Using artificial intelligence to support students' active learning

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Abstract

The necessity of supporting students to be active learners warrants the development and integration of active learning approaches within curricula. Technology, particularly with the advancement in generative artificial intelligence (GenAI), provides opportunities to develop such approaches. This case study presents an example of an innovative method of using GenAI to promote interactive learning. The approach involved students' working through a series of questions, as in an open book assessment format, but with the opportunity to use GenAI as a virtual tutor. This provided a mechanism for students to practise active learning while receiving individualised support from GenAI. Our evaluation suggested that students found the approach effective as it enabled them to learn through knowledge application instead of rote learning and provided opportunities to use GenAI to obtain instant, personalised feedback which they could act on to improve on their learning.

Keywords: artificial intelligence, active, learning, personalised

Introduction

Active learning by its very nature requires active approaches to maintain students' engagement with their own learning at a high level (Graffam, 2007). Teaching methods that boost higher-order cognitive skills, such as critical thinking and knowledge application, have been shown to promote deep learning, leading to better academic performance (Freeman *et al*., 2018). Educational frameworks promoting active learning have been the natural consequence. Recognising its pedagogical value, Keele University has set active learning as one of the four themes across all its curricula. However, making learning active can be challenging, especially in implementing easily adopted approaches of readily apparent direct benefit to students. In this case study, we show how GenAI may offer a solution to this problem by using it as a tool to devise a learning approach which students find effective in helping them learn actively.

Active learning in education

Technology and digital tools can support students to interact fully with their work, stimulating their higher-order thinking skills and helping them to get the most from such active learning (Li *et al.,* 2024). . Within our medicine curriculum, the learning outcomes are focused on developing in students critical thinking skills to enable them to apply knowledge appropriately and solve problems. Peer-learning and formative assessments, which enable students to monitor and build their understanding (Nicol and Macfarlane, 2006), also support learning. In our teaching context, we use end-of-module formative assessments to help students consolidate their learning: we ask them to work through a set of questions which they can self-mark in accordance with the marking criteria we provide. This does, however, depend on the students' ability to assess their own work accurately, a level of skill which obviously will vary; more importantly, it does nott provide the rapid, personalised feedback needed to guide students in real time to make improvements (Badyal *et al*., 2019). Furthermore, since providing this level of personalised tutor feedback is unsustainable when working with large groups, the exploration of the application of digital tools like generative artificial intelligence (GenAI), with its capacity to provide instantaneous responses, can arguably help to provide an on-demand learning experience.

GenAI as a pedagogical tool

The advancement of artificial intelligence, particularly GenAI models which can create content, provides new possibilities for developing learning tools and enabling students to engage more actively in their learning. The latest GenAI models, like ChatGPT, are very sophisticated in their responses and so well-suited to complementing the tutor role by offering individualised learning experiences and tailored guidance (Bahroun *et al*., 2023). An example of this can be found in the study by Pardos and Bhandari (2024), who showed that ChatGPT can guide students in solving mathematical problems. A GenAI model, capable of generating human-like responses, can therefore function as a virtual tutor. Recent studies have shown that teachers are beginning to deploy GenAI tools to help provide real-time support to students (Ruiz-Roja *et al*., 2023); not only

can GenAI create questions; it can also assess responses to them and provide feedback, as we have previously shown in the case of the ChatGPT and Gemini models (Ali and Aynsley 2024). It is clear that GenAI can empower students by offering them personalised learning experiences. In this case study, we report on an innovative on-demand approach for students to obtain feedback on their answers, consequently helping them address their knowledge gaps and actively engage in learning.

As we have said, enabling students to assess their understanding accurately and in a timely manner is likely to promote a more objective and proactive approach to improvement. However, research into student engagement with GenAI for the purposes of self-assessment and obtaining feedback on complex factual content remains limited. This study, therefore, aimed to address the gap by examining how setting up GenAI as a virtual tutor might support learning effectively, drawing on students' evaluation of the GenAI feedback and their perceptions of its benefits to them.

The study implemented a GenAI-supported activity within a foundation year Medicine course (2023/2024) as part of a series of sessions designed to help students consolidate their learning. The rationale for using the GenAI models ChatGPT and Gemini was based on their documented potential to provide tutor-like responses in real time (Ali and Aynsley, 2024). As large language models (LLMs), both ChatGPT and Gemini's capacity for real-time content generation aligns with active learning principles, facilitating immediate, constructive feedback that helps students identify and address knowledge gaps. LLMs, owing to their scalability and adaptability, are suitable for diverse pedagogic applications, particularly in subjects that require feedback on critical thinking and complex problem-solving. We aimed to foster knowledge application by encouraging students to tackle progressively more challenging short-answer questions (SAQs) that required them to apply critical thinking. By incorporating GenAI as a virtual feedback mechanism, we sought to bridge the limitations of traditional self-marked formative assessments and provide instant tailored feedback.

Method

Our small-scale study included seven students (mixed gender), all with similar educational backgrounds. Students worked in small groups of two or three through a set of SAQs that were designed to increase in complexity and based on Bloom's Taxonomy (Anderson and Krathwohl, 2001). After completing each question, students submitted their response to either ChatGPT or Gemini via a structured prompt (i.e computer instructions) that included the SAQ and marking criteria. We have previously shown this prompt structure to be effective in guiding GenAI models to provide feedback that is aligned with curriculum objectives, offering both accuracy in assessment and constructive feedback to support student learning (Ali and Aynsley, 2024).. The GenAI models provided instant feedback, highlighting correct answers and areas for improvement. Students worked through the questions following this format, after which they were asked to provide an evaluation of the session.

We used a questionnaire to collect evaluation data in a structured and systematic way. We reasoned that the format would enable the capture of both quantitative and qualitative data, providing a comprehensive view of participants' perspectives which could then be considered in terms of generalisability to the wider population (Kelley *et al*., 2003). The university's Educational Research Ethical Committee approved the study, ensuring voluntary participation with informed consent. To maintain confidentiality, no personal data were collected during the evaluation.

Evaluation

Student feedback was overwhelmingly positive. All the students (n=7) either agreed or strongly agreed when asked if they found our GenAI-supported learning approach a useful way to learn. To obtain insights into the specifics of what students found useful, we undertook a cross-compare analysis of the students' free-text comments. The structured use of SAQs facilitated active learning, helping students to progress beyond memorisation and engage critically with the material. Students appreciated this approach, noting that it offered "*an efficient way of learning and retaining information rather than just memorising*". This suggested that, as an alternative to didactic learning, our format actively engaged students in knowledge application – and thus learning. The integration of GenAI models like ChatGPT and Gemini proved essential in this active engagement by helping students identify and fill knowledge gaps immediately. Students recognised this as a benefit which would improve their learning, as this student's comment shows: "*It made me realise my strengths and weaknesses which would make me a better student but an overall a better and more improved learner*".

The second benefit, emphasised by all the students, was that our GenAI approach could help them be efficient learners because, we deduce, they could both test their understanding and obtain feedback detailing what they needed to improve. Since they could obtain this feedback instantly, they could just as quickly amend their learning (Badyal *et al*., 2019) without having to wait for tutor comment. One student pinpointed this advantage: that GenAI can "*provide feedback when teachers aren't available*". Students also realised that getting feedback by themselves was a great way to learn and revise well: "*Certainly, I'll be implementing it in the future to aid in my revision*." We might therefore conclude that GenAI can enhance both learning and independent study by providing students with the revision tools to self-manage their progress.

Thirdly, with our prompt i.e. specific instructions GenAI gave individualised feedback as well as suggestions as to how to improve answers; students liked being "*provided with improvements and a model answer*". Echoing the principles that feedback should be tailored and should include clear examples(Hattie and Timperley, 2007), to obtain personalised feedback like this allows students immediately to refine their learning by applying the constructive advice. The main benefits identified by the students may thus be categorised into three themes: active learning, efficiency in learning and personalised learning (figure 1).

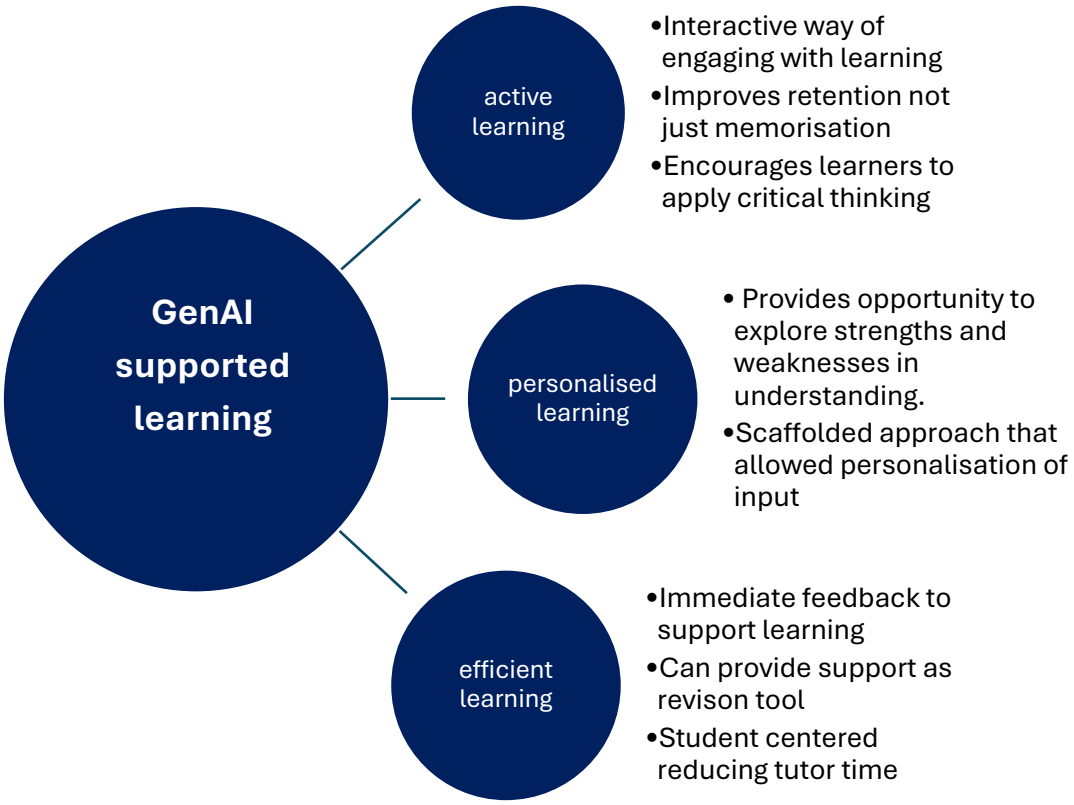

Figure 1. The main benefits gained through a GenAI-supported learning approach

While both GenAI models were seen as providing effective feedback, all the students preferred Gemini's. Comparison of their comments revealed that they valued Gemini as more constructive and better suited to more complex content. With limitations such as a tendency to overlook answers that were formatted differently, students found ChatGPT's feedback less effective: "*it wasn't capable in providing accurate feedback to the given prompt compared to Gemini*". So, model selection is significant in designing effective GenAI-supported learning activities.

Evaluation

Analysis of the responses suggests that students foundour GenAI-supported approach interactive and effective for their learning, so corroborating our overall observation of their engagement within the session. The findings also provide insights and highlight important factors which could influence the generalisability of our approach. Reflecting on these factors we make the following recommendations as an outcome of our case study (table 1).

Table 1. Factors which need to be considered and recommendations for the implementation of our GenAI learning approach

Influencing factors	Recommendation
In-class task design	The approach engages students in knowledge application and enables them to use GenAI to obtain immediate feedback which they can then act on to improve their learning. We believe our GenAI approach may be used across different disciplines by adapting the in-class activity and tailoring it to the desired learning outcomes of one's module or curriculum. For instance, instead of SAQs, students could be tasked with analysing text, case studies or similar activities requiring them to employ critical thinking and other higher cognitive skills. Complementary to the task, a marking guideline may then be devised which students can use to prompt GenAI to assess their work and offer feedback.
Effective prompting	We should emphasise that the effectiveness of GenAI to provide the appropriate feedback depends on effective prompting. We recommend that prompts should have a clear structure, providing context and instructions. Interested readers seeking more guidance on prompt writing are directed to the work of Indran *et al*., (2023) as well as 'prompt engineering' resources such as that provided by University of Sydney.
Balance of tutor and GenAI support	We recommend balancing tutor support and GenAI support to ensure proper use of GenAI so that the accuracy of the generated feedback and content is maintained. GenAI is not error-free and the fact that it can provide inaccurate content has been documented (Lo, 2023, Ding *et al*., 2023). To mitigate this, our approach makes use of defined parameters; *i.e*., prompted to mark and give feedback on the basis of the set marking guidelines. In other words, the system is trained with content which we have quality assured.

Limitations and conclusion

We believe our case study has provided promising insights into and evidence in support of the deployment of GenAI to foster active learning. However, we recognise that the small cohort size, a single discipline focus and a single data collection point of our study may limit the generalisability of our findings. Consequently, studies are planned to address these limitations by undertaking research within more large and diverse student cohorts. Additionally, implementing a longitudinal design, with multiple data collection points throughout the academic year, would allow us to observe to what extent and in what ways students' engagement, learning gains and perceptions of GenAI evolve over time. This could provide valuable insights into the sustainability and longer-term benefits or limitations of GenAI-supported active learning. Another focus will be to determine

whether there are variations in how well the approach works in different subjects. To address this question, our future research will focus on collaborating with colleagues in other disciplines to further understanding of how best to design the tasks and prompts so that the approach may be adaptable for different subject areas. In spite of having such work still to do, we believe that our approach has high pedagogical value and that the design is simple enough to be applied in different disciplines and educational settings.

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