Analysis of the Interactions and Impact of Generative Artificial Intelligence on Human Learners

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***Abstract*—Generative Artificial Intelligence (GAI) technologies have rapidly evolved, demonstrating the ability to generate human-like responses and outputs across various fields. Within education, GAI tools like ChatGPT have garnered significant attention, leading to a debate on their potential risks and benefits. Concerns centre around the potential harm to educational integrity and system efficacy, while proponents argue for the benefits of enhanced learning processes and increased accessibility. Despite divided opinions, GAI's integration into the educational landscape is undeniable. This paper provides a comprehensive overview of the various perspectives on GAI's educational impact, the motivations behind its use, and current methods for measuring GAI-user interactions. By analysing these dimensions, the study aims to develop a nuanced understanding of GAI's role in education, emphasising the need for accurate metrics to evaluate its influence on learning outcomes.**

***Index Terms*—GAI, interaction, impact, learning, measure.**

I. Introduction

Technology is constantly evolving, the rate of which can go well beyond expectations, as seen with recent developments in Generative Artificial Intelligence (GAI). The latest GAI technologies have demonstrated an ability to produce output related to a broad range of fields while generating human like responses [1]. It's potential use is currently being explored by a number of industries, with no particular boundaries being drawn. GAI has been used to help develop climate mitigation strategies [2], in academia to write abstracts [3], in medicine [4], in story writing [5], and many other applications.

Within education, GAI has brought divided opinions. Due to the increasing popularity of GAI tools, such as ChatGPT [6] and Copilot [7], there has been significant interest in understanding the potential risks and benefits [8]. There have been concerns about how these tools may be harmful to the education system and possibly deteriorate student integrity [9]. While much research has been devoted to investigating the downsides and negative consequences of using GAI, there is also a growing field that explores the potential benefits of GAI usage in education, as there are aspirations for leveraging its utility in developing more effective learning processes [10], as well as to better understand the main reasons for it's appeal [11].

Educational institutions were already operating in a digital environment when advanced GAI tools became commonly accessible. Because of this accessibility, powerful utility, and user-friendly interface, GAI not only became a trend, but has continued to remain relevant in student life [8]. As such, observations have been made linking how students engage with the tool and their learning outcomes. A common problem encountered in the field is the necessity of characterizing and quantifying the impact of GAI on students and the educational process. As the body of research on GAI as a learning tool has increased, there has been development of new metrics and criteria to measure GAI's output quality, as well as the interactions experienced by human learners. A core argument outlined in this paper is that by accurately capturing these elements, the overall process a student goes through when using the tool can be better understood and, consequently, the relationship between GAI and a student's output quality, or improved understanding, can be described. Without any method to quantify the impact that GAI technologies could have, concerns about GAI usage may be misplaced, and the overall effect of GAI, whether harmful or beneficial, is driven by the context of its use. Since GAI is already established as an easily accessible tool, whose potential has proven to be huge and beneficial, it is necessary to know how to measure the user-GAI interaction, to be able to estimate and understand the impact that these can have on the user and the environment that surrounds were GAI is employed.

This research aims to provide a comprehensive overview of the various perspectives and analytical approaches used to explore the interactions and consequences of GAI-user relationships. The scope has been narrowed to contexts where students use GAI in the form of chat-bot technology, highlighting a client-server scheme. To attain a full understanding, the study will begin with developing context around GAI's application and also aim to expose the motivations behind its usage. The potential impact of GAI on student learners will then be explored by considering several perspectives in the literature. Finally, current methods of measuring GAI-user interactions will be discussed.

The article is organized as follows: Section II shows the

usage cases of GAI in education fields, section III explores the impact GAI has depending on the context and its usage, section IV explains and details the different ways of measuring the human-GAI interactions, section V discusses the scope and limitations of the articles presented and potential ways of improving existing methodological approaches.

II. Usage

Due the increasing accessibility of GAI, the technology has become a recurrent tool in many fields. A frequent use case, often found in the form of a chatbot, is the generation of natural language texts, involving providing prompts or questions on a topic of interest. In response, the GAI produces a response that tries to satisfy the requirements outlined in the prompt [12]. Such text generated by the GAI, in many cases, can have a level of reasoning similar to a human being. The use of GAI for this purpose is commonly found among students, reasons for which have been explored in the literature; notably, trust in GAI-generated content, time-saving, and it's intuitive interface have been critical to its wide spread adoption [11].

In addition to taking advantage of the text generated by GAI, there is a field of research that has focused on using GAI as a tool to enhance the learning process. Taking advantage of its ability to generate text instantly with considerable certainty, students have found that ChatGPT can provide instant support for concerns that they may have and which sometimes cannot be resolved by teachers, either because of the volume of student concerns in a class or lack of time. In the case of [13], ChatGPT was used to improve the writing skills of students learning a foreign language. To achieve this, students were permitted to use ChatGPT for feedback, as it can give corrections and suggestions based on the provided text. By repeating this iterative process, students sought to improve their skills based on their criteria to accept the recommendations and accompanied by the supervision of a teacher.

A more critical case is when GAI is used in the solution of exams and homework, the dynamics are the same as the previously mentioned cases and with the same mobility, time and versatility; however, there are situations in which the GAI performance depends on the type of problem. In [14], ChatGPT was used by pharmacy students to resolve a problem-based learning task, where the interpretation of a case study and factual information was required. Over the course of two hours, students proposed and discussed solutions to the trigger question and were permitted to use ChatGPT to clarify terminology and find resolutions. After the session, students were given a survey that assessed attitudes, engagement, and participation. The students' reception of the tool was mixed for its interpretation of the case study and related problem-solving skills, while the more knowledge based skills were generally perceived to be effective, though issues related to inaccurate or irrelevant responses were also reported.

Outside of the classroom setting, GAI has also shown great performance in other learning processes or assistance in various tasks. In the field of programming, GAI is capable of generating functional code from scratch in various programming languages that serve as learning material for the learner or as a solution to the user's problems. In [15], ChatGPT's ability to support independent learning in the context of programming was assessed. Various questions were posed that intended to elicit educational responses, and the content generated was subsequently analysed to assess its efficacy in supporting the learner. A similar approach was taken in [16], though with a broader scope to encompass mathematics, algorithms, creative writing, and the generation of practice materials. Both studies argued that, overall, ChatGPT is useful in providing comprehensive responses, with the potential to individualise the experience. However, limitations were also noted, specifically its ability to determine the learner's skill level, as there were instances of the tool assuming too much in terms of user knowledge. Also, the need to ask the right questions to receive quality responses was highlighted, and inaccurate responses were observed at times as well. Instead of replacing critical thinking and communication skills, the studies argued that the widespread use of GAI would make them more relevant, as the effective use of these technologies to solve complex problems requires an evaluation of how the content generated fits into a bigger picture.

III. Impact

Knowing the different motivations behind the use of GAI, regardless of the field, is necessary to understand in which context is applied. Depending on how the GAI is used, the consequences can vary, an example of this can be seen in [13], where the primary research purpose was to investigate whether GAI usage can facilitate student learning and help improve writing ability in the context of foreign language learning. Using an intervention method to evaluate the student writing products, the authors tracked the writing quality of the students before, during, and after a one month training period. The experimental group was permitted to use ChatGPT for self-assessment and peer-assessment during the training period, while the control group was not. Through statistical analysis of the test results, the authors concluded that the use of GAI can improve written text quality. Using focus group discussions with the experimental group, post-intervention qualitative assessment was conducted, and several reasons were proposed to explain this statistical difference. Specifically, GAI's ability to give specific feedback in correcting grammatical mistakes, as well as improve the student's abilities through explanations of corrections. The previous points can be seen as a long-term positive impact on the student's interaction with GAI tools.

An example of a different impact is shown in [17], where the research aimed to expose the drivers behind why students choose to use ChatGPT in their studies and its potential impact. Employing surveys conducted to a group of over 600 students, trying to collect as much information as possible

related to the frequency of ChatGPT usage, the reasons and causes behind the use of this tool (such as work overload and time pressure), and the consequences that these have caused on students. The research concluded that the usage of ChatGPT was found to be positively correlated with academic workload and time pressure, but most importantly, the use of ChatGPT was found to be correlated with memory loss, procrastination, and poor academic performance, showing that it has a strong negative impact, not only on student academic life but on their other abilities too.

In [18], the authors hypothesize that GAI positively affects student learning achievement, and the key factors mediating this impact are student self-efficacy (confidence in achieving their goals) and cognitive engagement (actively exerting mental effort to achieve these goals). To test the hypothesis, data on each variable were collected through surveys, except academic performance, which was based on the student's GPA. Having collected the data, regression analysis and bootstrapping were applied to test the hypotheses. In particular, bootstrapping was used for testing the mediating relationships of the explanatory variables. The results supported the hypotheses. It was found that learning achievement was significantly correlated with ChatGPT usage, and the positive relationship is mediated by self-efficacy and cognitive engagement. The previous cases indicate that the impact of GAI usage depends on the motivations behind the use of this tool such as time pressure or desire for improvement, and the environment where GAI is used, which could have supervised assistance or not.

IV. Measurable Relationships

Important to the research is the question of how to measure GAI usage. The degree of its use is often explicitly dealt with as it helps delineate the relationships or impacts being explored. The first part of the study in [17] was devoted to developing a scale of ChatGPT usage, the approach of which was based on prior research. ChatGPT usage was defined as "the extent to which students use ChatGPT for various academic purposes including completion of assignments, projects, or preparation of exams." 12 items for the scale were proposed based on this definition, and the number was reduced to 10 following an evaluation from 5 experts. 165 students were provided with the 10-item Likert type scale that included a range of 1=never to 6=always. Following the receipt of the distributed surveys, the factor structure of the scale was analysed using exploratory factor analysis, which resulted in 2 of the items being dropped. It was concluded that the remaining 8 items were valid and reliable, and were appropriate for use in the next part of the study. In a similar vein, [18] developed a 5-point Likert scale to measure the quantity of GAI usage, based on a scale from prior research, and experts reviewed it for final adjustments.

Different contexts of study give way to different methods for measuring GAI usage. The approach of surveys to is common in the literature when the goal is to measure its impact, as usage typically requires a broader definition. When specifically looking at collaborative writing, [19] took a more fine grained approach, where each interaction between GAI and user was counted, and the total usage was expressed as a percentage of all types of action, including those that involved not prompting the GAI.

Another key element in this kind of research is having a way to represent the interactions between the user and GAI tools. Being capable of quantifying or characterizing this interaction makes it possible to measure aspects of GAI-user impact and collaboration, and to analyse the decision-making process of the users while using the tool.

In [18] the interaction between students and GAI was measured through characteristics such as self-efficacy and cognitive engagement. The proposed relationships were developed based on discussions of theory from the literature. In particular, interactive theory, often used to described interactions between humans and machines, places significance on the feedback received by individuals during an interactive process. This was highlighted in the study, as GAI was noted for its potential to provide more accurate self-assessments given tailored and immediate feedback, an ability underpinned by its vast educational resources and dynamic adjustment of content. Along this reasoning, it was hypothesised that there is a correlation between GAI usage and learning achievement.The hypothesis of self-efficacy mediating the GAI interaction was developed based on prior research showing the correlation between a student's confidence in completing a task and their academic achievement. It was proposed that by interacting with GAI, student ability is augmented over a diverse range of skills leading to the belief that they can achieve more. In addition, the personalised learning experience offered by GAI tools makes complex knowledge more accessible, further improving the confidence of human learners. Cognitive engagement was also argued to mediate the relationship. Based on prior research, it is noted that cognitive engagement in education refers to the degree of active participation and mental effort during a learning activity, and that a higher level of cognitive engagement is correlated with improved learning outcomes. Once again, GAI's ability to provide an interactive experience plays a vital role. On the one hand, a kind of gamification takes places, whereby students can easily explore various subjects that stimulate their curiosity. On the other hand, it is noted that extracting quality information from a GAI tool requires inputting quality prompts. In this way, students must engage in an iterative process of critically evaluating the generated content and refining their prompts if needed. For these reasons, the student-GAI interaction is hypothesised to be mediated by cognitive engagement. Finally, the authors argue that self-efficacy and cognitive engagement are themselves related, as students with higher levels of self-efficacy are more willing to expend cognitive effort to achieve the desired outcome. Hence, they hypothesise that GAI interactions lead to self-efficacy, which in turn leads to higher levels of cognitive engagement, and consequently improved academic outcomes. The data on these variables was captured through surveys, where the scales for measuring cognitive engagement and self-efficacy were borrowed from the literature. Fig 1 shows how the various

aspects of the student-GAI interaction are related. The weights of each link indicated the strength of the relationship observed and were calculated by applying bootstrapping on the sample data. With this, the proposed hypotheses were supported.

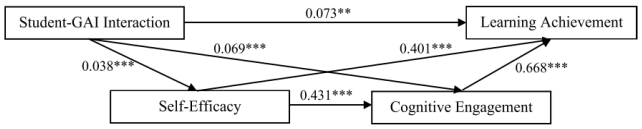

Fig. 1. Graph representation of students-GAI interaction[18].

[19] looked at GAI interactions from the perspective of collaborative writing and aimed to develop a new visualisation technique, CoAuthorViz. The dataset used is based on writing sessions of human authors who were permitted to make calls to ChatGPT-3 and either incorporate the prompts or ignore them. By recording key events, such as how often the writer accepts, edits, or ignores ChatGPT suggestions, the writer's level of interaction with the writing tool could be assessed. The frequency of these events with respect to ChatGPT-3 calls and authorship in sentences were then calculated and used as the basis for novel indicators. The relationship between the CoAuthorViz metrics and writing quality was also explored using the TAACO tool. Various dimensions of writing features were analysed to link connections between output and writing behaviour. Based on the analysis, user profiles were developed. In particular, three case studies were found to emerge: fully autonomous writer, autonomous writer with ChatGPT-3 assistance, and ChatGPT-3 dependent writer.

Similarly, in [20] authors measured the time university students spent using aText, a software for text redaction, for their final year project. In this work, the metrics developed relied on straight forward calculations. The number of times each student accepts an aText suggestion was divided by the total prompts made. The study focused on the different categories proposed by the program on how to improve the text redaction, as it not only provided the opportunity to see how much the students rely on aText but also to observe the weaker aspects in the student writing and how they overcome their lack of abilities with aText. In Table I, the various recommendations made by aText are given by frequency of acceptance.

TABLE I
FREQUENCY ON INTERACTING WITH ATEXT[20]

Recommendation	acceptance rate
Splitting of long sentences	55,82 %
Introduction of acronyms	100 %
Use of subjectivity indicators	42,68 %
Variation of connectors	65,18 %
Systematizing of using 1st person verbs person	20,49 %
Lack of definitions	78,04 %

V. DISCUSSION

The foregoing has presented various perspectives on student-GAI usage, impact, and interactions. This section focuses on various contradictions and commonalities found across the literature, and discusses potential methodological approaches in further research.

There is evidence to support the notion that GAI is beneficial to student learning, as several studies corroborate this argument [13][18]. However, other studies stand in contradiction [17]. In attempting to understand these contradictory results, a noteworthy dimension is whether GAI has been incorporated into the learning process as a legitimate tool. The study by [17] investigated students who were using GAI outside of the classroom setting, and were likely completing their academic work in ways unintended by the curriculum. Students who use GAI to complete an assignment as a stress-coping mechanism are unlikely to aim for an educational experience, but are simply trying to produce a result as quickly as possible, irrespective of their own understanding. This is contrasted with study designs like those found in [13], where GAI is explicitly used in the learning process, rather than as a tool to produce the final result.

A limitation found in current research is that the quantity of GAI usage is not always clearly taken into account. In [13], there was a one month training period, where students in the experimental group were permitted to use GAI. However, the extent to which individual students in this group actually used GAI was not tracked. This is unlike other studies where GAI usage was surveyed and quantified [17][18]. In addition, studies such as [19] and [20] also tracked GAI usage by counting the number of interactions, despite not necessarily investigating GAI's impact. Although not all contexts allow for a straight-forward method of measuring usage frequency in this way, the concepts drawn from these studies could be particularly useful if GAI usage is taken into account. Notably, [19] developed a concept of dependency which draws similarities with studies such as [15] and[16], where the potential efficacy of a GAI centred learning process was evaluated. It was noted there there is a risk of dependency on GAI, and learners are required to critically evaluate the content produced in order to effectively use the tool, not the least due to its tendency to produce unreliable information. Both [15] and [16] highlight that the way students interact with the tool can determine the quality of learning outcomes. Again, this draws similarity with other research. In particular, [18] developed at length concepts of cognitive engagement and self-efficacy. However, a noteworthy limitation in this study was that no direct observations of GAI usage were made, as the study relied on self-reporting, which hinders the development of metrics to describe the interactions. The difficulty of observing GAI usage outside of the experimental setting need not be emphasised; however, certain methodological approaches, such as students in a classroom setting, lend themselves well to making direct observations.

A bigger issue is establishing what kinds of measurable interactions make up GAI usage. Looking to research outside of GAI may help develop notion in this regard. In [21], Google searches made by students translating a text were

recorded to understand how frequently external sources were relied on, and what kind of queries were made. As critical evaluation of GAI generated content may involve using web searches to verify the information, the approach in [21] could be relevant in determining the extent to which students engage with the tool, as a student who unquestioningly accepts GAI content is unlikely to use web searches for further verification. In [22], collaborative learning was studied by capturing multi-modal data in the form of audio and writing logs. This could be particularly fruitful in the context of intervention studies, such as [13], where conversations between students could be analysed with respect to the GAI interactions that are occurring at the time. Since GAI was reported to facilitate collaboration in [13], this type of data could yield insightful results. In a similar way, the text conversations that students have with a chatbot GAI could be captured and analysed. The iterative nature of GAI-student interactions was noted and relied upon in [18] to argue for cognitive engagement as a mediating factor in improve learning outcomes; however, no direct observations of this process were made. This could be overcome by using data captured by the GAI-student conversations.

The current state of the literature in this field has produced a body of thought-provoking results that will likely develop into a rich domain. The most relevant limitation is the inconsistent approach used when accounting for the interactions, and the lack of direction observations being made. By using methods that allow for direct observations, the potential impact of GAI usage on the learning process can be linked to the specific kind of GAI-student exchange that occurs, and metrics describing these interactions can be developed. It is possible that concepts such as dependency, cognitive engagement, and self-efficacy will reappear in studies that take this approach, with the additional benefit of well-defined metrics in place to analyse the observations. Having achieved this, a more accurate statement of GAI's influence on learning outcomes can be made, and its legitimate involvement in learning processes can be based on an informed understanding of what yields effective learning. Finally, an outline of risks associated with its usage can be better delineated, giving an opportunity to motivate its proper use by students outside of the classroom.

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