Combine DGBL With AI System: A Technical Guidance to Reduce Teacher’ s Burden in Digital Game-Based Learning

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Abstract: Game-based learning has been regarded as a increasing popular method in current teaching process, however, it really burdens teacher as it requires teachers to invest abundant energy and time to design. Aims at reducing teaching burden, this research has proposed a guidance system design based on large language model (LLM) and blockchain technology. In this design, system framework has been divided into 3 layers: user layer, application layer and technical layer. Initially, teachers input their instructional plans, while students signing up their learner profiles. This information is securely recorded on the blockchain for data integrity. The results stemming from data prediction and feature engineering are then incorporated into the LLM , facilitating the visualization of strategies tailored to address specific learning challenges. As the process advances, the information undergoes automated scrutiny to evaluate the learning conditions, ultimately selecting an appropriate DGBL cases with a proven track record in similar scenarios. This aids teachers in crafting personalized learning blueprints, informed by the insights gleaned from the feature engineering analysis and its impact on students' learning experiences. The concluding phase involves tracking and assessment, wherein an automated evaluation of student performance is conducted based on study data and LLM-generated questionnaires. Teachers subsequently review the results and recommendations to enhance the quality of their instructional methodologies, and the learner portrait will also be renewed according to received data. This guidance system still has some disadvantages, such as lacking sequential consistency in the responses generated by the model. In summary, a future direction for this research is to develop specific LLM systems for specific school segments and instructional needs to help teachers implement DGBL.

Keywords: Digital game-based learning, Large language model, Blockchain

1. Introduction and Background

Implementing game-based learning still presents certain challenges, especially in terms of the demands it places on teachers' capabilities. During the implementation of game-based learning, teachers need to spend a significant amount of time calculating the difficulty level and time investment of games and assessing whether students' knowledge levels meet teaching requirements after the game concludes (Venera-Mihaela & Boghian, 2014). However, not every teacher has the energy to invest substantial time in evaluating the outcomes of game-based learning, which really burdens teachers when designing game-based learning. Teachers have found that they have to invest abundant time in design instructional games during teaching process, and hope to reduce this kind of burden while they think game-based learning can be effective.

Therefore, it is essential to discuss how to construct a game-based learning system to support teachers design activities during teaching process. This article will describe a learning analysis system build on blockchain and large language model, which aims at assisting teachers to establish game-based learning.

2. Literature Review

2.1 Game-based Learning (GBL)

Game-based learning refers to a pedagogical approach that utilizes game environments or elements to conduct instructional activities, impart teaching knowledge, and achieve educational objectives (P.-Y. Chen et al., 2022).

Embracing the use of game-based learning strategies often demands an increased level of preparation and allocation of resources. Teachers find themselves have to invest abundant time into the exploration and selection of appropriate educational games that align with their instructional goals (De Gloria et al., 2014; DeCoito & Estaiteyeh, 2022). Furthermore, they must acquire proficiency in the art of seamlessly integrating these games into their pedagogical practices (Su et al., 2019). There is a natural inclination among some teachers to resist the adoption of game-based learning due to concerns about the extra effort required. Moreover, the learning curve associated with incorporating game-based elements into teaching should not be underestimated. Teachers must familiarize themselves with the mechanics, dynamics, and aesthetics of various educational games to ensure their effective implementation (Belda-Medina & Calvo-Ferrer, 2022). In summary, the reluctance of teachers to embrace game-based learning can be attributed, in part, to the heightened demand for preparation and resources it entails. This research is responsible for this question.

2.2 Large Language Model

Large language models (LLM) are a type of natural language processing (NLP) model based on deep learning neural networks, primarily designed for understanding and generating natural language text (M. Chen et al., 2021). Compared to regular language models or analytical approaches, LLM allow models to learn features at various abstraction levels when processing text, from characters and vocabulary to higher-level grammar and semantics (Austin et al., 2021). Consequently, large language models are widely used for a variety of natural language processing tasks, including sentiment analysis, named entity recognition, summarization generation, machine translation, text classification, search engine enhancements, intelligent question-answering systems (Guu et al., 2020), and more.

In the field of education, LLMs are also considered to have numerous potential applications. LLM can facilitate personalized education by analyzing students' learning needs, interests, and abilities. Educators can use these models to generate customized learning plans, course materials, and exercises to meet the needs of each student (Abd-alrazaq et al., 2023; Owan et al., 2023). For instance, LLMs can provide tailored resources for each student, thereby enhancing the learning outcomes (Murgia et al., 2023). Secondly, LLMs can be integrated into educational tools and platforms to offer immediate learning support (Abd-alrazaq et al., 2023). Specifically, students can pose questions to LLM-based tools, and the model will provide answers based on the complexity of the question and the student's knowledge level (Kiesler et al., 2023). Consequently, employing large models aids in helping learners access learning materials and somewhat alleviates the burden on teachers. Additionally, LLMs can generate educational resources such as lesson plans, lecture notes, exercises, and quizzes (Gilson et al., 2023; Shen et al., 2023), as well as evaluate learners' performance throughout the learning process, thereby providing learners with real-time feedback on their learning performance (Ajevski et al., 2023). As previously mentioned, the design of game-based learning necessitates teachers to seek relevant teaching resources and design game-based learning instructional plans based on learners' situations. LLMs can assist users in finding relevant resources and providing answers based on user feedback, making them a potential tool for instructional support.

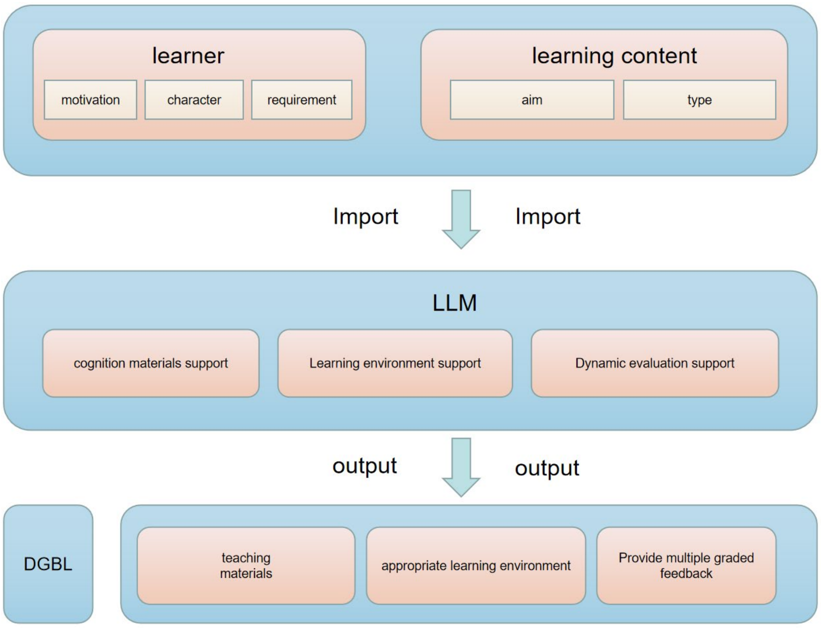

Figure 1: The function of LLM to DGBL

2.3 Blockchain

Blockchain is a cryptography technology that generates, stores, and analyses data according to distributed consensus algorithms (Alsharari, 2021; Gadekallu et al., 2022). Its fundamental concept revolves around decentralization, achieved through distributed ledgers and robust cryptographic techniques, enabling secure, transparent, traceable, and tamper-proof data storage and exchange (Guergov & Radwan, 2021). Notably, blockchain technology has found utility in the field of education. Firstly, its decentralized and secure features position it as a safe storage and verification method for student academic records and achievements. Information can be stored in a distributed manner on the blockchain, thus mitigating the risk of diploma fraud and academic record manipulation, and facilitating easier verification by prospective employers and educational institutions (Alam, 2022; Alammary et al., 2019); students have the option to selectively share their academic records and achievements without disclosing all information, thereby safeguarding their privacy and allowing them to have better ownership of their educational data (Saleh et al., 2020; Steiu, 2020). Consequently, blockchain is considered a potential tool for safeguarding data produced during teaching process.

3. Technical Structure and Working Process

3.1 Structure

The following figure 2 has shown the working process of LLM-blockchain guidance system.It includes 3 layers to support the guidance for teachers to design game-based learning: user layer, application layer, and technical layer.

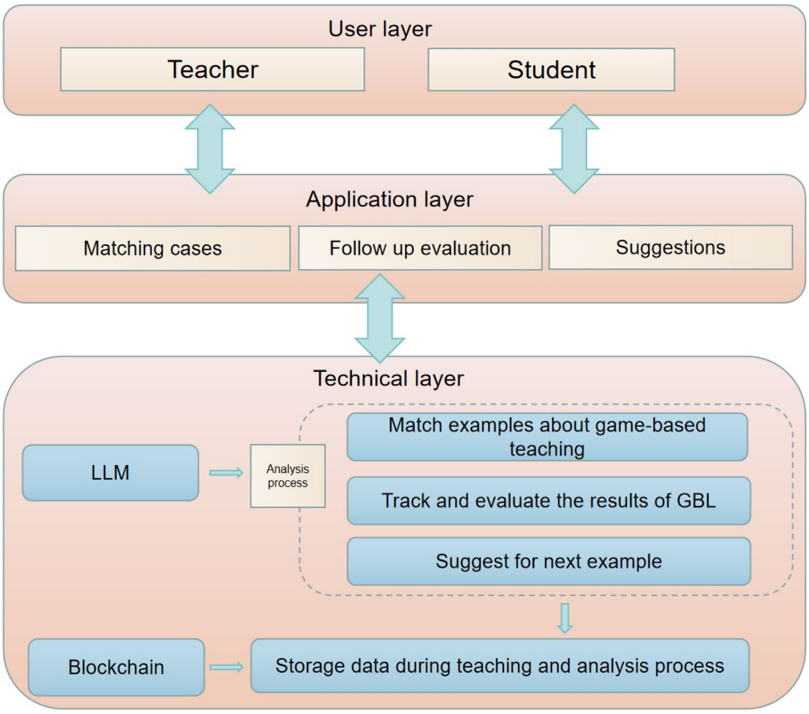

Figure 2. System layers

User Layer

User layer has mentioned 2 main using groups using this system, teachers and students. This layer is responsible for collecting data from users, specifically, which can receive data that being scanned automatically from digital games and input manually from users. In addition, it also responsible for transform data from other layers to user's interface. At the same time, teachers and students can also transform and observe data during teaching process, in order to update and grasp the tendency of data fluctuation.

Application Layer

The application layer, then, is where the data analysis that serves as the basis of suggestions to teachers regarding the implementation of DGBL takes place. It will responsible for connect technical layer with user layer, which has provided functions based on technical support. Firstly, it will help teachers to match cases, in order to provide practical references for teachers to design DGBL process. Meanwhile, it is also helpful to follow up evaluation during learning process when users allow it to track data produced in DGBL and input manually by users, which means it can provide assistance for evaluating learner's performance and make things clearly to satisfy teacher's requirements about learner analysis. Consequently, based on the matched cases and learners analysis results, it can provide suggestions for teachers regarding specific requirements set by users.

Technical Layer

Two technologies in technical layer, LLM and blcokchain, are responsible for supporting system framework in technical dimension.

LLM (LLM) deals with data analysis process in system. Based on the input of diverse datasets, LLM utilizes the transformer architecture, which consists of encoder and decoder components. Encoder in LLM can take the input text and converts it into a series of high-dimensional representations, which captures the contextual information of the text that are generated by stacking multiple layers of self-attention mechanisms and feed-forward neural networks. This enables LLM to capture long-range dependencies and contextual information effectively, therefore analysis learner's performance and teacher's instruction. In addition, using multiple layers in the encoder-decoder framework helps in learning complex patterns and generating high-quality responses, especially the self-attention mechanism enables the model to capture long-range dependencies and contextual information effectively, allowing it to generate coherent and contextually appropriate responses (Naidu & Sevnarayan, 2023). This enables LLM can generate smooth suggestions based on its complex encoder structure, as a result, LLM can be an effective technology to accomplish analyzed process in guidance system.

Blockchain deals with the storage of data. During the using process, data will be divided into private chain, public chain and alliance chain, aims at ensuring all types of information can be storage well instead of leaking it.

3.2 Working Process

This guidance system design for providing guidance for DGBL design and implement. Initially, teachers input their instructional plans, while students signing up their learner profiles. This information is securely recorded on the blockchain for data integrity. The results stemming from data prediction and feature engineering are then incorporated into the LLM , facilitating the visualization of strategies tailored to address specific learning challenges. As the process advances, the information undergoes automated scrutiny to evaluate the learning conditions, ultimately selecting an appropriate DGBL cases with a proven track record in similar scenarios. This aids teachers in crafting personalized learning blueprints, informed by the insights gleaned from the feature engineering analysis and its impact on students' learning experiences. The concluding phase involves tracking and assessment, wherein an automated evaluation of student performance is conducted based on study data and LLM-generated questionnaires. Teachers subsequently review the results and recommendations to enhance the quality of their instructional methodologies, and the learner portrait will also be renewed according to received data.

4. Discussion and Conclusion

This research has proposed a system to design DGBL teaching process, which aims at reducing teacher's burden during design process. Currently, this system has covered the whole implement process of DGBL from teaching plan before class and learner portrait after class. Therefore, it seems like a practical system that can be used in realistic teaching circumstance. However, this system is based on the LLM system, which means it will caused variety of problems that brought by LLM itself.

One of the limitations is the lack of explicit modelling of sequential dependencies, as each markerin LLM is processed independently in parallel, which can sometimes lead to a lack of sequential consistency in the responses generated by the model (Brown et al., 2020). Another challenge is the potential for over-reliance on surface-level patterns in the training data, leading to the generation of responses that appear reasonable but are incorrect or meaningless. This has been referred to as the "cueing problem" in language modelling (Liu et al., 2023). For example, some researchers have found that the LLM produces completely irrelevant research ideas and literature when generating literature reviews (Leiter et al., 2023; Lin, 2023). Therefore, based on the current workings of the system, the accuracy of the answers generated by the system may be challenged, and the accuracy and sequence consistency of LLM answers generated under different conditions may be a factor to consider.

Secondly, as LLM answers are based on existing databases and pre-training rather than independent thinking (and indeed, LLMs are unlikely to be able to think independently), the quality of their answers is heavily dependent on the quality of the training materials which will still require extensive pre-training by the developer or instructor. Therefore, it remains to be explored whether this can actually reduce the burden on teachers. In addition, the output of the LLM is based on statistical rules and patterns learned during the pre-training process, which may lead to the generation of answers that lack practical judgement and logical reasoning. For example, when a researcher uses LLM to analyse data from the literature, Type I errors may occur, which may affect the veracity of the research data analysis (Dalalah & Dalalah, 2023). Therefore, if one intends to use LLM in a specific educational field, one needs to develop training LLM according to the characteristics of this field so that this system can be more relevant for teaching in a particular field.

In summary, a future direction for this research is to develop specific LLM systems for specific school segments and instructional needs to help teachers implement DGBL.

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