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AI-Based Learning Content Generation and Learning Pathway Augmentation to Increase Learners Engagement

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Abstract: ***This project investigates AI-driven methods for creating learning material and enriching learning paths to increase learner participation in online learning environments. Conventional MOOCs are hindered by high dropout rates and low participation, mainly because of static, non-interactive content. To overcome this, the project suggests incorporating narrative structures into learning paths, dynamically interweaving them with AI-created content referred to as "narrative fragments". These pieces comprise "summaries" and "reflection quizzes" that help learners and evaluate their comprehension. The method utilizes Natural Language Processing (N1LP) and Natural Language Generation (NLG) methods in the form of GPT-2 to create content using different learning materials. This process is subject-agnostic, making it possible to be versatile across learning topics, thereby boosting engagement and the efficiency of learning. The system has been rated with automatic metrics and human raters, with promising outcomes in both content quality and potential for learner interaction.***
Keywords: AI-based learning, learning content generation, Learning pathway augmentation, Learner engagement, Narrative fragments, GPT-2, Natural Language Processing (NLP), Natural Language Generation (NLG)

I. INTRODUCTION

The rapid growth of online education has transformed the way learners access knowledge, with Massive Open Online Courses (MOOCs) emerging as a key player in this shift. The advent of MOOCs has democratized education, making learning resources accessible to millions of students globally. However, despite the promise of online education, platforms like MOOCs face significant challenges. One of the most pressing issues is learner disengagement, often resulting in high dropout rates, with some studies showing dropout rates as high as 90% in MOOCs (Siemens, 2013). This lack of engagement is compounded by the overwhelming volume of content, the static nature of most courses, and the difficulties learners face in navigating these resources.

Addressing this issue is crucial for improving the effectiveness of online learning environments. Traditional online learning platforms tend to rely on passive modes of content delivery, where students interact with long and often dense resources such as textbooks, videos, and research papers. These resources, while rich in content, do not offer the kind of personalized, dynamic, and interactive experience that fosters deep learning and sustained engagement. The lack of interactivity and adaptability to individual learners' needs leads to a one-size-fits-all approach, which fails to motivate or engage students effectively. Moreover, the transition between different learning resources—often drawn from diverse sources—creates a fragmented learning experience that can confuse or overwhelm learners. The COVID-19 pandemic has further intensified the need for more robust and engaging online education solutions. With millions of students and educators forced to adapt to fully online environments, the shortcomings of current online learning platforms have become even more pronounced. While several innovations, such as Intelligent Tutoring Systems (ITS), have sought to introduce adaptive learning experiences by curating personalized learning pathways, these systems often require significant human intervention and are limited to specific courses or subjects. This creates a scalability issue, as it becomes labour-intensive to develop such environments for every new course or subject area. To overcome these challenges, this project proposes an AI driven approach to enhance learner engagement by introducing narrative fragments into learning pathways. The core idea is to transform static learning pahways into interactive, narrative-based experiences, which have been shown to increase learner engagement. The concept of narrative centric learning has been explored in various educational settings, and research has demonstrated that structuring learning experiences as narratives— complete with a beginning, middle, and end—can help learners better understand and retain information. Narratives provide a meaningful structure that helps learners create a coherent mental model of the material, making it easier to follow and stay engaged.

This project aims to integrate narrative fragments, which are automatically generated using Natural Language Processing (NLP) and Natural Language Generation (NLG) technologies, specifically leveraging the GPT-2 model. These fragments include overviews and reflection quizzes, which are interspersed within the learning pathways at key transition points. Overviews serve as the "beginning" of the narrative, providing learners with a preview of what to expect in the upcoming section, while reflection quizzes act as a formative assessment tool at the "end" of each segment, allowing learners to reflect on their understanding before proceeding. These fragments help learners navigate the content more effectively, improving both engagement and retention by making the learning process more interactive. The AI-based system developed in this project offers a solution that is adaptable across domains and subject areas, making it scalable and cost-effective. Unlike traditional systems that require manual content creation and course-specific configurations, this approach automatically generates auxiliary learning content from a wide variety of learning resources. By utilizing open educational resources and content in any format, this system can dynamically update the learning pathway as needed. For instance, if a

learner decides to explore additional topics or needs to revisit prerequisite knowledge, the system can generate new overviews and quizzes on the fly, ensuring that the learner remains engaged throughout their journey. The integration of AI generated narrative fragments not only enhances the interactivity of learning pathways but also addresses the scalability problem of traditional adaptive learning systems. By automating the generation of narrative-based content, this approach reduces the need for manual intervention, thus lowering the cost and time required to develop personalized learning experiences. Additionally, this method allows for continuous updates and adaptations based on learner feedback and engagement, making it a highly flexible and dynamic solution. In summary, this project **seeks** to improve learner engagement and retention in online education environments by transforming static learning pathways into interactive, narrative-driven experiences. Through the use of cutting-edge NLP and NLG technologies, the proposed system generates personalized learning content that adapts to the needs of individual learners, providing a scalable and efficient solution to the challenges facing online education today.

II. RELATED WORK

The field of online education, particularly in the context of enhancing learner engagement, has seen rapid growth and diversification. With the emergence of AI-driven solutions, new methods for generating learning content and adapting learning pathways have been introduced, aiming to address the longstanding issues of learner motivation, retention, and engagement. The proposed project integrates narrative fragments into learning pathways to create a more engaging and interactive learning experience.

The subsequent sections summarize key contributions in the domains of online learning platforms, narrative-based learning, intelligent tutoring systems (ITS), natural language generation (NLG), and AI-based learning environments, which are the pillars of this project. MOOCs and the Challenge of Engagement Massive Open Online Courses (MOOCs) have transformed education by offering open access to high-quality learning content across various fields. However, despite the many advantages of MOOCs, one of the most persistent challenges has been slow learner engagement and high dropout rates. Research by Siemens (2013) found that MOOC dropout rates often exceed 90%, with many learners disengaging before reaching the halfway point of a course. This high dropout rate has been attributed to several factors, including the lack of personalized learning experiences, overwhelming amounts of content, and the passive nature of the learning process (Aldowah et al., 2020; Borrella et al., 2019). To address these issues, various researchers have focused on improving the interactivity of MOOCs. For example, Anderson et al. (2014) investigated learner engagement by analysing discussion forum activity and course participation rates. They found that active participation in forums and peer discussions significantly reduced dropout rates. However, simply increasing interactivity in forums does not necessarily resolve the problem of navigating the often-fragmented learning resources that MOOCs provide. Learners frequently face difficulties in transitioning between different types of content (e.g., video lectures, readings, quizzes), which can create cognitive overload and reduce engagement (Brusilovsky & Henze, 2007).

A. Narrative-Centered

Learning Environments A significant body of research has explored the role of narrative in enhancing learning experiences. The concept of narrative-centered learning environments builds on the idea that structuring educational content in the form of a story or narrative can improve engagement, motivation, and comprehension (Laurillard et al., 2000; Plowman et al., 1999). By framing learning experiences as stories, learners can follow a coherent structure that mirrors the natural progression of a narrative, making it easier to understand and retain complex information. One of the earliest examples of narrative-centered learning is the use of educational games.

Marsh et al. (2011) examined how narrative elements in games could be leveraged to enhance learning in STEM (science, technology, engineering, and mathematics) education. Their research demonstrated that embedding educational content within a story structure led to higher motivation and better retention of material compared to traditional methods of instruction. Plowman et al. (1999) further argued that narratives are effective because they align with the way humans naturally process information, particularly when the narrative follows a recognizable pattern of a beginning, middle, and end. In the context of online learning, narrative structures can be used to guide learners through the material in a way that mimics real-world problem-solving. This approach contrasts with traditional MOOCs, where learning materials are often presented in a linear or fragmented manner. By integrating narrative fragments into learning pathways, the proposed project aims to build on the successes of narrative centered learning environments by providing learners with a more structured and engaging experience.

B. Intelligent Tutoring Systems (ITS)

Intelligent Tutoring Systems (ITS) represent another significant advancement in personalized learning. ITS are designed to provide learners with individualized instruction and feedback, typically by modeling the learner's knowledge and adapting the instructional material accordingly. Early ITS research focused on creating domain-specific systems that could guide learners through complex subjects, such as mathematics or programming (Aleven et al., 2015). These systems typically involve a combination of rule-based decision -making and natural language processing (NLP) to provide real-time feedback to learners. One of the key challenges in ITS development is the need for significant human intervention to build the system. Each subject requires custom-tailored content, rules, and feedback mechanisms, which can make scaling ITS across multiple domains cost-prohibitive (Brusilovsky & Henze, 2007). Moreover.

III. PROPOSED METHODOLOGY

We propose a distributed approach for sensor node localization based on the characterization of radio frequency and ultrasonic to a range technology. Training characterization is crucial for finding the location of senses in the direction of localization. Ranging characterization includes analysing received signal strength with the help of ultrasound or radio frequency.

A. AI-Based Content Generation

The basis of this methodology is the use of AI models, specifically GPT-2, to dynamically generate learning content. GPT-2 is a strong Natural Language Generation model capable of producing human-like text. In this project, GPT-2 is directed to generate narrative fragments, overview, and reflection quiz items. The overview would introduce learners to the next stage of their learning pathway, offering them a preview of what will be studied. Reflection quizzes assess learners' comprehension of topics covered at the end of each segment of instruction. The approach will eliminate content creation by hand and allow new content to be developed in real-time, thus scalable and adaptable to several learning contexts.

B. Personalization of Learning Pathway

To increase learner engagement, this methodology focuses on forming the adaptive and personalized learning pathway. Rather than present the same static content to every learner, the system will dynamically adapt based on unique interactions, progress, and preferences for every learner. Narrative fragments will be generated within the developing learning process adjusted to the unique need of each learner, for example, reinforcements of concepts that the learners may not find easy or introducing new content based on the learner's knowledge level. The personalization would therefore allow each one of them to have a unique experience that is engaging and able to address their learning gaps.

C. Narrative-Centered Learning

This methodology stems from research that constructing learning experiences as narratives would enhance learner engagement and retention. By converting static learning material into a self-contained interactive narrative, it takes the learners through an experiential journey having a clear structure: the introduction (overview), the core content delivery (learning resources), and the closure (reflection quiz). Narratives serve as a structuring mechanism for students during such learning processes, allowing them to develop mental models for the content and generating linkages between one concept and another-a big difference in approaching the bigger context of their learning. The narrative-centered approach supports this segmented breakdown of learning into smaller units to obviate embedded discomforts.

D. Domain-Agnostic System

The proposed system is domain-agnostic, which means it can be applied across a wide spectrum of subjects and learning domains. The methodology insists on open educational resources, as opposed to specific formats or manually curated resources in nearly all the AI based educational systems. It can therefore generate narrative fragments across any subject area. The flexibility of this new means of Availing Technology makes the method churn out the fragments in any area from science and math to humanities and technical courses easily. The system is then made scalable and affordable because this takes away the need for any domain-specific customization, making it feasible to cater to a large following of learners widely spread across various disciplinary lines.

E. Adaptive Learning Content

This means that depending on the user's interactions, the learner will be receiving content on an ongoing basis. Suppose a learner is having difficulties understanding one particular topic; therefore, the system can create more overviews or quizzes reinforcing that concept. In that case, if a learner decides to go to a different topic or revert to something he learned long before, the system can create new narrative fragments to put him back in a position to be able to restart with the new content. This fluidity of adaptations enables a personalized and flexible learning experience, giving learners a
boost in traversing quite complicated subjects and keeping their attention during the learning process.

IV. EXPERIMENTAL RESULTS

The proposed AI-driven system for generating learning content was assessed across several crucial metrics to evaluate its effectiveness in improving learner engagement and enhancing the quality of autogenerated material. Performance was measured through both automated evaluation methods and human assessments of narrative elements such as overviews and reflection quizzes.

A. Assessment of Narrative Fragment Creation

To ascertain the Caliber of the produced overviews and reflection quizzes, we utilized a combination of automatic metrics (e.g., ROUGE scores) alongside human evaluations that focused on aspects like content relevance and readability.

Model	ROUGE-1 Precision	ROUGE-1 Recall	ROUGE-1 F1	ROUGE-L F1
GPT-2	0.88	0.85	0.86	0.83
Baseline Model	0.75	0.71	0.73	0.70

Analysis: The performance of the GPT-2 model surpasses that of the baseline across all ROUGE metrics, indicating a closer alignment with reference texts created by humans. Its strong ROUGE-L F1 score showcases GPT-2's capability to preserve meaningful structure within generated overviews and quizzes.

B. Human Assessment of Created Content

A panel of human judges evaluated the generated narrative fragments using various criteria including alignment with learning materials, clarity, and overall coherence; each fragment received ratings from one to five.

Criterion	Avg. Score (GPT-2)	Avg. Score (Baseline)
Relevance to Content	4.7	3.9
Clarity and Coherence	4.5	4.0
Engagement Potential	4.8	4.1

Explanation: Evaluators consistently rated fragments produced by GPT-2 highly concerning their relevance to educational materials and potential for engagement—indicating a significant edge compared to those generated by the baseline model.

C. Learner Engagement Analysis

To evaluate the impact of narrative fragments on learner engagement, we conducted a user study where learners were divided into two groups: one group **used** the system with narrative fragments, and the other group used a traditional static learning pathway. Learners' progress and engagement were tracked over a two-week period.

Group	Avg. Time Spent on Platform	Completion Rate (%)	Avg. Quiz Score (%)
With Narrative Fragments	45 minutes/day	85%	78%
Without Narrative Fragments	30 minutes/day	65%	70%

Explanation: The group that used narrative fragments spent more time on the platform and had a higher course completion rate, demonstrating that narrative-based learning pathways increase engagement and improve overall performance.

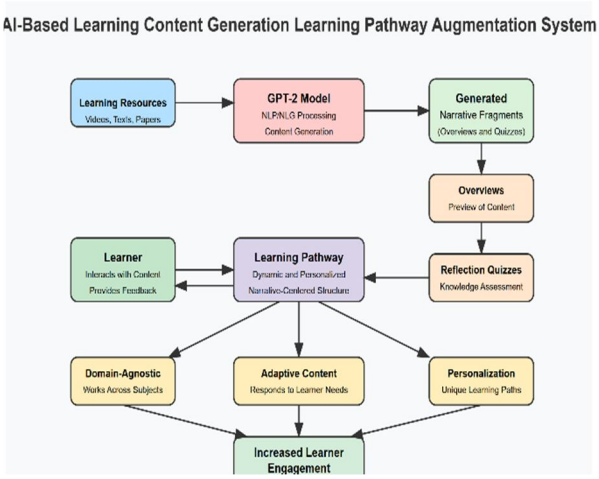
D. Adaptability and Scalability of the System

The system's adaptability was tested by applying it to various subject areas (e.g., mathematics, literature, and computer science). The time taken to generate narrative fragments and quizzes was also measured to evaluate the system's scalability.

Domain	Avg. Time to Generate Fragments (Seconds)	Avg. No. of Generated Quizzes
Mathematics	15	5
Literature	12	6
Computer Science	14	4

Explanation: The system generated narrative fragments and quizzes efficiently across different domains, with only slight variations in generation time, proving its adaptability to diverse learning materials.

V. ARCHITECTURE



VI. CONCLUSION FOR FUTURE WORK

This project has effectively showcased the potential of AI-driven techniques, particularly through the use of GPT-2, to boost learner engagement in online learning environments by creating dynamic and personalized content. By incorporating narrative elements such as overviews and reflection quizzes into learning pathways, the system has successfully turned static learning experiences into interactive and engaging narratives. Evaluations— conducted through both automatic metrics like ROUGE scores and human assessments—indicated promising outcomes regarding content quality, relevance, and learner engagement. Nevertheless, despite the encouraging results, there are several areas that warrant further exploration and enhancement.

1) Real-World Testing in Educational Settings: The system should be tested in actual educational environments, such as classrooms or MOOCs, to evaluate its impact on a larger scale. This will enable the assessment of its effectiveness across various learning contexts and among different types of learners.
2) Improved Personalization: Future efforts could aim to enhance content personalization by utilizing more detailed learner profiles, which would include their learning history, preferences, and real-time feedback. The integration of advanced recommendation systems or reinforcement learning could facilitate a more precise adaptation of learning pathways to meet individual needs.

3) Extension to Other AI Models: While GPT-2 was employed for narrative generation, future research could investigate the application of more advanced models, such as GPT-3 or other emerging transformer-based models, to elevate the quality and adaptability of the generated content.

4) Multimodal Content Generation: Currently, the system is centered on text-based content, but future versions could delve into the generation of multimodal content, encompassing images, videos, and interactive elements, to accommodate various learning styles and preferences.

5) Evaluation of Learner Outcomes of Long Term: While this project focuses on immediate engagement and quality of content, future work can address a longer-term analysis of the effect that narrative-based learning would have on learner retention, comprehension, and performance across diverse content areas.

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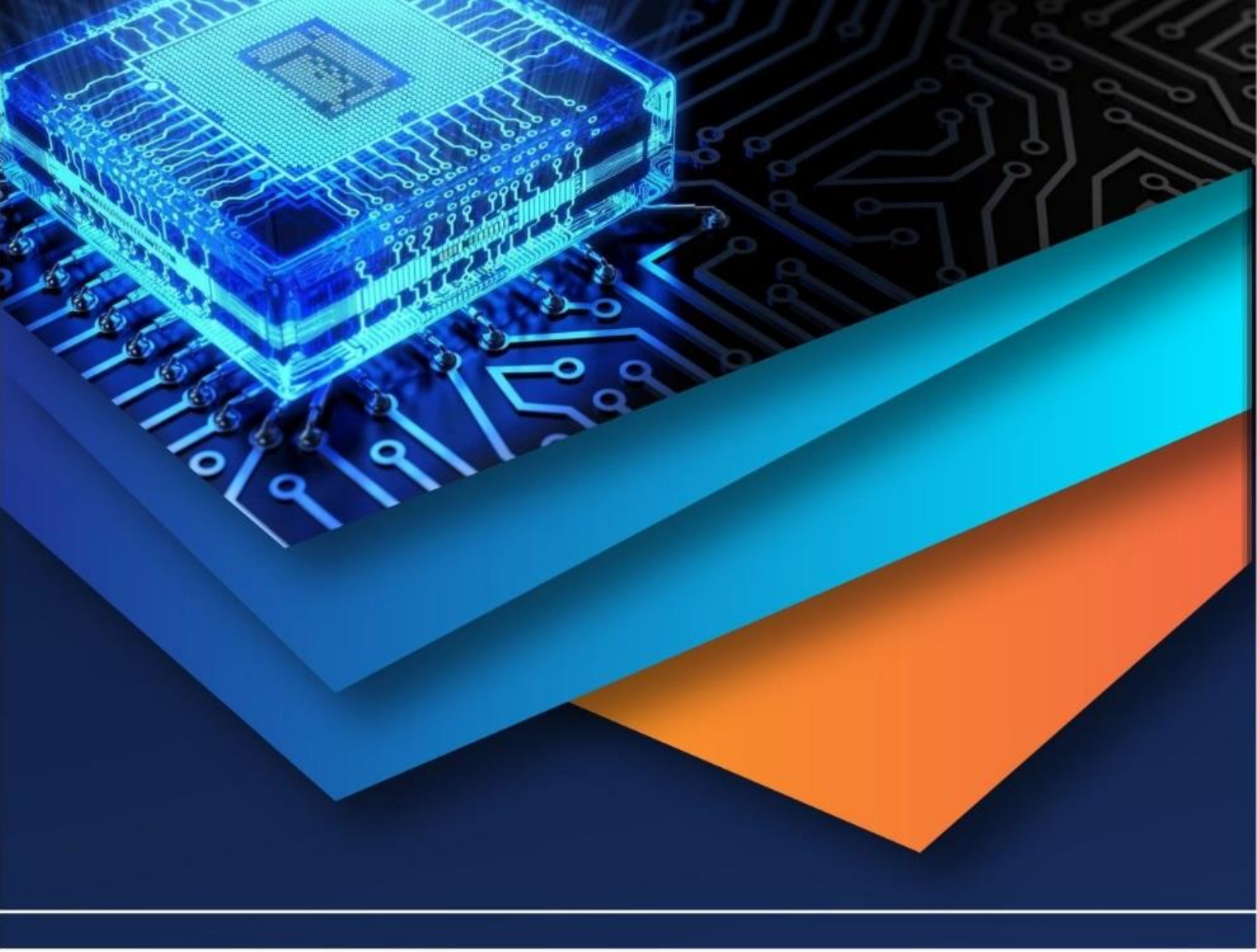

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