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Exploring Patterns of Generative AI Utilization in Education

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Abstract

Generative AI, particularly ChatGPT, has gained widespread recognition and is making a significant impact in education. By automating a considerable portion of report assignments and homework, Generative AI, GAI for short, has revolutionized the learning process. Methods and tools should be developed to effectively harness the potential of GAI. The possibilities offered by GAI are extensive, surpassing our current understanding. It enables adaptable education that can cater to the diverse needs of individual students, while also alleviating the workload of teachers, among other benefits. The main objective of this paper is to provide a comprehensive overview of the potential applications of GAI. We concentrate on the shared abstract characteristics of different utilization methods, showcasing their capacity to be classified into discernible patterns. With these patterns, we anticipate the development of future methodologies for the use of GAI in education area. Simple demonstrations will be showcased at the conference.

Keywords: generative AI, exercise generation, personalized learning, streamlined education

1 Introduction

GAI exhibits proficiency not only in responding to basic inquiries but also in summarizing sentences, making comparisons, and demonstrating reasoning abilities. Additionally, it showcases competence in tackling computational problems. By formulating well-crafted prompts for GAI, it is possible to extract enhanced responses. OpenAI, in their educational guide [1], highlights the potential for efficiency and individual optimization in incorporating GAI into the realm of education. The utilization of GAI in education is still in its early stages. Mollick [2] has employed GAI as an instructional tool within his MBA classes, where students refine GAI's outputs through iterative revisions to compose a written article. This educational process entails repeated prompt-based interactions to instruct and train GAI, culminating in the collaborative production of a final article by both the student and GAI. This instructional approach, rooted in knowledge dissemination, demonstrates efficacy in advanced-level courses such as MBA. However, diverse methodologies are requisite for integrating Generative AI (GAI) into other academic tiers or for distinct objectives. In [3], the advantages and drawbacks of employing Artificial Intelligence (AI) in education are discussed separately, addressing both its usage by educators and students. While this categorization suffices for conventional AI, it falls short in accommodating the immense capabilities of GAI. Reference [4] proposes a novel application in science education. Despite

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numerous ongoing studies yielding published papers [5][6][7][8][9], the existing body of research remains inadequate. The authors contend that exploring the potential of individualized employment of GAI is essential, alongside organizing illustrative instances of usage and establishing patterns. By doing so, the authors assert that the educational impacts and merits of GAI will become more evident. Studies from this perspective are not sufficient. The primary objective of this paper is hence to systematize and present patterns of utilization, followed by a summary of the relating issues.

There exists multiple forms of education. One of the most traditional and widely recognized methods, particularly at the elementary level, revolves around the acquisition of knowledge and skills. In this approach, the teacher imparts their knowledge and skills to students within the classroom. This instructional method works effective through repeated exercise-solving and types of assignments. It is crucial to devise teaching materials that maintain students' engagement and prevent monotony. Diverse forms of practice exercises are deemed effective for this style of learning, which places a substantial burden on teachers to prepare such materials. E-learning systems have been developed [10][11] to alleviate this burden, enabling personalized learning experiences while reducing the workload of teachers. Some of these systems feature automatic exercise generation capabilities. However, the current application of several AI technologies is limited to pre-defined patterns or specific domains of knowledge. As a result, the burden on teachers within this educational framework remains significant, and the integration of GAI holds promise for alleviating this challenge.

GAI can also serve the purpose of automatically generating guidance for students. By incorporating school- and class-specific information, the advice provided by GAI can be made more targeted and pertinent. For instance, GAI has the ability to output the specific knowledge acquired by a student, including the corresponding class and timeframe, and offer clear recommendations regarding areas that require review. This functionality can be achieved by employing well-crafted prompts for GAI. In practice, various new tools can be utilized to streamline the system and enhance the incorporation of external information.

Ensuring reliability stands out as a prevalent challenge for GAI. Given the current level of technology, the activities involving GAI are not exempt from potential errors. In the context of education, the exercises and advice generated by GAI may not be flawless and can contain errors that are challenging to identify automatically from an external perspective. Additionally, there may be underlying, undiscovered factors that could give rise to unforeseen issues when employing GAI. We propose exploring the possibilities of utilizing GAI in educational through patterns.

2 Modeling GAI and Human Interactions with Patters

The conventional classroom entails a simple dynamic between the teacher and students, with their roles clearly defined. The inherent simplicity of traditional classrooms necessitates minimal discussion regarding class structure and the roles of the participants. However, with the emergence of GAI as a potential new stakeholder within the classroom, simplicity gives way to various complexities. GAI can assume different roles in different situations, allowing for flexible interactions among all participants. Consequently, there is a need for a framework that can effectively organize and discuss the relationships among the three participants including GAI. In other words, it examines the direction of communication among these stakeholders and reveals the flow of information and knowledge. This clarification will clarify the difference from conventional education and will be useful for the development of related technologies.

In the field of information technology (IT), it has become commonplace to categorize business relationships or transactions based on the roles of the involved stakeholders, typically distinguishing them business entities (B) and private customers (C). There are various forms of business enterprises, but B is the entity that focuses on abstract commonalities while ignoring the differences. Similarly, C is the entity that focuses only on properties common to different individual customers. When products, in a broad sense, flow from B to C, the transaction is referred to as B-to-C, often denoted as B2C. Other cases are named in the same way. By characterizing the flow of products at an abstract level in this way, it is possible to discuss the abstract nature of transactions and also to have a bird's-eye view of the properties and functions required of IT systems. Abstraction works effectively here.

Table 1: Patterns in Class

Instructional Pattern	**Role**		**Explanation**
	Knowledge Provider	**Knowledge Receiver**	
Teacher-to-Student (T2S)	Teacher	Student	✓Traditional classes transferring knowledge ✓GAI works as Teacher’s assistant to reduce his load
GAI-to-Student (G2S)	GAI	Student	✓GAI replaces teacher ✓Knowledge transfer is main purpose ✓Risk of improper use
Student-to-GAI (S2G)	Student	GAI	✓Focusing on knowledge output and utilization ✓Similar to active learning method
Student-to-Student (S2S)	Student	Student	✓Focusing on knowledge output and utilization ✓GAI assists both sides of students

This paper extends this notion from IT to the area of education. In the above case of IT, the point is from which entity to which entity the products in a broad sense flow. In the extension to education, the focus should be on knowledge instead of products, and the key point is from which entity to which entity knowledge is transferred. We thus have two positions to consider: *knowledge provider* and *knowledge recipient*. Taking classical classroom education as an example, the knowledge provider corresponds to the “teacher” and the knowledge recipient is the “student”. The knowledge flows from the “teacher” to the “student”.

Based on this idea, we classify typical educational interaction structures into four patterns, as illustrated in Table 1. We subsequently provide a brief explanation for each pattern in accordance with Table 1. Note here that the word of teacher in the table refers to a human teacher, and the student refers to a human student. For instance, in T2S, knowledge is provided by a human teacher and received by human students, while in G2S, the knowledge provider is replaced by GAI. Complex combinatorial cases can also be considered by combining with these patterns.

2.1 T2S and G2S Patterns

T2S, Teacher-to-Student, exemplifies a traditional pedagogical approach. Inside this paradigm, a human teacher plays as a central role. GAI can function as an invaluable cognitive aide to the teacher. The class in this type includes lots of indispensable tasks, with the development of instructional materials, including assignments and homework, representing a customary burden for educators. Personalization assumes an essential role in effective education, necessitating tailored educational resources that align with individual students' performance and aptitude. GAI can assist teachers in crafting customized teaching materials, encompassing the automated generation of explanatory documents and exercises in diverse formats. Furthermore, it can evaluate students' responses to essay works and succinctly summarize lengthy compositions. By undertaking these responsibilities, GAI can alleviate the teacher's workload and contribute to streamlined education. With the use of ICT and e-learning tools [10][11], educational efficiency can be further enhanced. Remark that GAI remains in a subsidiary role in T2S, minimizing the likelihood of issues such as inadequate responses, hallucination and other limitations.

G2S, GAI-to-Student, is an advanced version of T2S, wherein GAI substitutes for the role of human teachers. GAI with other future automation tools possesses the capacity to autonomously generate explanations and assign tasks to students throughout the learning process. It can furnish responses to student inquiries with a certain degree of accuracy. Despite the rapid advancement of GAI, its present capabilities may fall short of facilitating comprehensive G2S implementation. The progression of G2S is anticipated to unfold gradually through collaborative endeavors between GAI and human teachers.

There exists inappropriate applications of G2S that diminish its educational efficacy. A typical scenario arises when students are tasked with solving homework or assignments solely through GAI, instead of actively engaging in the process themselves. For instance, students may be instructed to condense a lengthy document, articulate their impressions after reading it, or compose a report on a given theme. These tasks serve as effective means for fostering reading comprehension and expressive skills. However, their effectiveness is compromised when G2S is employed inappropriately. One potential solution to this predicament is to mandate evidence of learning. This can be achieved by having students vocalize the text aloud or document their entire thought process in audio or text format, which is also employed in cognitive science as a method to study cognitive processes [12]. By keeping such a clear record, one can indirectly prove that one has worked on the project. Additional possibilities include utilizing videos captured during the learning process and physiological data gathered from sensors. Reference [13] proposes a technique for estimating the degree of attention by extracting blink information from videos of students engaged in learning. This method can help determine whether students are inappropriately relying on GAI while tackling a task. In [14], it is demonstrated that comprehension level of a lecture can be evaluated through the analysis of detailed data such as response time during exercises.

This approach holds promise for future application.

3.2 S2S and S2G Patterns

These learning patterns are founded on the dissemination and practical application of learned knowledge. In S2S, students play the role of teachers. They can deepen their understanding by teaching their knowledge or sharing with other peer students. Teaching assistants (TA) also fall under this pattern, as they refine their comprehension of knowledge and skills through their teaching engagements. This method has the advantage that students from both sides can learn at their own positions. GAI can serve as an aide to TAs by offering insightful hints and tips pertaining to their activities, compensating for any deficiencies in their knowledge.

S2G represents an elevated version of S2S, whereby GAI assumes the role of the knowledge recipient. Students learn by applying their own new knowledge to GAI, as GAI itself lacks the capacity to generate perfect answers independently due to its limited knowledge and other reasons. This methodology aligns with the approach proposed in [2]. While this method can contribute to the development of creativity and expressive ability, there are still issues to be addressed for the purpose of fostering basic academic skills.

3 Conclusions

GAI possesses capabilities that surpass those of traditional AI, and its potential continues to expand. Through our experiments utilizing the IT Passport and Fundamental Information Engineer Examinations, renowned Japanese certification in the field of IT, we have confirmed that GAI can roughly achieve passing scores under specific conditions. This implies that GAI can already be deemed to possess the capabilities of a teaching assistant in university classes. While previous studies [2][4][5] have presented some pioneering examples, their scope of application remains relatively limited. We need studies that can encompass the full range of possibilities, and further we need comprehensive architectural frameworks within which GAI operates in education field. This paper is pioneering in its utilization of patterns to elucidate the potential uses of GAI, explore feasible architectures, and contribute to future advancements in education. Experiments are presently underway to validate the implementation of these patterns, and the findings will be published in a forthcoming issue of this paper. Selected trial results will also be presented through live demonstrations at our conference booth.

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