# Using Artificial Intelligence Tools in Teaching Students the Elements of Probability and Statistic

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# ABSTRACT

This study explores the affect of integrating Artificial Intelligence tools into teaching the probability and statistics course. The research had two directions to study. First if teachers integrating AI tools for teaching affects students academic performance and second if students usage and their attitudes towards ChatGPT affect their academic performance.

The research have been done in one of the universities of Almaty Kazakhstan. There were 74 second year students of engineering faculty studying probability and statistics course. The experiment took 15 weeks and quasi experimental method was used. There were two period of experiment traditional and experimental period, where in experimental period teacher integrated AI tools in process of teaching. Jamovi app have been used to analyse data , with the tests like Shapiro Wilk test, Correlation Matrix and Friedman Anova test.

Three hypothesis have been checked for and we could reject the first hypothesis and conclude that teachers integrating AI into their teaching does improve students academic performance. For the two other hypothesis about using and attitude of students toward ChatGPT we could reject both of them partly and conclude that if students use ChatGPT and their attitude towards it have negative correlation with their academic performance. It means the more they use ChatGPT, lower their academic performance and if they have positive attitude their academic performance is lower.

The study found the significance of using ChatGPT and other AI tools in probability and statistics course and some challenges that might occur. So instructors should take into account that challenges regarding students use of ChatGPT and guide them properly.

Key words: Artificial Intelligence, Chat GPT, probability and statistics, attitude, academic performance

# АҢДАТПА

Бұл зерттеу жасанды интеллект құралдарын ықтималдық және статистика курсын оқытуға біріктірудің әсерін зерттейді. Зерттеу екі негізгі бағытта жүргізілді. Біріншіден, егер мұғалімдер жасанды интеллект құралдарын оқыту процесіне біріктірсе, бұл оқушылардың үлгеріміне қалай әсер ететіні қарастырылды. Екіншіден, студенттердің ChatGPT-ті қолдануы мен оған деген көзқарасы олардың оқу үлгеріміне әсер ете ме деген сұраққа жауап ізделді.

Зерттеу Алматы қаласындағы Қазақстанның жоғары оқу орындарының бірінде жүргізілді. Зерттеуге инженерлік факультеттің ықтималдық және статистика пәнін оқитын 74 екінші курс студенті қатысты. Эксперимент 15 аптаға созылып, квази-эксперименттік әдіс қолданылды. Эксперименттің дәстүрлі және эксперименттік екі кезеңі болды, мұнда эксперименттік кезеңде мұғалім оқыту процесіне жасанды интеллект құралдарын енгізді.

Деректерді талдау үшін Jamovi бағдарламасы қолданылып, Шапиро-Уилк тесті, корреляциялық матрица және Фридман ANOVA тесті секілді әдістер пайдаланылды.

Зерттеу барысында үш гипотеза тексерілді. Бірінші гипотеза расталмады, нәтижесінде мұғалімдердің жасанды интеллект құралдарын оқытуға біріктіруі оқушылардың үлгерімін шынымен жақсартатыны анықталды. Екінші және үшінші гипотеза — студенттердің ChatGPT-ті қолдануы және оған деген көзқарасы үлгерімге әсер етеді деген болжам — ішінара жоққа шығарылды. Яғни, студенттер ChatGPT-ті неғұрлым жиі қолданса және оған оң көзқараста болса, олардың үлгерімі соғұрлым төмен болуы мүмкін деген қорытындыға келдік.

Бұл зерттеу ықтималдық және статистика курстарында ChatGPT және басқа жасанды интеллект құралдарын қолданудың маңыздылығын, сондай-ақ туындауы мүмкін кейбір мәселелерді анықтады. Сондықтан оқытушылар студенттердің ChatGPT-ті қолдануына қатысты осы мәселелерді ескеріп, оларды дұрыс бағыттауы қажет.

Түйінді сөздер: Жасанды интеллект, ChatGPT, ықтималдық және статистика, көзқарас, үлгерім

# АННОТАЦИЯ

В данном исследовании рассматривается влияние интеграции инструментов искусственного интеллекта на преподавание курса теории вероятностей и статистики. Работа велась в двух направлениях: во-первых, выяснялось, влияет ли использование преподавателями инструментов ИИ на академическую успеваемость студентов; во-вторых, исследовалось, как использование студентами ChatGPT и их отношение к нему соотносятся с их успеваемостью.

Исследование проводилось в одном из университетов города Алматы (Казахстан). В нем приняли участие 74 студента второго курса инженерного факультета, обучающиеся на курсе теории вероятностей и статистики. Эксперимент длился 15 недель и имел квази экспериментальный характер. Он включал два этапа — традиционный и экспериментальный. В ходе экспериментального этапа преподаватель интегрировал инструменты искусственного интеллекта в образовательный процесс.

Для анализа данных использовалось приложение Jamovi, с применением таких методов, как тест Шапиро–Уилка, корреляционный анализ и критерий ANOVA по Фридману.

В рамках исследования были проверены три гипотезы. Первая гипотеза была опровергнута, что позволило сделать вывод: интеграция инструментов ИИ преподавателями действительно способствует повышению успеваемости студентов. Что касается двух других гипотез, связанных с использованием ChatGPT студентами и их отношением к нему, они были частично опровергнуты. Это позволяет предположить, что активное использование ChatGPT и положительное отношение к нему отрицательно коррелируют с академической успеваемостью. Иными словами, чем чаще студенты используют ChatGPT и чем позитивнее к нему относятся, тем ниже их результаты.

Данное исследование подчеркивает важность использования ChatGPT и других инструментов искусственного интеллекта в обучении теории вероятностей и статистике, а также выявляет потенциальные проблемы, связанные с их применением. В связи с этим преподавателям рекомендуется учитывать данные аспекты и направлять студентов в правильное русло при использовании таких технологий.

Ключевые слова: искусственный интеллект, ChatGPT, теория вероятностей и статистика, отношение, академическая успеваемость.

# INTRODUCTION

The century of technology where day by day technology is improving and entering every aspect of our lives. In the 21st century technology has become one of the indivisible elements in our lives and in the last five years along with it Artificial Intelligence has become very popular and each and every one of us are now using it from daily tasks to specialized ones. So if we look through the definitions, what is Artificial Intelligence itself and what does it do? A quickly growing field of computer science that focuses on creating intelligent machines that can think and act like humans is Artificial intelligence (AI) (Deng, J. & Lin, Y., 2023). So the Artificial Intelligence tools are created to reduce the workload and make the tasks easier in most of the aspects of our life.

The history of artificial intelligence started from the Greek people , when they speculated that intelligent machines could be created. Later in the modern era the creation of artificial intelligence first began in 1956 in Dartmouth College. Back then it was the first gathering for creating Artificial Intelligence machines (Deng, J. & Lin, Y., 2023)..

There are a lot of types of AI tools nowadays being used. Some of the examples of AI tools are: Machine Learning (ML) Tools, Natural Language Processing (NLP) Tools, Computer Vision Tools, Robotic Process Automation (RPA), Expert Systems, Reinforcement Learning Systems and Generative AI Tools. All these tools are broadly used in many spheres and all of them have their sphere of influence and usage and all of them do different jobs.

One of the areas where AI is being used very broadly is the system of education, starting from the lower grades to higher education and up to university. AI is being used both by teachers and students for many purposes and by the researchers, master students, Phd students as well. As we are all living under the same circumstances no one can escape from today's conditions of living, coming to AI and integrating it to our life we have to learn to use it beneficially in order to reach improvements not going to disadvantages instead.

There are a lot of AI tools used in education for now like Intelligent Tutoring Systems (ITS), Adaptive Learning Platforms, Natural Language Processing (NLP) Tools, AI-Powered Assessment Tools, Automated Content Generation Tools, Visualization and Simulation Tools and so on. All of them do different things like generating ideas, answering questions, finding solutions and so on. One of the frequently used AI tools which all of us have heard and used daily is ChatGPT.

ChatGPT is a tool that was made by OpenAI and is based on the GPT language model technology (Kirmani, 2022). This chatbot is very smart and can do a lot of different text-based tasks, from answering simple questions to more complicated ones like writing thank-you letters and helping people have hard conversations about productivity problems (Liu, 2021). ChatGPT described by Deng & Lin (2023) as “ a natural language processing (NLP) system developed by OpenAI. It is designed to generate human-like conversations by understanding the context of a conversation and generating appropriate responses.”

Psychologist Sydney Pressey in Professor at Ohio State University mentioned about AI in education back in 1950 that “Devices which at once inform a student about the correctness of his answer to a question, and then lead him to the right answer, clearly do more than test him; they also teach him.” (Pressey, 1950).
So yes, ChatGPT has entered every aspect of the education system enormously. From students to professors and researchers all use it somehow for academic purposes.

Teachers use ChatGPT to create questions, tests, presentations and so on. While students use it to understand new topics, solve questions, translate texts, get ideas for their projects and so on. ChatGPT has become somehow the personalized tutor or assistant for people in the field of education.

There are debates around ChatGPT’s implication for education. Qadir(2022) praised ChatGPT for providing an adaptive and personalized environment, while there are other researches which note some risky sides of using ChatGPT for education. Susnjak(2022) mentioned about the negative effect of ChatGPT on students' higher order thinking skills and Cotton(2023) noted about the scientific integrity while using ChatGPT. Like this there are a lot of advantages and disadvantages of using ChatGPT in education which we will provide more detailed information in literature review about it.

The Probability and Statistics course is one of the important branches of mathematics which is used in many other majors and fields around the world like education, public health, social sciences, economics, engineering, and computer science. While being used in many fields the importance should be given to the education of this subject. Unfortunately as other math disciplines most of the students suffer in understanding, studying and applying probability and statistics courses to their life. As they don't know why they need this subject, they don't see the real application of it in life, understanding it will be difficult for them, for them it's again a bunch of formulas later used nowhere.

Unfortunately the traditional methods of math disciplines don't give students motivation to study or even try to understand them. In probability and statistics courses we need more new engaging and interesting methods. We need to give the visualization of concepts, imagination and idea of usefulness of the subject. Context-rich tasks, simulations, and applications have been found to enhance comprehension and memory (Chance, 2007). That's why recently many researchers are focused on math education methods to make it more engaging and improve the learning outcomes. As well there were several researches done in teaching probability and statistics courses.

The increasing accessibility of Artificial Intelligence (AI) tools such as ChatGPT, opens up new avenues for enhancing probability and statistics education. Both students and teachers are broadly using it. In this research we focused on teachers and students' use of ChatGPT in Probability and Statistics courses and how it influences the learning outcomes. So in our research teachers used ChatGPT in the teaching process and students as well, in the end we will be analyzing what changes will give us the use of ChatGPT by teachers and by students.

Problem statement

The use of AI, especially ChatGPT, is growing in the field of education day by day. There is a lot of research about how ChatGPT influences the process of teaching and learning in many fields like language learning, computer science, social sciences and so on. The benefits and limitations of applying ChatGPT in these fields have been determined somehow.

Probability and Statistics courses are one of the essential branches of mathematics used in many fields of our life today and have become indivisible disciplines in many branches of our academic and professional life. As ChatGPT is being used in teaching and learning of this subject as well, unfortunately there is not a lot of research about its impact on students' learning outcomes.

Therefore this research focused on the impact of ChatGPT on the process of teaching and learning. We will be analysing the integration of ChatGPT by teachers during the Probability and Statistics course and how it influences the students' learning outcomes. Another side of research will focus on student attitude toward ChatGPT from an academic perspective, its usage and reliance on ChatGPT and whether they have any correlation with learning outcomes. Overall we will see if integrating ChatGPT improves academic outcomes and does students' attitude toward ChatGPT have any effect on their academic performance and learning outcomes.

Research Questions

1. What is the impact of integrating ChatGPT into teaching methodologies on students' academic performance in probability and statistics?
2. How significantly does students' use of ChatGPT as an educational resource influence their understanding and academic performance?
3. Is there a significant correlation between students' reliance upon ChatGPT and their academic achievement in probability and statistics?
4. What is the impact of ChatGPT on students' motivation to engage with probability and statistics?

Research Objectives

1. To examine the impact of integrating ChatGPT into teaching methodologies on students' academic performance in probability and statistics.
2. To analyze the influence of students' use of ChatGPT as an educational resource on their understanding of the subject and academic performance.
3. To determine the correlation between students' reliance upon ChatGPT and their academic achievement in probability and statistics.
4. To explore the impact of ChatGPT on students' motivation to engage with probability and statistics

Hypothesis

1. Null Hypothesis ($H_0$): Integration of ChatGPT into teaching methodologies does not improves students academic performance in probability and statistics course.

Alternative Hypothesis ($H_1$): Integration of ChatGPT into teaching methodologies improves students academic performance in probability and statistics course.

2. Null Hypothesis ($H_0$): Students use of ChatGPT is not correlated to their academic performance.

Alternative Hypothesis ($H_1$): Students use of ChatGPT is correlated to their academic performance.

3. Null Hypothesis ($H_0$): Students attitude towards ChatGPT does not affect their academic performance.

Alternative Hypothesis ($H_1$): Students attitude towards ChatGPT affects their academic performance.

# 1. LITERATURE REVIEW

## 1.1 Introduction to literature review

Artificial Intelligence, one of the fast growing areas in all of the fields starting from education to medicine, has become very popular among people. Nowadays everyone is somehow using AI in their life and it's really easy and fast to use for solving certain problems. So what is Artificial Intelligence itself and from where did it come?

"AI is a branch of computer science that focuses on creating intelligent machines that can think and act like humans." (Deng, J. & Lin, Y., 2023). As mentioned by Deng and Lin, AI itself is a branch of computer science. All of the AI tools focus on creating a machine that can think and act like a human by using a huge source of data. Now AI has improved a lot and it's used in many fields. Now the question is where did it come from, how did it develop, what are challenges and benefits of AI particularly ChatGPT as we will be focusing more on it.

Further we will review articles related to the students' attitude towards AI, some ethical and equity concerns about AI and so on. Another part of the review will be about teaching Probability and Statistics courses, what methods have been used before and were they efficient or not, teacher readiness to imply ChatGPT or AI to their courses and development and some other sides of the dissertation topic.

## 1.2 History of ChatGPT and key concepts related to it.

There are many types of AI tools developed for different purposes, and ChatGPT is natural language processing (NLP) which uses algorithms to understand and communicate like a human. Back in 1956 in Dartmouth College the possibility of creating an Artificial Intelligence was discussed and after there were created different tools of Artificial Intelligence.

ChatGPT is a public tool that was developed by OpenAI based on the GPT language model technology (Kirmani, 2022). ChatGPT is an advanced chatbot competent at dealing with a range of text-based requests, from answering basic questions to completing complex duties such as creating gratitude messages and facilitating difficult conversations on productivity problems (Liu, 2021).

As Brockman(2016) mentioned OpenAI was founded in 2015. The company has released a lot of AI tools one of which is ChatGPT and now it has become very popular.

GPT: Generative Pre-trained Transformer was first developed in 2018. First version of GPT-1 was released in June 2018, after GPT was improved into GPT-2 and was released in February 2019. In June 2020 a much more powerful version of GPT-3 was released which contained more than 175 billion parameters. So all this three versions of GPT were trained to predict the next word in the sentences. The purpose of them was text generation, understanding, summarizing, coding, translating and so on. Later in November 2022 ChatGPT was released, the chat-based interface built on top of the GPT models like GPT-3.5 and later on a new version of GPT- GPT-4. In short we can say that the GPT is an engine of the car, the ChatGPT is the car itself which helps people to drive it easily.

Budzianowski and Vulić(2019) mentioned that the concept of ChatGPT are improved through a two-step process: The concepts behind GPT are refined through a two-step process: generative, unsupervised pre training with unlabeled data, followed by discriminative, supervised fine-tuning to enhance performance on certain tasks.

### 1.2.1 Key concepts related to ChatGPT

Natural Language Processing (NLP) is a domain of artificial intelligence that uses algorithms to analyze and interpret human language, including text and speech, in order to determine meaning and find appropriate data (Manning, C., & Schutze, H. , 1999).

Generative Pre-Trained Transformer(GPT) is a machine learning model that in order to understand and generate human-like language uses unsupervised and supervised techniques (Radford, 2018)

Language Model: The trained Artificial Intelligence in order to produce text that is similar to human language (MacNeil, 2022)..

Transfer Learning: Artificial intelligent tools like ChatGPT have the capability to use knowledge gained from one task in order to improve the performance in other related tasks.

Attention Mechanism: When making predictions, an attention mechanism is used in neutral networks in order to allow a model to focus only on specific aspects of input data (Niu, Z., Zhong, G., & Yu, H. , 2021).

Chatbot: King(2022) mentioned in his paper that a chatbot is a computer program especially designed over the internet to simulate conversation with human users. Similarly Chatbots interactive or conversational tools that provide prompt response to the used (Okonkwo, C. W., & Ade-Ibijola, A. , 2020).

Generative Model: A generative model is the model that creates new data , rather than merely categorizing or predicting using incoming data (Pavlik, 2023).

## 1.3 Artificial Intelligence in Education: Opportunities and Challenges

### 1.3.1 Artificial Intelligence in Education

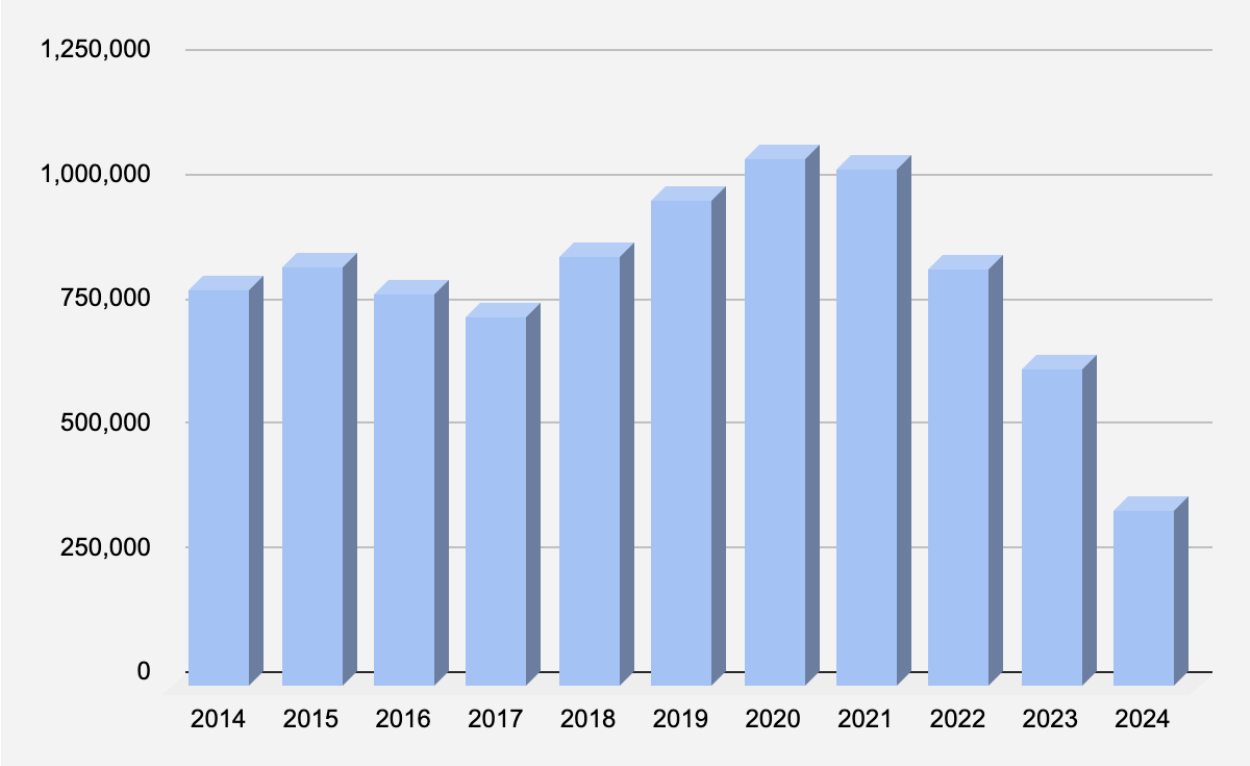
Artificial intelligence has been growing rapidly over the time in many fields. While integrating Artificial intelligence into education or any other field researchers were always concerned about its impact. While integrating AI or ChatGPT into education, what impacts is it going to give the students and teachers? Does its advantages overcome its disadvantages? Is it really helpful for teachers to use and will it be efficient? Will students using ChatGPT for their lessons, understanding concepts and other purposes of study help them to understand subjects better or will it be the reason for decline of their deep understanding of topics and higher order knowledge?

All these questions were concerning teachers and researchers around the world for a long time. Especially during COVID-19 when most of the schools and universities around the world shifted to online or distance learning, the use of AI grew

dramatically. At that time after 2019 the researchers around the world were concerned about AI in education. Even before that there was a lot of research done on this area, in order to understand the impact of AI in education, the challenges students and teachers may face, limitations of using AI for education, benefits and other questions were looked through.

The statistics of published articles taken from Google Scholar platform with the key word of "AI in education" from 2014 until 2024 has shown that in 2014 there were around 790,000 articles published on this field which has grown in 2015 up to 840,000 articles. However in 2016 and 2017 the amount of articles has declined by time and then in 2018 it started to grow again. A year after COVID-19, 2020 was the peak of the articles published about "AI in Education" with the number of 1060000 papers published as well in 2021 almost the same number followed it. But from 2022-2024 the amount of articles published in this field has declined by time, which in 2024 a total of papers published in Google Scholar were around 350,000. This decline can have a lot of reasons like the change of rules and regulations of Google Scholar, shift of the researchers area of interest and so on. But here we will be focusing on the most relevant ones which match our research and we will try to review the most important findings about AI in Education and especially about ChatGPT in Education.

*Figure 1.3.1 The articles published between 2014-2024 in Google Scholar about "AI in Education"*




We can see the illustration of the data in figure 1.3.1.

Alongside the increase in use of AI tools, most importantly ChatGPT in Education, a lot of research has been done to determine the opportunities which they can give to teachers, researchers, students and anyone else involved in the field of

education. A lot of the researchers have focused on opportunities and challenges that ChatGPT can give in the field of education.

### 1.3.2 ChatGPT can improve efficiency in education

Improved efficiency is one of the opportunities that ChatGPT can give teachers, researchers, students and administration in education. Improved efficiency means completing the tasks faster with less effort , while having fewer resources like time, energy and cost.

Deng and Lin(2023) in their article published in China in 2023 noted that ChatGPT can help to increase the efficiency by making the communication automatic. It means no human resources or effort needed for it, ChatGPT answers and solves the problems in real time, automatically without any human conversation. It eliminates the need for manual conversations, which can save time and resources. ChatGPT allows faster conversations by generating responses quickly (Deng, J. & Lin, Y., 2023).

Similarly Chen and Chen(2020), and Muneer and Alshater(2022) noted that ChatGPT increases the efficiency in education. After reviewing and analyzing different publications on the impact of AI in Education, Chen and Chen(2020) have noted that it has improved "effectiveness, efficiency, and quality of the work done by instructors". ChatGPT and other advanced chatbots, by automating certain tasks and processes can improve the efficiency of research. For instance it can be used to generate reports and summaries of research findings, or can extract and analyze the data (Alshater, M. & Muneer., 2022).

Malik(2023) noted in his research that ChatGPT can help in assisting with literature review. It can summarize and extract key information from a lot of academic literature and save time for researchers. So by saving time the researchers in the field of education can focus more on much more important aspects which include the methodology which they integrate into their experiment and so on. Similarly, Chan and Zary(2019) mentioned that AI tools can replace a significant amount of similar work and reduce the workload of teachers and administrators.

Through comprehensive semi-structured interviews Isiaku and Felix(2024) engaged 75 scholars in higher education in North Cyprus. The results of the study has shown that ChatGPT has a potential in improving educational efficiency, promoting innovation and helping with generation of new ideas.

So using ChatGPT in education by teachers, students and researchers can help them to improve the efficiency of their work. For teachers it can help them to save their time and improve the efficiency, effectiveness and quality of their work. It can also help instructors create their lesson materials much more effectively by using less effort and extracting from a wide range of resources the important ones. For researchers ChatGPT helps them for literature review, from a lot of papers to extract the most important ones and to increase the efficiency of their research.

### 1.3.3 Accuracy of solutions given by ChatGPT

Deng and Lin(2023) stated that ChatGPT can give more accurate answers than normal conversations with people or other communication tools. It is because ChatGPT is trained based on a large set of conversations, which lets it understand the context of

a conversation and generate right answers. A powerful natural language processing(NPL) system ChatGPT Improved Accuracy (CGA) model allows deep learning-based artificial intelligence(AI) architecture to produce more accurate and meaningful discussions (Deng, J. & Lin, Y., 2023).

Correspondingly, Muneer and Alshater(2022) revealed in their research that ChatGPT and other advanced chatbots can possibly improve the accuracy or research by finding and fixing the errors in data or analysis. For instance, ChatGPT could be used to check for errors or inconsistencies in financial data or to confirm the accuracy of research findings.

Kim et al.(2019) found out in their research that ChatGPT trained on a dataset of human-graded essays was able to grade essays written by high school students accurately, having correlation of 0.86 with the grades put by humans. The results of the research showed that ChatGPT was able to recognize the essential components of well-written essays and was able to provide comments that were identical to those of human graders. Chen and Chen(2020) noted that more and more data will be produced by AI systems to give a better understanding of the teaching and learning process, allowing for accurate content recommendation.

We have seen that there are researchers who found ChatGPT to be accurate in education, however there are also some other researches that contradict with the previous findings.

The accuracy and reliability of information given by ChatGPT Moreover, the accuracy and reliability of the information provided by ChatGPT raises serious issues. Even if it can produce answers to a large number of requests, there is a chance that the answers will be highly incorrect or prejudiced, especially if the training data has errors or biased.If inaccurate or prejudiced information is spread, such errors may have a negative impact on academic research and instruction (Isiaku, 2024). Some inaccurate outputs by ChatGPT were highlighted in giving references, citations, scientific conclusions and mathematical expressions (Foroughi, 2023).

There are concerns about reliability and accuracy of the information that ChatGPT produces in education. When asked about the potential ethical issues related (Adiguzel, 2023).

When using ChatGPT it is better to check for factual accuracy for the important information or solutions you are looking for. Sometimes ChatGPT can give errors or just do miscalculations.in mathematical questions ChatGPT let alone the important formulas, sometimes it can just confuse plus with minus in the process of solution and that is where all the solution will be incorrect. Like this ChatGPT can make mistakes in other fields of education as well like essay writing and so on.

In their research Dao and Le(2023) explained that ChatGPT has shown different levels of accuracy in solving mathematical questions, succeeding in topics which are more simple, but facing challenges when the questions get more complex.

As we noted before AI models can not always produce factually accurate answers. That's why it is highly recommended to check for factual accuracy while doing important tasks. When essays are written by ChatGPT the essential information should be checked for errors or inconsistencies. Use relevant sources to check for the

important information (Debby R. E. Cotton, 2024). Azaria et al(2023) also described in their research that although ChatGPT has a great potential in education, it still has limitations like inaccuracies and ethical concerns.

Finally from the papers we have looked through we can see that the results of research are divided into two groups, one saying that ChatGPT gives accurate results and the other group showing some concerns about the accuracy of the answers given. Mostly for simple tasks the accuracy of the ChatGPT can be high or in a normal range, however doing the complex tasks especially in mathematics it can be a problem because ChatGPT can get confused or doesn't have deep understanding of some mathematical problems. So it is highly recommended to recheck the responses we get from ChatGPT.

### 1.3.4 The effect of ChatGPT on motivation and engagement

Can ChatGPT improve the motivation of students to study more? Especially mathematics disciplines which many people do not have motivation to study as they think these are a bunch of complex formulas later used nowhere. We have found a lot of research done around the world which says that ChatGPT can improve the motivation of students to study. Now we will try to review the most relevant ones here.

Talking about motivation we can understand a lot of things. In education there can be a lot of motivation, motivation to study, understand , learn, work, teach, do research and so on. So can ChatGPT enhance these motivations or on the contrary it will reduce the motivation of people to learn and study more.

ChatGTP can enhance the motivation to learn for students. If we generally analyze how ChatGPT works we can see that it helps students to find questions quickly. Being efficient can be the reason for enhancing the motivation of students and teachers. Let's take a case where we need to learn a new concept or topic which we do not know anything about. There are several ways to do it, go ask someone who knows about it, search for it from libraries and books, look for it through the internet and another way is using AI tools like ChatGPT. ChatGPT gives timely answers immediately and another positive side of it is that it considers the level of the knowledge according to the request and explains the level you are ready to take if you give correct directions. This can be the reason that it can improve the motivation of people to study more. Cunnungham-Nelson et al.(2019) have mentioned in their research that one of the reasons for students' high motivation and achievement can be that it promotes and enhances personalized learning, which we have mentioned about before. So we can say that personalized learning and efficiency of ChatGPT can be a reason for students' high motivation to study and learn. Similarly Xia et al.(2022) mentioned in their findings that the primary results of applying AI can increase motivation and engagement.

There is also a lot of research noting the AI tools that boost motivation. Fiialka et al.(2023), Ngo(2023) and Nazari et al.(2021) have praised the incorporation of AI, highlighting advantages including improved engagement, motivation, and enthusiasm for learning. Interestingly, the majority of these studies have focused on smart AI tools like ALEKS, Smart Sparrows, Grammarly, Knewton, Codecademy and InstaTex,

emphasizing how well they support customized learning routes, offer immediate feedback, and enable task modification.

However there are also other findings contradicting the previous ones saying that use of ChatGPT can enhance motivation. Especially that findings are focused more on higher order thinking skills and creativity of their own. As ChatGPT and other AI tools give answers quickly and offer a wide range of solutions it can cause laziness to its users by time. People might be discouraged to work further themselves to perform several tasks and may depend on ChatGPT a lot which can reduce their motivation to work and perform without it.

ChatGPT may simplify the process of acquiring answers or information, perhaps diminishing students' incentive to engage in independent investigation and formulate their own findings or solutions (Kasneci, 2023).

Furthermore ,there has been an evolution toward asynchronous and self-directed learning, where students are allowed more flexibility to learn and do tasks at their own speed. Students who might have other obligations or who might find it difficult to attend in-person classes, or who skip their lessons out of other reasons can benefit from these tools, which enables them to work at a time that works for them. However the digital gap, where students in low-income or rural locations might not have access to the technology or internet connectivity required to fully participate in remote learning, has been brought to light by transition to online learning. Additionally, it carried with it difficulties like a lack of accountability, motivation and interaction (Baidoo-Anu, 2023) .

As we can see there are different points of views about ChatGPT and motivation. Some say it can boost motivation, others say it can reduce motivation. However the results depend on the type of motivation we are talking about. If we are talking about the motivation to work individually it can be both reducing and boosting depending on the person, as some people like to learn while interacting with people while others feel more comfortable to study alone which can be motivated more by ChatGPT, as it does not require human interaction. In general ChatGPT can boost and reduce motivation, it only depends on which area and how we are using it and under which condition we are using it.

### 1.3.5. Personalized learning by ChatGPT

Personalization in education is one of the key points to reach wanted learning and teaching outcomes. Personalized learning focused on each student's needs and style of learning and perception of information. Rather than traditional methods of teaching where for everyone there was one model, personalized style can help to enhance effectiveness of teaching and learning outcomes. There has been a lot of research about personalized learning styles. Especially in the era of technology and Artificial Intelligence growing, many researchers have focused on its effectiveness in the field of education to enhance personalized learning. We will look through some relevant articles published in the last few years about personalized learning and teaching by the help of ChatGPT.

ChatGPT remembers the conversations which were done during your interaction with it. It records all your conversations which can help it to understand you better and give responses according to the previous knowledge it knows about you. It can be very useful for personalized learning. In real life teachers when having a large number of students might not be able to personalize the teaching and remember everyone's capabilities at a time to work better with them. However as ChatGPT has the ability to respond to you based on the previous knowledge it knows that you can work better for students in terms of personalization (Haque, 2022). ChatGPT can give responses according to prompts and previous interactions (Shen, 2023).

ChatGPT works based on a large set of data. As we said before, it's humanized artificial intelligence. However it doesn't have consciousness and feelings, but based on the large amount of knowledge it has in all fields it can be adopted to act like a human, which can help for better interactions. Based on students' requests and needs it can give answers with different structures and tones. Aljanabi(2023) and Mohammadreza et al.(2024) noted that ChatGPT can give responses with different tones and structures.

Chatbots have the ability to save and remember the previous interactions which helps them to respond in a more personal way. By each interaction a person makes with chatbots the dialogues become more and more personalized (Mohammadreza Farrokhnia, 2024). Similarly other findings also highlight the ability of AI tools like ChatGPT, to remember and recall past interactions. By recalling past interactions they can offer prompt and better personalized assistance (L. Chen, P. Chen and Z. Lin, , 2020).

So when the education is personalized what are the benefits of it for students learning. This has been investigated and the benefits were noted by several researchers. When learning and studying, feedback is one of the key factors to help students see their roadmap. It helps them to determine the thing they are going through. When starting to study something we need to know if we are in the right way, did we choose the correct methods for it, is this method going to take me to the destination we are looking for and so on. All these things are related to personalized feedback which students need in the process of learning. For teachers it might be hard to give every student timely personalized feedback because of the big workload. However ChatGPT or any other AI tool is able to do this job instead of teachers. ChatGPT and other AI tools can provide adaptive and personalized feedback (Qadir, 2022).

There are many fields of education that need timely assistance for students to achieve better learning outcomes and academic performance. In math education personalized assistance is very important as studying and learning math is not very simple. All the topics are connected to each other and they need analysis all the time. For example, while solving one question the first thing we should do is to choose the right method to solve it, then we should follow several steps and be aware so that we don't make any mistakes in the process, because one little mistake like confusing minus with plus can result in totally incorrect results. This personalized assistance can be done by ChatGPT, efficiently, timely and cheaper. Chen et al.(2020) found in his research

that a ChatGPT can provide a personalized math tutoring to students which can result in enhanced learning outcomes.

Sallam (2023) showed how ChatGPT can offer individualized learning experiences and improve scientific writing abilities in healthcare students. About academic writing or essay writing also many researchers have focused on how they can be improved by ChatGPT or can it be even helpful (Rahman, M. M., & Watanobe, Y. , 2023). The results showed that ChatGPT can give personalized assistance to students in their academic works and essay writing and improve their scientific writing and comprehension (Sallam, 2023).

There are other findings which note that ChatGPT facilitates formative evaluation and individualized instruction (Willis, 2023). Formative assessment means ongoing assessment during learning or studying not after. This is done by teachers during classes however ChatGPT is also able to help with formative assessment in order to enhance student learning outcomes and academic performance. Another benefit is differentiated instruction which is not less important. There are different types of learners like visual, audial and kinesthetics. ChatGPT can help with the differentiated instruction based on the previous and current information about the person communicating with it and based on instructions given to it.

AI-driven educational systems are progressively being developed to facilitate individualized learning by adjusting the pace and substance of training to accommodate individual learning requirements. Akyuz(2020) and Natal'ya and Kopceva (2023) noted that these systems adaptively modify the learning trajectory according to a student's advancement, facilitating more efficient mastery of content. The adaptive capability is enhanced by data analytics, where AI systems assess learners' behaviours, performance patterns, and interactions in real time to teilor content delivery (Rane, 2023).).

In such environments, students receive tailored exercises and targeted feedback that represent their current level of comprehension, leading to more relevant and engaging learning experiences (Hirankerd, K., & Kittisunthonphisarn, N., 2020). By matching instructional materials to each student's distinct learning style, this method of instruction not only promotes differentiated learning but also increases learner autonomy and motivation.

We looked through the benefits of personalized learning by AI tools, how they affect students' learning outcomes positively and so on. However everything has its limitations along with the benefits. One thing cant be completely perfectly designed; it doesn't matter by whom and where. Many researches have found that ChatGPT enhances learning by personalized learning and noted many benefits of it from different perspectives, however there are other papers which noted that ChatGPT can't offer proper personalization for individuals.

David and Leticia(2023) noted in their research that however ChatGPT can offer a high range of solutions to the questions and help students a lot, its information can be general sometimes. When the information given is general in that case the answers given may lack personalization for individual students.

Similarly other researchers offered for more research to be done about personalization by ChatGPT. More research is required to demonstrate how this kind of individualized learning may actually take place and how best to use this tool to support students' individualized learning in various settings (Xia, 2022).

In general ChatGPT is able to offer personalized tutoring and learning which may help students and educators to teach and learn more effectively. Alongside this when the learning is personalized it may have other effects on students ' learning as well. One of the benefits that it has is that it encourages informal learning and supports underserved populations (Jain, 2018). Another important thing for students is motivation and achievement in the process of learning. Cunningham-Nelson et al.(2019) has mentioned in his research that personalization of learning promotes motivation and achievement. So personalization is really important and AI can be of a big help about this topic. As noted by Lodge et al.(2023) AI tools have the potential to enhance accessibility, personalisation and overall learning experience.

### 1.3.6. ChatGPT and creativity

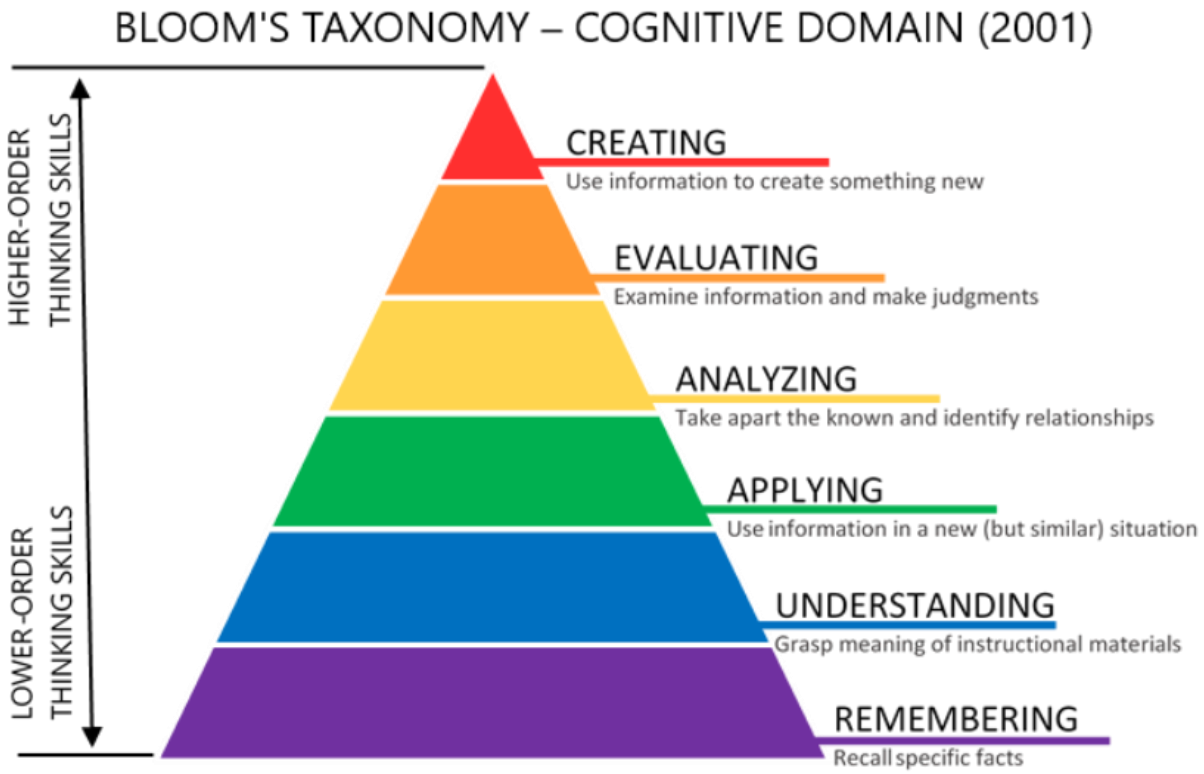
In the process of learning we have two categories of thinking: lower order thinking skills and higher order thinking skills. Benjamin Bloom has created the Bloom’s taxonomy which shows the orders of thinking. It starts from remembering the information. It generally recalls some specific information. After remembering comes understanding. It generally means grasping the meaning of the instructional materials, not just recalling them. After remembering and understanding the information the next step comes application of it. Application in new but slightly similar situations not completely different. Those three steps are lower order thinking skills, where in general we work with the information we have, there is no need to create or develop something new.

Coming to higher order thinking skills it includes analyzing, evaluating and creating. We can say that analyzing is taking the information and taking apart the known and identifying the relationships. After analyzing the evaluation takes part. Evaluation is when we examine the information and make some judgments about it, if it's right or wrong, or is it relevant to what we are working on and so on. The last and highest element in Bloom's Taxonomy is creating.

Creating comes the last after all the steps described before. Creating is passing all five steps from remembering to evaluating in order to create something new. This is considered the highest point of learning. So in the era of technology and Artificial intelligence are there advantages or disadvantages for creating new ideas. Do AI tools like ChatGPT improve the creativity of students or does it damages the ability of them to be creative and create new ideas and things?

Below in figure 1.3.6.1 we can see the illustration of Bloom’s Taxonomy.

*Figure 1.3.6.1 Bloom's Taxonomy*




Now we will look through the papers that talk about ChatGPT and creativity. There are two sides of this topic. The first one is that ChatGPT gives creative results and the second is does it improve the creativity of people or decline their creativity. Isiaku et al. (2024) in his paper noted two sides of ChatGPT's effect. First it was mentioned that Artificial Intelligence was perceived as "a catalyst for heightened productivity, accelerated skill acquisition, enhanced creativity, and the generation of novel ideas." This result of his was in general understanding . When narrowing down to specific fields different results were found after experiment.

The participants were concerned about the limitations of ChatGPT, especially its impact on creativity. Isiaku et al. (2024) noted that "Concerns have been raised about ChatGPT's potential to restrict creative thinking because of its finite idea pool." there are answers of students concerned about ChatGPT's impact on creativity:

"ChatGPT might have a detrimental impact on writing abilities… potentially lowering the quality of writing and encouraging a practice of text dumping by research writers."

" ChatGPT could potentially impede writing proficiency, leading to a decline in the standard of written content and fostering a habit among researchers of excessive information Inclusion."

Malik et al.(2023) acknowledged that ChatGPT's effect on creative thinking can be different which depends on its usage and alignment with educational objectives.

Similarly Kasneci et al.(2023) noted a very important point about usage of ChatGPT. It was found out that ChatGPT can lead to over dependance for both teachers and students. He mentioned that for students it can lead to:

"a decline in their higher-order cognitive skills such as creativity, critical thinking, reasoning, and problem-solving. This is because the use of ChatGPT can result in simplification of the process of obtaining answers or information, which can have a negative impact on the students' motivation to perform independent research and arrive at their own conclusions or solutions"

So researchers findings may lead us to think a little bit when trying to apply ChatGPT to study as it has a high possibility to decline higher order thinking skills which is very important for most of the fields and for our life. That's why as education is becoming more and more dependent on Artificial Intelligence and we can't escape the use of it we have to know how to lead students and to where. As we cant escape usage of AI we have to put our focus on developing student's higher order thinking skills such as creativity and critical thinking (González-Pérez, L. I., & Ramírez-Montoya, M. S. , 2022).

David and Lecitia(2023) in their findings mentioned that generative models can only give answers and solutions according to the data they have and which are seen during the training, which can limit the originality and creativity of the responses given. Based on the information taken before it can't go beyond it and create something new that havent seen before. Similarly Ziegler et al.(2019) found that generative model-based music composition systems which generate music based on data given before, have a limited ability to create diverse and original melodies. This research tells us that ChatGPT can have a lot of information however while creating responses its answers can be limited on the creativity side that can't be compared to human abilities for sure.

In contrast to David and Lecitia(2023) and Ziegler et al.(2019) there are other researchers who noted that ChatGPt creates creative responses. The use of AI technologies also equips students with 21st century abilities, such as creativity and critical thinking, which makes it easier to evaluate and assess complex skills (Luckin, 2016)and encourages deep thinking through AI (Chiu, 2023b).

Similarly Eke(2023) mentioned in his findings that:

"A wide range of tasks can be accomplished by ChatGPT, including language translation, text summarization, question answering, creative writing (such as poetry or fiction), generation of high-quality long or short form content (such as blog posts), responding to prompts in conversation, explaining complex subjects, concepts, or themes, and fixing errors in existing code or generating new codes".

As we have noted there are different findings about ChatGPT and creativity. While one says that it improves the creativity of students, others say that it reduces it. Also about the creative results there are also contradictions between findings. In general we can say that it doesn't matter what we have to train our students and educators in terms of AI usage. However, it's very developed and helpful. Now we should consider the drawbacks of it and be cautious about them. Not relying fully on ChatGPT and any other AI tool, but focusing on enhancing understanding and learning outcomes and academic performance.

### 1.3.7. Limited capabilities of ChatGPT and its dependence on data.

Alongside having benefits everything has its limitations too. ChatGPT can be improved, advanced for now and perform a lot of different tasks, but it has its limitations too. Isiaku et al.(2024) mentioned in his research the limitations of ChatGPT as limitations in algorithmic bias and AI information retrieval , AI produces content using training data and may have limited data sources, danger of spreading false information. Limitations in the extent of information retrieval and the possibility of algorithmic bias are additional difficulties when using ChatGPT, because AI depends on the trained algorithm and the available data sources, biases and errors could appear in the output (Isiaku, 2024).

Another problem facing while using ChatGPT is generating wrong information. ChatGPT relies only on the data it has but if we ask some question which is out of the sources it has it will make up information which does not exist which leads to serious problems. David and Lecitia (2023) mentioned in their research that ChatGPT has limitations like generating wrong information, biases in data training , which can augment existing biases and privacy issues. Even with all of the potential educational advantages, ChatGPT currently has a number of significant built-in flaws, including producing incorrect responses and fabricating articles. Qadir(2022) gave an example in his research that while doing research the author asked ChatGPT to generate books and articles related to his research paper, ChatGPT generated make-up articles which did not exist at all and even gave bibliographic details of the article with a URL which didn't exist. These limitations about fake articles and books have been reported in other researches as well. Also when ChatGPT was asked about its limitations while used in education it provided information and gave a make-up article “Ribeiro and Vala, 2020” to support its information which did not exist at all (Baidoo-Anu, 2023).

Similarly Deng and Lin (2022) mentioned about the limitation that it can only produce texts based on the input given to it and it can not access outside data or browse the internet. This implies that it cannot produce answers to difficult or unusual queries and cannot offer precise or current information on a variety of subjects. Another drawback is that ChatGPT may generate responses that use offensive or biased language because it was trained on a big dataset of human language. It is very important that ChatGPT users understand these restrictions and apply the model correctly. From another side Cotton et al. (2023) noted that due to their frequently limited language skills, chatbots may generate content that is not exactly human-like, contains repetitious words or phrases, or uses strange or inconsistent terminology.

Another limitation which has a great impact and worries the instructors is about academic integrity while using ChatGPT. Even professors are worried now to use essays as a form of assessment as it can be written by ChatGPT easily (Eke, 2023)

Another limitations mentioned by researchers are:

- The lack of human ability to assess the trustworthiness of data it was trained on (Lecler, 2023)
- To evaluate the accuracy of the generated information (Sallam, 2023) Similarly Azaria et al.(2023) also mentioned inaccuracy of the information given.

- It does not have access to internet which has limited knowledge of the world events (Stokel-Walker, C., & van Noorden, R., 2023)
- Fabricates the references which does not exist in reality (Choi, 2023)
- Its impact on the development of lateral competencies (Sánchez-Ruiz, 2023).

Seerisha et al.(2024) mentioned that in mathematics education ChatGPT can have its positive impacts as improved learning experiences but we should consider the limitations while using it to get better, effective and responsible implementation. Mathematics education is especially related to higher order thinking skills and needs careful consideration while implementing ChatGPT into its education.

Similar to the research before Muneer and Alshater (2022) listed six limitations of using ChatGPT which we will try to review in a table to become more clear. We can see the limitations in table 2.3.7.1

As we have seen there are a lot of limitations about ChatGPT usage in any other field and especially in education. As education is one of the most important fields in any society where all other professions and professionals go through education to gain knowledge, we have to be careful in terms of implementation of ChatGPT in education. One negative impact or any other withdrawal which ChatGPT can have in education can have bigger effects on everyone's life, as future doctors, lawyers, teachers, economists etc study for society's future. If we only control this part, education, then we can be more relieved about the rest of our life. As the CEO of OpenAI, company which developed ChatGPT said:

"ChatGPT is incredibly limited but good enough at some things to create a misleading impression of greatness. It's a mistake to be relying on it for anything important but a preview of progress. We have lots of work to do on robustness and truthfulness."

In table 2.3.7.1 we can see the six limitations given about ChatGPT usage mentioned in one of the researches. The six limitations are dependence on data quality, limited domain knowledge, ethical considerations, potential for misuse, dependence on technology, redundant, clichéd, or irrelevant to the subject matter. We can see their definitions below in the table one by one. The research have been made three years before in 2025 so in the period of three years there might be a lot more limitations found or the current limitations might have been converted into advantages by some other researches.

*Table 2.3.7.1 Limitations of the use of ChatGPT mentioned in a research article of Muneer and Alshater(2022)*

| | |
|---|---|
| Dependence on data quality | The quality and applicability of the data that ChatGPT and other sophisticated chatbots are educated on have a significant impact on their performance. The chatbot's performance may suffer if the training data is skewed, lacking, or otherwise problematic. |
| Limited domain knowledge | The inability of ChatGPT and other sophisticated chatbots to effectively analyze or interpret data or findings may result from their lack of domain knowledge or competence in economics and finance. |
| Ethical considerations | Many ethical questions are brought up by the use of ChatGPT and other sophisticated chatbots in economics and finance research, including the possibility that the bots will eventually replace human labor or reinforce biases in the data they are trained on. Researchers who use ChatGPT and other sophisticated chatbots in their work must carefully weigh these ethical considerations. |
| Potential for misuse | There is a chance that ChatGPT and other sophisticated chatbots will be abused or utilized for malevolent or immoral ends, including creating spam or pretending to be other users. Researchers must be mindful of this issue and take precautions against their chatbots being abused. |
| Dependence on technology | The functionality and performance of ChatGPT and other sophisticated chatbots are dependent on the underlying technology's current condition. The performance and capabilities of chatbots may evolve as technology does, necessitating that researchers modify and update their techniques. |

| | |
|---|---|
| Redundant, clichéd, or irrelevant to the subject matter | The language model may lack sufficient context for the subject matter, resulting in the generation of responses that are either irrelevant or overly generic. |

### 1.3.8 Concerns about academic integrity

From the ancient times it doesn't matter when or where academic integrity was one of the main concerns of educators and policymakers. Academic integrity in the process of learning and in exams or during any other assessment is one of the most important parts of education. Every time there were ways to cheat for students, like cheating from one another or by cheat sheets. Now by the era of technology the risk of cheating has grown as it's easier now to cheat for students, it doesn't matter when and where now all of us have an access to the internet which gives us a lot of opportunities to study and improve ourselves. At the same time access to internet raises the risk of cheating and academic integrity.

As AI tools and ChatGPT have improved and everyone is now using it especially for educational purposes the risk of cheating has increased. Many researchers and educators are worried about it and have mentioned the risks of ChatGPT on academic integrity. Mohammadreza et al.(2024) noted that challenges to education encompass a deficiency in contextual comprehension, threatening of academic integrity, perpetuation of inequality within educational systems, normalization of plagiarism, and a decline in higher-order cognitive abilities.

Similarly other researchers mentioned the risk of ChatGPT usage on exams and education.Since ChatGPT's launch, numerous worries regarding online assessment security and exam cheating have been voiced (Garg, M., & Goel, A., 2022) Susnjak(2022) stated that the legitimacy of online tests may be at stake because of ChatGPT's ability to produce writing that appears human, particularly in higher education settings where these tests are becoming more common. Additionally, it has been demonstrated that ChatGPT is capable of answering test questions in the legal and medical domains (Kung, 2022).

In an empirical investigation, Fijačko et al. (2023) showed that, compared to earlier research employing other AI tools, ChatGPT's responses to university life support tests were, on average, correct, pertinent, and substantially more aligned with resuscitation criteria. Like this academic integrity is seriously threatened by ChatGPT's performance, particularly in higher education (Debby R. E. Cotton, 2024).

In academic circles, questions have been raised about ChatGPT's legitimacy, acceptability, and applicability. According to Oguz et al. (2023), these issues revolve around their capacity to support the writing of scholarly articles (Dwivedi et al., 2023) and thorough discharge summaries (Patel, S. B., & Lam, K. , 2023). These concerns cast doubt on the objectivity of studies carried out in the fields of education and other professions. Nonetheless, the ethical issues surrounding the use of ChatGPT in a

learning environment must be acknowledged. Their use may give rise to a number of ethical and academic integrity concerns (Eke, 2023).

Potential plagiarism is a major worry because ChatGPT may unintentionally produce content that looks similar to previously published works, which could cause students to unintentionally break academic integrity rules by neglecting to properly credit the created information.

However there are a lot of concerns about the academic integrity, when ChatGPT is used there are researchers noting that despite academic integrity it can help a lot. Lin(2023) in his research stated that even if there are concerns about academic integrity, ChatGPT can foster learning environments when it is used ethically, by promoting deeper learning and better outcomes for students.

Despite many concerns about academic integrity AI tools can also be used to foster honesty and academic integrity. For instance with the use of TurnItIn technologies like revision aid and Pearson's Write-to-Learn tools, AI has been utilized to promote and nurture honesty and academic integrity as well as enhance learning and studying (H. Sutton, 2019)

So ChatGPT and other AI tools can be a high risk for academic integrity, but when used properly it can foster learning outcomes. Also AI tools can be used also to enhance academic integrity like Turnitin which checks for plagiarism. It is like Artificial Intelligence tools are creating risks and from another side looking and creating solutions, however we don't know in the future how it is going to impact our life. There are two possibilities: either it will be a great tool for improving all the fields or it will impact in a very negative way by declining the higher order thinking skills. Michael Hopf has said that “Hard times create strong men. Strong men create good times. Good times create weak men. And, weak men create hard times.”

### 1.3.9 Ethical Issues of Artificial Inlelligent tools

One of the challenges that we can face while using Artificial Inlelligence can be the ethical issues it have. While integrating AI tools for teaching and learning we have to consider the etical issues that AI have. These ethical issues include data privacy, algorithmic bias and so on.

One of the main problems that we can face is data privacy. AI can but there are potential risks for misuse, fraud or any consensual policy, as there are no clear data governance policies of Artificial Intelligence. Kerr(2020) in his work have noted that educators should inform students of how AI based platforms source, store and utilize users information, in order to preserve trust and avoid legal conflicts.

*Table 1.3.9.1 The Table of opportunities which ChatGPT gives, descriptions ans the list of papers where this opportunities have been noted*

| **Opportunities** | **Description** | **Papers** |
|---|---|---|
| ChatGPT enhances efficiency | Improved efficiency means completing the tasks faster with less effort , while having fewer resources like time, energy and cost. Using ChatGPT in education by teachers, students and researchers can help them to improve the efficiency of their work | Chen and Chen(2020); Muneer and Alshater(2022); Deng and Lin(2023); Chan and Zary(2019); Isiaku and Felix(2024) and Malik(2023) |
| ChatGPT gives accurate answers | It gives more more accurate results than human, as the answers are based on a huge set of data | Deng and Lin(2023); Muneer and Alshater(2022); Kim et al.(2019) Chen and Chen(2020) |
| ChatGPT enhances motivation and engagement | ChatGPT promotes and enhances personalized learning which leads to enhanced motivation and engagement. | Cunnungham-Nelson et al.(2019); Xia et al.(2022); Fiialka et al.(2023); Ngo(2023) and Nazari et al.(2021) |
| ChatGPT provides personalized learning | Personalized learning focused on each student's needs and style of learning and perception of information. Rather than traditional methods of teaching where for everyone there was one | Shen et al.(2023); Haque et al.(2022); Aljanabi(2023); Mohammadreza et al.(2024); Chen et al.(2023); Ilieva et al.(2023); Rahman & Watanobe(2023); Qadir(2022); Willis(2023); |

| | | |
|---|---|---|
| | model, personalized style can help to enhance effectiveness of teaching and learning outcomes. | Noroozi et al.(2012); Sallam (2023); Akyuz(2020); Sireesha et al.(2024); Natal'ya and Kopceva (2023); Rane et al.(2023); Okonkwo &Ade-Ibijola(2020); Hirankerd & Kittisunthonphisarn(2020); Jain et al.(2018); Lodge et al.(2023) |
| ChatGPT enhances creativity | Creativity is one of the higher order thinking skills. It means after understanding, analyzing, evaluating some information then creating a new one, which is totally new. ChatGPT can help to improve higher order thinking skills and it gives creative results by itself. | Isiaku et al. (2024); Malik et al.(2023); David and Lecitia(2023); Ziegler et al.(2019); Luckin et al.(2016); Chui et al.(2023b); Eke(2023) |
| ChatGPT helps to improve academic integrity | AI tools can also be used to foster honesty and academic integrity. An example is Turnitin. | Sutton(2019); Crowe(2017); Murphy(2019) |

*Table 1.3.9.2 The Table of limitations which ChatGPT gives, descriptions and the list of papers where this limitations have been noted*

| **Limitations** | **Description** | **Papers** |
|---|---|---|
| Algorithmic bias | Biases in the training or the underlying design of the model are reflected in systematic and unfair tendencies in the answers | Isiaku et al.(2024) |
| generating wrong information | Information that appears credible but is factually inaccurate, deceptive, or completely made up. | David and Lecitia (2023); Cotton et al. (2023); Lecler et al.(2023); Muneer and Alshater (2022) |
| Privacy issues | Disclosure of data and the potential use or remembrance of user input. This is a critical topic for AI applications in ethics and education. | David and Lecitia (2023); Muneer and Alshater (2022) |
| Fabricating articles | It can make-up the articles and references which does not exist in reality. | Qadir(2022); David and Lecitia (2023); Choi et al.(2023) |
| Dependency on data | ChatGPT doesn't think, it only predicts answers based on the data it was trained on. That's why it is dependent on data. | Deng and Lin (2022); Stokel-Walker & van Noorden(2023); Muneer and Alshater (2022) |
| Academic integrity | ChatGPT can produce human-like responses which may be a risk to academic integrity. From another side it is easy and time saving to use which also raises the possibility | Eke(2023); Mohammadreza et al.(2024); Garg & Goel, 2022); Susnjak(2022); Kung et al.(2022); Choi et al.(2023); Fijačko et al. (2023); Cotton et |

| | | |
|---|---|---|
| | of cheating. | al.(2023); Oguz et al. (2023);Dwivedi et al.(2023);<br>Patel & Lam(2023) |
| Inaccuracy of data | As ChatGPT is highly dependent on data when there is no answer on the data it was trained on it will make up the results which cant be accurate all the time. Also it does not have the ability tocheckthe information it's trained on to confirm the accuracy of the results it gives. | Azaria et al.(2023); Cotton et al., 2024);<br>Dao and Le(2023) |
| Ethical considerations | Refers to the duty of developers, users and organizations to guarantee the equitable, secure and human value respecting application of Artificial Intelligence technologies. | Muneer and Alshater (2022) |
| Motivation | ChatGPT can decrease the motivation of students to work independently and think by themselves for new solutions. | Kasneci et al.(2023); David and Lecitia (2023) |
| Personalized learning | The information ChatGPT gives is generalized which may lack personalization. | Xia et al., 2022; David and Leticia (2023) |
| Creativity | As ChatGPT works and gives answers based on the data trained it can not be able to create new ideas not | *González-Pérez & Ramírez-Montoya, 2022;* Ziegler et al.(2019);<br>David and Lecitia (2023) |

| | | |
|---|---|---|
| | existing in its memory. From another side people become more dependent on ChatGPT which reduces their higher order thinking skills, like creativity. | |

Another key problem is the algorithmic bias, especially when Artificial Intelligent systems are used to assess student performance to adapt instructional material. When there is bias in training data in can results in unfair learning experiences or it can even misrepresent student abilities. Bulut et al. (2024) mentioned that ethical standards and regulatory frameworks are needed to guide the development of educational AI systems. So before everything else the privacy of the data is very important, thats why we have to explain to students the risks that it can have and guede them properly. Important information like bank account number, private information and so on shouldnt be given to AI systems if it doesnt have privacy policies.So we have looked through papers and tried to find out about opportunities and limitations that ChatGPT can have in education. In table 2.3.1 we can see the overall review of opportunities that ChatGPT can give. In table 2.3.2 we can see the limitations of the ChatGPT can have in education. These tables have been created to make the information more clear and in visual form.

## 1.4 Teaching Probability and Statistics

In today's fast-evolving education world, Artificial Intelligence has emerged across disciplines as a transformational tool. Within this integration into the pedagogy of probability and statistics, opportunities have arisen in personalized learning, adaptive assessment, and student engagement. Generally, traditional ways of teaching statistics and probability are faced with hurdles such as conceptual misunderstandings, anxiety related to mathematical content, and limited accommodation to learners' needs. AI tools like intelligent tutoring systems, machine learning algorithms, and language models such as ChatGPT can mitigate these issues. This review looks into recent research on AI in the teaching of probability and statistics and their effects, limitations, and teaching implications.

A lot of research is describing the fundamental problems which teachers and students are facing in teaching and learning probability and statistics. Students mostly struggle to understand some abstract concepts of probability such as conditional events, probabilistic inference and randomness. Highlighted in research how cognitive biases, such as gamblers fallacy or an inaccurate risk assessment, impair students capacity to learn (Chernoff, 2025). Also traditional teaching methods when used for teaching probability and statistics, which usually include memorization over conceptual comprehension, may stop students from using the knowledge taken in real world

situations. The problem may arise first because students did not understand the concept deeply enough to apply it in real world situations, second students may lose interest in studying probability and statistics as it may seem too difficult for them.

According to synthesis works, research in probability education has a long history and originates in psychology, statistics, and mathematics education (Batanero C. &., 2016). Teaching probability and statistics start in different levels of education in different countries. For example most USA states have taken away probability from primary school curricula and now they start studying it in lower secondary school (Langrall, 2018). In Central Asian countries as Kazakhstan, Tajikistan, Kyrgyzstan, Uzbekistan and Turkmenistan probability and statistics is taught at 10-11 grade in high school and at university according to the speciality.

Langrall(2018) in his research stated that students who only experience probability in secondary school but not primary, may not be able to fully understand the main probability concepts and be prepared for the later studies. In most countries students are taught from their primary school the concepts of probability and some statistics in order to develop their reasoning in this field. However when coming to the countries which start probability and statistics from high school it can be difficult for students to deeply understand the concepts and apply them to real world situations.

So teaching the students from an early age is one of the essential parts as well as the teachers knowledge of how to teach the students the concepts. If the teacher knows his or her subject very well and knows how to teach students according to their learning style, experience and so on then there will be improvement in students both understanding, implication and academic performance. Many schools and universities have programs for enhancing teachers' knowledge of subjects and teaching.

Apart from teaching general mathematics, teaching probability and statistics courses in early childhood education have many difficulties and not only. Explaining the concepts in higher education can be hard as well. Probability and Statistics is usually empirical and context-driven, when traditional mathematics frequently stresses abstraction and symbolic reasoning. This difficulty needs a unique method for preparing teachers who teach probability and statistics in order not only to teach the concepts, but at the same time to be professional both in conceptual knowledge and pedagogical flexibility. Just being professional and knowing the subject very well does not guarantee effective teaching, as for effective teaching both conceptual knowledge and teaching skills are needed.

Any teaching includes two essential elements: conceptual knowledge and pedagogical knowledge. If we combine both of them there will be positive impacts in teaching and learning. So we will look through these two elements.

Strong content knowledge is very important, as evidenced by a substantial body of literature. Research like that conducted by Batanero et al. (2004), Hourigan & Leavy (2020), and de Vetten et al. (2019) shows that PTEPs continue to struggle with basic statistical concepts like fairness, randomness, and informal inference. Further demonstrating the direct correlation between deep conceptual and procedural knowledge and instructional quality and student outcomes is Ma's (1999) comparative study of Chinese and American teachers.

Ball et al. (2008) make a distinction between "specialized content knowledge" and "common content knowledge," both of which are important for successfully instructing the probability and statistics course. Shulman (1986) mentioned in his research that content-only attention is insufficient without incorporating pedagogical strategies. Which tells us that content knowledge is a must for a teacher.

The second important element for teaching statistics and probability courses or any other course is pedagogical content knowledge. Understanding probability and statistics and being able to teach it are separated by pedagogical content knowledge. As mentioned by Heaton&Mickelson(2002) and Leavy(2010), even when PTEPs comprehend statistical concepts fully, it is usually difficult for them to create meaningful learning tasks or address student misconceptions. Which again highlights that without pedagogical content knowledge it's very difficult to teach students effectively and help them to understand and imply the knowledge.

By submerging PTEPs in practice-based learning, guided inquiry tasks (Heaton, R. M., & Mickelson, W. T. , 2002) and lesson study models (Leavy, 2010) provide promising frameworks. The ability to create researchable questions, evaluate students' works, and modify lessons are all essential elements of successful statistical instruction, all of which are enhanced by these experiences.

Redesigning preservice courses to better incorporate probability and statistics teaching is the goal of several initiatives. Metz(2010) have organized and updated undergraduate courses using the GAISE framework and NCTM standards. Similarly Bilgin et al.(2017) have created an online module that focuses on real world data analysis and interpretation. The necessity of consistency between the theoretical knowledge and classroom implementations have been highlighted by these programmatic interventions.

Groth(2013) in his research suggested a model course that included collaborative learning, lesson planning, and analysis of student misconceptions. These initiatives are in line with the suggestions made by Franklin et al.(2015) to organize preservice education using integrated and tiered coursework for teaching.

Increasingly, digital tools are used to support PTEP learning. Essential skills in probability and statistics education, data visualization and analysis can be facilitated by software including CODAP and TinkerPlots, according to studies by Frischemeier&Biehler(2018) and Casey et al.(2020). These researches have been done five years ago and now in 2025, AI tools are developing very quickly with different functions. There are many types of AI tools which can be used in education and in any other field. From generating information to creating graphics and images which are very important for teaching and learning. As well as the personalized learning and teaching assistant for more effective teaching and learning. These instruments let PTEPs design activities using the real world data and improve their teaching effectiveness and statistical thinking capacity.

Studies also reveal how PTEPs view statistics. Teachers have anxiety and perceived difficulty which affects their inclination to teach the subject (Estrada, A., & Batanero, C. , 2020). Especially female PTEPS and those without probability and

statistics course experience show more negative attitudes, suggesting a need for ongoing and effective support throughout training.

According to Denton's(2023) systematic review, two pillars of effective teacher preparation which are content knowledge and school based experience, are underrepresented in many studies. Even if they are included in guidelines for teacher preparation, only a small portion of studies specifically addressed AMTE standards connected to practice based learning and candidate reflection(AMTE, 2017).

There are notable expectations like Leavy's(2010) who used iterative lesson design and peer feedback and Heaton & Mickelson's(2002) who applied student inquiry in actual classrooms. These researches show us how transforming situated learning experiences can be for acquiring PTEP content knowledge as well as pedagogical competency.

Denton (2023) in his systematic review came to the conclusion that content development is widely discussed in much literature, however the pedagogical approaches and opportunities are now well represented.

In the field of teaching and learning as we understand, content knowledge is not the only thing. That's why many different types of methodologies have been experienced in the teaching field. We have also experienced teaching probability and statistics courses with the help of AI tools and wanted to see if it helps to enhance students academic achievement. Further we will look through integration of AI tools into the education of probability and statistics course. This will have contribution in field of math education which can help instructor and students to use Artificial Intelligent tools more effectively while knowing its advantages and disadvantages. In teaching any subject, instructor have to focus in content and methodology as we have mentioned before. If students are aware and given instructions about the methodology used for teaching it can increase the effectiveness of the new methods used for teaching.

# 2. METHODOLOGY

In this section we will look through the methodology that has been used in this research, starting from research design to participants and analyzing methods and so on. We are looking for if integrating AI tools in the process of teaching and learning improves students academic performance and their attitude toward the Artificial Intelligent tools. Research uses single group, time series queasy experiment design.

## 2.1 Research Design

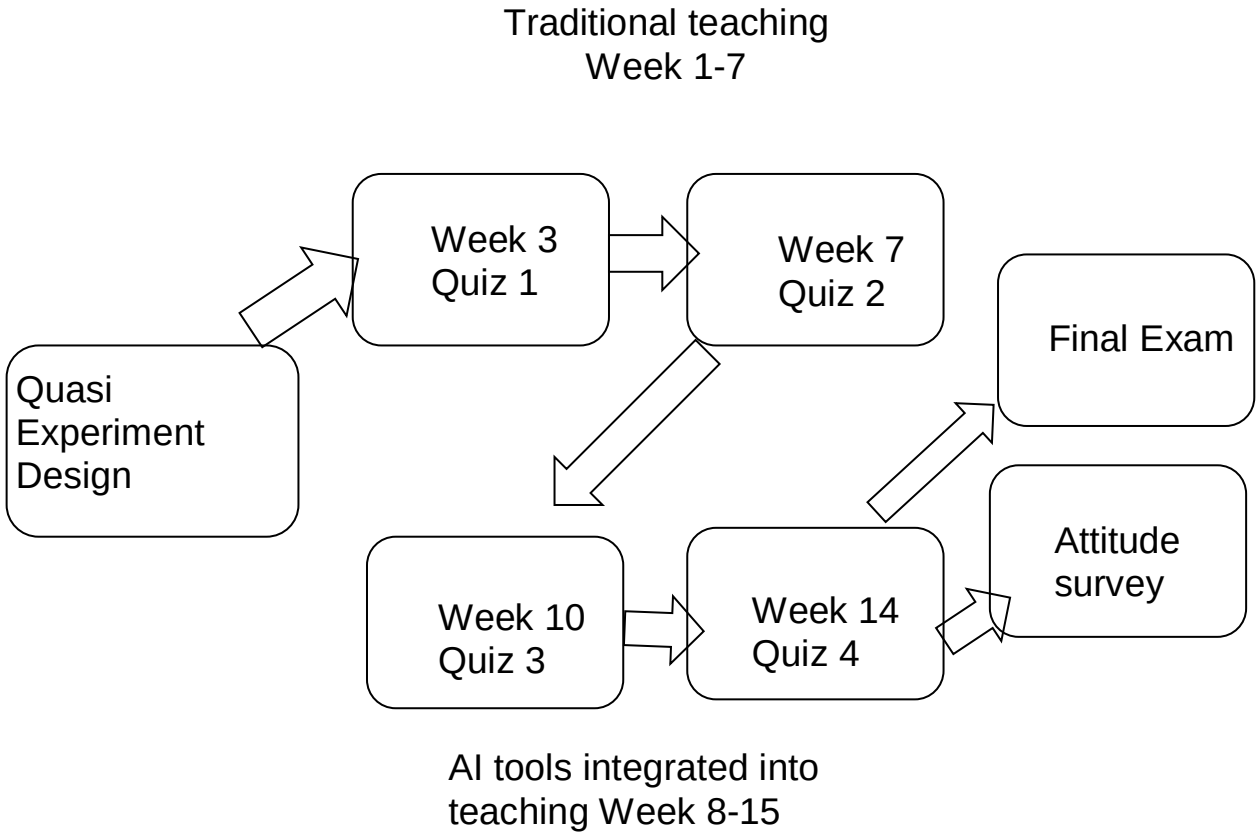
There are a lot of methods for performing research. If we look through the methods there are commonly three methods we can choose to perform our research: quantitative, qualitative and mixed methods. Creswell(2018) has described the difference between quantitative and qualitative methods as "in terms of using words (qualitative) rather than numbers (quantitative), or better yet, using closed ended questions and responses (quantitative hypothesis) or open ended questions and responses (qualitative interview questions)". So yes the quantitative method is saying by itself, we mainly focus on numbers and work with them, however when it is qualitative we focus more on words, on the quality of the information. As for mixed methods it is when we use both quantitative and qualitative methods together.

For this research we have chosen to use a quantitative method. The quantitative method has a lot of advantages to use like measurability, generalisability, clarity, efficiency and so on. When we have a large number of samples it is easier to use quantitative methods and later we can interpret the results to the larger population.

So the experiment design we have used for this research is single group, time series quasy experiment design. We use queasy experiments when we do not have random assignments of our sample groups. So it is a more natural realistic type of method which we evaluate and look through changes from the natural processes which happen. In this type of design we did not have traditional and control groups. Instead we had a group of students and we used a time series quasy experiment which means we did an experiment with the same group of students without assigning them to any other groups and dividing them and at some point we integrated new teaching instruments. With the help of some tools we looked to see if the academic performance of the students have changed before and after integrating new teaching AI tools by time through some phases.

The experiment was made in a period of 15 weeks of which the first 7 weeks students were taught probability and statistics courses with the traditional teaching methods. After the 7th week and the last 8 weeks, students were taught by the help of some AI tools like ChatGPT and Gamma app. ChatGPT and Gamma app were systematically integrated into classroom instruction in classroom, generating questions for homeworks, for creating quizzes and final illustration development for better understanding of some concepts in Probability and Statistics courses. The students academic performance has been measured by the help of four quizzes and one final exam. Quizzes have been taken every one month to check the improvement over time. We can see the illustration of the timeline of experiment in Figure 3.1.1.

*Figure 3.1.1 Quasi-experiment design timeline of the experiment*




## 2.2 Participants

The research have been done in one of the universities of Almaty. The participants were second year students of engineering faculty studying in different majors, like mathematics statistics, computer science, machine learning and so on. There were 74 students of Probability and statistics course participating in this course. The age of students ranging from 18-21. All of the participants were taught by the same instructor during 15 weeks and all the instructional methods were the same for everyone without any discrimination. The population of the research was students studying Probability and Statistics course. There are many types of methods when coming to sampling, convenience sampling is one of the easiest and convenient once as we can tell from its name. For choosing sample from population convenience sampling have been used, which means all of the students who were enrolled in the researchers course have been chosen for experiment.

The students have been informed about the experiment and its purposes. Also they were provided with informed consent. Students were also informed that the experiment is not going to affect their grades or it does not have anything to do with the relationship between instructor and students based on the experiment outcomes.

## 2.3 Instructional Procedure

The instructional procedure started at the beginning of the academic year. One semester the course has been taught as well as the experiment has been performed.

The first 7 weeks were the weeks of traditional instruction methods. Every week there were two lessons, each lesson was 75 minutes long. During this period of time students were taught by the traditional methods, by normal slides, using white board and books. All the illustrations, examples and definitions were directly taken from the instructional book that had been chosen by the instructor and had been confirmed by the faculty at the beginning of the semester. During this time no AI tools have been used for teaching. As students come to solve problems and homeworks most of the time they use AI tools regardless of whether teachers use it or not.

The next eight weeks the AI assisted phase of the experiment had started. After teaching students seven weeks with traditional methods, the rest of the time AI tools have been integrated into instruction to see if there will be any development on students' academic performance over the time, before and after integration of AI tools in the teaching process.

Various tools have been integrated into the teaching process. ChatGPT has been used to generate real life questions for the topics passed during those weeks, for generating homeworks which had a lot of problems of a similar nature to help students understand the concepts and their applications better. ChatGPT was also used to create quizzes and final questions, by the instruction given to it about the level of the knowledge of students and what should be tested exactly. ChatGPT was also used for the guidance of how to teach certain topics step by step, and how to make some topics more interesting for students. The structure of the lesson, what should be done during which phase, how to make the division of time and so on. In general ChatGPT was like a teacher assistant and also giving systematic guidelines for more effective classes.

Probability and Statistics courses are one of the important disciplines of mathematics used in many fields nowadays. But many people find it hard to understand. As we know there are three types of learners in general: visual, audial and kinesthetic. For Probability and Statistics course visualization is very important in order to let the students better understand and imagine the concepts they are learning. For this purpose when integrating AI, Gamma app was used to create more understandable and visual presentations. Another tool, Canva AI, has been used to create visual graphs and charts for some concepts of Probability and Statistics like poisson distribution, normal distribution, exponential distribution , uniform distribution, geometric distribution and so on.

During the second phase where AI tools were integrated into class, the instructor explained to students the benefits of using AI tools and how to use them properly to enhance learning orally. So the students were aware that in the last eight weeks the materials were taught by the help of AI tools..

## 2.4 Assessment Instruments and Data Collection Tools

There were two instruments for collecting the data from the students. The first one was for academic assessment and the second one was an attitudinal assessment of students toward ChatGPT, as ChatGPT was the main instrument integrated into the process of our teaching and from observations majority of students use ChatGPT for their studies.

Academic Assessment: in total there were four quizzes taken from students during the semester and at the end of semester on the final exam. Quiz one and Quiz two were taken in the first seven weeks where the instruction was by traditional methods. Every three- four weeks one quiz was performed from the topic which had been covered in that period of time. After seventh week Quiz three and Quiz four have been performed in the period of AI integration into teaching. At the end of the semester, a final exam was taken from everyone which covered all the topics passed from the first week until the end of the semester.

For every quiz there were a total of seven questions and two variations in order to prevent cheating of students from one another. For every quiz there were questions of different difficulty levels starting from easy to hard ones. A total of 100 points were appointed to every quiz and the points have been divided into questions according to the level of its difficulty. Additionally for every quiz there was a bonus task of seven points for helping students to get some extra points. The bonus tasks were only included in quizzes but not in final examination. For every quiz 60 minutes have been given to students to solve questions. For the final exam there were a total of seven questions making up 100 points. 120 minutes have been given to students to complete their final examination and there were three variations of the final exam for students.

Sample quiz and final exam are given in Appendix you can check for reference.

Also ChatGPT have been used to create exercises for class and homeworks for student in experimental period. In Table 2.4.1 sample questions are given that have been generated by ChatGTP.

Attitudinal survey: the survey has been created and taken from the students at the end of the semester. The survey has been created using other research questions and ChatGPT. The questions have been chosen carefully which were reliable to our sample and what we were focused on. After creating the survey by researchers it has been validated through expert feedback of two instructors in mathematics education. The survey consisted of 46 questions in total, one of which was to ask the name and surname of the student. The rest of the questions were all Likert scales ranging from 1(totally disagree) to 5(totally agree). The survey has been taken through google forms in online form, which is easier for analyzing and is not time consuming. The students had 10-15 minutes to complete the survey. After the survey has been completed after analyzing three key constructs with 3-4 questions in each, they have been chosen to perform further research.

*Table 2.4.1 Sample questions created by ChatGPT for exercise and homework*

| |
|---|
| Let the joint PDF of $X_1$ and $X_2$ be<br>$f(x_1, x_2) = 4x_1(1 - x_2), if\ 0 \leq x_1 \leq 1\ and\ 0 \leq x_2 \leq 1$ and 0 otherwise<br>1. Find the marginal PDF of $X_1$<br>2. Find the marginal PDF of $X_2$<br>3. Compute P($X_1 \leq 0.2$)<br>4. Compute P($X_1 \geq 0.5$ and $X_2 \leq 0.5$)<br>5. Find the conditional PDF $fx_2\|x_1(x_2\|0.4)$ |
| Let the joint PDF of $X_1$ and $X_2$ be<br>$f(x_1, x_2) = 3/2(1 - {x_1}^2), if\ 0 \leq x_1 \leq 1\ and\ 0 \leq x_2 \leq 1$ and 0 otherwise<br>1. Find the marginal PDF of $X_1$<br>2. Find the marginal PDF of $X_2$<br>3. Compute P($X_1 \leq 0.4$)<br>4. Compute P($X_2 \geq 0.3$ and $X_2 \leq 0.2$)<br>5. Are $X_1$ and $X_2$ independent? |
| Let the joint PDF of $X_1$ and $X_2$ be<br>$f(x_1, x_2) = 4x_1x_2, if\ 0 \leq x_1 \leq 1\ and\ 0 \leq x_2 \leq 1$ and 0 otherwise<br>1. Find the marginal PDF of $X_1$<br>2. Find the marginal PDF of $X_2$<br>3. Compute P($X_1 \geq 0.3$)<br>4. Compute P($X_1 \geq 0.6$ and $X_2 \leq 0.4$)<br>5. Are $X_1$ and $X_2$ independent? |
| Let the joint PDF of $X_1$ and $X_2$ be<br>$f(x_1, x_2) = 3/128{x_1}^2, if\ 0 \leq x_1 \leq 4\ and\ 1 \leq x_2 \leq 3$ and 0 otherwise<br>1. Find the marginal PDF of $X_1$<br>2. Find the marginal PDF of $X_2$ |

3. Compute P($X_2 \leq 0.2$)
4. Compute P($X_1 \geq 0.4$ and $X_2 \leq 0.5$)
5. Find the conditional PDF $fx_1|x_2(x_1|0.5)$

Let the joint PDF of $X_1$ and $X_2$ be

$f(x_1, x_2) = 1/15, if \ -2 \leq x_1 \leq 3 \ and \ 1 \leq x_2 \leq 4$ and 0 otherwise

1. Find the marginal PDF of $X_1$
2. Find the marginal PDF of $X_2$
3. Compute P($X_2 \leq 0.2$)
4. Compute P($X_1 \geq 0.4$ and $X_2 \leq 0.5$)
5. Find the conditional PDF $fx_1|x_2(x_1|0.5)$

## 2.5 Data Analysis.

The Jamovi app, statistical software has been used to perform analysis of the data. The analysis was quantitative and consisted of different tests. First of all, all the data have been analyzed for normality by the Shapiro Wilk test. Further, according to the results of the Shapiro Wilk test, a type of further analysis has been chosen.

Correlation matrix have been used to see the relationship between academic performance and attitude of students toward ChatGPT. According to normality test either Spearman's or Pearson's correlation have been chosen for correlation matrix. Also descriptives have been performed by Jamovi app.

For analyzing the progress of students by time and quizzes Anova Friedman test was used. After Anova Friedman Pairwise comparisons have been performed using the Durbin Conover test.

## 2.6 Ethical considerations.

While performing the experiment all the ethical issues have been considered. The students have been informed about the experiment and its purposes in the beginning of classes. During the experiment it was made sure that the participation of students are voluntary and it does not affect their grades and attitude of the instructor toward the students. All of the students have been given online informed consent form about the experiment. In the process and in the end of the experiment it was made sure that the anonymousness of the students were kept confidential. However in survey taken in the end of the semester names and surnames of the students were asked, it was only for analysis purposes. In order later to check for the relationship between students academic performance and their attitude names of students were collected. However further during analysis and any other procedure the names of the students will not be revealed in any costs. Only researches has access to the names of the students, when performing analysis and showing the results students will be coded like Participant1,

Participant2 and so on. After the analysis of the data is finished all the data which have been collected will be deleted completely in the period of six month.

All of the participants in the current study were older than 18 years old and all of them participated voluntarily. The integration of AI tools for the purposes of enhancing academic performance was the experiment of the current study and students were aware that they are being used for educational purposes.

# 3. RESULTS

## 3.1 Introduction

This chapter presents the results of the data analysis after the quasi experiment method has been used to see if integration of AI tools especially ChatGPT improves academic performance and if it the academic performance of students have anything to do with their attitude toward ChatGPT in Probability and Statistics course. The data were collected from 74 students studying in the second year of university in the period of 15 weeks of study. In this chapter we will present both the results of analysis of four quizzes and one final, also the results of the attitude survey.

The results in this chapter will be organized according to the hypothesis of the study. In total we have three hypotheses to be tested and according to them we will perform the data analysis and present the results. First the changes in quiz results will be analyzed before and after integrating ChatGPT in teaching and presented. Second, the correlation between students' academic performance and their usage of ChatGPT will be analyzed and presented. Lastly, the effect of students' attitude will be checked on their academic performance.

## 3.2 Integration of ChatGPT into teaching methodologies and students academic performance in probability and statistics courses.

Now we will look through the changes occurred by the time when ChatGPT and other AI tools were integrated into teaching probability and Statistics courses.
First of all we can see in Table 4.2.1 below the descriptive statistics of all four quizzes and the final exam. As we can see, the total number of students analyzed results are 74. Mean , median, standard deviation and other statistics are shown in Table 4.2.1. As we can see from the results the means of the quizzes before and after integrating ChatGPT into teaching have grown significantly. The mean of Quiz 1 and Quiz 2 are 57.8 and 69.7, where the means of Quiz 3 and Quiz 4 are 65.8 and 82.8, where we can notice an elevation of the results in quiz four more than other quizzes and quiz three is more than quiz one. However the first two or even three quizzes didn't show very high results but the mean of the final exam and quiz four were very good of average 82.8 and 79.6.

So we have seen the results of the descriptives. We can tell that there are differences in the results of academic performance before and after integration of ChatGPT, but we look more into it to prove it statistically. First of all below in Figure 3.2.1, Figure 3.2.2, Figure 3.2.3, Figure 3.2.4 and Figure 3.2.5 we can see the distribution of quizzes and final exam.

*Table 3.2.1 Descriptive statistics of quizzes 1, 2, 3, 4 and final exam*

| | **Quiz 1** | **Quiz 2** | **Quiz 3** | **Quiz 4** | **Final** |
|---|---|---|---|---|---|
| N | 74 | 74 | 74 | 74 | 74 |
| Missing | 0 | 0 | 0 | 0 | 0 |
| Mean | 57.8 | 69.7 | 65.8 | 82.8 | 79.6 |
| Median | 57.0 | 70.0 | 62.5 | 85.0 | 80.8 |
| Standard deviation | 22.1 | 21.3 | 23.7 | 16.0 | 11.7 |
| Minimum | 12.5 | 1.00 | 20.0 | 32 | 50.0 |
| Maximum | 100 | 100 | 100 | 100 | 100 |

All of the figures have been created using Jamovi software. From the visuals we can see that Quiz 1 and Final exam are normally distributed. But to check statistically we can use the Shapiro Wilk test. Performing normality tests is very important, because we can choose the type of test to perform after we know if the data is normally distributed or not.

Table 4.2.2 shows the results of the Shapiro Wilk test which we performed to check for normality. If the p value is less than 0.05 then it means our data is not normally distributed, otherwise it is normally distributed.

We can see that the results of Shapiro Wilk p value is more than 0.05 for Quiz 1 and Final exam which confirms the normal distribution of data. Quiz 2, Quiz 3 and Quiz 4 are not normally distributed.

*Table 3.2.2 Shapiro Wilk test results*

| | Quiz 1 | Quiz 2 | Quiz 3 | Quiz 4 | Final |
|---|---|---|---|---|---|
| N | 74 | 74 | 74 | 74 | 74 |
| Shapiro-Wilk W | 0.98 | 0.94 | 0.94 | 0.89 | 0.97 |
| Shapiro-Wilk p | 0.38 | 0.003 | 0.003 | <0.001 | 0.151 |

*Figure 3.2.1 Distribution of test scores of Quiz 1*

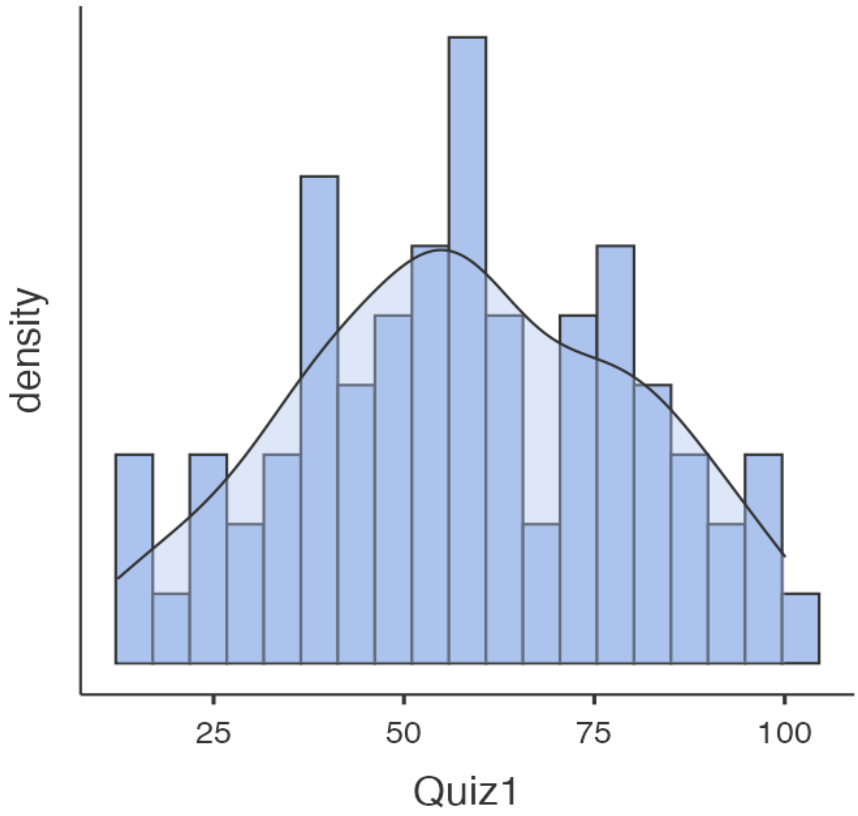


*Figure 3.2.2 Distribution of test score of Quiz 2*

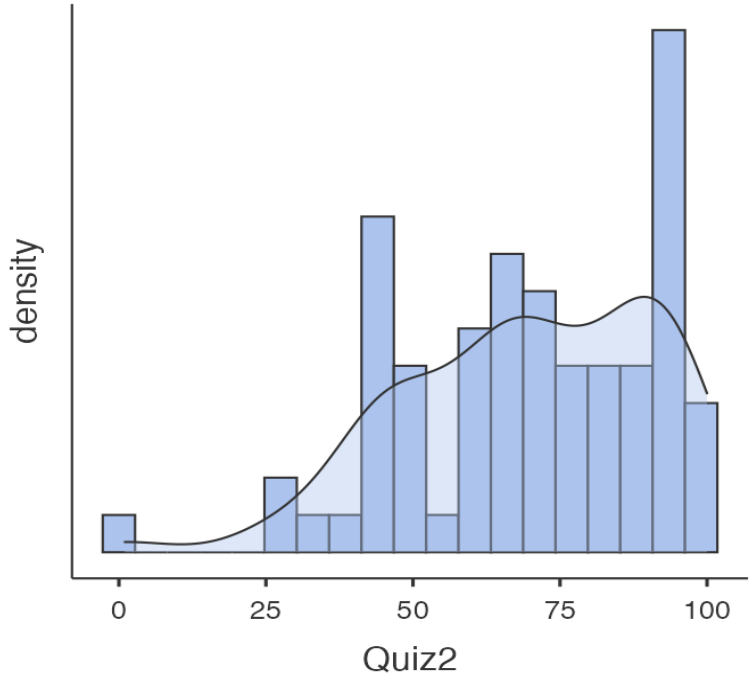



*Figure 3.2.3 Distribution of test score of Quiz 3*

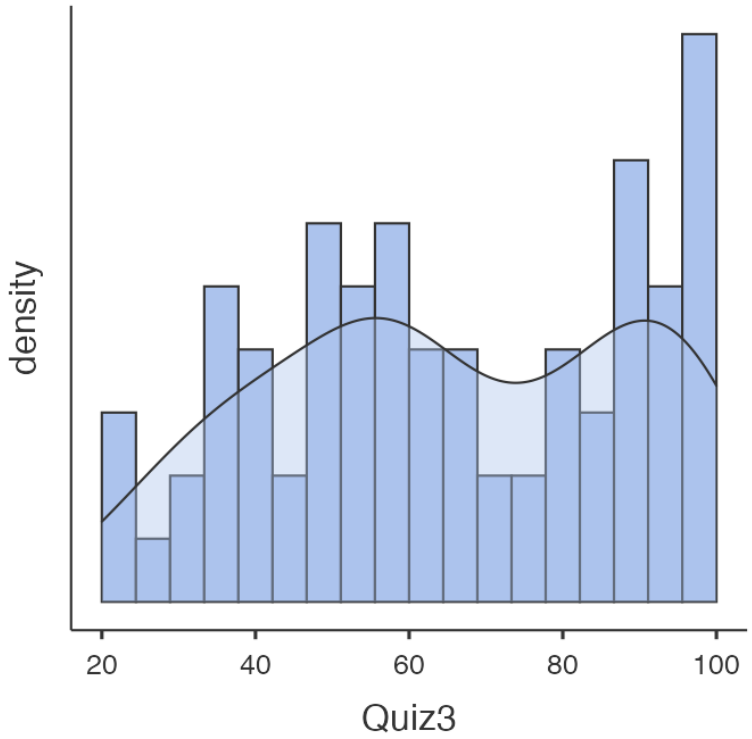


*Figure 3.2.4 Distribution of test score of Quiz 4*

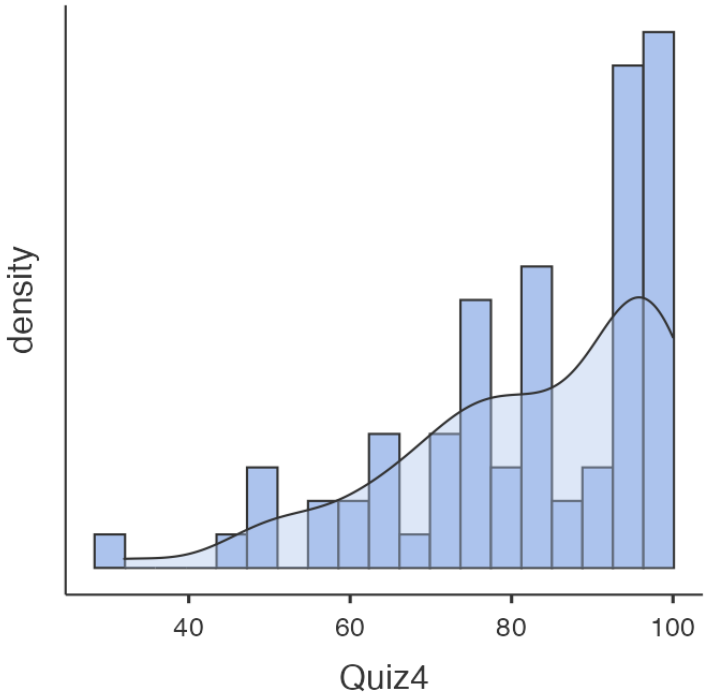
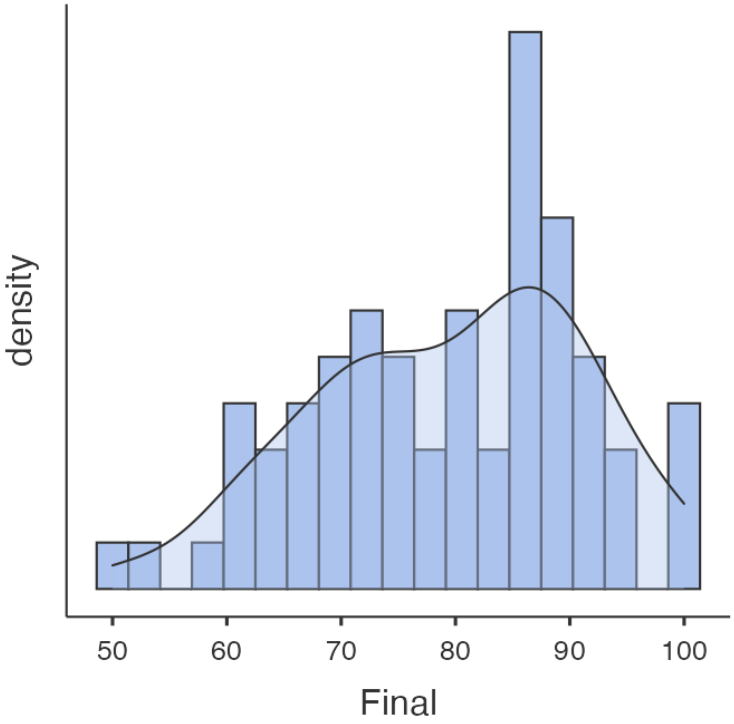



*Figure 3.2.5 Distribution of test score of final exam*



After checking for normality we chose the Anova Friedman test to check if there were any significant differences in quiz scores and finals in the period of time. As the data were partly normally distributed and partly not normally distributed we chose Anova as it is not dependent on normality of the data. The result of the Anova Friedman test came out to be less than 0.001 which tells us that there is a significant difference between the quiz scores and final exam. So after the Friedman Anova test now we want to analyze from which quiz to which one there were changes occurred. For pairwise comparisons we used the Durbin-Conover test. In table 4.2.3 we can see the results for the Durbin-Conover test.

*Table 3.2.3 Pairwise Comparisons- Durbin-Conover test*

| Pairs | Statistic | p |
|---|---|---|
| Quiz 1 - Quiz 2 | 4.32 | <0.001 |
| Quiz 1 - Quiz 3 | 2.4 | 0.017 |
| Quiz 1 - Quiz 4 | 8.91 | <0.001 |
| Quiz 1 - Final | 7.48 | <0.001 |
| Quiz 2 - Quiz 3 | 1.92 | 0.056 |
| Quiz 2 - Quiz 4 | 4.59 | <0.001 |
| Quiz 2 - Final | 3.16 | 0.002 |
| Quiz 3 - Quiz 4 | 6.51 | <0.001 |
| Quiz 3 - Final | 5.08 | <0.001 |
| Quiz 4 - Final | 1.43 | 0.154 |

As we can see from Table 4.2.3, for all the pairs of quizzes and finals except for Quiz3-Quiz4 and Quiz4-Final p values are statistically significant. Which tells us that there were elevations in quiz results when comparing all the pairs except the ones we mentioned. In general there were good results in elevation of quiz scores over time, before and after integrating ChatGPT into teaching.

By the results obtained from the analysis we can reject our first null hypothesis saying that integration of ChatGPT into teaching methodologies does not improve students academic performance in probability and statistics courses. So we can say that integration of ChatGPT into teaching methodologies improves students academic performance in probability and statistics courses.

*Table 3.2.4 Descritives of usage of ChatGPT*

| | Я часто использую ChatGPT для академических задач. | Я использую ChatGPT для изучения новых академических концепций | ChatGPT помогает мне повысить продуктивность академической рабо | Chat GPT полезен, полезен и эффективен для обучения. |
|---|---|---|---|---|
| N | 74 | 74 | 73 | 74 |
| Missing | 0 | 0 | 1 | 0 |
| Mean | 3.92 | 4.14 | 3.99 | 4.38 |
| Median | 4.00 | 4.00 | 4 | 4.50 |
| Sd | 1.00 | 0.849 | 1.01 | 0.735 |
| Minimum | 1 | 1 | 1 | 2 |
| Maximum | 5 | 5 | 5 | 5 |

## 3.3 Students use ChatGPT and its correlation with academic performance.

For analyzing the second hypothesis we have looked through the correlation of quizzes and final results with four elements of our survey about usage of ChatGPT for academic purposes. Here are these four elements: “I often use ChatGPT for academic tasks.”, “Chat GPT is useful, helpful, and effective for learning.”, “ChatGPT helps me to increase the productivity of academic work.” and “I use ChatGPT to explore new academic concepts or topics.”. Below in Table 4.3.1 we can see the descriptive statistics of our questions about usage of ChatGPT.

As we can see, the mean for all of them is more than 3.9 which means agreement to the questions. Now we will see the correlation of them with quizzes and final exam. As the usage of ChatGPT is really high we will check if it is negatively or positively academic performance.

*Table 3.3.2 Correlation of Quiz 1 and Final exam with usage items*

| | | **Quiz 1** | **Final** |
|---|---|---|---|
| Я часто использую ChatGPT для академических задач. | Pearson's r | -0.044 | -0.068 |
| | df | 72 | 72 |
| | p-value | 0.708 | 0.564 |
| Chat GPT полезен, полезен и эффективен для обучения. | Pearson's r | -0.247 | -0.102 |
| | df | 72 | 72 |
| | p-value | 0.034 | 0.389 |
| ChatGPT помогает мне повысить продуктивность академической рабо | Pearson's r | -0.388 | -0.192 |
| | df | 71 | 71 |
| | p-value | < .001 | 0.103 |
| Я использую ChatGPT для изучения новых академических концепций | Pearson's r | -0.302 | -0.112 |
| | df | 72 | 72 |
| | p-value | 0.009 | 0.341 |

Table 3.3.3 *Correlation of Quiz 2, Quiz 3 and Quiz 4 with usage items*

| | | **Quiz 2** | **Quiz 3** | **Quiz 4** |
|---|---|---|---|---|
| Я часто использую ChatGPT для академических задач. | Spearman's rho | -0.076 | -0.122 | -0.010 |
| | df | 72 | 72 | 72 |
| | p-value | 0.517 | 0.300 | 0.931 |
| Chat GPT полезен, полезен и эффективен для обучения. | Spearman's rho | -0.114 | -0.261 | 0.045 |
| | df | 72 | 72 | 72 |
| | p-value | 0.332 | 0.025 | 0.703 |
| ChatGPT помогает мне повысить продуктивность академической рабо | Spearman's rho | -0.143 | -0.231 | -0.122 |
| | df | 71 | 71 | 71 |
| | p-value | 0.229 | 0.049 | 0.303 |
| Я использую ChatGPT для изучения новых академических концепций | Spearman's rho | -0.030 | -0.118 | 0.014 |
| | df | 72 | 72 | 72 |
| | p-value | 0.797 | 0.318 | 0.906 |

So we performed correlation tests between usage items and quizzes. We used this Correlation Matrix. In the Correlation Matrix there are two tests, Pearson and Spearman's test. If our data is normally distributed then we use Pearson otherwise Spearmans. Like this we divided the quizzes and finals into two groups. In table 4.3.2 we can see the correlation matrix of Quiz 1 and Final with usage items, where the Pearson test was used in the Correlation Matrix. In table 4.3.3 Quiz 2, Quiz 3, Quiz 4 test results were checked with usage items, where Spearman test was used.

As we can see from results for most of the items there weren't any statistically significant results. Only for Quiz 1 and Quiz 3 we can notice statistically significant correlation. But the correlation they have shown is negative correlation which says that students who used ChatGPT more and thought that it helps them to improve their academic performance came out to do worse in exams. But for almost all of the relations even with no statistical significant result we noticed negative correlation in all of them even if it was very weak and not statistically significant.

Based on the analysis results for the hypothesis stating that students' use of ChatGPT is not correlated to their academic performance we did not find strong evidence to reject the null hypothesis. However there were some significant results with Quiz 1 and Quiz 3. Also the negative correlation of the majority of items even if it's statistically not significant. So we can partly reject the null hypothesis and say that usage of ChatGPT negatively affects the academic performance of students to some point.

## 3.4 Students' attitude toward ChatGPT and its effect on their academic performance

In this part we checked the correlation of academic performance and attitude of students toward ChatGPT. We have chosen two attitude factors to analyze: first one is motivation of students in using ChatGPT and their reliance on it, second one is students thinking that ChatGPT is more convenient and useful than traditional tools like books, articles and Google.

In Table 3.4.1 we can see the descriptives of the motivation factor. The mean of all three items are around 3.3 which is a little higher than neutral attitude. It means that students are motivated to use ChatGPT but not very motivated. So students have a slightly positive attitude towards ChatGPT in terms of motivation.

So for analyzing we used the Correlation Matrix, again dividing the tests by the normality. In Table 3.4.3 we can see the correlation matrix of Quiz 1 and Final. Pearson test was performed. The correlation is between academic performance and motivation towards ChatGPT usage and reliance on ChatGPT.

*Table 3.4.1 Descriptives of motivation factor*

| | **Chat GPT мотивирует меня больше работать или учиться.** | **Я мотивирован использовать Chat GPT больше.** | **Chat GPT заставляет меня больше полагаться на ИИ, чем на традици** |
|---|---|---|---|
| N | 74 | 74 | 74 |
| Missing | 0 | 0 | 0 |
| Mean | 3.28 | 3.49 | 3.24 |
| Median | 3.00 | 3.00 | 3.00 |
| Standard deviation | 1.26 | 1.06 | 1.10 |
| Minimum | 1 | 1 | 1 |
| Maximum | 5 | 5 | 5 |

As we can see from Table 3.4.3 there is no statistically significant correlation between items and Quiz 1 and Final exam. This tells us that they don't have to do anything with each other. It doesn't matter if students are motivated or rely on ChatGPT, when correlated to Quiz 1 and Final it says that it doesn't have any effect.

In Table 3.4.4 we can see the correlation between Quiz 2 and motivation items. Quiz 2 has shown a statistically significant correlation with all three items. But the correlation is negative. Which says that students who were motivated and relied more on ChatGPT tend to do worse in their Quiz 2.

So for the correlation of motivation we get negative correlation with Quiz 2. And for the item “ChatGPT makes me rely more on AI than on traditional learning methods.” Quiz 2 and Quiz 3 have shown statistically significant p value. For other items there wasn't any significant correlation. We can conclude for the first factor that we found correlation with Quiz 2 and Quiz 3 and no significant results with other tests.

Table 3.4.2 *Descriptives of convenience factor*

| | **ChatGPT более удобен, чем традиционные инструменты, такие как к** | **ChatGPT более полезен, чем Google, для выполнения определённых** | **ChatGPT предоставляет ответы лучше, чем те, которые я могу найт** |
|---|---|---|---|
| N | 74 | 74 | 74 |
| Missing | 0 | 0 | 0 |
| Mean | 4.03 | 4.18 | 3.26 |
| Median | 4.00 | 4.00 | 3.00 |
| Standard deviation | 1.07 | 0.984 | 1.23 |
| Minimum | 1 | 1 | 1 |
| Maximum | 5 | 5 | 5 |

For Quiz 3 and Quiz 4 there weren't any statistically significant results, however the Spearman's rho for all pairs were negative even though the numbers were very small. Based on this information we can conclude that they have negative correlation but we can say that they may have some kind of correlation, as we are noticing the negative correlation in all of the pairs.

The second factor we have chosen to analyze for correlation, we can see the results in Table 3.4.5 and Table 3.4.6. Similarly with the first factor we have divided the tests based on their normality and performed Pearsons and Spearmans tests by the help of Correlation Matrix.

*Table 3.4.3 Correlation between motivation and Quiz 1 and Final exam*

| | | **Quiz 1** | **Final** |
|---|---|---|---|
| ChatGPT мотивирует меня больше работать или учиться. | Pearson's r | -0.135 | -0.077 |
| | df | 72 | 72 |
| | p-value | 0.251 | 0.517 |
| Я мотивирован использовать ChatGPT больше. | Pearson's r | 0.110 | 0.056 |
| | df | 72 | 72 |
| | p-value | 0.350 | 0.636 |
| ChatGPT заставляет меня больше полагаться на ИИ, чем на традици | Pearson's r | -0.135 | -0.114 |
| | df | 72 | 72 |
| | p-value | 0.251 | 0.333 |

*Table 3.4.4 Correlation between motivation and Quiz 2, Quiz 3, Quiz 4*

| | | **Quiz 2** | **Quiz 3** | **Quiz 4** |
|---|---|---|---|---|
| ChatGPT мотивирует меня больше работать или учиться. | Spearman's rho | -0.234 | -0.157 | -0.080 |
| | df | 72 | 72 | 72 |
| | p-value | 0.044 | 0.182 | 0.499 |
| Я мотивирован использовать ChatGPT больше. | Spearman's rho | -0.264 | -0.174 | -0.018 |
| | df | 72 | 72 | — |
| | p-value | 0.023 | 0.139 | 0.877 |
| ChatGPT заставляет меня больше полагаться на ИИ, чем на традици | Spearman's rho | -0.352 | -0.277 | -0.047 |
| | df | 72 | 72 | 72 |
| | p-value | 0.002 | 0.017 | 0.692 |

We can see from the results of correlation that Quiz 3 has significant p value with two items. The item that ChatGPT is more convenient than traditional tools had significant correlation with Quiz 1, Quiz 3 and final exam. The correlation with all of them was negative, which tells us that the ones who thought that ChatGPT is more convenient than their academic performance were worse, the ones who didn't rely on it tend to do better on their exams. For the rest of the pairs the r value was negative, even if the results were not statistically significant all the pairs giving weak negative

correlation tell us that in general there might be a possibility that the ones that have a positive attitude toward ChatGPT tend to do worse in their exams.

We will state the results of the research according to the goals set and the analysis done after the data have been collected. The research have been done to look for three hypothesis which have been set before the research have started. The main purpose of the study was to identify the use of ChatGPT on students academic achievement.

We mainly had two directions to study. The first one was whether teachers using ChatGPT for teaching purposes influences students academic performance. The second one was if students usage of ChatGPT influence their academic performance and to which extend. Also it we have looked through different factors of which could effect students academic performance while using ChatGPT. We had three hypothesis to look through, the first one was about teachers using ChatGPT and the other two were about students using ChatGPT and its influence and not only. Other factors regarding the students and ChatGPT have been taken into account.

The three null hypothesis we had are:

1. Null Hypothesis ($H_0$): Integration of ChatGPT into teaching methodologies does not improves students academic performance in probability and statistics course.
2. Null Hypothesis ($H_0$): Students use of ChatGPT is not correlated to their academic performance.
3. Null Hypothesis ($H_0$): Students attitude towards ChatGPT does not affect their academic performance.

The research have been conducted in one of the universities of Almaty, Kazakhstan. The participants were second year students of engineering faculty, mainly first and second year students. All of them have been studying the course of Probability and Statistics. They have been taught by the same instructor all along the research period. The lessons were conducted in English laguage for all the students. Number of participants were around 74 students in total. Everyone had two lessons a week, every lesson of the length of 75 minutes nad 150 minutes per week in total. The period of the research conducted was one full semester which is 15 weeks.

For the research quasi experiment method have been used. We have divided the semester into two periods, in first half students have been taught ny the traditional method the course of Probability and Statistics. It was the period of seven weeks.

*Table 3.4.5 Correlation of convenience factor and Quiz 1, Final*

| | | **Quiz 1** | **Final** |
|---|---|---|---|
| ChatGPT более удобен, чем традиционные инструменты, такие как к | Pearson's r | -0.235 | -0.337 |
| | df | 72 | 72 |
| | p-value | 0.044 | 0.003 |
| ChatGPT более полезен, чем Google, для выполнения определённых | Pearson's r | -0.217 | -0.170 |
| | df | 72 | 72 |
| | p-value | 0.063 | 0.148 |
| ChatGPT предоставляет ответы лучше, чем те, которые я могу найт | Pearson's r | -0.202 | -0.153 |
| | df | 72 | 72 |
| | p-value | 0.085 | 0.192 |

Table 3.4.6 *Correlation of convenience factor and Quiz 2, Quiz 3, Quiz 4*

| | | **Quiz 2** | **Quiz 3** | **Quiz 4** |
|---|---|---|---|---|
| ChatGPT более удобен, чем традиционные инструменты, такие как к | Spearman's rho | -0.122 | -0.340 | -0.164 |
| | df | 72 | 72 | 72 |
| | p-value | 0.301 | 0.003 | 0.162 |
| ChatGPT более полезен, чем Google, для выполнения определённых | Spearman's rho | -0.036 | -0.154 | -0.157 |
| | df | 72 | 72 | 72 |
| | p-value | 0.759 | 0.191 | 0.182 |
| ChatGPT предоставляет ответы лучше, чем те, которые я могу найт | Spearman's rho | -0.029 | -0.341 | -0.175 |
| | df | 72 | 72 | 72 |
| | p-value | 0.804 | 0.003 | 0.136 |

After that the next eight weeks were the period of experiment, where teacher have used ChatGPT and other AI tools for teaching the students the elements of Probability and Statistics. The students have been aware of the process of the experiment and have been given instructions of how to use ChatGPT effectively for their studies, like when and for what its better to use it and for what its not.

*Table 3.4.7 Summary of hypothesis*

| Hypothesis | Methods used for analysis | Result |
|---|---|---|
| 1.Integration of ChatGPT into teaching methodologies does not improves students academic performance in probability and statistics course | 1.Shapiro Wilk for normality test<br>2. Anova Friedman<br>3. Durbin Conover | 1. Some of the data are normal, some not<br>2. $p<0.001$ for Anova test.<br>3. $p<0.05$ for 8 pairs out of 10 |
| 2. Students use of ChatGPT is not correlated to their academic performance | 1. Shapiro Wilk for normality test<br>2. Correlation Matrix | 1. Not all data normal<br>2. Negative correlation |
| 3. Students attitude towards ChatGPT does not affect their academic performance. | 1. Shapiro Wilk for normality test<br>2. Correlation Matrix | 1. Not all data normal<br>2. Negative correlation |

In total four quizzes and one final exam have been taken from the students for checking the academic performance. In the end of the course attitude test have been taken from the students as well. It included a lot of questions about the use of ChatGPT and the attitude of students toward it. Many factors have been taken into consideration and the main focus was on the hypothesis set for the research.

For analysing the data collected jamovi app have been used. In Jamovi according to the data tests have been chosen to analyze the data. Shapiro Wilk, Pearson correlation, Spearman correlation, Correlation matrix, Anova Friedman, and Durbin Conover tests have been used for analysing the data.

The main findings of the research came out to be very interesting. The first part of the research which was focused on teachers using ChatGPT have showed that when teachers use ChatGPT and other AI tools it effectively increases the academic performance of the students according to the results of our analysis. The second part was about students attitude and their usage of ChatGPT. We have found that the students using ChatGPT effects their academic performance negatively to some extend, which means the more they use ChatGPT the less their academic performance will be. Another finding is that the students who are more motivated to use ChatGPT for the academic purposes tend to have worse grades compared to those who are not. The last finding was that the students who choose using ChatGPT over traditional learning tools tend to do worse in their academic performance compared to those who doesnt rely on

ChatGPT a lot. So further we will state more in details the results of our finding and compare it with the previous researches which have been done, it our research agrees of disagrees with the previous researches we will state them one by one in details.

In table 3.4.7 we can see the three hypothesis and what did they give us to have better idea od what we have done and then we will proceed to the detailed discussion of our findings.

## 3.5 Discussion of Hypothesis 1

Null Hypothesis 1: Integration of ChatGPT into teaching methodologies does not improves students academic performance in probability and statistics course

The results of the analysis have shown us that integrating ChatGPT for teaching methodologies have improved students academic performance in probability and statistics course with the $p<0.001$. This finding shows that integrating ChatGPT into teaching the probability and statistics course have a positive impact on students academic performance.

The results of the Durbin Conover test showed us that the test score of the students have increased significantly before and after integration of ChatGPT in teaching. This suggests that ChatGPT have a positive effect on teaching process when used correctly. ChatGPT can give timely feedback, generate real life problems which are very crucial for the probability and statistics course. Usually in textbooks the examples and problems are from decades before which can be not interesting for students, when ChatGPT can generate problems and questions suitable for todays students. Also ChatGPT can create questions based on the knowledge of the students with different level of difficulty with many similar problems which helps students to understand some concepts and formulas which are very hard, deeply.

AI tools for creating presentations for classes have been used as well like Gamma app, Canva and so on. AI tools are able to create creative and understandable content which will catch the attention of students. Traditional presentation creating tools can be boring for todays students in the era of technology and Artificial Intelligence. According Zopf et al.(2004) 65% of the population is visual learners. So in the process of teaching using effective visual tools is very important for catching students attention and helping them to understand the content very well. As well Canva AI have been used to create images.

The reason why integration of ChatGTP and other AI tools improved academic performance can be visualization of content and personalized learning. The teacher used ChatGPT to create a lot of questions with real life direction and asked the students to solve all of them one by one. Another reason can be students using ChatGTP to solve this questions too. Teacher explained the students of how and when to use ChatGPT, some oral directions have been given. During classes even the students who havent understood or it was hard for them to understand the lesson tried to solve the questions with the help of ChatGPT and would get something, of course the teacher was always ready to help as well as other students.

Even if AI is developing very quickly it still has a lot of limitations. While creating the questions or asking for solutions ChatGPT can make a lot of mistakes.

When creating questions or asking for directions the information generated have been always rechecked by the teacher for the accuracy and many times the ChatGPT would make mistakes. The teacher could not control how the students are using ChatGPT, but would remind them to recheck the solutions which ChatGPT gives. Sometimes it can even make mistakes in giving formulas or some solutions. Still the abilities of AI is limited as when it doesnt know some information it can just imitate and give false answers. Foroughi et al.(2023), Wardat et al.(2023), Azaria et al.(2023) and many other researchers also noted in their works about the inaccuracies that ChatGPT gives, like false references, citations, scientific conclusions and wrong mathematical expressions.

In conclusion we can say that integrating ChatGPT and other AI tools can enhance the academic performance of the students, but the accuracy of the material generated by AI tools should be checked by the Teacher for the relevance of the information. Teacher shouldnt believe the answers that ChatGPT gives 100%, especially if its for teaching purposes. Better if the results are checked by the relevant sources like books or official websites for mathematics. If the teacher relies on ChatGPT and other AI tools 100% and uses the information given by it without rechecking it can lead to the wrong understanding of many other students. So we can say that ChatGPT is a great tool for helping teachers teach more effectively, but the teacher should be careful while using it.

## 3.6 Discussion of Hypothesis 2

Hypothesis 2: Students use of ChatGPT is not correlated to their academic performance.

As the result of the analysis for the hypothesis we couldnt find strong evidence to reject the null hypothesis. There were five exams in total so we made a correlation analysis for all of them with the factor of the usage of ChatGPT. Not all of the items gave us significant p value to reject the null hypothesis. However there were significant p value for Quiz 1 and Quiz 3. Alongside with it majority of the correlation coefficients were negative. The negative correlation tells us about the inverse correlation between items, which suggests that if one increases the other decreases. So we have rejected the null hypothesis partly and we can conclude that the students use of ChatGPT is correlated with their academic performance.

The obtained results can tell us that when students tend to use ChatGPT more for their studies it mostly likely that they are going to get lower grades in their tests than those who use it less. In this research we did not look for the reason as we had limited time for the study, but there can be a lot of factors bringing to this results.

One of the main reasons related to this topic can be overreliance on ChatGPT. Another reason for this can be that even if ChatGPT is very fast in explanation and can give personalized learning and so on, it does not improve the higher order thinking skills. Mostly ChatGPT and other AI tools can effect lower order thinking skills and students may suffer with the higher order thinking skills which needs deeper thinking, analysing and creating. Especially mathematics majors all need higher order thinking skills and deeper understanding of the topics.

Kasneci et al.(2023) noted a very important point about usage of ChatGPT. It was found out that ChatGPT can lead to over dependance for both teachers and students. He mentioned that for students it can lead to:

Kasneci et al.(2023) mentioned in his research that ChatGPT can cause “a decline in their higher-order cognitive skills such as creativity, critical thinking, reasoning, and problem-solving.” He noted that the cause for that can be ChatGPT simplifies the process of obtaining the answers or information and it can lead to the negative impact on students will to perform their own independent research and make their own conclusions or solutions. In math without performing your own solutions can be hard to reach the correct results, as solving the problems need logical and creative solutions, not only application of formulas. As well Susnjak(2022) mentioned that ChatGPT effects negatively the higher order thinking skills. González-Pérez and Ramírez-Montoya (2022) in their research suggested that its impossible to escape the use of ChatGPT in rhis time thats why we have to focus more on students higher order thinking skills more.

So the result obtained for this hypothesis is supported by the works of Susnjak(2022) and Kasneci et al.(2023). However we dont know for sure was this the reason for students academic performance decline, but as probability nad statistics need the higher order thinking skills and ChatGPT mostly can negatively impact on it it can be one of the major reasons.

However the analysis have been done there are some limitations that should be considered for further research. The reason behind the decline on academic performance while using ChatGPT should be looked through further. Also the number of the participants should be increased for more accurate results.

## 3.7 Discussion of Hypothesis 3

Hypothesis 3: Students attitude towards ChatGPT does not affect their academic performance.

As the results of the analysis of two factors about the attitude of the students we can say that students attitude towards ChatGPT does affect their academic performance. We reject the null hypothesis as in the result of the analysis we got significant p values for some exams. As we have noted before we had five exams and both factors had significant p values minimum with two of the exams and the rest of the pairs almost all of them had a negative correlations coefficients even if the p value wasnt significant. This tells us that the more students hold positive attitude towards ChatGPT, the worse their academic performance is going to be.

The two factors we did the correlation test were motivation of using ChatGPT and their reliance on it. The second one is students thinking that ChatGPT is more convenient then the traditional tools for education. In table 4.7.1 we can see the mean of the items that we have used for analysis the attitude.

*Table 3.7.1 Mean of the items used for attitude test*

| Item | Mean value |
|---|---|
| ChatGPT мотивирует меня больше работать или учиться. | 3.28 |
| Я мотивирован использовать ChatGPT больше | 3.49 |
| ChatGPT заставляет меня больше полагаться на ИИ, чем на традиционные методы обучения. | 3.24 |
| ChatGPT более удобен, чем традиционные инструменты, такие как книги или Google. | 4.03 |
| ChatGPT предоставляет ответы лучше, чем те, которые я могу найти в книгах или статьях. | 4.18 |
| ChatGPT более полезен, чем Google, для выполнения определённых задач. | 3.26 |

We had mainly six items. The item that students are motivated to use ChatGPT have showed negative correlation with Quiz 2. This sujjests that the ones who have high motivation of usage of ChatGPT tend to do worse on their exams, but the evidence is not strong. From the table 5.4.1 we can see mean values for the items. Mean for motivation and relience are near around 3.5 which shows a little higher attitude of students than neutral. From the mean values we can tell that students doesnt rely and arent that much motivated by ChatGPT or to use ChatGPT itselfe, however the resutlrs is higher than the neutral. Despite significant p values all three items have showen negative correlation coefficients with other exams as well. Majority of the pairs showing negative correlation even if not all of them significant can tell us that the more students have motivation to use ChatGPT and rely on it, the worse their academic performance will be.

Many researhches have stated on their studies that ChatGPT enhances motivation to study. Xia et al.(2022) mentioned that the primary results of applying AI can increase motivation and engagement. Fiialka et al.(2023), Ngo(2023) and Nazari et al.(2021) have praised the incorporation of AI, highlighting advantages including improved engagement, motivation, and enthusiasm for learning.

However David and Leticia(2023) had a contradictory statement with other researches, noting that it does not increase motivation. There are contradictory results about ChatGPT boosing motivation. Compared to other researches the results of our study is more neutral about ChatGPT boosting motivation to study and work, its a little above

the neutral point but still not very high. The interesting was that the motivation showed negative correlation with academic performance.

Another item about relying on ChatGPT more than traditional tools showed negative correlation with Quiz 2 and Quiz3, with other exams the correlation coefficient was negative as well but very week. This shows that relaying on ChatGPT doesnt help students much , in dontradiction can be the reason of worsening the academic performance. However the mean value was slightly higher than neutral, but the correlation with academic performance was a negative correlation. It can be again connected with the higher order thinking skills previously mentioned about.

The items of convenience gave us significant results as well. Firstly the mean for the item of students tink that ChatGPT is more convenient than traditional tools is 4.03 which they agree with it. Yes of course its convenient, before in literature review we have mentioned the advantages of ChatGPT. Usually its very easy and fast to use. But in the results of the analysis we saw the negative correlation with Quiz 1, Quiz 3 and Final exam, which tells us that the more we think its convenient to use the worse we do in our exams. This can be the result of the laziness that ChatGPT results on. It gives quick fast solutions and we usually become lazy to try to understand and dig dipper into problems. For sure ChatGPT and other AI tools are convenient to use, but instructors have to control and give students instructions of how to use it in order to benefit from it, not to kill their curiousness to study further.

So for the third hypothesis we have to reject the null hypothesis and we can conclude that the attitude of students toward ChatGPT does affect their academic performance. For now the findings suggest that the attitude and academic performance are negatively correlated. We dont know the real reason behind it because it wasnt considered into account for this study. Further studies should focus on this reasons.

From all of our hypothesis and results we can conclude that the teachers using ChatGPT and other AI tools for teacher can enhance the academic performance of students, but in our case of study all of the information generated by ChatGPT have been rechecked by instructor and compared to the relevant sources if needed. There have been noticed a lot of errors and mistakes while generating and solving questions by ChatGPT.

When coming to students their usage and attitude towards ChatGPT had negative effects on their academic performance. However we didnt research the reason behind it as this was the result of our research we dont know the main reason behind it. But from the previous researches we could see that many disadvantages of ChatGPT have been mentioned, like over reliance, negative effect on higher order thinking skills, dependency on data, inaccurate results and so on. This all could be the reasons behind students using ChatGPT impacting negatively on their academic performance. Teacher have been rechecking all the information given for accuracy. Students have been informed to recheck the information given by AI, however they may not have enough knowledge or might not want to recheck all the information they get from ChatGPT. So we have to be careful while using it.

# CONCLUSION

This study aimed to the effect of integrating AI tools into teaching of probability and statistics course. As the use of AI is increasing very much and both teachers and students use it for educational purposes we chose to focus on both fields. The study looked into two directions, first does teachers integrating ChatGPT and other AI tools effect the academic performance of students. The second directions was effect of students using of ChatGPT and their attitude toward it to the academic performance.

Three hypothesis have been analyses. The first one have been rejected conclusion that teachers integration of ChatGPT and other AI tools does improve students academic performance. The two other hypothesis were about students use and attitude toward ChatGPT and their correlation with academic performance. From the results of the analysis we partly rejected null hypothesis and can conclude that they have negative correlationship.

According to the statistics the use of technology and AI have been growing especially after COVID-19. Everyone is broadly using it, but for education we have to look through its advantages and disadvantages and make researches on it. So this study have a great contribution to the field of mathematics education in Kazakstan. Especially probability and statistics course is one of the courses whihc needs a good preparetion both for teachers and students. As instructors we have to know what to give to our students and what are they getting informations for our courses. We have to be aware of the accurateness and relevance of the information we give to our students. The results of our research suggests intsructors while using ChatGPT and other AI tools to be careful and not believe the information it gives fully. The second significant contribution our study have in field of mathematics education it that it tells instructors to be aware and help students to get correct information. As by using ChatGPT and relaying on it fully the students can make mistakes which will be better to prevent before it happens.

Althought we have got interesting and significant results from our research there are still some limitations that have to be mentioned. The first limitation of our study is number of participants. 74 students is not a very small number of students but its still small. If the sample would be bigger and from different universities, not only from one maybe we could have more accurate results. The second limitation is the time limit. The experiment was total of 15 weeks but it was divided into two periods, first for traditional method, second for integrating AI tools for teaching. If the period is increased the results and accuracy would increase. Another limitation the study have is that we didnt have enough time to dig into the reason of why students attitude and academic performance have negative correlation. We got that they ar negative but we dont know for sure the reason behind it.

Future research should focus firstly on the reason behind why students usage and attitude toward ChatGPT have negative correlation. The qualitative research would be a good option to look through the reasons behind this findings. Another thing that can be done in further researches is an extended period of time and it will be better to choose the sample from different universities.

The use of Artificial Intelligence in education is growing day by day and educators have to be aware of how it impacts the future of education. This study offers one more step toward learning the effects of AI in probability and statistics course. For sure the integration of AI does not only have challenges, but also powerful opportunities which we can look though as pedadogists and benefit from them for our students.

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# APPENDIX

## *Appendix 1. Attitude Test*

This survey is used for research purposes and the results will remain confidential.

1- strongly disagree 2- disagree 3- neutral 4- agree 5- strongly agree

| | Вопросы | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | Ваш пол? | | | | | |
| 2 | В каком году вы родились? | | | | | |
| 3 | Каков ваш текущий уровень обучения? | | | | | |
| 4 | Если вы получаете степень бакалавра, по какой специальности вы учитесь? | | | | | |
| 5 | Как бы вы оценили свои знания английского языка? | | | | | |
| 6 | Как бы вы оценили свою компетентность в использовании цифровых инструментов и технологий? | | | | | |
| 7 | Как часто вы используете ChatGPT? | | | | | |
| 8 | Я часто использую ChatGPT для академических задач. | | | | | |
| 9 | ChatGPT полезен в качестве дополнительного инструмента обучения. | | | | | |
| 10 | Я начал использовать ChatGPT, потому что это порекомендовал друг или коллега. | | | | | |
| 11 | ChatGPT более удобен, чем традиционные инструменты, такие как книги или Google. | | | | | |
| 12 | ChatGPT дает хорошо структурированные ответы. | | | | | |
| 13 | ChatGPT помогает мне решать сложные академические задачи. | | | | | |
| 14 | ChatGPT помогает мне генерировать новые идеи для академических проектов. | | | | | |
| 15 | Я использую ChatGPT для изучения новых академических концепций или тем. | | | | | |
| 16 | ChatGPT помогает мне готовить презентации или лекции. | | | | | |
| 17 | Chat GPT полезен, полезен и эффективен для обучения. | | | | | |
| 18 | ChatGPT дает хорошие объяснения. | | | | | |
| 19 | ChatGPT может помочь студентам сэкономить время. | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 20 | ChatGPT улучшает эффективность обучения. | | | | | |
| 21 | ChatGPT улучшает качество обучения. | | | | | |
| 22 | ChatGPT может помочь студентам лучше понять теории и концепции. | | | | | |
| 23 | ChatGPT можно использовать для перевода учебных материалов на разные языки, что делает их более доступными. | | | | | |
| 24 | Я считаю, что информация от ChatGPT в целом точная. | | | | | |
| 25 | ChatGPT помогает мне повысить продуктивность академической работы. | | | | | |
| 26 | ChatGPT мотивирует меня больше работать или учиться. | | | | | |
| 27 | ChatGPT может предоставлять ненадежную информацию по темам с небольшим количеством цитируемых источников. | | | | | |
| 28 | Для использования ChatGPT необходимы базовые знания в данной области. | | | | | |
| 29 | ChatGPT может давать неточные или ложные фактические ссылки. | | | | | |
| 30 | ChatGPT не может измерить значение сложных математических формул. | | | | | |
| 31 | ChatGPT дает неточные результаты — не является на 100% надежным. | | | | | |
| 32 | Я использую ChatGPT, потому что он удобен и прост в использовании. | | | | | |
| 33 | Я использую ChatGPT, потому что он помогает мне быстро найти точную информацию. | | | | | |
| 34 | Я бы порекомендовал ChatGPT другим в академических целях. | | | | | |
| 35 | В будущем я планирую продолжать использовать ChatGPT в академических целях. | | | | | |
| 36 | Мое удовлетворение ChatGPT возрастет благодаря более точному и надежному академическому контенту. | | | | | |
| 37 | Использовать ChatGPT интересно. | | | | | |
| 38 | Я мотивирован использовать ChatGPT больше. | | | | | |
| 39 | Я обеспокоен тем, что ChatGPT может предоставить неверную или предвзятую информацию. | | | | | |
| 40 | Я чувствую уверенность в проверке ответов ChatGPT | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | на точность. | | | | | |
| 41 | ChatGPT заставляет меня больше полагаться на ИИ, чем на традиционные методы обучения. | | | | | |
| 42 | Преимущества ChatGPT перевешивают любые мои опасения по этому поводу. | | | | | |
| 43 | ChatGPT более полезен, чем Google, для выполнения определённых задач. | | | | | |
| 44 | ChatGPT предоставляет ответы лучше, чем те, которые я могу найти в книгах или статьях. | | | | | |
| 45 | Стоимость использования ChatGPT (если это применимо) стоит той ценности, которую я получаю. | | | | | |
| 46 | Что самое полезное в ChatGPT? | | | | | |
| 47 | Каковы основные ограничения ChatGPT? | | | | | |
| 48 | Что бы вы хотели улучшить в ChatGPT? | | | | | |

## *Appendix 2. Quiz 1: Variant 1*

1.(10p).Let U be the universal set where U={1,2,3,4,5,6,7,8,9} and let A={1,2,3,4} and B={3,4,5,6}:

a. Find A∪B
b. Find A∩B
c. Find A′ (complement of A)
d. Find A′∩B

2.(15p). In a group of 50 students: 30 students study Mathematics, 20 students study Physics, 10 students study both Mathematics and Physics. How many students:

a. Study Mathematics or Physics?
b. Study neither Mathematics nor Physics?
c. Study only Mathematics?

3.(15p) .What is the probability of throwing a dice and getting :

a. An odd number
b. Number 5

4.(15p). Given that P(C)=2/5, P(D)=3/5, and P(C∪D=4/5:

a. What is P(C∩D)?
b. What is P(C′)?
c. What is P(C′∩D′)?

5.(15p). In a company, 75% of the employees have completed a project on time, and 40% of the employees have completed both their project and received a promotion. If an employee is randomly selected and has completed their project, what is the probability that they also received a promotion?

6.(15p). A factory produces 60% of its products from Machine A and 40% from Machine B. The defect rate is 3% for Machine A and 5% for Machine B. If a product is randomly selected and found to be defective, what is the probability that it was produced by Machine B?

7.(15p). A box contains 5 green, 7 red, and 3 yellow balls. If two balls are drawn at random without replacement, what is the probability that:

- a. Both balls are red?
- b. One ball is red and the other is yellow?

Bonusa(7p): An experiment has only two outcomes. The first has probability p to occur, the second probability p^2. What is p?

## *Appendix 3. Quiz 4: Variant 1*

1. (20p) Given the following probabilities:
P(A)=3/5,P(B)=2/3,P(A∪B)=⅘
What is:
    1. P(A∩B)?
    2. P(A′)?
    3. P(A′∩B′)?

2. (20p) A survey shows that 40% of employees use public transportation, and 25% use both public transportation and a bicycle. If an employee is chosen at random, what is the probability they use a bicycle given that they use public transportation?

3. (20p) The average height of employees is 170 cm with a standard deviation of 7 cm.
    1. What percentage of employees are taller than 180 cm?
    2. Out of 500 employees, how many are expected to be shorter than 160 cm?

4. (20p) A customer service department receives an average of 10 calls per hour.
    1. What is the probability the department will receive exactly 4 calls in an hour?
    2. What is the probability the department will receive no calls in the next hour?

5.(20p)

Let $X$ and $Y$ be two continuous random variables with the joint probability density function:

$$f(x, y) = \frac{1}{64}(x + y), \quad 0 \leq x \leq 4, \quad 0 \leq y \leq 4$$

    1. Find covariance
    2. Find correlation coefficient

Bonusb(7p):
A jar contains 12 green, 8 yellow, and 6 red marbles. Two marbles are drawn at random without replacement. What is the probability that:
    1. Both marbles are green?
    2. One marble is yellow and the other is red?

## *Appendix 4. Final exam: Variant 1*

1(10p). Explain the Law of Large numbers
2(15p). A bakery uses two ovens to bake cookies. Oven A bakes 60% of the cookies, while Oven B bakes 40%. The chance of burning cookies in Oven A is 2%, and in Oven B, it is 3%. If a randomly selected cookie is burnt, what is the probability it was baked in Oven B?
3(15p). The scores of a final exam in a statistics class are normally distributed. The average score is 90 and the standard deviation is 10.

1. What is the chance that a randomly chosen student scores more than 85 on the exam?
2. What is the chance that a randomly chosen student scores less than 65 on the exam?

4(15p). A printing press produces 2,000 brochures every day. Each brochure has a 7% chance of having a printing error. What is the probability that exactly 10 brochures will have a printing error in one day?
5(15p). In a group of 200 students, their ages range from 10 to 40 years.

a. What is the probability that a randomly selected student is between the ages of 10 and 15?
b. What is the probability that a randomly selected student is less than 7 years old?

6(15p). A bag contains 5 yellow marbles, 6 green marbles, and 4 purple marbles. A marble is drawn at random.

a. What is the probability that the marble drawn is green?
b. What is the probability that the marble drawn is not yellow?

7(15p). Following is joint distribution:

| X/Y | 1 | 2 | 3 | |
|---|---|---|---|---|
| 0 | 0.15 | 0.04 | 0.1 | |
| 1 | 0.06 | 0.1 | 0.1 | |
| 2 | 0.2 | 0.2 | 0.05 | |

a. Find covariance
b. Find Correlation Coefficient

*Appendix 5. Lesson Plan for Instructional lesson (Traditional Phase)*

| Section | Details |
|---|---|
| Lesson Title | Introduction to Set Theory and Discrete Probability |
| Target Group | Second-year university students |
| Duration | 75 minutes |
| Learning Objectives | - Define basic set theory terms (set, subset, union, intersection, complement, etc.)<br>- Understand the concept of events and sample spaces<br>- Perform basic operations using the algebra of events<br>- Describe and identify discrete probability spaces<br>- Apply rules of combinatorics (permutations and combinations) |
| Materials Needed | - Whiteboard and markers<br>- Student textbook<br>- Hand-drawn diagrams of Venn diagrams<br>- Printed practice problems for the next lesson |
| Warm-Up / Review (10 min) | - Ask: “What is a set? Can you give a real-world example of a set?”<br>- Ask students about sets they've seen in mathematics so far |
| Direct Instruction (50 min) | - Explain key topics with examples:<br>• Set Theory: definitions, notation, real-life examples<br>• Algebra of Events: union, intersection, complement, Venn diagrams<br>• Discrete Probability Space: sample space, outcomes, examples (coin, dice)<br>• Basic Combinatorics: factorials, permutations, combinations<br>- Solve 2–3 examples on the board for each topic |
| Summary / Q&A (15 min) | - Ask students to summarize the key points in their notebooks<br>- Answer any remaining questions or clarify symbols/formulas |
| Assessment / Evaluation | - Student engagement and participation during discussion<br>- Ability to answer review questions orally<br>- Note-taking completeness and accuracy |
| Homework (Optional) | No homework assigned. Practice will take place in the next lesson. |

*Appendix 6. Lesson plan for Practical Lesson ( Traditional Phase)*

| Section | Details |
|---|---|
| Lesson Title | Practice on Set Theory, Algebra of Events, and Combinatorics |
| Target Group | Second-year university students |
| Duration | 75 minutes |
| Learning Objectives | - Apply set operations to solve problems<br>- Identify sample spaces and calculate probabilities in discrete cases<br>- Solve basic combinatorics problems using formulas for permutations and combinations<br>- Work independently and explain their solutions to peers |
| Materials Needed | - Whiteboard and markers<br>- Student textbook<br>- Prepared set of problems (from textbook or worksheets)<br>- Notebook and pens |
| Lesson Structure | |
| Warm-Up / Review (10 min) | - Ask 2–3 quick oral questions:<br>• “What is the symbol for union?”<br>• “What does a sample space mean?”<br>• “What is the difference between a permutation and a combination?”<br>- Review key notations and formulas on the board |
| Guided Problem Solving (15 min) | - Solve 1–2 problems together:<br>• Venn diagram problem (e.g., students who like coffee/tea)<br>• Combinatorics problem (e.g., choosing committee members) |
| Student Practice (15 min) | - Students work individually or in pairs on 3–5 textbook problems |

| | |
|---|---|
| | - Teacher walks around and helps if needed |
| Student Practice (15 min) | - Students work individually or in pairs on 3–5 textbook problems<br>- Teacher walks around and helps if needed |
| Board Work and Peer Learning (25 min) | - Volunteers solve problems on the board<br>- Others continue solving on paper<br>- Discuss solutions together<br>- Encourage peer explanation |
| Quick Revision and Summary (10 min) | - Ask reflection questions:<br>• “What kind of problems were easiest? Hardest?”<br>• “What formula did you use for this problem?”<br>- Write 3 key takeaways on the board |
| Assessment / Evaluation | - Participation during board work<br>- Accuracy of individual work<br>- Observation of progress compared to previous lesson |
| Homework | Solve related questions from the book |

*Appendix 7. Lesson plan ( Experimental period)*

| Section | Details |
|---|---|
| Lesson Title | Moments, Dispersion, and Correlation Coefficient |
| Target Group | Second-year university students |
| Duration | 75 minutes ( 2 lessons) |
| Learning Objectives | - Understand the concept and significance of moments (mean, variance, skewness, kurtosis)<br>- Calculate and interpret measures of dispersion (variance, standard deviation)<br>- Compute and interpret the correlation coefficient<br>- Use AI tools (ChatGPT and Gamma) to support problem-solving and concept understanding |
| Materials Needed | - AI-generated PowerPoint presentations (Gamma)<br>- ChatGPT access for students<br>- Prepared problems generated by ChatGPT<br>- Whiteboard and markers<br>- Student notebooks |
| | Lesson Structure |
| Revision (10 min) | Briefly review key ideas from previous topic (e.g., mean and expected value)<br>- Ask students to recall and define prior terms<br>- PPT slide with visual summary used (created in Gamma) |
| Concept Explanation (35 min) | - Understand the concept and significance of moments (mean, variance, skewness, kurtosis)<br>- Calculate and interpret measures of dispersion (variance, standard deviation)<br>- Compute and interpret the correlation coefficient<br>- Use AI tools (ChatGPT and Gamma) to support problem-solving and concept understanding |
| Problem Solving (20 min) | - Solve 2–3 problems on the board with students<br>- Other students solve same or similar problems individually |

| | |
|---|---|
| | - Teacher walks around helping, and students can consult ChatGPT to verify calculations, definitions, or solution steps |
| Revision & Homework (10 min) | - Recap key formulas and interpretation from the lesson<br>- Assign homework (problems generated using ChatGPT) |
| Assessment / Evaluation | - Observation of participation in solving problems<br>- Quality and accuracy of solutions (in-class and homework)<br>- Use of ChatGPT for explanation or verification |
| Homework | - Solve a set of problems on variance, moments, and correlation generated by ChatGPT |