The Future of Engineering Education
2024 Annual Conference & Exposition
Oregon Convention Center
Portland, OR . June 23 - 26, 2024

ASEE

Paper ID #43769

Design and Development of Survey Instrument to Measure Engineering Students' Perspectives on the Use of ChatGPT

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Abstract

Chat Generative Pre-Trained Transformer (ChatGPT) is a language model created by engineers working in Open Artificial Intelligence. It is a type of artificial intelligence system that generates human-like text responses to a wide range of prompts and questions. ChatGPT offers several advantages including 24/7 support, quick response to questions, finding research-related information, writing a coding program, etc. Despite these advantages, ChatGPT has limited contextual understanding of a certain topic, which can lead to incorrect/irrelevant responses. It can also be biased based on the data used to train the program, which can lead to unfair or inaccurate feedback. ChatGPT can unfortunately be vulnerable to causing security risks, which may lead to data breaches and sensitive information of students being leaked. With the rising popularity of ChatGPT, just like any other online resource, the over-reliance on it could lead to a decline in independent problem-solving skills and critical thinking in an academic setting.

This research project aims at understanding the students' perspectives on the use of ChatGPT in engineering. This topic is relevant, timely, and important as ChatGPT as created sufficient stir in education. By exploring students' experiences and perspectives, we aim to shed light on different aspects of usage of ChatGPT and glean critical insights. The objective of this study was to design, develop and validate a survey instrument that measures engineering students' perceptions on the use of ChatGPT. To meet the objective of this research study, a survey instrument was designed which included five dimensions: learning tool (10 items), trustworthiness (5 items), ethical considerations (5 items), ease of access (6 items), and concerns with ChatGPT (6 items). To collect the evidence for content validity and face, the survey instrument was reviewed by three content experts and three potential participants. The survey instrument was revised/updated using the feedback from both content experts and potential participants. The data for this study was collected in summer and fall 2023, and 323 responses were included in the analysis. Exploratory factor analysis (EFA) revealed four factors learning tool, trustworthiness, ease of access and concerns with ChatGPT, and the dimension 'ethical considerations' was suggested to be removed after the EFA. The Cronbach's alpha ranged between 0.62 to 0.82 suggesting good internal consistency reliability between the items.

Keywords: ChatGPT, concerns with ChatGPT, ease of access, ethical considerations, learning tool, trustworthiness

Introduction

Chat Generative Pre-Trained Transformer (ChatGPT) is a language model created by engineers working in Open Artificial Intelligence (OpenAI). It is a type of artificial intelligence (AI) system that generates human-like text responses to a wide range of prompts and questions. ChatGPT was developed through a process called machine learning, which trains an algorithm with a large dataset of text data (Azaria, 2022). For ChatGPT, the algorithm was created with text data from the internet, composed of articles, books, and other sources of written languages. This process along with natural language processing (NLP) and deep learning has helped the algorithm to train and learn patterns in language and develop the ability to generate human-like responses (Jiao et al., 2023).

ChatGPT was originally designed for use by developers, researchers and organizations building services and applications requiring NLP capabilities. ChatGPT can be used by anyone who wants to communicate or find information in a natural language (George & George, 2023). It can be used for many purposes, such as providing recommendations, answering questions, generating response texts, and more. As ChatGPT uses deep learning and NLP, the quality of responses will vary on the quality of data used to train the language model in the given specific language (Shen et al., 2023). At the moment, OpenAI has versions in a limited number of languages such as English, Spanish, French, German, Italian, Dutch, Japanese, Chinese, and Korean (Jiao et al., 2023).

In education and academia, ChatGPT has proven itself to be versatile in many uses. As it is commonly known, one of the advantages of ChatGPT is that it can provide 24/7 support for students and gives relevant feedback to help understand certain material (AlAfnan, 2023). It can also help reduce workloads by automating certain tasks for both students and educators, such as grading assignments and providing feedback to students (Baidoo-Anu & Owusu Ansah, 2023). In addition to providing services to analyze large amounts of data to generate comprehensive responses not otherwise apparent through normal methods, ChatGPT can assist researchers and educators in finding relevant research papers, studies, and articles based on specific keywords and topics (Halaweh, 2023). Despite these advantages, ChatGPT has limited contextual understanding of a certain topic, which can lead to incorrect or irrelevant responses. It can also be biased caused with the provided data used to train the program, which can easily lead to feedback that can be viewed as unfair or inaccurate (Borji, 2023). ChatGPT can unfortunately be vulnerable to causing security risks, which may lead to data breaches and sensitive information of students to be leaked (Nair, Sadhukhan, & Mukhopadhyay, 2023). With the rising popularity of ChatGPT, just like any other online resource, the over reliance on it could lead to a decline in independent problem-solving skills and critical thinking in an academic setting (Shen et al., 2023).

Currently, ChatGPT is a topic of discussion everywhere and this topic is gaining huge momentum in research as well. Several research articles published recently essentially describe the working process of the ChatGPT, impact on academia, its performance, use in writing research related work (George & George, 2023; Kung et al., 2023; Lund & Wang, 2023; Shen et al., 2023; van Dis et al., 2023). In this research study, the use of ChatGPT in engineering will be explored through students' perspectives.

Literature Review

Research on Chat Generative Pre-Trained Transformer (ChatGPT) has proliferated in recent years, reflecting the growing interest in artificial intelligence (AI) and natural language processing (NLP) technologies. Initially developed by engineers at Open Artificial Intelligence (OpenAI), ChatGPT has garnered attention across various disciplines, with studies focusing on its applications, limitations, and implications for diverse domains. This literature review seeks to explore research done on ChatGPT, both within the broader context and specifically in engineering. Furthermore, it aims to interpret the methodologies used, particularly the use of survey instruments, in understanding and gauging student perspectives on this transformative tool.

Research on ChatGPT spans a wide spectrum, involving investigations into its architecture, capabilities, and societal impact. Initial studies often delved into the technical aspects of ChatGPT, mentioning its underlying mechanisms and the efficacy of its language generation algorithms. For instance, Azaria (2022) provided insights into the machine learning processes that sustain ChatGPT's functionality, shedding light on its training data and model architecture. Subsequent research beyond technical intricacies explored the practical applications of ChatGPT across various domains. Studies highlighted its role in facilitating human-computer interaction, improving customer service experiences, and supplement content generation tasks. Kung et al. (2023) examined the use of ChatGPT in customer service settings, specifically mentioning clinical decision-making, emphasizing its ability to streamline communication processes and enhance user satisfaction. Furthermore, investigations into ChatGPT's societal implication have raised ethical and socio-cultural concerns. Scholars have scrutinized issues pertaining to bias, fairness, and privacy in ChatGPT-generated content. Borji (2023) investigated the presence of biases in ChatGPT responses, underscoring the need for addressing algorithmic inequities and to mitigate strategies to deal with such problems.

Within the realm of engineering education, ChatGPT has emerged as a promising tool for enhancing learning experiences and facilitating open access of knowledge. Studies have explored its utility in aiding students with coursework, providing real-time support, and automating certain tasks. Lund and Wang (2023) conducted a comprehensive analysis of ChatGPT's applications in education, highlighting its potential to assist students in problem-solving and concept elucidation. The study explored the importance of integrating ChatGPT into teaching approaches to augment student learning outcomes. Moreover, investigations into student perspectives on ChatGPT within engineering education have gained traction. Researchers have utilized survey instruments to gauge student perceptions and concerns regarding the integration of ChatGPT into the learning environment. AlAfnan (2023) developed a survey-based approach to examine students' experiences with ChatGPT in a wide variety of coursework. The study assessed various dimensions, including ease of access, usefulness as a learning tool, and concerns regarding reliability and privacy. Similarly, Halaweh (2023) conducted a survey to explore student perceptions of ChatGPT's role in assisting with coding assignments and research inquiries within engineering disciplines. The findings focused on student attitudes towards ChatGPT, encompassing both positive and negative sentiments.

In summary, research on ChatGPT spans a diverse array of topics, ranging from technical intricacies to socio-cultural implications. Within engineering education, survey-based studies have provided nuanced insights into student perceptions on the topic, allowing for technological interventions aimed at enhancing learning outcomes. As the field grows, more research will shed light on the transformative potential of ChatGPT and its implications for engineering education. In this research study an attempt is made to design and develop a survey instrument characterized by dimensions such as learning tool efficacy, trustworthiness, ease of access, and concerns with ChatGPT. This survey instrument will offer valuable insights into student perspectives and inform the ongoing discourse surrounding the integration of AI technologies in engineering education.

Methods

1. Development of the Survey Instrument

In the summer of 2023, the survey instrument was developed. As indicated in Table 1, the instrument is constructed using five scales. The survey's purpose was to gather information about students' opinions about ChatGPT as a learning tool, including their views on its reliability, ethical issues, accessibility, and ease of use. There were 32 items in all on the five scales of the instrument. The participants were asked to rate their opinions about using ChatGPT on a 5-point Likert-type scale. The five-strongly agree, four-agree, three-neither agree nor disagree, two-disagree, and one-strongly disagree levels served as the anchors for the Likert scale. There was also a separate demographics section with questions about the participants' backgrounds. In this study an attempt is made to design, develop, and validate the survey instrument. Two other studies have been conducted using this collected data (1) Factors Influencing Engineering Students' Perceptions on the Use of ChatGPT (Sajawal & Kittur, 2024), and (2) Examining Students' Beliefs on the Use of ChatGPT in Engineering (Sajawal & Kittur, 2024).

The scales were inspired by various survey instruments found in the body of literature (Susnjak, 2022; Haensch et al., 2023; Khalil & Er, 2023; Ngo, 2023; Romig, 2023). The contents of each scale have been modified to better suit the participant pool, which consists of engineering students, even though the scales are shared. These modifications range from word choices to total question replacements.

2. Evidence of Content Validity and Face Validity

Three faculty members who are not part of the research team but have substantial experience designing survey instruments reviewed the items to gather evidence of the instrument's content validity. Furthermore, three possible participants were given the survey items, and their comments on the items' clarity and phrasing was solicited to gather evidence of the instrument's face validity. These sources were used to inform changes that were made to the questions, such as making them more specific and rewording some of them to reduce repetition.

3. Exploratory Factor Analysis
Procedure
The survey instrument's factor structure was ascertained through the use of exploratory factor analysis (EFA). Three weeks in the summer of 2023, a major public university in the United States provided the data for EFA. To increase the response rate, two reminders were sent out: one in the

second week and one in the third. The course instructors and department program chairs were requested to reach out to the participants. To prevent bias in the responses from the participants, Qualtrics' feature of randomizing survey questions was used. Ten participants received a $20 Amazon gift card as an incentive for taking part in this study through a lucky draw.

Table 1. Overview of Scales within the Instrument

Scale (# of items)	Definition	Example Items
Learning Tool (10)	Students' perceptions on the use of ChatGPT as a learning tool in doing homework, completing assignments, projects, etc.	- ChatGPT can be used to write essays - ChatGPT can be used to expand general knowledge
Trustworthiness (5)	Students' perceptions on the relevancy, accuracy, and trustworthiness of the information retrieved from ChatGPT.	- The information retrieved from ChatGPT is accurate - The ChatGPT's response to questions is relevant
Ethical Considerations (5)	Students' perceptions regarding using the information retrieved from ChatGPT through the ethical lens.	- It is ethical to use ChatGPT to find solutions to exams - Using ChatGPT to complete academic work is a violation of ethics
Ease of Access (6)	Students' perceptions regarding the ease of accessibility of ChatGPT to look up for answers/solutions and find the required information.	- It is easy to access information from ChatGPT - It is easy to find answers from ChatGPT
Concerns with ChatGPT (6)	Students' perceptions regarding the concerns/issues with the use of ChatGPT	- ChatGPT hinders critical thinking - ChatGPT can generate incorrect or misleading information, leading to academic errors

Analytical Approach

To verify the assumption of univariate normality, the kurtosis and skew of each of the 32 items were examined prior to conducting the factor analysis (Seltman, 2013). The suitability of the survey instrument was assessed using the Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) test. Given that the KMO test measures shared variance among items, scores above 0.8 indicate the possibility of a factor structure and, consequently, a factor analysis. By calculating the item correlation matrix, Bartlett's test of sphericity is used to determine whether factor analysis is feasible. A significant test result of $p<0.05$ suggests that the data is factorable. The factors were extracted using principal axis factoring (PAF), which takes measurement error into consideration when doing self-report research (McCoach, Gable, & Madura, 2013). The promax with Kaiser normalization rotation method was used with standard kappa (kappa=4) because it allows for factor correlation, which was thought to be likely in this analysis.

The number of factors was determined using the Kaiser's criterion method, parallel analysis, and scree plots after the data's factorability was confirmed (McCoach, Gable, & Madura, 2013; Kittur, 2023). According to McCoach, Gable, and Madura (2013), items with factor loadings less than 0.4 (<0.4) or cross loadings greater than 0.3 (>0.3) on at least two factors were eliminated. After the survey instrument's factor structure was finalized, Cronbach's alpha (α) was used to assess each scale's internal consistency reliability. A α greater than 0.6 ($\alpha>0.6$) is considered good, and an

α>0.8 is preferred (McCoach, Gable, & Madura, 2013; Kittur, 2023). The statistical software program SPSS was used to conduct the entire EFA.

Results

Participants
The exploratory factor analysis included 323 responses in total. On the 32 survey item responses, there were no missing values for the 323 responses. Table 2 displays the demographic data for the participants. Approximately 50% of the final sample were men and 28% were women. The participants self-identified as American Indian or Alaskan native (5.26 percent), Black or African American (4.64 percent), Asian (18.6 percent), Hispanic or Latinx (11.2 percent), and White (54.5 percent). Among the participants, undergraduate students made up more than 70%. There were twelve distinct engineering majors among the responders.

Table 2. Demographic Information of Participants

Category	N	%
Total	323	100
Gender		
Male	161	49.8
Female	91	28.2
Not indicated	53	16.4
Others	18	5.57
Degree		
Undergraduate	232	71.8
MS	18	5.57
Ph.D.	20	6.19
Not indicated	53	16.4
Race/Ethnicity		
White	176	54.5
Asian	60	18.6
Hispanic or LatinX	36	11.2
Black or African American	15	4.64
American Indian or Alaska Native	17	5.26
Native Hawaiian or Other Pacific Islander	2	0.60
Not indicated	17	5.26
Academic Department		
Computer Science	38	11.8
Mechanical Engineering	59	18.3
Electrical and Computer Engineering	24	7.43
Biomedical Engineering	62	19.2
Aeronautical Engineering	39	12.1
Civil Engineering	12	3.71
Chemical Engineering	6	1.86
Industrial and Systems Engineering	9	2.79
Aerospace Engineering	9	2.79
Environmental Engineering	15	4.64
Architectural Engineering	7	2.17
Engineering Physics	1	0.31
Engineering Undecided	1	0.31
Not indicated	41	12.7

Exploratory Factor Analysis

Seltman (2013) states that when the absolute values of skewness and kurtosis for each of the 32 survey items were less than 3.0, an acceptable limit was reached (see Table 3). Some of the aspects that students were confident about the use of ChatGPT based on the average response ratings (greater than 4.0 out of 5.0) are ChatGPT can be used to find answers to questions (mean=4.02), ChatGPT can be used to brainstorm ideas (mean=4.44), ChatGPT can be used to rephrase/re-write a sentence/paragraph (mean=4.12), ChatGPT can be used to expand general knowledge (mean=4.2), it is a good practice to re-write the information retrieved from ChatGPT in our own words (mean=4.17), ChatGPT is easy to use (mean=4.27), ChatGPT responds quickly to questions (mean=4.3), and ChatGPT can generate incorrect/misleading information, leading to academic errors (mean=4.4). However, the aspects that students expressed relatively lower confidence on the use of ChatGPT based on the average response ratings (lower than 3.0 out of 5.0) include ChatGPT can be used to write research papers (mean=2.99), the ChatGPT's response to questions can be used without reviewing it (mean=1.79), ChatGPT provides answers to all questions (2.13), and it is ethical to use ChatGPT to find solutions to exams (mean=2.27).

The items were found to be suitable for factor analysis by Bartlett's test for sphericity ($p<0.001$). The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) (KMO=0.83) permitted the extraction of factors for accounting meaningful variance, if factor analysis was to be carried out (McCoach, Gable, & Madura, 2013). The data could be used to infer four factors, five factors, and four factors, respectively, according to Kaiser's criterion, scree plot, and parallel analysis. Despite not matching the set of factors that were hypothesized, four factors were chosen. Varimax rotation was employed because the factor correlations were not highly correlated (<0.33) (McCoach, Gable, & Madura, 2013).

In the survey instrument, multiple items with factor loadings less than 0.4 and three cross-loaded items were eliminated (Pett, Lackey & Sullivan, 2003). Some of the items that were exclude are 'ChatGPT can be used to find information for project work', 'ChatGPT can be used to rephrase/re-write a sentence/paragraph', 'It is ethical to use ChatGPT to find solutions to exams', 'It is a good practice to re-write the information retrieved from ChatGPT in our own words', 'ChatGPT supports multiple languages, aiding in international academic collaboration', 'ChatGPT respects user privacy by protecting personal data', 'ChatGPT is limited in providing personalized feedback or tailored individual guidance', 'ChatGPT's responses may perpetuate discriminatory or exclusionary narratives in academic settings', etc. The EFA yielded four final factors, but the scale labeled "Ethical considerations" was left off the list. Table 4 displays the factor loadings of the final factor structure. The first factor (F1) factor loadings ranged from 0.6 to 0.69; second factor (F2) factor loadings from 0.48 to 0.49; third factor (F3) factor loadings from 0.48 to 0.58; and fourth factor (F4) factor loadings from 0.66 to 0.78. The reliability of the four factors' internal consistency, as measured by Cronbach's α, varied between 0.62 and 0.82, suggesting good reliability.

Table 3. Descriptive Statistics of Survey Items

#	Measure	Mean	SD	Skew	Kurtosis
	Learning tool				
1	ChatGPT can be used to write essays	3.51	1.20	-0.89	-0.43
2	ChatGPT can be used to write a software code/logic	3.93	0.96	-1.45	1.91
3	ChatGPT can be used to complete assignments	3.62	1.12	-0.96	-0.15
4	ChatGPT can be used to find answers to questions	4.02	0.83	-1.61	2.39
5	ChatGPT can be used to find information for project work	3.95	0.92	-1.50	2.32
6	ChatGPT can be used to brainstorm ideas	4.44	0.71	-2.01	2.71
7	ChatGPT can be used to find solutions to exams	3.25	1.27	-0.59	-1.09
8	ChatGPT can be used to write research papers	2.99	1.37	-0.28	-1.48
9	ChatGPT can be used to rephrase/re-write a sentence/paragraph	4.12	0.89	-1.59	2.92
10	ChatGPT can be used to expand general knowledge	4.20	0.84	-1.70	2.90
	Trustworthiness				
11	The information retrieved from ChatGPT is accurate	3.41	1.01	-1.06	-0.44
12	The ChatGPT's response to questions is relevant	3.93	0.65	-2.31	2.39
13	The ChatGPT's response to questions can be used without reviewing it	1.79	1.08	1.34	0.62
14	ChatGPT provides adequate information as requested	3.68	0.92	-1.50	1.42
15	ChatGPT provides answers to all questions	2.13	1.17	0.77	-0.79
	Ethical considerations				
16	It is acceptable to use the responses from ChatGPT to write essays	3.54	1.27	-0.57	-1.03
17	It is ethical to use ChatGPT to find solutions to exams	2.27	1.26	0.58	-1.17
18	It is a good practice to re-write the information retrieved from ChatGPT in our own words	4.17	0.90	-1.52	2.44
19	Using ChatGPT to complete academic work is a violation of ethics	3.44	1.29	-0.59	-0.99
20	ChatGPT should be integrated into academic integrity policies	3.83	1.04	-1.26	0.96
	Ease of access				
21	It is easy to access information from ChatGPT	3.85	1.05	-1.31	1.12
22	It is easy to find answers from ChatGPT	3.73	0.94	-1.18	0.66
23	ChatGPT is easy to use	4.27	0.70	-1.40	2.66
24	ChatGPT supports multiple languages, aiding in international academic collaboration	3.95	0.68	-2.17	2.84
25	ChatGPT responds quickly to questions	4.30	0.67	-1.49	2.97
26	ChatGPT respects user privacy by protecting personal data	3.39	1.14	-1.08	-0.31
	Concern with ChatGPT				
27	ChatGPT hampers creativity	3.17	1.31	-0.20	-1.39
28	ChatGPT hinders critical thinking	3.22	1.27	-0.27	-1.34
29	ChatGPT negatively influences writing skills	3.29	1.29	-0.34	-1.29
30	ChatGPT is limited in providing personalized feedback or tailored individual guidance	3.70	1.04	-1.12	0.41
31	ChatGPT can generate incorrect/misleading information, leading to academic errors	4.40	0.67	-1.48	2.22
32	ChatGPT's responses may perpetuate discriminatory or exclusionary narratives in academic settings.	3.37	1.17	-0.74	-0.78

Note. *N*=323, all items were rated on five-point scales

Table 4. Factor loadings of the survey item structure

#	Items	F1	F2	F3	F4
	Learning tool (*Cronbach's α = 0.79*)				
1	ChatGPT can be used to write essays	0.61			
3	ChatGPT can be used to complete assignments	0.69			
7	ChatGPT can be used to find solutions to exams	0.60			
8	ChatGPT can be used to write research papers	0.62			
	Trustworthiness (*Cronbach's α = 0.62*)				
11	The information retrieved from ChatGPT is accurate		0.49		
12	The ChatGPT's response to questions is relevant		0.48		
14	ChatGPT provides adequate information as requested		0.48		
	Ease of access (*Cronbach's α = 0.62*)				
22	It is easy to find answers from ChatGPT			0.58	
23	ChatGPT is easy to use			0.57	
25	ChatGPT responds quickly to questions			0.48	
	Concern with ChatGPT (*Cronbach's α = 0.82*)				
27	ChatGPT hampers creativity				0.76
28	ChatGPT hinders critical thinking				0.78
29	ChatGPT negatively influences writing skills				0.66

Note. F1 = Learning tool, F2 = Trustworthiness, F3 = Ease of access, F4 = Concern with ChatGPT

Conclusions, Implications, Limitations, and Future Work

This paper used a survey instrument to gather opinions on ChatGPT use from engineering students. The final four factors are learning tool, trustworthiness, ease of access, and concern with ChatGPT. The research team adhered to the necessary procedures in the design and development of the survey, gathering data for face and content validity, factor analysis, and internal consistency reliability for each of the four factors. The four proposed factors were confirmed by the EFA results, and one factor (ethical considerations) was eliminated. The internal consistency reliability (Cronbach's α) for the four factors ranged from 0.62 to 0.82, indicating good reliability, and the factor loadings for the final factors ranged from 0.48 to 0.78.

This research study offers several implications. This study has several ramifications. Teachers and/or academic institutions can use this survey tool to find out how their students feel about using ChatGPT and gain insightful information that will help shape the guidelines and policy regarding ChatGPT use in the classroom. Additionally, this study provides implications for students to comprehend the issues surrounding ChatGPT, including ethical considerations, tool trustworthiness, and inaccurate information retrieved from ChatGPT.

This study has some limitations like all other studies. The data collected is not representative as the respondents are from a single university. The respondents are mostly undergraduate engineering students, and the survey could be further administered to understand the doctoral students' perceptions on the use of ChatGPT in engineering. Further studies can be conducted to determine the factors influencing the undergraduate and graduate students' perceptions on the use of ChatGPT in engineering considering different demographic parameters such as gender identity, race/ethnicity, class standing, engineering major, etc.

Acknowledgement

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