure 4.6

Outliers in Data of Experimental Group – Understanding Level – Below Average Students – Posttest

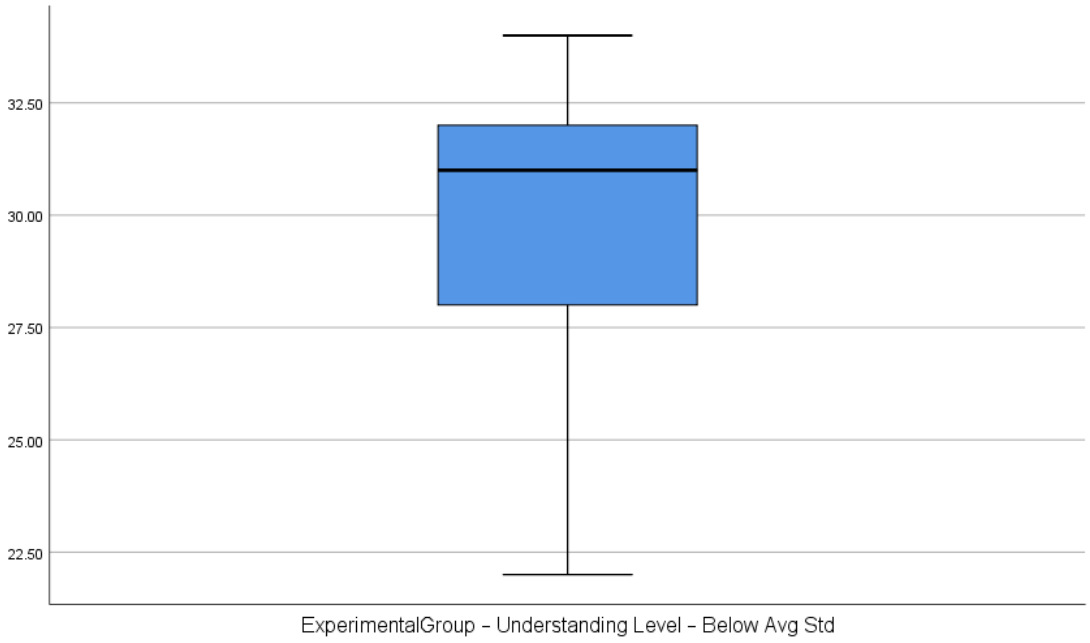


Figure 4.7

Outliers in Data of Control Group – Understanding Level – Average and Above Average Students – Posttest

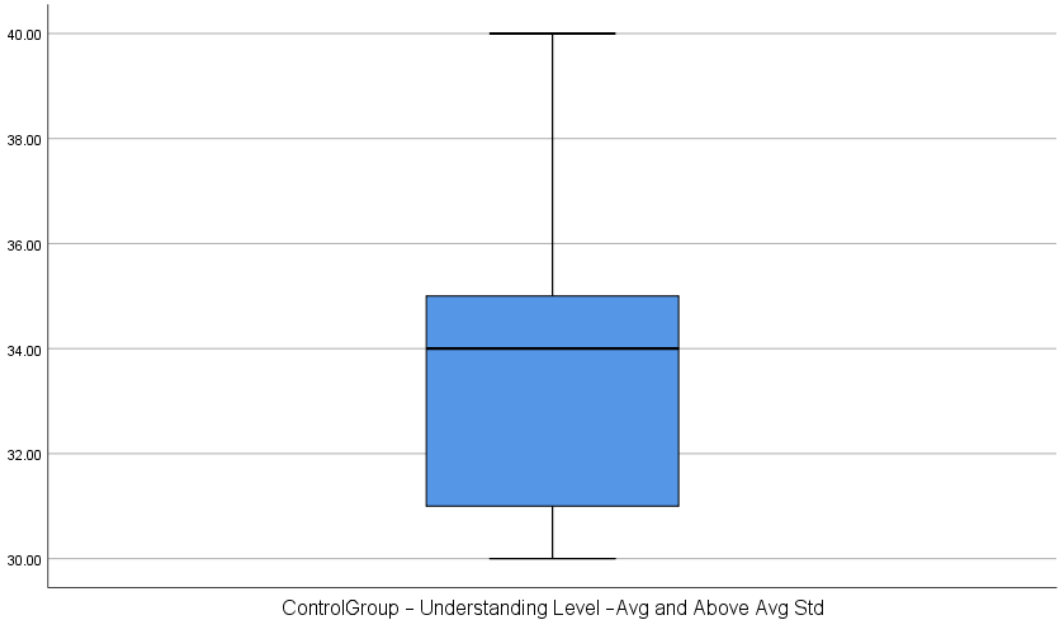
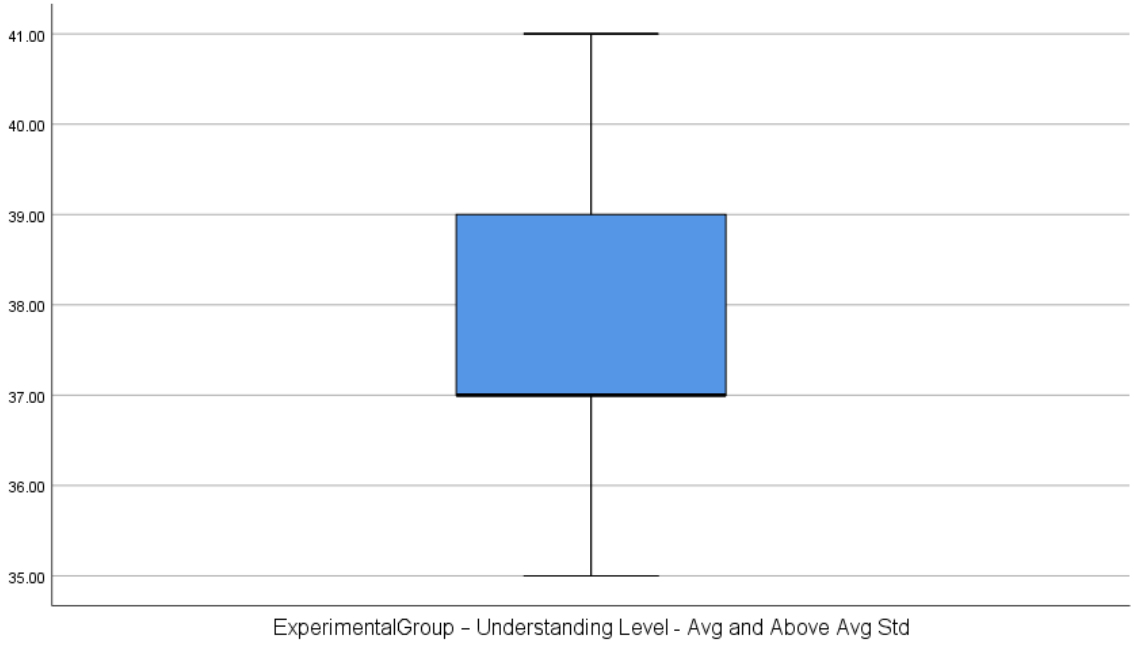


Figure 4.8

Outliers in Data of Experimental Group – Understanding Level – Average and Above Average Students – Posttest



The figures above illustrate that the values in the datasets in control group range from 17 to 29 in below-average performing students and 30 to 40 in average and above-average performing students while in the experimental group the values range from 22 to 34 in below-average performing students and from 35 to 41 in average and above-average performing students. Furthermore, there are no data points beyond the upper and lower whiskers in both figures, indicating the absence of outliers in the datasets. Consequently, the data satisfies the fourth assumption necessary for employing the independent samples t-test, which the researcher has utilized for conducting comparisons between the control and experimental group.

- **Homogeneity of Variance.** To assess the homogeneity of variance among the samples or groups, the researcher conducted Levene's test using IBM SPSS Statistics version 26. This test examined whether there was a significant difference in variance

between the segments of control and experimental groups. The results are outlined below.

Table 4.10

Levene's Test for Checking Homogeneity of Variance – Understanding Level – Below Average Students – Posttest

F	df1	df2	Sig.
0.239	1	32	0.63

Table 4.11

Levene's Test for Checking Homogeneity of Variance – Understanding Level – Average and Above Average Students – Posttest

F	df1	df2	Sig.
0.905	1	24	0.35

The significant values in the above provided tables are 0.63 and 0.35, exceeding the p-value of 0.05, suggesting that the variability between the two groups is not significantly different. In other words, there is no significant variance difference between the groups. Consequently, the dataset fulfills the fifth assumption required for conducting an independent samples t-test. Based on these findings, the researcher employed an independent samples t-test for the current study.

4.2.1.2 Independent Samples t-test of Results based on Understating Level. To evaluate student's learning at understanding level of revised Bloom's taxonomy, the researcher conducted a comparison between the two groups after teaching control

group using active learning methodology but without the use of ChatGPT and the experimental group using active learning methodology integrating the use of ChatGPT. The researcher analyzed the scores of the post-test of both the groups using independent samples t-test via IBM SPSS Statistics version 26. The ensuing results are detailed below.

Table 4.12

Independent Samples t-test Results of Students Learning at Understanding Level – Below Average – Posttest

Variable	**N**	**Mean**	**df**	**t-value**	**P**
Control group	17	24.29	32	-5.09	0.001
Experimental group	17	29.88			

Table 4.13

Independent Samples t-test Results of Students Learning at Understanding Level – Average and Above Average – Posttest

Variable	**N**	**Mean**	**df**	**t-value**	**P**
Control group	13	33.46	24	-4.52	0.001
Experimental group	13	37.92			

In the tables provided above, a distinct contrast is evident in the post-test mean scores between the control and experimental groups. The students who performed below average in the pretest and those who performed average and above average in the control group exhibited a mean score of M=24.29 and 33.46 respectively, whereas in the experimental group, the students who performed below average in the pretest

and those who performed average and above average in the control group showed a higher mean score of M=29.88 and 37.92 respectively. Furthermore, with a p-value of .001 or $p < 0.05$, we reject the null hypothesis $H_0$1b(ii) which states that there is statistically no significant difference in students' learning in post-test at Understanding Level of Revised Bloom's taxonomy of control group and experimental group.

4.2.2 Objective 1b(iii) – Applying Level

To assess the test results of students effectively and to avoid biasness, rubrics that were specifically designed for this purpose were used (annex-J). The researcher planned to employ an independent samples t-test for comparing the mean scores of the test for applying level of revised Bloom's taxonomy of the control group and the experimental group following a six-week intervention. The researcher tested the assumptions necessary for conducting the independent samples t-test There were five assumptions for the independent-sample t-test. The process and outcomes of assumption testing are described below.

Assumptions for Conducting Independent Samples t-test

• **Continuity of Dependent Variable** In this study, the dependent variable was students' learning, quantified by their raw scores on tests. As these scores represent a continuous variable, the data satisfies the initial requirement for conducting an independent samples t-test.

• **Independence of Observations** The control and experimental groups in this study were treated as distinct entities since participants in one group were not affiliated with the other. Furthermore, although students worked collaboratively in groups, each

student's observations were taken independently, meeting the requirement of the second assumption for running an independent samples t-test.

• **Approximate Normal Distribution of the Dependent Variable** To evaluate the normality of the data, the researcher performed a Shapiro-Wilk test using IBM SPSS Statistics version 26 on the datasets independently for both the control and experimental groups to ensure that there is no statistically significant deviation from normality within the research dataset of each group. Further details on conducting this test are presented in the tables below.

Table 4.14

Shapiro-Wilk Test for Checking Normality of Data of Control Group & Experimental Group – Applying Level

	Shapiro-Wilk		
	Statistic	df	Sig.
ControlGroup – Applying Level	0.89	30	0.006
ExperimentalGroup – Applying Level	0.8	30	0.001

The significance values, or p-values, observed in the tables above, which are less than or equal to 0.05, suggest that the datasets do not adhere to a normal distribution.

Since the assumption of normal distribution of data could not be proved, the statistical analysis t-test for this dataset was replaced by Mann-Whitney U test as it does not assume normality and is suitable for comparing two independent groups.

Given the potential influence of outliers on non-parametric tests such as the Mann-Whitney U test, prior to conducting the Mann-Whitney U test, a visual

inspection of box plots was conducted to detect outliers that could potentially influence the analysis. However, upon examination, no outliers were identified in either dataset. Further interpretation of the results is provided below.

Figure 4.9

Outliers in Data of Control Group – Applying Level

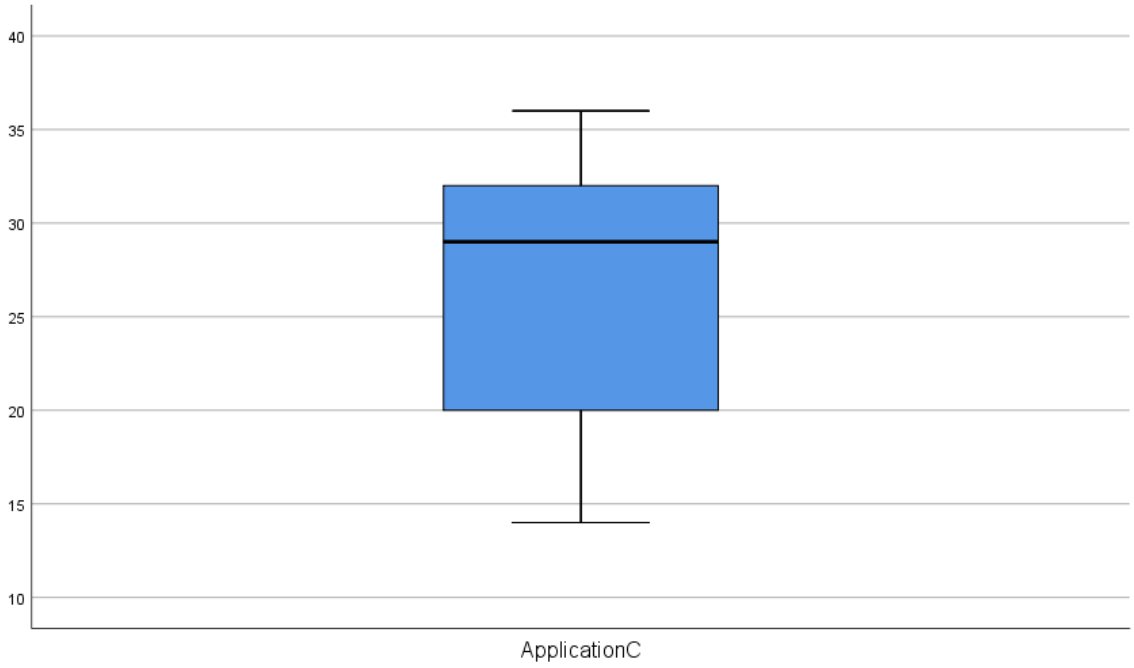
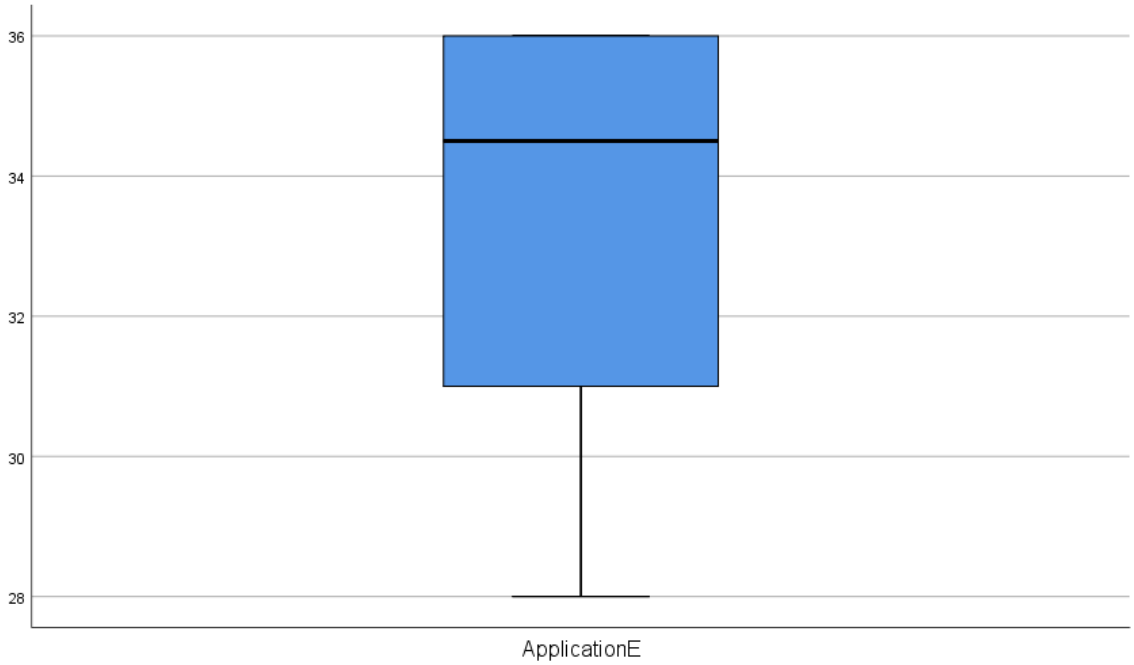


Figure 4.10

Outliers in Data of Experimental Group - Applying Level



The figures above illustrate that the values in the datasets range from 14 to 36 and from 28 to 36 in control group and experimental group respectively. Furthermore, there are no data points beyond the upper and lower whiskers in both figures, indicating the absence of outliers in the datasets.

- **Homogeneity of Variance.** As it was important to check the assumption of homogeneity of variance before conducting Mann-Whitney U test, to assess the homogeneity of variance among the samples or groups, the researcher conducted Levene's test using IBM SPSS Statistics version 26. This test examined whether there was a significant difference in variance between the control and experimental groups. The null hypothesis for this test was: H_0: There is no statistically significant difference in variance between the two groups. The results are outlined below.

Table 4.15

Levene's Test for Checking Homogeneity of Variance - Applying Level

F	df1	df2	Sig.
21.25	1	58	.001

The significant value in the provided table is 0.001, which is less than the p-value of 0.05, suggesting that the variability between the two groups is significantly different. Therefore, the null hypothesis, which posits no significant variance difference between the groups, is rejected. Consequently, the dataset does not fulfill the assumptions of normality of data and homogeneity of variance, t-test could not be conducted. Based on these findings, the researcher employed a non-parametric test, i.e., Mann-Whitney U test.

4.2.2.1 Mann-Whitney U Test of Results based on Applying Level. To evaluate student's learning, the researcher conducted a comparison between two groups after teaching control group using active learning methodology but without the use of ChatGPT and the experimental group using active learning methodology integrating the use of ChatGPT. The researcher analyzed the post-test scores of applying level of both the groups using Mann-Whitney U test via IBM SPSS Statistics version 26 as the assumptions for independent t-test could not be met for the dataset. The ensuing results of the test are detailed below.

Table 4.16

Mann-Whitney U test Results of Students Learning at Applying Level

Variable	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z statistic	P
Control group	30	28.6	622.00	157.00	-4.38	.001
Experimental group	30	33.43	1208.00			

In the table provided, a distinct contrast is evident in the post-test mean ranks and their sum between the control and experimental groups. The control group exhibited a mean rank of 28.6 and sum of ranks was equal to 622, whereas the experimental group showed a higher mean rank and sums of ranks of 33.43 and 1208 respectively. Furthermore, the U value of 157, Z statistic of -4.381, and a p-value of .001 (below the significance level of 0.05) suggests strong evidence against the null hypothesis indicating a statistically significant difference between the groups. Hence, we reject the null hypothesis $H_0$1b(iii) which states that there is statistically no significant difference in students' learning in post-test at Applying Level of Revised Bloom's taxonomy of control group and experimental group.

PART TWO: QUALITATIVE DATA ANALYSIS

4.3 Content Analysis – ChatGPT Accounts Conversation History

To answer the overarching research question, and to provide a deeper understanding of data presented in the above sections, and to provide additional insights, content analysis was carried out of the conversation history made by the students in the provided ChatGPT accounts during the time of their study. A total of 30 students which were part of the experimental group formed a total of 10 groups with each group comprising of 3 students randomly selected. The students were then

provided ChatGPT accounts that they used during their time of study in an active learning environment which included both theory and lab work as per the course requirements of HEC. The active learning process was divided into four key stages of trigger, activity, discussion, and summary, with additional lab activities to enforce learning of concepts and practice for code. Each students' group had access to use ChatGPT in every stage of the learning process. The teaching learning phase ensured students learn about the basic concepts of programming using C++ as base programing language. The topics that were covered during the time of this study included but were not limited to variables, primitive data types, operators, input/output statements, conditional structures, iterative structures, and modular programming using functions. The activities of lab work were primarily divided into three types: developing programs based on given problem statements, analysis of code, and writing comments in code, which included finding and correcting errors in a given code snippet, and running a code to find its output.

The process of qualitative analysis involved generating open codes from the conversation history of the participants, doing axial coding, and generating major themes. After thorough analysis, the interaction of students with ChatGPT was divided into following categories and sub-categories as illustrated in the table below.

Table 4.17

Content Analysis of ChatGPT Conversation History

Categories	Sub-categories
Conceptual Understanding	Asking questions about a concept
	Seeking clarification related to a concept
	Confirming understanding related to a concept
	Asking for examples to illustrate a concept
Coding	Generating code to perform some task
	Getting help in identifying and correcting errors in code
	Seeking explanation of a certain code
	Asking for syntax of a programming construct
	Asking for output of code
	Generating equivalent code
Exploration	Asking in-depth query about a concept
	Asking about advanced concepts and coding questions
	Asking why-questions

Table 4.17 presents the major categories and their sub-categories that were identified in the conversations of the participants' ChatGPT accounts during the time to their learning. The analysis is made of the conversations initiated by the participants along with additional probes that they made in those conversations. Major themes that were identified in the content analysis fall within three categories which the researcher has named as Conceptual Understanding, Coding, and Exploration. The interaction of students that fall under the category of conceptual understanding helped students in their learning at understanding level of revised Bloom's taxonomy, hence the name.

In the second category, the interaction of students with ChatGPT helped them in learning code. In other words, it improved learning of students under the domain applying level of revised Bloom's taxonomy.

The third category that was identified included advanced queries of students that were related to asking about topics that were above the basic level that was the target of this course. In this category, students' queries also included questions that seems to have emerged after brainstorming, and critical thinking about the topics they were learning. For example, they asked why a certain code worked in a certain manner, or why the different data types consume different sizes in memory.

The results of the analysis indicated satisfactory responses to students queries with exception of very few inaccurate responses that were provided by ChatGPT in which program codes were generated. Additionally, it was observed that on further clarification of the participant's initial question or statement during the subsequent conversation, the correct codes were generated afterwards.

In addition to the above-mentioned details, it was observed that:

- Code in various programming languages was generated occasionally due to user preferences not being set to generate C++ code, or the user did not ask to generate code by explicitly mentioning C++ in his query.
- ChatGPT could effectively comprehend messages from users with spelling and grammatical errors.
- It successfully interpreted prompts and generated correct responses for those prompts that were typed in Urdu using an English keyboard.

It is evident from the content analysis that the participants used ChatGPT both for learning in theory and lab hours which is clear from their conversation history

which is related to both understanding of concepts and learning about code; the same was indicated in the table 4.2 in which the responses of students are summarized about their usage of ChatGPT at both understanding level and applying level of revised Bloom's taxonomy. Though each group of students participated in learning the same topics, their usage of ChatGPT provided them with a personalized learning experience as the way queries were made by each group differed from other groups. The results from quantitative analysis which showed significant difference in students' learning and their positive reaction related to the use of ChatGPT aligns with the results of the qualitative analysis, which demonstrates the effective use of ChatGPT by students in their learning.

From the analysis of conversations initiated in ChatGPT by the participants it was evident that students used ChatGPT as a supplementary aid to their learning which provided them with a personalized learning experience and immediate feedback where required. It could be concluded that combined with the active learning methodology of collaborative learning in groups and discovery-based learning methods which were used to design an active learning environment for the purpose of this study, ChatGPT is an effective learning aid which could not only positively influence affective reaction of students but also significantly improve learning of students.

To answer the overarching question of this study on how ChatGPT can be used for enhancing active learning at undergraduate level, the researcher recommends the method he used in his experimental study: the students need to be divided into groups and active learning lessons need to be planned based on four key stages of trigger, activity, discussion, and summary, with additional lab activities planned beforehand. After that exploratory and collaborative learning strategy should be used

for the implementation of those lesson plans and ChatGPT may be used as a learning aid for personalized support. With the use of ChatGPT in their learning, the students can learn about concepts much like a human would explain it to them by making queries in the form of a conversation. They can get immediate help where required in the application of learned concepts, and problem-solving. They could use ChatGPT to reinforce learned concepts by getting clarification about it or asking for relevant examples.

Chapter 5

SUMMARY, FINDINGS, DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

"I never teach my pupils; I only attempt to provide the conditions in which they can learn."

-Albert Einstein-

This chapter begins with a summary of the research work, providing a brief overview of the problem under investigation and the details of research methodology. Following the summary, the findings of the study are presented, highlighting significant outcomes observed through the analysis. Next in this chapter is the discussion section which compares the results of this study based on objectives of this study, and the overarching question, with other studies in the field of AI and education. Further ahead in this chapter, the conclusions drawn from the research findings are presented, offering insights from the study. The later sections in this chapter offer recommendations based on the findings of this study to different stakeholders, suggestions for future researchers for further research in this area, and the limitations that the researcher had during this research work.

5.1 SUMMARY

With the acceptance and implementation of active learning being an effective method of teaching than traditional methods, and with the advancement of technology, the researchers have been focused on innovative methods of using technology and active learning to better achieve learning outcomes. Though in Pakistan at higher education level, the practice of treating theory and lab in a course

as separate modules continues, the researcher has tried to reduce the gap between them and has offered an idea of merging them together in an active learning environment aided with the technology of artificial intelligence. For this purpose, the researcher designed an active learning environment based on Fink (2003) and Felder & Brent (2009). The lesson plans were designed following the active learning-based teaching model specific to computer science education, delineated into four key stages: trigger, activity, discussion, and summary (Hazan et al., 2011); and the framework guiding the construction of these plans was the Backward Design Template (Bowen, 2017). The researcher conducted an experimental study to evaluate the effect of using ChatGPT on learning of students. Furthermore, the researcher also assessed their reaction for using ChatGPT in their learning. Lastly the researcher analyzed the conversations that occurred between the participants and ChatGPT to answer the research question on how ChatGPT can be used effectively to improve learning in an active learning environment. The research approach for this study was mixed methods. The quantitative part included a quasi-experimental design with non-equivalent comparison groups, which included a pretest and a post-tests to assess one variable under investigation: learning, and a survey method to assess another variable: reaction. For the qualitative part, content analysis was carried out of the conversations with ChatGPT. Tha validity of the instruments that were designed was ensured through experts. The researcher tested the assumptions for running the statistical tests before applying them to the actual data set. The results of assumptions testing indicated that independent samples t-test, and Mann-Whitney U test are the most appropriate statistical tests for the data set for the experimental part of this study. Furthermore, the details of the findings extracted from both quantitative and qualitative means are discussed as under.

5.2 FINDINGS

1. The participants were divided into two matching groups based on their scores in pre-test and their previous experience of studying computer science at HSSC level. According to the results of pretest, there were 17 below average, 01 average student and 12 above average-performing students in control group as well as experimental group; half of them in each category were those who had previous experience of studying computer science and the remaining had not studied computer science at HSSC level. (See Table 3.1)

2. The results of the quantitative analysis of data related to the reaction level of Kirkpatrick model indicated that the students were positively affected by the use of ChatGPT during their active learning. (See Table 4.3)

3. The mean scores of the results of the questionnaire related to the affective reaction indicated that there is statistically significant effect of using ChatGPT on students' affective reaction at undergraduate level. (See Table 4.1)

4. The mean scores of the results of the questionnaire related to the utility judgment indicated that there is statistically significant effect of using ChatGPT on students' utility judgment in understanding level of revised Bloom's taxonomy at undergraduate level. (See Table 4.2)

5. The mean scores of the results of the questionnaire related to the utility judgment indicated that there is statistically significant effect of using ChatGPT on students' utility judgment in applying level of revised Bloom's taxonomy at undergraduate level. (See Table 4.2)

6. For quantitative analysis of the data from the results of pretest related to understanding level of revised Bloom's taxonomy, the normality of the dependent variable was checked for running an independent sample t-test using the Shapiro-Wilk test. The results showed that the data set of this study was normally distributed. (See Table 4.4)

7. For quantitative analysis of the data from the results of pretest related to understanding level of revised Bloom's taxonomy, the homogeneity of variance among groups was checked using Levene's test. The results indicated that there is no difference in the variance of one group to the other group. (See Table 4.5 and Table 4.6)

8. The results of the t-test analysis indicated that there is statistically no significant difference in students' learning in pre-test at Understanding Level of Revised Bloom's taxonomy of control group and experimental group because the p value was greater than 0.05 and the mean scores of the control group and the experimental group in pre-test were almost equal. (See Table 4.7 and Table 4.8)

9. For quantitative analysis of the data from the results of post-test related to understanding level of revised Bloom's taxonomy, the normality of the dependent variable was checked for running an independent sample t-test using the Shapiro-Wilk test. The results showed that the data set of this study was normally distributed. (See Table 4.9)

10. For quantitative analysis of the data from the results of post-test related to understanding level of revised Bloom's taxonomy, the homogeneity of variance among groups was checked using Levene's test. The results indicated that there is no

difference in the variance of one group to the other group. (See Table 4.10 and Table 4.11)

11. The results of the t-test analysis indicated that there is statistically significant difference in students' learning in post-test at Understanding Level of Revised Bloom's taxonomy of control group and experimental group because the p value was less than 0.05 and the mean scores of the experimental group in post-test were greater than the mean scores of the control group. (See Table 4.12 and Table 4.13)

12. For quantitative analysis of the data related to applying level of revised Bloom's taxonomy, the normality of the dependent variable was checked for running an independent samples t-test using the Shapiro-Wilk test. The results showed that the data set of this study was not normally distributed. (See Table 4.14)

13. For quantitative analysis of the data related to applying level of revised Bloom's taxonomy, the homogeneity of variance among groups was checked using Levene's test. The results indicated that there is difference in the variance of one group to the other group. (See Table 4.15)

14. Based on the above two findings, non-parametric test, i.e., Mann-Whitney U test was applied; the results of which indicated that there is significant difference in students' learning in post-test at Applying Level of Revised Bloom's taxonomy of control group and experimental group because $p<0.05$ and the value of Z statistic suggests that the control group has a lower rank sum mean score than the experimental group in post-test. (See Table 4.16)

15. The results of the content analysis indicated that the conversations of students with ChatGPT fall under three categories; two of which were related to their learning

at understanding level, and applying level of revised Bloom's taxonomy, and the third category was related higher-order thinking skills. (See Table 4.17)

15. Interpreting the results of the content analysis revealed that the students used ChatGPT as a supplementary aid to their learning which provided them with a personalized experience of learning.

16. Comparing the results of the qualitative analysis with the results of the quantitative analysis it was revealed that ChatGPT is effective as a learning aid which could positively influence students' learning at understanding level and applying level of revised Bloom's Taxonomy.

Based on the above findings, it was evident that the use of ChatGPT has a positive effect on students' active learning at undergraduate level.

5.3 DISCUSSION

5.3.1 Reaction

This main objective of this study was to assess the effect of using ChatGPT on active learning of students. The first objective based on this main objective was about understanding the reaction of students who use ChatGPT in their learning. The results of the study revealed that the reaction of students who used ChatGPT in their learning was positive in terms of both affective reaction and utility judgment. The affective reaction was assessed on responses of students on questions that inquired their choice of using ChatGPT to learn more in future, their opinion on using ChatGPT in classroom, their enthusiasm in using ChatGPT in classroom, and their experience about it. As the research was focused on the understanding and applying level of revised Bloom's taxonomy, their utility judgment was divided into two categories, i.e., utility judgment at understanding level and utility judgment at applying level. The

utility judgment assessed the reaction of students at understanding level which mainly focused on the theoretical part of the course and at applying level which targeted on the lab work. The results related to affective reaction of this study are in line with the studies of Bitzenbauer (2023), Chan and Hu (2023), and Lozano and Blanco Fontao (2023) that revealed that students have a positive opinion about the integration ChatGPT into the classroom. Furthermore, the results of this study related to the utility judgment regarding ChatGPT are in line with the study of Singh, Tayarani-Najaran, and Muhammad Yaqoob (2023), the results of which revealed that students believe that ChatGPT can be used to provide explanation to students for things that they could not understand well during class, and to assist students in coding by generating code. In the same vein, the results are consistent with the findings of the study of Shoufan (2023) who targeted on students in a computer engineering program and observed that students considered ChatGPT as an effective and valuable tool for learning that provided well-structured responses and satisfactory explanation of their queries.

5.3.2 Learning

Another objective of this study was to assess the learning of students who use ChatGPT in an active learning environment. The results revealed that ChatGPT had positive effect on learning of students in terms of understanding level and applying level of revised Bloom's taxonomy. The results are in line with many of the previous studies presented in the comprehensive review of Bahroun, Anane, and Zacca (2023) in terms of the use of AI like ChatGPT in improved learning outcomes. Additionally, the results of this study are in line with the studies presented in the review related to the use of generative AI like ChatGPT in transforming creative programming education, and in providing explanations for programming concepts, suggesting that

AI can enhance the understanding of complex programming principles. Furthermore, the review also revealed that through integration of advanced chatbots and text generation models, active learning and problem-solving skills can be enhanced which is in line with the results of this study.

5.3.3 Overarching Question

The qualitative analysis of this study revealed that students used ChatGPT as a supplement in an active learning environment. This finding resonates with the research by Mohamed (2023), which similarly advocated for considering ChatGPT as a valuable adjunct to traditional teaching methods, supporting and enriching the learning process. The analysis also indicated that the students used ChatGPT because it provided them with personalized learning experience which helped them in improving their learning at both understanding and applying level of revised Bloom's taxonomy. The above findings of this study aligns with the perspectives presented by Kooli in his study (2023), which emphasized the importance of adapting to the AI-driven environment by integrating AI-technologies like ChatGPT into educational contexts. Aligning with Kooli's perspective, this study highlights the value of ChatGPT as a tool to enhance learning experiences as it offers students access to vast amount of knowledge and personalized learning opportunities. Moreover, the results of this study reinforces the notion in Kooli's study that while ChatGPT serves as a valuable supplement in education, it should not replace the essential role of human expertise, judgment, and creativity.

Building on the conclusions drawn from both quantitative and qualitative analyses in the preceding chapter, it is evident that ChatGPT facilitates a personalized learning journey through conversation for students within a discovery-based active learning framework. This finding aligns with the study of Zhu, Sun, Luo, Li, and

Wang (2023) which highlighted ChatGPT's potential as an invaluable tool for students, particularly in the increasing need for personalized learning support, and Jeon and Lee (2023), who emphasized the role of ChatGPT as an interactive interlocutor by providing meaningful dialogue and as an evaluator by providing real-time feedback and assessment, motivating students to delve deeper into subjects of their interests and develop curiosity and self-learning ability.

It was also evident from the results of qualitative analysis that the responses from ChatGPT were accurate in terms of providing satisfactory answers to the students which helped them in their learning at both understanding level and applying level of revised Bloom's taxonomy. This finding is in line with the study of of Jeon and Lee (2023) which states that ChatGPT as content provider can be used to collect a large amount of information. In the context of programming, the findings of this study are consistent with the study of Ouh, Gan, Jin Shim, and Wlodkowski (2023) which highlights ChatGPT's significance as a vital support tool for students grappling with programming challenges. It emphasizes ChatGPT's role in facilitating exploration of alternative methods to address code-related issues within programming courses.

5.4 CONCLUSION

There has been a growing trend of traditional teaching methods in which students are passive learners being replaced with strategies that actively engage students like active learning. In Pakistan, though courses at higher education level that include credit hours for both theory and lab are treated as two separate modules, the researcher proposes a strategy of combining both and creating an active learning environment where students can actively engage in groups with the technology at front and discover learning. The researcher conducted a study to utilize ChatGPT as

technology aid in an active learning classroom at higher education level in a federal government college to evaluate its effects on active learning of students. By designing an active learning classroom specific to computer science education and developing lesson plans using Backward Design Approach, the effect of ChatGPT on active learning of students was measured in terms of learning of students at understanding and applying level of revised Bloom's taxonomy and students' affective reaction and utility judgment after the use of ChatGPT. The results revealed that ChatGPT had positive effect on students' learning and their reaction. Moreover, the students who learned using ChatGPT performed better in tests at both understanding level and applying level of revised Bloom's taxonomy.

5.5 RECOMMENDATIONS

The current study yielded the following recommendations based on its findings:

1. The use of ChatGPT in an active learning classroom has a significant effect on students' learning thus, teachers may provide opportunities for students to use ChatGPT in their active learning classroom environments for improving learning of students at higher education level.
2. Teachers may provide opportunities for students to use ChatGPT as a learning aid in an active learning classroom to help them in learning of new concepts, building on already existing ones, and application of those concepts.
3. Teachers may provide opportunities for students to use ChatGPT as a learning aid in an active learning classroom to help them in learning programming constructs, understanding code, debugging code, and generating code for solution of problems.

4. Teachers may plan lessons for discovery-based collaborative active learning approach using ChatGPT as a learning aid for personalized support of students in their everyday practice.
5. Teachers may utilize ChatGPT in programming courses as students have positive affective reaction and utility judgment regarding its use during their learning at classroom.
6. Administrators of educational institutions may encourage the use of smart gadgets in classroom by students to provide access to AI tools like ChatGPT during their learning for a personalized and supportive learning experience.
7. The Higher Education should consider integrating the theory and lab courses instead of treating them as separate modules and utilize AI tools like ChatGPT for their integration and effective implementation of active learning.

5.6 SUGGESTIONS (FUTURE WORK)

As research in the field of AI in education continues to evolve, there remain avenues for future investigation and development. The following suggestions offer guidance for researchers seeking to contribute to the advancement of knowledge in this area.

1. Since the current study was based on evaluating only the first two levels of Kirkpatrick's model, future researchers can conduct a similar study to evaluate all four levels of Kirkpatrick's model.
2. Since this study was based on evaluating the Understanding and Applying level of revised Bloom's taxonomy, because of the type of course that was selected for the purpose of this study, future researchers can conduct a study to evaluate these levels along with other levels of revised Bloom's taxonomy.

3. Since this study was targeted on evaluating active learning by targeting a course at higher education level, future researchers can conduct an experimental study to evaluate a single learning activity instead of targeting on a whole course or part of that course.
4. Since this study was focused on evaluating learning of students based on achievement of learning objectives only, future researchers can conduct a study to evaluate long-term effects on problem-solving skills and holistic learning.
5. Since this study made a comparison of two groups: one that used ChatGPT and the other that did not use ChatGPT during their learning, another line of research for future work is to compare the performance of students based on the level at which they are using ChatGPT. For example, to compare the final marks of the students who are more familiar with the tool and use it more frequently to those who do not.
6. Since this study was focused on evaluating the effects of ChatGPT (version 3.5) which was freely available for public use, future researchers can target on other chatbots that have recently been released for public access.
7. Since this study used the free version of ChatGPT (version 3.5) that was available at the time of conducting this study in a programming course, future researchers can use Codex and other AI tools in classroom, which have developed by the same company i.e., OpenAI, and are specifically designed to assist in programming, and can see its effects in classroom.
8. Since this study was conducted in a technology-enabled classroom where students interacted with ChatGPT during their learning, a similar study can be conducted by future researchers but in a flipped classroom and the effects can

be measured on the use of ChatGPT or any other chatbots both at home and in the classroom setting.

5.7 LIMITATIONS

Since public-sector colleges in Pakistan are not mixed-gender, the researcher could only choose one gender to target on and hence he chose boys college for the purpose of this study. In addition to that, every student could not be provided an individual ChatGPT account for the sake of easier data collection and analysis rather each group of three students was provided one ChatGPT account to work collaboratively on it. Apart from that, as conducting a pre-test at applying level of revised Bloom's taxonomy was a time-consuming task, considering the busy class-schedule of students at college, to avoid loss of their class timings for the courses that were part of this study, and as more than half of the students already had no experience of studying computer science at HSSC level, conducting pre-test to assess applying level of revised Bloom's taxonomy was avoided altogether.

Furthermore, despite balancing the control group and experimental group based on the students' previous experience of studying the subject of computer science at HSSC level and their existing knowledge assessed through pretest, there could be other factors at play that could have affected their engagement in the learning process and influenced the results of this study. One other limitation of this research could be related to the measurement of learning outcomes. Since evaluation of learning was solely done by conducting pre-tests and post-tests, this might not have captured all aspects of students' learning outcomes.

Lastly, the attendance of students could not be controlled by the researcher, and neither its variability was considered in data analysis. The inconsistency in attendance could have influenced the results of this study.

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APPENDIX A

Topic Approval Letter

NATIONAL UNIVERSITY OF MODERN LANGUAGES
FACULTY OF SOCIAL SCIENCES
DEPARTMENT OF EDUCATIONAL SCIENCES

M.L.1-3/ES/2023/430 Dated: 26-06-2023

Name: **Shamsuddin Qureshi** **Reg No. 40-M.Phil/Edu/S22**

Subject: **APPROVAL OF M.Phil THESIS TOPIC AND SUPERVISOR**

1. Reference to Letter No, M.L.1-4/Edu/2021/430, dated 26-06-2021, the Competent Authority has approved the title/theme/Practical/Theoretical Implication and Supervisor in 16th BASR Meeting dated 21st June 2023 and the recommendations of Faculty Board of Studies vide its meeting held on 27th April 2023.

a. **Supervisor's Name & Designation**
Dr. Aisha Bibi,
Assistant Professor,
Department of Educational Sciences NUML, Islamabad.

b. **Co-Supervisor's Name and Designation**
Dr Wajeeha Shahid,
Associate Professor,
Department of Educational Sciences

c. **Topic of Thesis**

Enhancing Active Learning through Chatbots: A *Quasi-Experimental* Study using ChatGPT at Undergraduate Level.

d Theme: ICT in Education

e. Practical Application: Technology

2. You may carry out research on the given topic under the guidance of your Supervisor and submit the thesis for further evaluation within the stipulated time by **30th June 2024** for further processing as per NUML MPhil Timeline. **(Timeline Attached)**.

3. As per policy of NUML, all MPhil/PhD thesis are to be run on turnitin by QEC of NUML before being sent for evaluation. The university shall not take any responsibility for high similarity resulting due to thesis run from own sources.

4. Thesis is to be prepared strictly on NUML's format which can be taken from MPhil/PhD Coordinator.

Dr. Wajeeha Shahid
Head
Department of Educational Sciences

Distribution:

Mr. Shamsuddin Qureshi (M.Phil Scholar)

Dr. Aisha Bibi (Thesis Supervisor)

Dr Wajeeha Shahid (Thesis Co-Supervisor)

APPENDIX B

Permission Letter

The Honorable Principal
Islamabad Model College for Boys, H-9,
Islamabad

SUBJECT: **PERMISSION TO CONDUCT EXPERIMENTAL STUDY FOR MY M.PHIL. RESEARCH.**

Respected sir,

I am writing to request permission to conduct an experimental study at Islamabad Model College for Boys H-9, Islamabad as part of my M.Phil. research being carried out at the Department of Educational Sciences, National University of Modern Languages, Islamabad under the supervision of Dr. Aisha Bibi, Assistant Professor, and co-supervision of Dr. Wajeeha Shahid, Associate Professor. My research study, titled "Enhancing Active Learning through Chatbots: A Quasi-Experimental Study using ChatGPT at Undergraduate Level" aims to investigate the effect of using ChatGPT on active learning of students at undergraduate level.

The study will involve students of a single class participating in an experimental study which will involve active learning environment in a technology-enabled classroom with provision of computer systems and internet access to students for one of their courses. The anticipated duration of the study is 06 weeks.

I assure you that every effort will be made to ensure that this research is conducted with the utmost respect for the college's policies and procedures. The study will adhere to all ethical guidelines, and any data collected will be kept confidential and used solely for research purposes. I am committed to ensuring that this research has no adverse impact on the daily operations of the college.

I kindly request your permission to get access to the computer laboratory of the college during the period of my classes for the purpose of this research.

I also request permission to approach and involve the undergraduate students of BSCS enrolled in first semester for their courses of Problem Solving and Programming (Theory and Lab) in the study.

I am aware of and will comply with any requirements or restrictions imposed by the college during the course of my research.

Furthermore, I am open to discussing any concerns or suggestions you may have regarding the research study. Your input and guidance would be greatly appreciated.

Thank you for considering my request. I am excited about the potential contributions that this research could make to both academia and the college community. I look forward to your positive response.

Yours Sincerely,

Shamsuddin Qureshi

Research Scholar @ National University of Modern Languages, Islamabad

APPENDIX C

Request for Validity Certificate

Subject: Request for Validation of Test Instruments for Academic Research

Dear sir/madam,

I hope this letter finds you well. My name is Shamsuddin Qureshi, and I am currently pursuing the degree of M.Phil. from the department of Educational Sciences at the National University of Modern Languages, Islamabad, under the supervision of Dr. Aisha Bibi, Assistant Professor, and co-supervision of Dr. Wajeeha Shahid, Associate Professor. I am reaching out to you because of your esteemed expertise in the field of Computer Science, and I am in need of your valuable insights and guidance.

I am in the process of conducting an experimental study as part of my M.Phil. research, titled "Enhancing Active Learning through Chatbots: A Quasi-Experimental Study using ChatGPT at Undergraduate Level." The primary aim of my research is to investigate the effect of using ChatGPT on active learning among undergraduate students.

To achieve this goal, I have designed test instruments that will be used as pre-test and post-tests to evaluate the learning of students participating in the study. Furthermore, I have also designed a questionnaire to measure students' reaction that use ChatGPT during this experiment. These instruments are a crucial component of my research, and I believe that your expertise could greatly enhance their credibility.

I would be honored if you could spare some time to review and validate the test instruments I have developed. Your expert opinion and feedback would not only strengthen the credibility of my research but also contribute significantly to its overall quality.

I have attached the test instruments along with the list of learning objectives that I want to achieve with this letter for your convenience. If you are willing to assist me in this endeavor, please let me know your availability for a discussion or review. I am open to any suggestions or modifications you may recommend to improve the instrument.

I understand that your time is valuable, and I genuinely appreciate your consideration of my request. Your support would be immensely valuable to the success of my research project.

Thank you for your attention, and I look forward to your positive response. Please feel free to reach out to me if you require any further information or if you have any questions.

Once again, I am truly grateful for your willingness to help, and I am excited about the potential impact that this research could have on the field of ICT in education.

Yours sincerely,

Shamsuddin Qureshi

Research Scholar

National University of Modern Languages, Islamabad

APPENDIX D

Test to Assess Student's Learning at Understanding Level

Name: _____ Duration: 60 minutes

Roll No: _____

Encircle the correct answer from the given options (a, b, c, d) for each question.

1. **What is the primary purpose of variables in a programming language?**
   - **a.** To implement loops
   - **b.** To store and manipulate data
   - **c.** To control program flow
   - **d.** To execute mathematical operations
2. **When differentiating between data types of variables, which characteristic is NOT typically considered?**
   - **a.** Data storage size
   - **b.** Data type compatibility
   - **c.** Data variable name
   - **d.** Data value range
3. **What is the primary purpose of using comments in a programming language?**
   - **a.** To execute code effectively
   - **b.** To enhance code readability and provide explanation
   - **c.** To give directions to the compiler
   - **d.** To deal with errors
4. **Which of the following variable names is NOT considered meaningful?**
   - **a.** studentName
   - **b.** variable1
   - **c.** temperatureInCelsius
   - **d.** total_sales_revenue
5. **In C++, what is the significance of ensuring compatibility when assigning values to variables?**
   - **a.** It determines the variable's data type
   - **b.** It avoids memory leaks
   - **c.** It prevents syntax errors
   - **d.** It ensures the variable's scope
6. **What does the scope of a variable refer to?**
   - **a.** The range of values it can hold
   - **b.** Where it is declared and can be accessed
   - **c.** The data type of the variable
   - **d.** The number of values it can store

7. **Which of the following is NOT a valid way to enhance code readability?**

   a. Adding single-line comments

   b. Using meaningful variable names

   c. Writing lengthy and detailed comments for every line of code

   d. Adding multi-line comments

8. **Which arithmetic operation can be used to calculate the average of two numbers stored in variables A and B?**

   a. (A + B) \ 2

   b. A + B \ 2

   c. A + B / 2

   d. (A + B) / 2

9. **What is the key difference between implicit and explicit type casting?**

   a. Implicit casting requires the use of a keyword

   b. Explicit casting is done automatically by the compiler

   c. Implicit casting is done automatically by the compiler

   d. Explicit casting is used only for arithmetic operations

10. **In C++, what can type casting help achieve in mathematical expressions?**

    a. It can change the variable's scope

    b. It can change the variable's data type

    c. It can prevent overflow and underflow

    d. It can increase precision

11. **Overflow and underflow in numerical calculations can lead to:**

    a. Runtime error

    b. Compilation errors

    c. Loss of precision or unexpected results

    d. Destruction of variable

12. **Which of the following control structures is responsible for decision-making in programming?**

    a. Sequence

    b. Selection

    c. Iteration

    d. Loops

13. **What is the primary purpose of control structures in programming logic?**

    a. Performing logic operations

    b. Controlling program execution flow

    c. Controlling user choices

    d. Managing input and output operations

14. Which conditional statement is used to make multiple decisions in a program in a structured way?

a. if
b. if-else
c. switch
d. while

15. What is the primary purpose of the 'if' statement in programming?

a. To run a block of code
b. To compare values
c. To make decisions
d. To perform logic operations

16. Which conditional statement is used to handle multiple cases based on the value of an expression?

a. if
b. if-else
c. switch
d. for

17. What is the purpose of the unary operators in programming?

a. They perform arithmetic operations
b. They change the value or state of variables
c. They are used to create complex conditions
d. They iterate through loops

18. Which operators are used for arithmetic, relational, and logical operations in programming?

a. Unary operators
b. Ternary operators
c. Binary operators
d. Conditional operators

19. What is the primary role of the ternary operator in programming?

a. Performing arithmetic calculations
b. Simplifying decision-making
c. Implementing loops
d. Handling exceptions

20. Which type of operators are used for comparing values in programming?

a. Arithmetic operators
b. Relational operators
c. Logical operators
d. Conditional operators

21. What do logical operators (AND, OR, NOT) primarily do in programming?

a. Perform arithmetic calculations
b. Combine conditions
c. Make decisions
d. Perform relational operations

22. What does operator precedence determine in programming?

a. The order of execution of statements

b. The order of operations in expressions

c. The values that can be placed after a decimal point

d. The result of an equation

23. When evaluating expressions involving multiple operators, what should be considered to ensure correct results?

a. Operator precedence

b. The order of appearance

c. Types of variable

d. Unary operators

24. What is the primary purpose of loops in programming?

a. Re-executing the program

b. Printing of arrays

c. Repeating a sequence of instructions

d. Printing a sequence of numbers

25. In programming, how is a 'for' loop primarily used?

a. To create nested loops

b. To repeat a sequence of instructions for a specified number of times

c. To execute a loop body once and then check the condition

d. To print a sequence of numbers

26. Which loop type is best suited for scenarios where the loop body must execute at least once?

a. for loop

b. while loop

c. do-while loop

d. nested loop

27. In programming, what is the primary purpose of a while loop?

a. To execute a loop body repeatedly as long as a specified condition is true

b. To execute a loop body at least once and then check the condition

c. To execute a loop body for a specified number of times

d. To execute a loop body repeatedly as long as a specified condition is false

28. What is the main advantage of using nested loops in programming?

a. Print matrices

b. Simpler control structures

c. Handling complex repetitive tasks

d. Initialization of multiple variables

29. In programming, what does the term "nested loops" refer to?

a. Loops that are defined within a function

b. Loops that are executed multiple times

c. Loops that contain other loops within their bodies

d. Loops that iterate without condition

30. What is the primary purpose of the 'break' statement in loops?

a. To stop the execution of the program

b. To exit a loop prematurely

c. To divide a complex variable into a simpler form

d. To repeat the loop

31. How does the 'continue' statement influence loop iteration in programming?

a. It repeats the loop indefinitely

b. It skips the current iteration and proceeds to the next.

c. It exits the loop prematurely

d. It continues the execution of the program when an error occurs

32. What is the primary purpose of modular programming in software development?

a. Enhancing code readability

b. Reducing program size

c. Improving code organization and maintainability

d. Minimizing the use of functions

33. In programming, when can modularization enhance code organization and maintainability?

a. When you use fewer functions to keep the code concise

b. When you use global variables extensively

c. When you break down a program into manageable functions

d. When you avoid using functions altogether

34. In programming, what is the primary role of functions?

a. To store and organize data

b. To create local variables

c. To execute a sequence of instructions

d. To improve code organization and reusability

35. What is the primary purpose of function prototypes in programming?

a. To declare functions without defining them

b. To optimize code for performance

c. To improve code readability

d. To pass multiple input parameters

36. What is the primary advantage of using function parameters in programming?

a. It reduces the need for functions

b. It makes code longer and more complex

c. It enhances code reusability and flexibility

d. It restricts the types of input data that can be used

37. What is the main advantage of using functions with multiple input parameters?

a. Improved code readability

b. Reduced program size

c. Enhanced program functionality

d. Simplified control structures

38. In the context of programming, what is the significance of passing arguments to functions?

a. It reduces the need for comments in the code

b. It broadens the scope of the variables

c. It enables data to be processed within the function

d. It changes the values of variables in the calling function

39. What does it mean when a function is described as "returning a value" in programming?

a. The function returns control to the calling function

b. The function provides output data that can be used in the main program

c. The function performs some action and prints the result as a value

d. The function exits and sends an error value

40. How is the 'exit' function primarily used in programming?

a. To terminate the program execution immediately

b. To exit a control structure

c. To send control back to the calling function

d. To close a specific file open in the program

41. What is a local variable in programming?

a. A variable defined within a function and can only be accessed within that function

b. A variable declared at the start of a program and accessible from any part of the program

c. A variable that is sent as a parameter in a function call

d. A variable used for loop control

42. When considering variables in programming, in which situation would a global variable be appropriate?

a. When you want to limit the variable's scope to a specific function

b. When you need the variable to be accessible from any part of the program

c. When you want to ensure the variable is only used within a loop

d. When you want to declare a variable within a specific block of code

43. When might you use default arguments in function parameters?

a. To force the caller to always provide values for all function parameters

b. To allow the function to work without any parameters

c. To provide predefined values for one or more function parameters if the caller doesn't specify them

d. To make the function return a default value if no arguments are passed

44. What is function overloading in programming?

a. Creating a function that performs several unrelated tasks

b. Writing functions with the same name but different return types

c. Creating multiple functions with the same name but different parameters

d. Defining functions with a variable number of arguments

45. How can static variables in functions be best characterized?

a. They are variables with global scope

b. They are variables that cannot be changed

c. They are variables that retain their values between function calls

d. They are variables whose values can be changed by any function in the program

46. When you pass a variable by reference to a function, what happens to the original variable?

a. It becomes inaccessible

b. It remains unchanged

c. It is deleted

d. It is modified within the function

APPENDIX E

Test to Assess Student's Learning at Applying Level

Name: _____ Duration: 60 minutes

Roll No: _____

Write code in C++ for the following problem statements. Ensure your code is well-commented to explain the logic used in each part of the program.

1. Create a C++ program that takes an integer input from the user and determines if it is positive, negative, or zero. Use `if-else-if` conditions to achieve this. Display an appropriate message based on the input.

   Requirements:

   - **Input:**
     - The program should prompt the user to enter an integer.
   - **Classification:**
     - Use `if-else-if` conditions to check whether the entered integer is positive, negative, or zero.
   - **Output:**
     - Display a message indicating whether the entered integer is positive, negative, or zero.

2. Create a C++ program that calculates the factorial of a given positive integer using a `while` loop. The program should also include input validation to ensure only positive integers are accepted.

   Requirements:

   - **Input Validation:**
     - The program should prompt the user to enter a positive integer.
     - If the user enters a non-integer value or a non-positive integer, the program should display an error message and prompt the user to enter the value again until a valid positive integer is entered.
   - **Factorial Calculation:**
     - Implement the factorial calculation using a `while` loop.
     - The factorial of a number n (denoted as n!) is the product of all positive integers from 1 to n. For example, $5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$.
   - **Output:**
     - Once a valid positive integer is entered, the program should calculate and display the factorial of that integer.

3. Create a C++ program to calculate the area of a circle using a function. The program should include a function named `calculateArea` that accepts the radius of the circle as a parameter and returns the area. Use this function to calculate the area of a circle with a user-provided radius.

   Requirements:

   - **Function Definition:**
     - Define a function named `calculateArea` that:
       - Takes a single parameter of type `double` representing the radius of the circle.
       - Returns the area of the circle as a `double`.
     - The formula to calculate the area of a circle is Area = $\pi \times \text{radius}^2$
   - **Input:**
     - The program should prompt the user to enter the radius of the circle.
     - Ensure the radius is a non-negative number. If the user enters a negative number, display an error message and prompt the user to enter a valid radius.
   - **Output:**
     - Use the `calculateArea` function to compute the area of the circle.
     - Display the calculated area with an appropriate message.

APPENDIX F

Questionnaire to Assess Reaction of Students

For measurement of affective reaction and utility judgments regarding the use of ChatGPT for learning

Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Disagree, 4 = Neutral, 5 = Somewhat Agree, 6 = Agree, 7 = Strongly Agree

Items	Scale							
	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree	
Using ChatGPT improved my understanding of the topics covered in this course.	1	2	3	4	5	6	7	Utility Judgement (Understanding level)
Using ChatGPT made me understand the topics covered in this course much faster.	1	2	3	4	5	6	7	
Using ChatGPT, I was able to learn programming concepts more easily.	1	2	3	4	5	6	7	
I used ChatGPT to explain concepts to me that I was feeling difficult to comprehend.	1	2	3	4	5	6	7	
I used ChatGPT to generate examples of code to understand the concepts that I was feeling difficulty in.	1	2	3	4	5	6	7	
Using ChatGPT, I was able to develop programs with less difficulty.	1	2	3	4	5	6	7	Utility Judgement (Applying level)
I used ChatGPT to explain code to me that I was feeling difficult to understand.	1	2	3	4	5	6	7	
I used ChatGPT to identify and correct errors that I made in programming.	1	2	3	4	5	6	7	
I used ChatGPT to generate equivalent and more optimized code.	1	2	3	4	5	6	7	
If I had the choice or opportunity, I would use ChatGPT to learn more about programming.	1	2	3	4	5	6	7	Affective Reaction
If I had to vote, I would vote in the favor of using ChatGPT in the classroom.	1	2	3	4	5	6	7	
I was enthusiastic about using ChatGPT in this kind of courses.	1	2	3	4	5	6	7	
Using ChatGPT to learn programming in this course was a positive experience.	1	2	3	4	5	6	7	

APPENDIX G

Validity Certificate (01/02)

Certificate of Validity

ENHANCING ACTIVE LEARNING THROUGH CHATBOTS: A QUASI-EXPERIMENTAL STUDY USING ChatGPT AT UNDERGRADUATE LEVEL

By Mr. Shamsuddin Qureshi

M.Phil. Scholar, Department of Educational Sciences, National University of Modern Languages, H-9, Islamabad, Pakistan.

This is to certify that the two research instruments used by the scholar in his study have been assessed by me and I find it to have been designed adequately to assess the effect of using ChatGPT on active learning of students at undergraduate level.

It is considered that the research instruments developed for the above-mentioned research title are according to the objectives and hypothesis of the research and can be used for data collection by the researcher with fair amount of confidence.

Signature: MK

Name: DR. MUZAFAR KHAN

Designation: HoD, SE Dept.

Institute: NUML, H-9.

APPENDIX H

Validity Certificate (02/02)

Certificate of Validity

ENHANCING ACTIVE LEARNING THROUGH CHATBOTS: A QUASI-EXPERIMENTAL STUDY USING ChatGPT AT UNDERGRADUATE LEVEL

By Mr. Shamsuddin Qureshi

M.Phil. Scholar, Department of Educational Sciences, National University of Modern Languages, H-9, Islamabad, Pakistan.

This is to certify that the two research instruments used by the scholar in his study have been assessed by me and I find it to have been designed adequately to assess the effect of using ChatGPT on active learning of students at undergraduate level.

It is considered that the research instruments developed for the above-mentioned research title are according to the objectives and hypothesis of the research and can be used for data collection by the researcher with fair amount of confidence.

Signature:

Name: Mahwish Pervaiz

Designation: Assistant Professor

Institute: Bahria University Islamabad

APPENDIX I

Lesson Plans

<table>
<tr><td colspan="3">WEEK 01
Stage 1 - Desired Results</td></tr>
<tr><td>ESTABLISHED GOALS</td><td colspan="2">Transfer</td></tr>
<tr><td rowspan="5">The enduring understanding and learning goals of the lesson.

By the end of the lesson, students will be able to
1. describe the purpose of variables in a programming language
2. differentiate between different data types of variables
3. explain the purpose of using comments in a programming language
4. create variables with meaningful names of data types relevant to their purpose in C++
5. correctly assign and reassign values to variables, ensuring compatibility with their data types
6. identify and explain the scope and lifetime of a variable
7. add single-line and multi-lines comments to enhance code readability.
8. write mathematical expressions using arithmetic operations on variables that produce correct intended output
9. differentiate between implicit and explicit type casting
10. perform type casting to achieve correct output in mathematical expression involving different data types
11. recognize, explain, and predict the effects of overflow and underflow in numerical calculations</td><td colspan="2">Students will be able to independently use their learning to...

create and use variables of different data types in programming languages while working on their code that will have names of variables relevant to their purpose
assign and reassign values to variables
identify the scope and lifetime of a variable
use comments in their code to add meta-information in their code
perform mathematical operations on variables
prevent errors in coding that could arise because of overflow and underflow in variable initialization
avoid errors or unexpected results in coding that could arise because of type conversion.
perform basic input, output operations using variables</td></tr>
<tr><td colspan="2">Meaning</td></tr>
<tr><td>UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>Students will understand...

variables are used to create memory spaces to store certain type of data
variables have limited range which if not observed could cause underflow or overflow
Variables have defined scopes and lifetimes within programs, affecting their visibility and memory management
Variable declaration involves specifying a data type and a name for a variable, while initialization assigns an initial value to it.
Basic input and output operations involve communication between a program and its user or environment.
Comments provide contextual information, enhancing code readability and collaboration</td><td>How do variables and data types contribute to the structure of a C++ program?
What factors determine the scope and lifetime of a variable within a program?
Why is it important to add comments to your code? How do comments enhance collaboration?
What considerations should be made when performing arithmetic operations on variables of different data types?
How does type casting influence the outcome of mathematical expressions involving variables?
Why should programmers be mindful of overflow and underflow when working with numerical data?
How can effective input and output operations enhance user interaction with a program?
In what ways can understanding variable declaration and initialization improve code reliability?
What strategies can be used to handle and prevent errors that arise due to type conversion?
How might you apply your knowledge of variables, arithmetic, and comments to solve a real-world programming challenge?</td></tr>
<tr><td colspan="2">Acquisition</td></tr>
<tr><td></td><td>Students will know...</td><td>Students will be skilled at...</td></tr>
<tr><td></td><td>Data Types and Variables:
Understand the concept of data types in programming.
Recognize common data types such as int, float, double, char, etc.
Comprehend the role of variables in storing and manipulating data.
Differentiate between variables and constants.
Variable Declaration and Initialization:
Know how to declare a variable with a specific data type.
Understand the purpose of variable initialization.
Recognize the syntax for initializing variables during declaration.
Scope and Lifetime:
Understand the scope of a variable within different parts of a program.
Comprehend the concept of variable lifetime and memory management
Comments:
Understand the importance of comments in programming.
Learn how to add single-line and multi-line comments.
Recognize the role of comments in improving code readability and communication.
Arithmetic Operations:
Understand basic arithmetic operators (+, -, *, /, %).
Comprehend the rules for performing arithmetic operations on different data types.
Recognize operator precedence and associativity.
Type Casting:
Understand implicit and explicit type casting (conversion) in programming.
Recognize situations where type casting is necessary.
Learn how to perform type casting to avoid data loss or errors.
Overflow and Underflow:
Understand what overflow and underflow are in numeric calculations.
Recognize the potential consequences of overflow and underflow.
Input and Output Operations:
Understand the role of input and output operations in programs.
Learn how to read input from the user and display output to the screen.</td><td>Creating and Using Variables:
Create variables with appropriate data types and meaningful names.
Assign and reassign values to variables based on their data types.
Variable Scope and Lifetime:
Identify the scope of variables within different code blocks.
Understand and manage the lifetime of variables to optimize memory usage.
Comments and Documentation:
Add single-line and multi-line comments to explain code functionality.
Document code effectively to enhance collaboration and readability.
Arithmetic Operations:
Perform arithmetic operations (+, -, *, /, %) on variables.
Understand operator precedence and use parentheses to control calculations.
Type Casting and Conversion:
Differentiate between implicit and explicit type casting.
Perform type casting to ensure compatibility and accurate results.
Preventing Overflow and Underflow:
Identify situations where overflow or underflow might occur.
Implement strategies to prevent overflow and underflow in calculations.
Input and Output Handling:
Prompt users for input and process it using standard input functions.
Display output to user
Applying Concepts to Problem Solving:
Apply acquired knowledge and skills to solve simple programming problems.
Analyze coding challenges and choose appropriate strategies to solve them.</td></tr>
</table>

Stage 2 - Evidence and Assessment		
Evaluative Criteria	**Assessment Evidence**	
	PERFORMANCE TASKS	**OTHER EVIDENCE**
Accurately describe the purpose of variables in a programming language students can correctly differentiate between different data types of variables clearly explain the purpose of using commnets in a programming langauge Demonstrates accurate creation of variables with appropriate data types and relevant names. Accurately assigns and reassigns values to variables based on their data types. Identifies scope and lifetime of variables in different code blocks accurately. Adds clear and relevant comments that enhance code readability and provide insights into code functionality. write mathematical expressions using arithmetic operations on variables to produce correct intended output Accurately defines implicit and explicit type casting. Provides examples illustrating when each type of casting is used. Demonstrates the ability to identify data type mismatches in a mathematical expression. Performs type casting effectively to ensure compatibility and accurate results. Applies appropriate syntax for explicit type casting in code. Generates the correct output by addressing type-related issues. Identifies scenarios where overflow and underflow can occur in numeric calculations. Clearly explains the concepts of overflow and underflow in programming. Demonstrates the ability to predict when overflow or underflow might occur in given scenarios. Consistently applies strategies to prevent or mitigate overflow and underflow effects in coding exercises.	Coding exercises Code analysis Code commenting	group activities discussion Peer review use of chatgpt

Stage 3 - Learning Plan
This stage encompasses the individual learning activities and instructional strategies that will be employed. This includes lectures, discussions, problem-solving sessions, etc. Use the following information for the planning of each class session.
Trigger
Begin with a thought-provoking question or scenario related to the day's topics to stimulate curiosity and relevance. Form small groups of 3 students. Explain that they will be self-directed learners for a portion of the session.
Learning Activity
Provide groups with laptops or access to computers with C++ IDEs, e-books, internet resources, *and access to ChatGPT* (for experimental group). Assign specific topics related to the goals, such as type casting, variable scope, overflow/underflow, etc. Instruct groups to research and learn about their assigned topic, practice in the IDE, and experiment with code, *and get help from ChatGPT both while studying about the topic and during their pratice of code* (for experimental group). Encourage collaboration within groups, exploration of reference books and online resources, *and the use of ChatGPT* (for experimental group).
Discussion
Gather the entire class together for a group discussion segment. Give each group a few minutes to present their findings, insights, and questions related to their assigned topic. Facilitate discussions where groups share challenges, discoveries, and any areas of confusion. Encourage interaction among groups by inviting questions and comments from peers.
Summary
Summarize the key takeaways from each group's presentation. Provide clarifications on any misconceptions or questions that arose during the discussions. Emphasize connections between different topics and highlight the significance of the day's learning.
Lab Activity
Transition to the lab portion, where students engage in hands-on coding exercises, code analysis, and code commenting that reinforce the concepts discussed earlier. Provide coding challenges that involve creating variables, performing arithmetic operations, dealing with variable scope, and handling type casting and overflow/underflow situations. Allow students to apply the knowledge through problem-solving and critical thinking which they acquired during the self-directed learning phase. Encourage the use of ChatGPT for experimental group instead of relying on the instructor to get help or for feedback.

WEEK 02
Stage 1 – Desired Results

ESTABLISHED GOALS	***Transfer***	
The enduring understanding and learning goals of the lesson. *By the end of the lesson, students will be able to* *1. Define and differentiate between sequence, selection, and iteration control structures.* *2. Recognize the importance of control structures in programming logic.* *3. Explain the purpose and usage of conditional statements (if, if-else, if-else-if, switch) in decision-making.* *4. Construct code using various conditional statements to control program flow effectively.* *5. Identify and comprehend unary operators, including their role in changing the value or state of variables.* *6. Apply unary operators appropriately in programming tasks.* *7. Define and categorize binary operators (arithmetic, relational, and logical) based on their functions.* *8. Demonstrate the correct use of binary operators in arithmetic, comparison, and logical operations.* *9. Describe the ternary operator and its purpose in concise decision-making.* *10. Implement the ternary operator to write concise and readable code.* *11. Explain the role and significance of relational operators in comparing values.* *12. Write code that employs relational operators to make comparisons.* *13. Define logical operators (AND, OR, NOT) and their application in combining conditions.* *14. Use logical operators to create complex conditions in decision structures.* *15. Define operator precedence and understand how it determines the order of operations in expressions.* *16. Evaluate and correctly interpret expressions involving multiple operators based on precedence rules.*	*Students will be able to independently use their learning to…* *Independently apply control structures (if, if-else, if-else-if, switch) to solve real-world programming problems.* *Implement decision-making processes using conditional statements to control program behavior effectively in practical scenarios.* *Produce clean, efficient, and well-structured code that leverages conditional structures to make decisions and control program flow.* *Utilize appropriate unary, binary, and ternary operators to enhance code readability and functionality in actual programming projects.* *Employ logical operators to manage multiple conditions and create solutions to intricate problem-solving situations.* *Interpret and evaluate expressions involving multiple operators correctly, based on the rules of operator precedence.* *Avoid common errors related to operator precedence when coding*	
	Meaning	
	UNDERSTANDINGS	**ESSENTIAL QUESTIONS**
	Students will understand… *Control structures, including sequential, conditional, and repetitive structures, are the building blocks of program flow.* *Sequential control structures dictate the order in which instructions are executed, forming the foundation of program execution.* *Control structures (if, if-else, if-else-if, switch) are fundamental tools for implementing decision logic and solving complex problems in programming.* *Repetitive structures (loops) enable programs to perform iterative tasks efficiently and systematically.* *Operators (unary, binary, ternary, relational, logical) are essential components of programming that facilitate data manipulation, comparison, and logical operations.* *Precise and well-structured conditionals ensure that programs respond accurately to various inputs and conditions.* *Efficient use of control structures and operators leads to code that is not only functional but also easy to read and maintain* *The principles of control structures and operators are applicable across different programming languages and environments.*	*How do control structures in programming help us create dynamic and responsive software?* *What is the role of decision-making in programming, and how do conditional structures facilitate it?* *How do unary operators impact the values of variables, and in what situations are they useful?* *How does the ternary operator streamline decision-making in code, and when is it beneficial to use it?* *What role do relational operators play in comparing data, and how do they contribute to program logic?* *How do logical operators enhance the complexity of conditionals, and what are their practical applications?* *Why is understanding operator precedence important, and how does it affect the outcome of expressions in code?* *In what ways do control structures and operators contribute to writing efficient and maintainable code?* *How can we apply our knowledge of control structures and operators to solve real-world programming challenges effectively?*
	Acquisition	
	Students will know…	*Students will be skilled at…*
	Control Structures: *Students will acquire a deep understanding of the fundamental concept of control structures, which are the building blocks of program flow in coding.* *They will learn about the three main categories of control structures: sequential, conditional, and repetitive, and how each influences the execution path of a program.* ***Conditional Structures:*** *Students will acquire knowledge of conditional structures, including if statements (if, if-else, if-else-if) and the switch statement.* *They will understand how to use these structures for decision-making and branching based on specific conditions.* ***Unary and Binary Operators:*** *Students will gain insight into unary operators and their role in altering the value or state of variables (e.g., increment and decrement operators).* *They will also learn about binary operators, including relational operators and logical operators.* ***Ternary Operator and Relational Operators:*** *Students will acquire knowledge of the ternary operator (?:) and its utility in concise decision-making.* *They will understand relational operators and their use in comparing values.* ***Logical Operators:*** *Students will learn about logical operators (AND, OR, NOT) and how they are employed to combine and manipulate conditions in programming logic.* ***Operator Precedence:*** *Students will acquire knowledge of operator precedence, which defines the order in which operators are evaluated in expressions.* *They will understand how to evaluate complex expressions correctly based on precedence rules.* ***Practical Applications and Examples:*** *Students will explore practical applications and real-world examples of control structures and operators in various programming contexts.* *They will see how these concepts are used to solve problems, make decisions, and control program flow.* ***Code Efficiency and Best Practices:*** *Students will gain insights into writing efficient and readable code by leveraging control structures and operators effectively.* *They will learn best practices for code organization, including the use of indentation, comments, and meaningful variable names.*	***Application of Control Structures:*** *Students will develop the ability to apply sequential control structures to create ordered execution paths in code.* ***Proficiency in Conditional Logic:*** *Students will acquire proficiency in constructing conditionals that evaluate expressions and control program behavior based on specified criteria.* ***Effective Use of Unary Operators:*** *Students will master the application of unary operators, including increment and decrement operators, to manipulate variable values.* ***Proficiency in using Binary Operators:*** *Students will develop proficiency in using binary operator: relational operators (e.g., <, >, ==) for comparisons and logical operators (e.g., &&, ||) for complex conditionals.* ***Application of the Ternary Operator:*** *Students will gain competence in utilizing the ternary operator (?:) for concise decision-making.* ***Evaluation of Operator Precedence:*** *Students will demonstrate competence in evaluating expressions with multiple operators, considering operator precedence rules.* *They will accurately interpret and assess the order of operations in complex expressions.* ***Code Efficiency and Best Practices:*** *Students will develop coding skills that prioritize code readability and organization.* *They will apply best practices such as using proper indentation, commenting, and selecting meaningful variable names.* ***Problem-Solving and Critical Thinking:*** *Students will hone their problem-solving skills by applying control structures and operators to address practical programming challenges.* *They will develop critical thinking abilities to analyze problems and select appropriate control structures and operators for solutions.*

Stage 2 - Evidence and Assessment		
Evaluative Criteria	**Assessment Evidence**	
	PERFORMANCE TASKS	**OTHER EVIDENCE**
Students can correctly identify and differentiate between sequential, conditional, and repetitive control structures. Students can construct well-structured if statements (if, if-else, if-else-if) and switch statements that accurately evaluate conditions and control program behavior and flow. Students can use unary operators (e.g., increment and decrement) to modify variable values correctly and efficiently. They accurately apply relational operators to compare values and make logical decisions. Students demonstrate proficiency in using logical operators (AND, OR, NOT) to combine conditions and create complex decision structures. Students can effectively utilize the ternary operator (?:) in code to create concise conditional expressions. Students can evaluate expressions involving multiple operators and adhere to operator precedence rules. Students produce code that adheres to best practices for readability, including proper indentation, commenting, and meaningful variable names. Students effectively apply control structures and operators to solve programming challenges and make decisions based on specific requirements. They demonstrate critical thinking skills by selecting appropriate control structures and operators for problem-solving.	Coding exercises Code analysis Code commenting	group activities discussion Peer review use of chatgpt

Stage 3 - Learning Plan
This stage encompasses the individual learning activities and instructional strategies that will be employed. This includes lectures, discussions, problem-solving sessions, etc. Use the following information for the planning of each class session.
Trigger
Begin with a thought-provoking question or scenario related to the day's topics to stimulate curiosity and relevance. Re-form the groups of students as before. Explain that they will be self-directed learners for a portion of the session.
Learning Activity
Provide groups with laptops or access to computers with C++ IDEs, e-books, internet resources, *and access to ChatGPT* (for experimental group). Assign specific topics related to the goals, such as different conditional structures and operators, and precedence of operators. Instruct groups to research and learn about their assigned topic, practice in the IDE, and experiment with code, *and get help from ChatGPT both while studying about the topic and during their pratice of code* (for experimental group). Encourage collaboration within groups,exploration of reference books and online resources, *and the use of ChatGPT* (for experimental group).
Discussion
Gather the entire class together for a group discussion segment. Give each group a few minutes to present their findings, insights, and questions related to their assigned topic. Facilitate discussions where groups share challenges, discoveries, and any areas of confusion. Encourage interaction among groups by inviting questions and comments from peers.
Summary
Summarize the key takeaways from each group's presentation. Provide clarifications on any misconceptions or questions that arose during the discussions. Emphasize connections between different topics and highlight the significance of the day's learning.
Lab Activity
Transition to the lab portion, where students engage in hands-on coding exercises, code analysis, and code commenting that reinforce the concepts discussed earlier. Provide coding challenges that involve using conditional statements to control program behavior, creating complex expressions and conditions using relational and logical operators, using ternary operator for concise decision-making, and performing arithmetic operations using unary operators. Allow students to apply the knowledge through problem-solving and critical thinking which they acquired during the self-directed learning phase. Encourage the use of ChatGPT for experimental group instead of relying on the instructor to get help or for feedback.

<table>
<tr><th colspan="3">WEEK 03
Stage 1 - Desired Results</th></tr>
<tr><td>ESTABLISHED GOALS</td><td colspan="2">Transfer</td></tr>
<tr><td rowspan="4">The enduring understanding and learning goals of the lesson.

By the end of the lesson, students will be able to
1. explain the purpose of loops in programming.
2. Differentiate between the three main types of loops: for, while, and do-while.
3. write code to apply the for loop with correct syntax to iterate over a range of values and perform repetitive tasks.
4. Create while loops with correct syntax that accurately control program flow based on conditions.
5. Apply the do-while loop with proper syntax for scenarios where the loop body must execute at least once.
6. explain the concept of nested loops and their use in complex repetitive tasks.
7. Develop code correctly that effectively uses nested loops for multi-dimensional data processing.
8. describe the purpose and application of the break statement to exit loops prematurely.
9. describe the continue statement and how it influences loop iteration.</td><td colspan="2">Students will be able to independently use their learning to…

Apply loop structures to solve more complex programming problems.
Implement nested loops and select the appropriate loop type for specific tasks.
Utilize loops to implement error-handling mechanisms and gracefully handle unexpected inputs.
Employ break statements judiciously to exit loops under specific conditions.
Choose the most efficient loop type for a given task.
Apply continue statements to skip specific iterations for efficiency.</td></tr>
<tr><td colspan="2">Meaning</td></tr>
<tr><td>UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>Students will understand…

Control structures known as loops are essential for automating repetitive tasks and managing program flow efficiently.
Different types of loops, including for, while, and do-while, offer varying approaches to repetitive execution based on specific conditions.
Nested loops provide a powerful mechanism for handling multi-dimensional data and performing complex repetitive operations.
Control statements like break and continue allow programmers to modify loop behavior and make decisions within loops.
Selecting the right loop type enhances code efficiency and maintainability.
Proficiency in loops is transferable across programming languages, enabling adaptability in diverse coding environments.</td><td>Why are loops essential in programming, and how do they contribute to efficient code execution?
What are the key differences between for, while, and do-while loops, and how do you choose the appropriate loop type for a given task?
How can nested loops be effectively used to tackle complex, multi-dimensional data processing tasks?
In what ways do control statements like break and continue influence the behavior of loops, and how can they be employed for problem-solving?
How can programmers select the right loop type and employ efficient looping techniques?</td></tr>
<tr><td colspan="2">Acquisition</td></tr>
<tr><td>Students will know…</td><td>Students will be skilled at…</td></tr>
<tr><td></td><td>Loop Concepts:
Students will acquire a comprehensive understanding of loop structures, their purpose, and their role in controlling program flow.
They will know the difference between the three main types of loops: for, while, and do-while.
for Loop Syntax and Usage:
Students will learn the syntax and usage of the for loop for controlled iteration.
They will understand how to set loop initialization, conditions, and iteration expressions.
while Loop Syntax and Usage:
Students will learn the syntax and usage of the while loop for conditional iteration.
They will grasp how to structure while loops to effectively control program execution.
do-while Loop Syntax and Purpose:
Students will gain knowledge of the do-while loop's syntax and its application for situations where the loop body must execute at least once.
Nested Loop Concepts:
Students will understand the concept of nested loops, where one loop resides within another.
They will learn how to structure nested loops for complex repetitive tasks.
Control Statements:
Students will acquire knowledge of the break statement and its role in exiting loops prematurely.
They will learn about the continue statement and how it influences loop iteration.</td><td>Application of Loop Structures:
Students will develop the ability to choose the suitable loop structure and apply it effectively in various programming scenarios.
Mastery of for Loops:
Students will become proficient in using the for loop for controlled iteration.
They will be skilled in applying for loops to iterate over a range of values and perform repetitive tasks accurately.
Proficiency in while Loops:
Students will develop the skill to use the while loop for conditional iteration.
They will demonstrate the ability to create while loops that accurately control program flow based on conditions.
Effective Utilization of do-while Loops:
Students will gain the skill to employ the do-while loop for scenarios where the loop body must execute at least once.
They will be able to create do-while loops that execute correctly based on initial conditions and user inputs.
Nested Loop Proficiency:
Students will master the application of nested loops for handling multi-dimensional data and performing complex repetitive tasks.
They will demonstrate the ability to nest loops appropriately for specific problem-solving.
Control of Loop Execution:
Students will acquire the skill to use the break statement to exit loops prematurely when specific conditions are met.
They will be skilled in applying the continue statement to skip specific iterations within loops effectively.</td></tr>
</table>

Stage 2 - Evidence and Assessment		
Evaluative Criteria	**Assessment Evidence**	
Students can explain the purpose of loops and differentiate between for, while, and do-while loops. They apply the correct loop type for specific programming challenges and demonstrate understanding of loop syntax. Students create for loops that correctly iterate over a range of values and perform repetitive tasks accurately. They use for loops to solve problems involving controlled iteration effectively. Students proficiently use the while loop for conditional iteration and control program flow based on conditions. They create while loops that execute accurately in response to specific conditions. Students demonstrate the skill to employ the do-while loop, ensuring it executes at least once based on initial conditions and user inputs. They use do-while loops appropriately in problem-solving. Students correctly implement nested loops for multi-dimensional data processing and complex repetitive tasks. They choose the appropriate nesting structure for specific problem-solving scenarios. Students effectively use the break statement to exit loops prematurely when specific conditions are met. They apply the continue statement judiciously to skip specific iterations within loops	**PERFORMANCE TASKS**	**OTHER EVIDENCE**
	Coding exercises Code analysis Code commenting Code optimization	group activities discussion Peer review use of chatgpt

Stage 3 - Learning Plan
This stage encompasses the individual learning activities and instructional strategies that will be employed. This includes lectures, discussions, problem-solving sessions, etc. Use the following information for the planning of each class session.
Trigger
Begin with a thought-provoking question or scenario related to the day's topics to stimulate curiosity and relevance. Re-form the groups of students as before. Explain that they will be self-directed learners for a portion of the session.
Learning Activity
Provide groups with laptops or access to computers with C++ IDEs, e-books, internet resources, *and access to ChatGPT* (for experimental group). Assign specific topics related to the goals, such as loops, for loop, while loop, do-while loop, nested loops, break statement, and continue statement. Instruct groups to research and learn about their assigned topic, practice in the IDE, and experiment with code, *and get help from ChatGPT both while studying about the topic and during their pratice of code* (for experimental group). Encourage collaboration within groups, exploration of online resources, *and the use of ChatGPT* (for experimental group).
Discussion
Gather the entire class together for a group discussion segment. Give each group a few minutes to present their findings, insights, and questions related to their assigned topic. Facilitate discussions where groups share challenges, discoveries, and any areas of confusion. Encourage interaction among groups by inviting questions and comments from peers. Ensure the discussion involves examples and practical use cases for each loop type, comparison of for, while, and do-while loops, and strengths and weaknesses of each loop type in different scenarios.
Summary
Summarize the key takeaways from each group's presentation. Provide clarifications on any misconceptions or questions that arose during the discussions. Emphasize connections between different topics and highlight the significance of the day's learning.
Lab Activity
Transition to the lab portion, where students engage in hands-on coding exercises, code analysis, and code commenting that reinforce the concepts discussed earlier. Provide coding challenges that involve using different types of loops and nested loops to repeat instructions based on different problem scenarios, break and continue statement to modify control of loop based on some condition Allow students to apply the knowledge through problem-solving and critical thinking which they acquired during the self-directed learning phase. Present code optimization challenges that provides students with a program that contains an inefficient loop for a certain situation. Encourage the use of ChatGPT for experimental group instead of relying on the instructor to get help or for feedback.

WEEK 04
Stage 1 - Desired Results

ESTABLISHED GOALS	***Transfer***	
The enduring understanding and learning goals of the lesson. *By the end of the lesson, students will be able to* *1. describe the concept of modular programming and its significance in software development.* *2. Identify scenarios where modularization can enhance code organization and maintainability.* *3. Define and recognize the purpose of functions in programming.* *4. explain the purpose of function prototype* *5. write code to declare, call, and prototype functions.* *6. describe the significance of using function parameters to pass input data to functions in programming.* *7. Develop functions that accept a single input parameter.* *8. Demonstrate the ability to pass arguments to functions and process them.* *9. Construct functions that accept multiple input parameters.* *10. effectively handle and manipulate multiple function arguments.* *11. Write functions that return values, enabling data or results to be used in the main program.* *12. describe how returning values from functions enhances program functionality.* *13. the purpose of the exit function in terminating program execution.* *14. Apply the exit function appropriately to exit a program based on specific conditions.*	*Students will be able to independently use their learning to…* *Apply function structures to solve complex programming challenges.* *Create modular programs with well-structured functions to enhance code readability and maintainability.* *Utilize modular programming principles to organize code into manageable and reusable functions.* *Recognize the benefits of code modularity in collaborative programming projects.* *Optimize code by breaking it into functions that encapsulate specific tasks or algorithms, promoting code reusability.* *Recognize situations where the use of functions can enhance code efficiency and scalability.*	
	Meaning	
	UNDERSTANDINGS	**ESSENTIAL QUESTIONS**
	Students will understand… *Modular programming involves dividing a program into smaller, manageable functions to enhance code organization and maintainability.* *Functions are fundamental building blocks in programming, allowing for code reuse, readability, and the structuring of complex tasks.* *Functions have a defined structure, including function headers, bodies, and return statements, and serve specific purposes in code execution.* *Functions can accept input parameters, including single and multiple arguments, to perform computations or processes.* *Some functions return values to the caller, enabling the transfer of data or results from the function to the main program.* *The exit function is a tool for prematurely terminating program execution based on specific conditions.*	*Why is modular programming important, and how does it contribute to code organization and maintainability?* *What are the fundamental elements of a function, and how do they contribute to its functionality and purpose?* *How do functions handle input parameters, and what is the role of function prototypes in function declaration?* *In what ways can functions enhance code reusability, readability, and maintainability?* *How does the exit function influence program execution, and when is it appropriate to use it to exit a program?* *How do functions that return values contribute to program functionality, and what are the key considerations when using them?*
	Acquisition	
	Students will know…	*Students will be skilled at…*
	Modular Programming Concepts: *Students will acquire an understanding of modular programming principles, including code organization and the role of functions.* ***Function Structure and Declaration:*** *Students will learn the structure of a function, including the function header, body, and return statement.* *They will understand how to declare functions with different return types and parameter lists.* ***Function Prototypes:*** *Students will grasp the concept of function prototypes and their significance in declaring functions before their actual implementation.* ***Functions with Single Input:*** *Students will learn how to create functions that accept a single input parameter and process it within the function body.* ***Functions with Multiple Inputs:*** *Students will learn how to construct functions that accept multiple input parameters and effectively handle and manipulate them.* ***Functions That Return Values:*** *Students will understand how to write functions that return values, enabling data transfer between functions and the main program.* ***Exit Function Usage:*** *Students will acquire knowledge of the exit function's purpose and how to use it to exit a program based on specific conditions.*	***Modular Programming Skills:*** *Students will develop the skill to break down a program into manageable functions that encapsulate specific tasks or algorithms.* ***Function Implementation:*** *Students will gain proficiency in implementing functions by defining function headers, writing function bodies, and incorporating return statements.* ***Function Prototype Proficiency:*** *Students will develop proficiency in creating function prototypes that accurately represent the structure and parameters of functions.* ***Handling Single Input:*** *Students will demonstrate the ability to create functions that accept a single input parameter and utilize it within the function's logic.* ***Managing Multiple Inputs:*** *Students will acquire the skill to construct functions that accept multiple input parameters and effectively process them.* ***Returning Values:*** *Students will develop the ability to write functions that return values, allowing data or results to be used in the main program.* ***Exit Function Application:*** *Students will be able to use the exit function to exit a program based on specific conditions or errors.*

Stage 2 - Evidence and Assessment		
Evaluative Criteria	**Assessment Evidence**	
Students can explain the concept of modular programming and provide examples of how it enhances code organization and maintainability. Students accurately define functions with proper function headers, bodies, and return statements. They demonstrate the ability to declare functions with various return types and parameter lists. Students effectively create functions that accept single input parameters and demonstrate the ability to process them within the function body. Students construct functions that accept multiple input parameters, correctly handle them, and use them within the function logic. Students write functions that return values, enabling data transfer from the function to the main program. Students apply the exit function appropriately to exit a program based on specific conditions.	**PERFORMANCE TASKS**	**OTHER EVIDENCE**
	Coding exercises Code analysis Code commenting	group activities discussion Peer review use of chatgpt

Stage 3 - Learning Plan
This stage encompasses the individual learning activities and instructional strategies that will be employed. This includes lectures, discussions, problem-solving sessions, etc. Use the following information for the planning of each class session.
Trigger
Begin with a thought-provoking question or scenario related to the day's topics to stimulate curiosity and relevance. Re-form the groups of students as before. Explain that they will be self-directed learners for a portion of the session.
Learning Activity
Provide groups with laptops or access to computers with C++ IDEs, e-books, internet resources, *and access to ChatGPT* (for experimental group). Assign specific topics related to the goals, such as modular programming using functions, their declaration and definition, and different type of functions according to number of parameters and return type. Instruct groups to research and learn about their assigned topic, practice in the IDE, and experiment with code, *and get help from ChatGPT both while studying about the topic and during their pratice of code* (for experimental group). Encourage collaboration within groups, exploration of online resources, *and the use of ChatGPT* (for experimental group).
Discussion
Gather the entire class together for a group discussion segment. Give each group a few minutes to present their findings, insights, and questions related to their assigned topic. Facilitate discussions where groups share challenges, discoveries, and any areas of confusion. Encourage interaction among groups by inviting questions and comments from peers. Ensure the discussion involves modular programming concepts emphasizing the benefits of code organization and reuse through functions, function structure, best practices, and function implementation.
Summary
Summarize the key takeaways from each group's presentation. Provide clarifications on any misconceptions or questions that arose during the discussions. Emphasize connections between different topics and highlight the significance of the day's learning.
Lab Activity
Transition to the lab portion, where students engage in hands-on coding exercises, code analysis, and code commenting that reinforce the concepts discussed earlier. Provide coding challenges that involve function definition, function calls, function prototypes, functions with single and multiple inputs, functions that return values, and the exit function. Allow students to apply the knowledge through problem-solving and critical thinking which they acquired during the self-directed learning phase. Encourage the use of ChatGPT for experimental group instead of relying on the instructor to get help or for feedback.

WEEK 05 Stage 1 - Desired Results		
ESTABLISHED GOALS	***Transfer***	
The enduring understanding and learning goals of the lesson. *By the end of the lesson, students will be able to* *1. Identify and explain the differences between local and global variables.* *2. Recognize scenarios where each type of variable is appropriate.* *3. Define and use default arguments in function parameters.* *4. describe how default arguments enhance function flexibility.* *5. explain the concept of function overloading and its role in creating multiple functions with the same name but different parameters.* *6. Implement and apply function overloading in coding exercises.* *7. Explain the concept of static variables in functions and their persistence between function calls.* *8. Utilize static variables for maintaining state across function invocations.* *9. write code to pass variables by reference to functions.* *10. describe the impact of passing by reference on function behavior and variable modification.*	*Students will be able to independently use their learning to...* *Apply the principles of variable scope to manage local and global variables effectively in complex programs.* *Recognize opportunities for using global variables sparingly.* *Implement default arguments and function overloading to create versatile functions that accommodate various use cases.* *Recognize the importance of designing functions that can adapt to different requirements.* *Utilize static variables to maintain state information across function calls in larger programs.* *Understand how static variables contribute to program efficiency.* *Apply variable passing by reference to modify variables within functions and understand its implications.*	
	.	
	UNDERSTANDINGS	**ESSENTIAL QUESTIONS**
	Students will understand... *Local variables have limited scope within the function where they are defined, while global variables can be accessed throughout the entire program.* *Default arguments allow functions to have optional parameters, enhancing their adaptability to different situations.* *Function overloading enables the creation of multiple functions with the same name but different parameter lists, providing flexibility in function design.* *Static variables retain their values between function calls, making them suitable for maintaining state information across invocations.* *Passing variables by reference allows functions to modify the original variable's value, providing an efficient way to work with large data structures.*	*How does variable scope affect the accessibility and lifetime of variables, and what are the best practices for managing local and global variables in programming?* *What role do default arguments play in function design, and how do they enhance function flexibility and usability?* *How does function overloading contribute to code organization and the development of adaptable functions?* *What are static variables, and how do they enable state persistence across function calls? How can they be utilized effectively in programming?* *What are the advantages of passing variables by reference in functions, and how does this impact memory usage and program efficiency?*
	Acquisition	
	Students will know...	*Students will be skilled at...*
	Local and Global Variables: *Students will understand the differences between local and global variables, including scope and lifetime.* *They will recognize the importance of variable scope management.* *They will learn why minimizing the use of global variables in favor of local ones is better for effective memory management.* ***Default Argument Syntax:*** *Students will learn the syntax for defining and using default arguments in function parameters.* *They will grasp how default arguments enhance function flexibility.* ***Function Overloading Principles:*** *Students will acquire knowledge of function overloading principles and the conditions for creating overloaded functions.* *They will understand the role of parameter lists in function overloading.* ***Static Variables in Functions:*** *Students will comprehend the concept of static variables in functions and their persistence.* *They will recognize scenarios where static variables are advantageous.* ***Passing Variables by Reference:*** *Students will understand the concept of passing variables by reference and its impact on function behavior.* *They will learn the syntax for passing variables by reference.*	***Variable Scope Management:*** *Students will develop the skill to manage local and global variables effectively based on the scope requirements of the program.* ***Default Argument Implementation:*** *Students will master the skill of defining and using default arguments in function parameters.* ***Function Overloading Implementation:*** *Students will gain proficiency in implementing function overloading by creating multiple functions with the same name but different parameter lists.* ***Static Variable Utilization:*** *Students will acquire the skill to use static variables to maintain state information across function calls.* ***Variable Passing by Reference:*** *Students will acquire the skill to pass variables by reference to functions.* *They will demonstrate the ability to modify variables within calling functions through pass-by-reference mechanisms.*

Stage 2 - Evidence and Assessment		
Evaluative Criteria	**Assessment Evidence**	
Students can differentiate between local and global variables, explain their scope and lifetime, and apply best practices for scope management. Students accurately define and use default arguments in function parameters to enhance function flexibility and usability. Students effectively implement function overloading by creating multiple functions with the same name but different parameter lists. Students can describe the concept of static variables and demonstrate their utilization to maintain state information across function calls in practical programs. Students demonstrate the ability to pass variables by reference to functions and modify them within functions.	**PERFORMANCE TASKS**	**OTHER EVIDENCE**
	Coding exercises Code analysis Code commenting Code optimzation	group activities discussion Peer review use of chatgpt

Stage 3 - Learning Plan
This stage encompasses the individual learning activities and instructional strategies that will be employed. This includes lectures, discussions, problem-solving sessions, etc. Use the following information for the planning of each class session.
Trigger
Begin with a thought-provoking question or scenario related to the day's topics to stimulate curiosity and relevance. Re-form the groups of students as before. Explain that they will be self-directed learners for a portion of the session.
Learning Activity
Provide groups with laptops or access to computers with C++ IDEs, e-books, internet resources, *and access to ChatGPT* (for experimental group). Assign specific topics related to the goals, such as variable scope, default arguments, function overloading, static variables, and variable passing by reference. Instruct groups to research and learn about their assigned topic, practice in the IDE, and experiment with code, *and get help from ChatGPT both while studying about the topic and during their pratice of code* (for experimental group).. Encourage collaboration within groups, exploration of online resources, *and the use of ChatGPT* (for experimental group).
Discussion
Gather the entire class together for a group discussion segment. Give each group a few minutes to present their findings, insights, and questions related to their assigned topic. Facilitate discussions where groups share challenges, discoveries, and any areas of confusion. Encourage interaction among groups by inviting questions and comments from peers. Ensure the discussion involves best practices for managing local and global variables to reinforce the relevant concepts further.
Summary
Summarize the key takeaways from each group's presentation. Provide clarifications on any misconceptions or questions that arose during the discussions. Emphasize connections between different topics and highlight the significance of the day's learning.
Lab Activity
Transition to the lab portion, where students engage in hands-on coding exercises, code analysis, and code commenting that reinforce the concepts discussed earlier. Provide coding challenges that involve variable scope, default arguments, function overloading, static variables, and variable passing by reference. Allow students to apply the knowledge through problem-solving and critical thinking which they acquired during the self-directed learning phase. Present code optimization challenges that provides students with program code that can be optimzed using local/global variables and passing variables as reference. Encourage the use of ChatGPT for experimental group instead of relying on the instructor to get help or for feedback.

APPENDIX J

Rubrics for Assessment of Test (Applying Level)

Program A

Write a C++ program that takes an integer input from the user and determines if it's positive, negative, or zero. Use if-else-if conditions to achieve this. Display an appropriate message based on the input.

Rubrics

Criteria	Excellent (4 points)	Proficient (3 points)	Basic (2 points)	Needs Improvement (1 point)	No Attempt (0 points)
Code Functionality	Determines integer nature accurately using if-else-if conditions and displays appropriate messages..	Minor issues present, such as incorrect determination in specific cases.	Major issues impacting the core functionality of the program.	Fundamental errors prevent the program from working as intended.	No attempt made or code does not compile/execute.
Code Readability and Structure	Code is highly readable and structured, following best practices.	Minor readability issues or inconsistencies in structure.	Readability affected due to unclear naming or formatting.	Lack of comments or messy structure impacts understanding.	No attempt made or code lacks basic structure/comments.
Problem-Solving and Logic	Clear and efficient logic with proper implementation of if-else-if conditions, handling all cases accurately.	Mostly logical, but some edge cases may not be handled properly.	Logical flaws impacting the correctness of the output.	Major logical errors or incomplete understanding of problem-solving strategies.	No attempt made or code lacks coherent logic.

Rubric Scoring Guide

- **12 points per criterion:** Excellent understanding and execution across all criteria.
- **9 points per criterion:** Proficient performance with some minor issues or areas for improvement.
- **6 points per criterion:** Basic understanding with noticeable deficiencies or errors.
- **3 points per criterion:** Substantial improvements needed across multiple aspects.
- **0 points per criterion:** No attempt made or code doesn't compile/execute properly or lacks critical functionality.

Program B

Create a C++ program that calculates the factorial of a given positive integer using a while loop. The program should also include input validation to ensure only positive integers are accepted.

Rubrics

Criteria	Excellent (4 points)	Proficient (3 points)	Basic (2 points)	Needs Improvement (1 point)	No Attempt (0 points)
Code Functionality	Correctly calculates factorial of a positive integer using a while loop and validates input for positive integers.	Partially correct factorial calculation or errors in loop usage or validation.	Fails to calculate factorial correctly or lacks loop structure or validation.	Doesn't calculate factorial or lacks necessary loop structure or validation.	No attempt made or code doesn't compile/execute.
Code Readability and Structure	Code is highly readable, well-structured, and follows best practices.	Mostly clear code with minor readability issues or structure inconsistencies.	Readability affected by unclear formatting or naming conventions.	Lack of comments or messy structure impacting understanding.	No attempt made or code lacks basic structure/comments.
Problem-Solving and Logic	Clear and efficient logic with proper loop implementation and input validation.	Mostly logical, but with some issues in loop structure or validation.	Logical flaws impacting the loop or inefficient implementation of validation.	Major issues in loop structure or flawed logic or validation.	No loop structure or code lacks coherent logic or validation.

Rubric Scoring Guide

- **12 points per criterion:** Excellent understanding and execution across all criteria.
- **9 points per criterion:** Proficient performance with some minor issues or areas for improvement.
- **6 points per criterion:** Basic understanding with noticeable deficiencies or errors.
- **3 points per criterion:** Substantial improvements needed across multiple aspects.
- **0 points per criterion:** No attempt made or code doesn't compile/execute properly or lacks critical functionality.

Program C

Develop a C++ program to calculate the area of a circle using a function. The program should have a function named calculateArea that accepts the radius of the circle as a parameter and returns the area. Utilize this function to calculate the area of a circle with a user-provided radius.

Rubrics

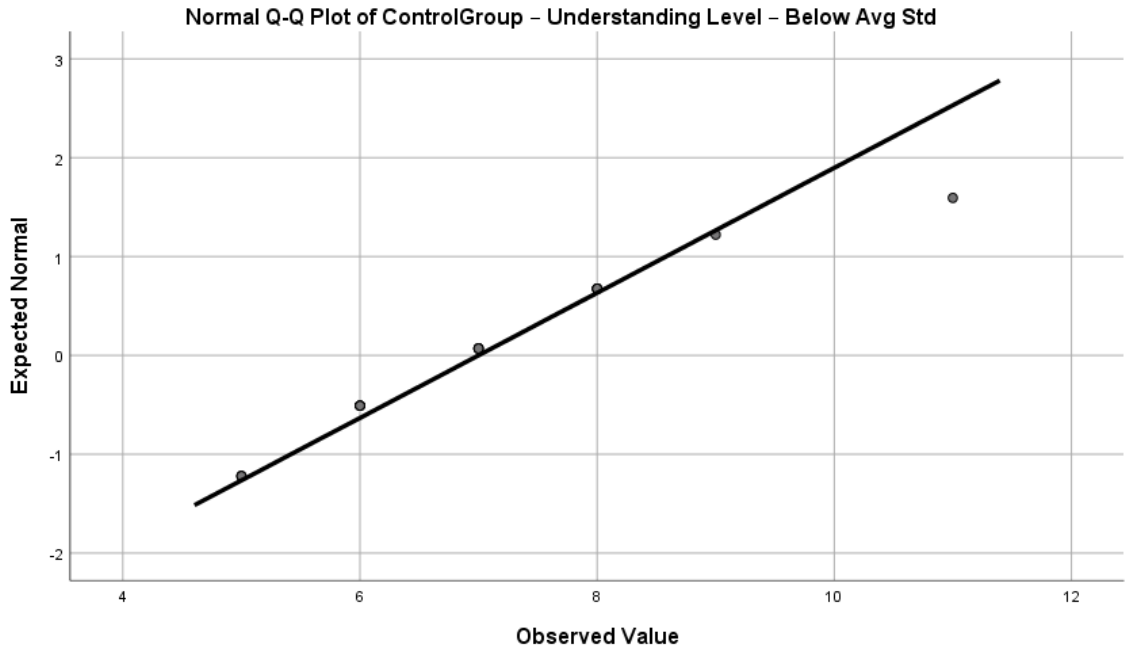
Criteria	Excellent (4 points)	Proficient (3 points)	Basic (2 points)	Needs Improvement (1 point)	No Attempt (0 points)
Code Functionality	Program accurately calculates the area of a circle using the provided function with input validation, proper parameter passing and return value.	Mostly correct calculation with minor errors in parameter passing or return value or validation.	Fails to calculate circle area correctly or lacks function structure or validation.	Doesn't calculate circle area or lacks necessary function structure or validation.	No attempt made or code doesn't compile/execute.
Code Readability and Structure	Code is highly readable, well-structured, and follows best practices.	Mostly clear code with minor readability issues or structure inconsistencies.	Readability affected by unclear formatting or naming conventions.	Lack of comments or messy structure impacting understanding.	No attempt made or code lacks basic structure/comments.
Problem-Solving and Logic	Clear and efficient logic with input validation, proper function implementation, including parameter handling and return value.	Mostly logical, but with some issues in function structure or return value handling or input validation.	Logical flaws impacting the function or inefficient implementation of parameters or return or validation.	Major issues in function structure or flawed logic in parameters or return value or validation.	No function structure or code lacks coherent logic in parameters or return or validation.

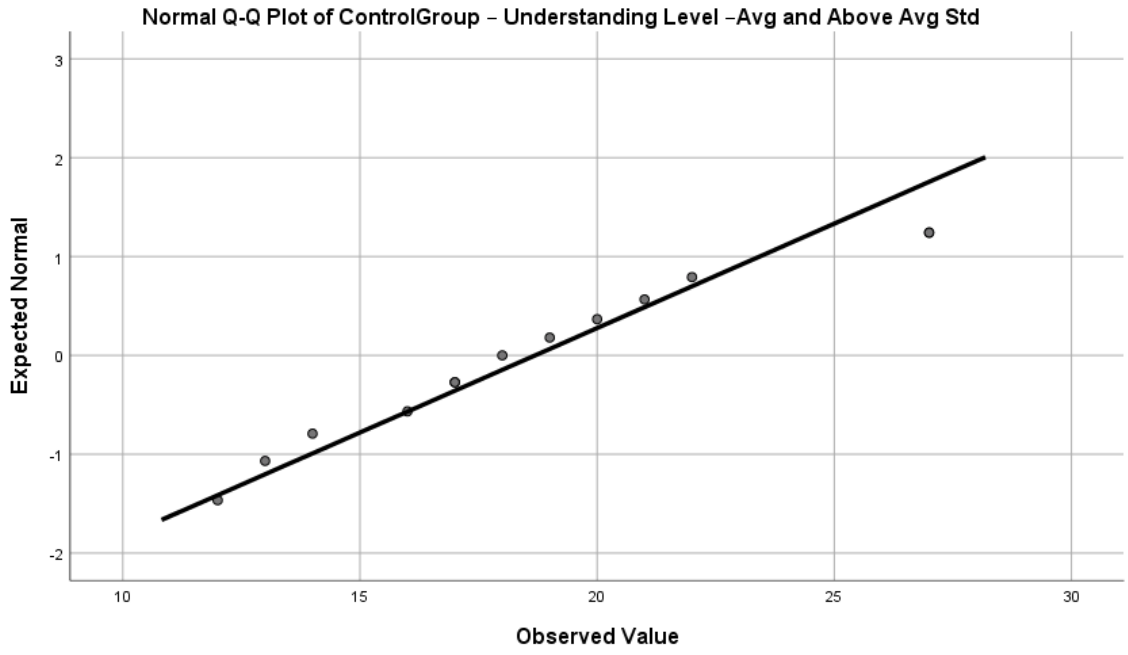
Rubric Scoring Guide

- **12 points per criterion:** Excellent understanding and execution across all criteria.
- **9 points per criterion:** Proficient performance with some minor issues or areas for improvement.
- **6 points per criterion:** Basic understanding with noticeable deficiencies or errors.
- **3 points per criterion:** Substantial improvements needed across multiple aspects.
- **0 points per criterion:** No attempt made or code doesn't compile/execute properly or lacks critical functionality.

APPENDIX K

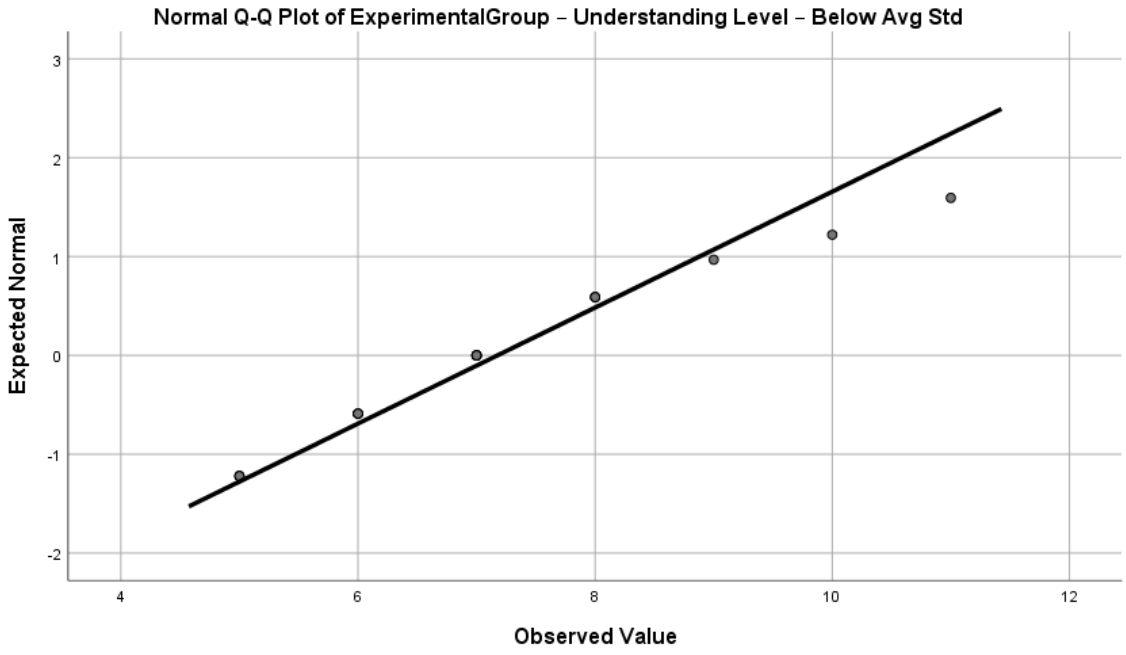
Normal Q-Q Plots of Data of Control Group – Understanding Level – Pretest

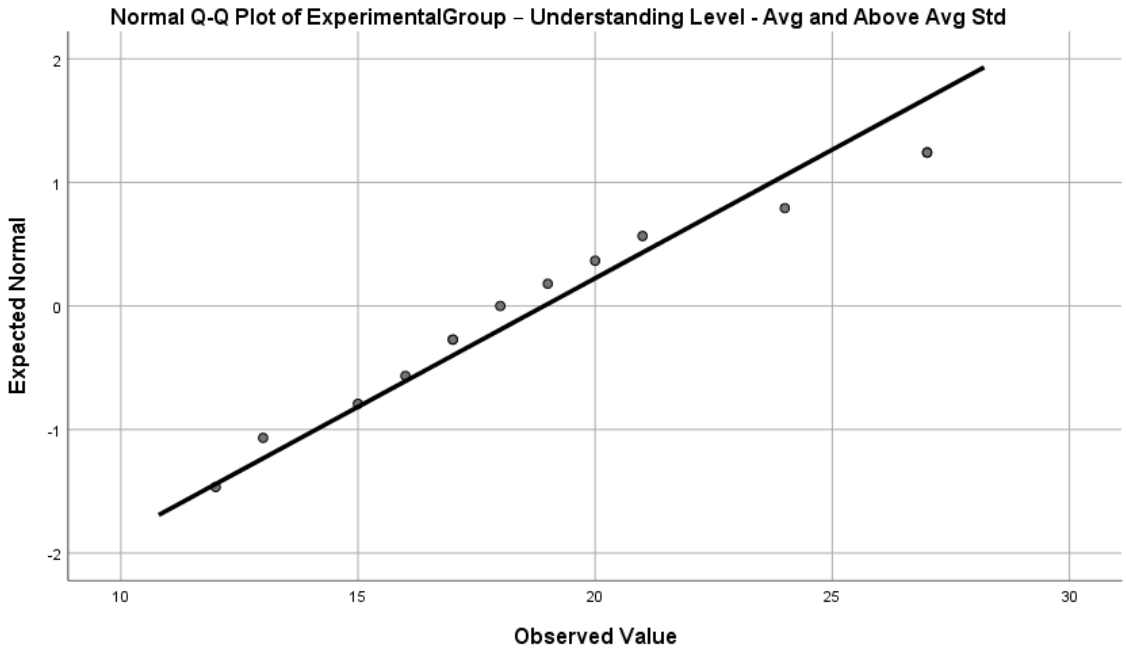




APPENDIX L

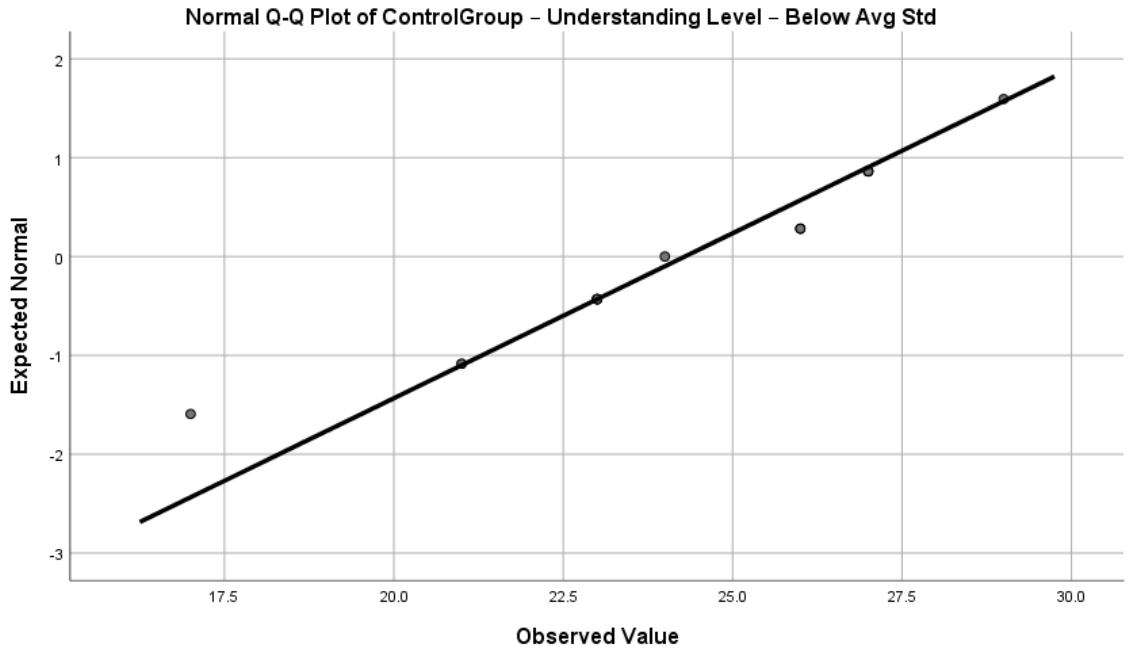
Normal Q-Q Plots of Data of Experimental Group – Understanding Level – Pretest

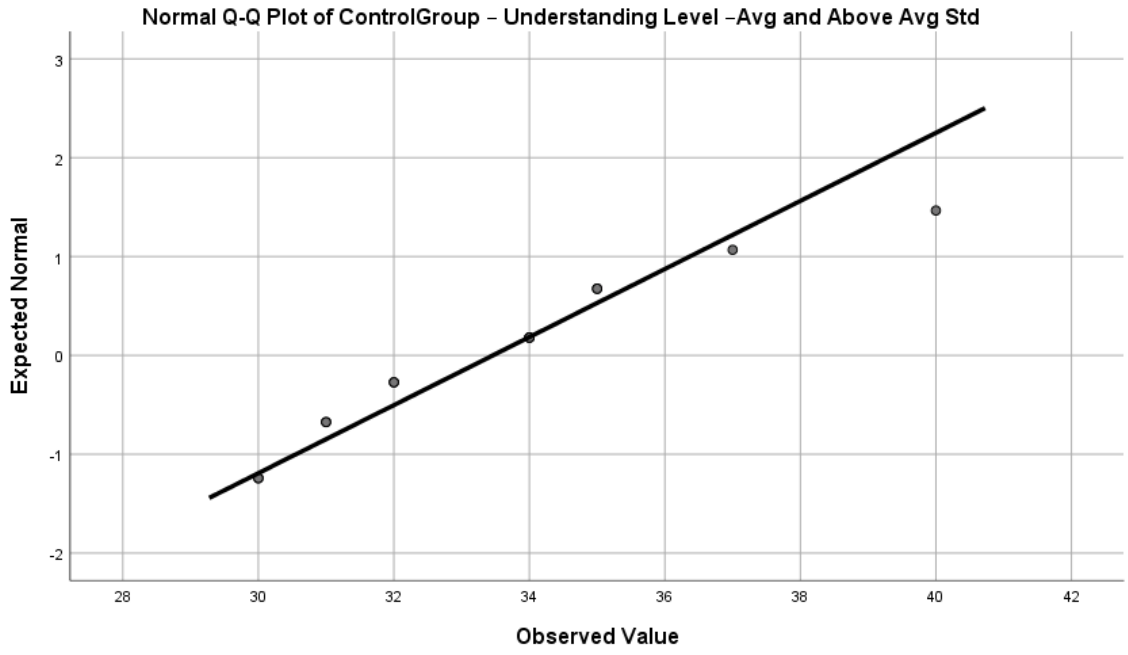




APPENDIX M

Normal Q-Q Plots of Data of Control Group – Understanding Level – Posttest





APPENDIX N

Normal Q-Q Plots of Data of Experimental Group – Understanding Level – Posttest