Section: Physiology

Original Research Article

EFFECTIVENESS OF GENERATIVE AI VERSUS TRADITIONAL RESOURCES FOR SELF-DIRECTED LEARNING IN PHYSIOLOGY AMONG MBBS STUDENTS: A COMPARATIVE INTERVENTIONAL STUDY

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ABSTRACT

Background: Self–directed learning (SDL) is an essential element of competency-based medical education (CBME), critical for training future physicians to learn independently. The increasing interest in the potential role of such Generative Artificial Intelligence (AI) tools, particularly tools such as Perplexity AI, as SDL resources, is starting to garner attention. This study aimed to compare the efficacy of Perplexity AI, the Google search engine, and conventional textbooks for promoting SDL among Phase I MBBS students in Physiology. **Objectives:** To evaluate the effectiveness of utilizing three learning aids, Perplexity AI, Google search, and conventional textbooks during SDL sessions in Physiology, on knowledge acquisition and student perceptions.

Materials and Methods: A comparative interventional study was done among 103 Phase I MBBS students in the Government Medical College, Manjeri. Subjects were randomly assigned to three groups. All groups utilised three different SDL tools (textbook, Google, and Perplexity AI) on three separate occasions, with each group rotating tools each session. Learning gains were tested using pre- and post-tests. Students' perceptionswere collected using a formal questionnaire. Statistics: ANOVA and Kruskal–Wallis statistics were used for comparison.

Results: Textbooks had the highest mean post-test scores (13.18 ± 3.36), while Perplexity AI and Google search had 12.83 ± 3.47 and 12.75 ± 3.52, respectively; the differences between them were not significant ($p > 0.05$). Students chose textbooks for reliability and consistency, while Perplexity AI won out for interaction, ease of use, and keeping the content fresh. Google was evaluated as less reliable because it was hard to determine what sources were credible.

Conclusion: Generative AI tools like Perplexity AI are promising for aiding SDL because they enable interactive access to recent information in a time-efficient manner. However, textbooks are still one of the most consistent and preferred sources of core learning. AI tools should be incorporated as adjuncts rather than substitutes for traditional didactics in medical training.

Keywords: Self-directed learning, Competency-Based Medical Education, Perplexity AI, Generative AI, Google Search, Textbooks, MBBS students, Physiology, Medical education, Heutagogy.

INTRODUCTION

Under the Competency-Based Medical Education paradigm, the restructured undergraduate medical education aims to position the Indian Medical Graduate (IMG) as a lifelong learner.[1] In this respect, SDL has become a key pedagogical approach to encourage students to manage their learning.[2] SDL allows students to determine their learning needs, set goals, find and use resources, apply learning strategies, and assess outcomes.[3] At a time when medical information is exploding, the ability to self-educate on such knowledge has become not just valuable, butnecessary for tomorrow's clinicians.[4]

Textbooks have historically been the most crucial reference in medical school. They provide peer-reviewed, well-organized, and complete exposure to the basic sciences, such as Physiology.[5,6,7] Search engines on the web, such as Google, enable instant access to much information. However, their credibility is often doubted because separating authenticated sources from false ones is problematic.[8]

With the advent of Generative Artificial Intelligence (GAI), a new class of digital learning resources exists.[9] Perplexity AI, which uses large language models (LLMs), can provide real-time, natural language responses to questions, outpacing human performance over large data sets.[10] Such systems present interactive, conversational support that may improve comprehension, involvement, and access to relevant information in a more timely fashion. Generative AI tools have features like prompt chaining, real-time references, and customization that attract heutagogic and autoregulated, self-determined, and intrinsically motivated learners.[11]

With their increasing use, there is little empirical evidence to support the advantages and effectiveness of Generative AI platforms over traditional tools and resources such as textbooks and Google search engines in medical education.[12] Some reports have suggested that AI chatbots foster personalized and self-paced learning, but others warn that implemented AI responses could be inaccurate, superficial, and shallow.[13] In addition, most studies have evaluated AI tools via prompt-response testing and not in a real scenario, as the learner experiences. This study was conducted to bridge this gap by assessing the effectiveness of Perplexity AI in comparison with Google Search and textbooks as SDL tools for learning Physiology among Phase I MBBS students. The investigation evaluated the gain in knowledge through test scores and students' perceptions of the improvement effect. This helps determine whether they find these resources helpful and are willing to adopt them for studying and learning in general.

MATERIALS AND METHODS

Study Design and Setting: A comparative interventional study in first-year MBBS students of Government Medical College, Manjeri, Kerala, in November – December 2024. We sought to investigate the utility of three resources, namely (1) Perplexity AI, (2) Google Search, and (3) standard textbooks, for SDL in Physiology.

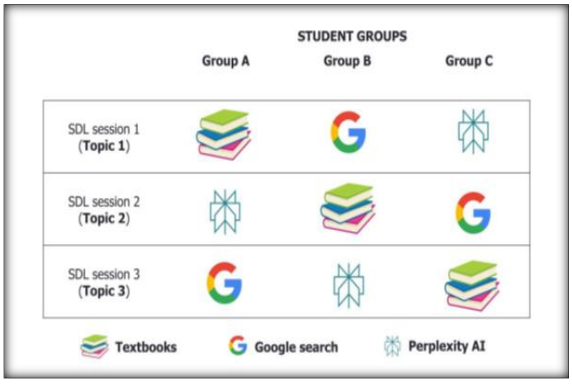
Participants and Sample Size: Of the 110 students of Phase I MBBS, 103 attended the study and voluntarily gave informed consent. Before the work began, the Institutional Ethics Committee approved the study. Participants were randomly assigned to one of three groups (group A, B, or C), which had access to one of the three learning resources and used it during the SDL sessions.

Intervention: SDL Sessions

Three Physiology concepts were chosen for the SDL learning:

1. Apoptosis
2. Intercellular junctions &cell adhesion molecules (CAMs)
3. Functional anatomy of the respiratory system & Surfactant

Each group utilized each resource in the three blocks, so all students had an opportunity to experience all three resources, albeit in a different sequence.



Each SDL session was twohours long and supervised by faculty. One resource was assigned per group per session, and students were trained to use only that resource.

Assessment Tools: Before the SDL session, each session included a 20-item MCQ pre-test, and a 20-item MCQ post-test was administered immediately after. The subject experts reviewed the MCQs and aligned them with the learning outcomes targeting the chosen topics.

Also, at the end of the session, the students filled out a structured perception questionnaire to determine their opinions about the usability, effectiveness, and preference of the three SDL tools. The Likert scale ranges from 1 to 5, and the survey includes domains such as reliability, accessibility, engagement, and perceived learning outcomes.

Data Analysis: Par scores were transferred to Microsoft Excel and analysed in RStudio statistical

software v2023.12.1. Descriptive statistics, means, and standard deviations were employed to summarize pre- and post-test scores. Within-group changes (pre- to post-test) were examined using a paired t-test. In contrast, between-group differences in performance and perception were analyzed using one-way ANOVA and the Kruskal-Wallis test. Statistical significance was defined when the p-value was lower than 0.05.

RESULTS

Participant Characteristics: This interventional comparative study enrolled 103 first-year MBBS students. All students completed the SDL sessions, pre- and post-tests, and the final perception survey.
The overall **mean post-test scores** (out of 20) across all three sessions were:

- **Textbook**: 13.18 ± 3.36
- **Perplexity AI**: 12.83 ± 3.47
- **Google Search**: 12.75 ± 3.52

Although the textbook group had the highest average score, the differences among the three groups were **not statistically significant** (ANOVA, $p > 0.05$).

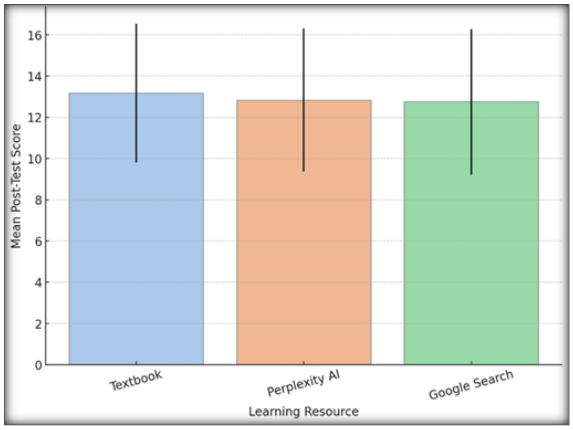


Figure 1: Comparison of Mean Post-Test Scores by SDL Tool

Figure 1 compares each tool's mean post-test scores with standard deviation error bars. This figure shows the average post-test performance across all three sessions.

Topic-Wise Comparison of Tools

A detailed comparison of mean post-test scores across the three SDL topics is presented below:

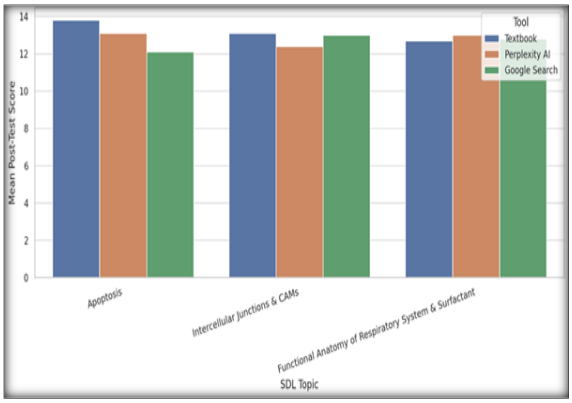


Figure 2: Mean post–test scores for each topic by learning tool

Figure 2 compares the mean post-test scores for three SDL topics—Apoptosis, Intercellular Junctions & CAMs, and Functional Anatomy of the Respiratory System & Surfactant—across three learning tools: Textbook, Perplexity AI, and Google Search. For Apoptosis, students using textbooks achieved the highest scores (13.8), followed by Perplexity AI (13.1) and Google Search (12.1), indicating textbooks may offer more clarity for complex cellular processes. All tools performed similarly in the Intercellular Junctions & CAMs, though Perplexity AI lagged slightly, suggesting comparable effectiveness among resources. Interestingly, Perplexity AI slightly outperformed the textbook and Google Search for the respiratory system topic, possibly due to its visual and interactive content integration. Overall, textbooks showed consistent performance, AI tools demonstrated promise in applied topics, and Google Search produced the lowest average scores, indicating variability in the quality of information retrieved.

Table 1: Topic-Wise SDL Tool Comparison (Mean ± SD)

SDL Topic	Textbook	Perplexity AI	Google Search
Apoptosis	13.8 ± 2.1	13.1 ± 2.2	12.1 ± 2.6
Intercellular Junctions & CAMs	13.1 ± 2.5	13.0 ± 2.4	12.4 ± 2.7
Functional Anatomy of the Respiratory System & Surfactant	13.0 ± 2.1	13.2 ± 2.2	12.65 ± 2.3

Table 1 shows a comparative view of mean post-test scores in the three core Physiology topics (with standard deviation)–Apoptosis, Intercellular Junctions & CAMs, and Functional Anatomy of the Respiratory System & Surfactant, achieved by MBBS students with three different self-directed learning tools (SDLT), namely Textbooks, Perplexity AI, and Google Search. In Apoptosis, students who followed textbooks performed significantly higher (mean score 13.8 ± 2.1) than students who used Google Search (mean score 12.1 ± 2.6). This suggests that textbooks offered the most reliable and structured content for this highly conceptual area, possibly due to the comprehensive nature of traditional academic resources.

The performance was relatively consistent when used for learning Intercellular Junctions & CAMs. Books (13.1 ± 2.5) and Perplexity AI (13.0 ± 2.4) have similar performance, while Google search lags (12.4 ± 2.7). This suggests that the topic may have been similarly available across the three resources or already known to the students. Ironically, in the

Functional Anatomy of the Respiratory System & Surfactanttopic, the Perplexity AI started with a mean of (13.2 ± 2.2), followed by the textbook (13.0 ± 2.1), and the lowest average was of Google (12.65 ± 2.3). Overall, Table 1 highlights that the effectiveness of each SDL tool varied depending on the topic, reinforcing the idea that no single method is universally superior. While textbooks provided consistent reliability, Perplexity AI stood out for its conciseness and user engagement.

Perception Survey Findings

A structured Likert-scale questionnaire assessed students' perceptions of the three learning tools. Key domains included ease of access, reliability, engagement, clarity, time efficiency, and helpfulness for SDL.

Table 2: SDL Tool Perception Comparison

Parameter	Textbook	Perplexity AI	Google Search
Ease of Access	4.5 ± 0.5	4.6 ± 0.6	4.2 ± 0.7
Reliability	4.8 ± 0.4	4.1 ± 0.8	3.6 ± 0.9
Engagement Level	3.8 ± 0.9	4.6 ± 0.7	3.9 ± 0.8
Clarity of Explanation	4.7 ± 0.6	4.2 ± 0.7	4.0 ± 0.8
Time Efficiency	3.9 ± 0.8	4.6 ± 0.6	4.0 ± 0.7
Helpfulness for SDL	4.5 ± 0.5	4.3 ± 0.7	4.1 ± 0.6

Table 2 provides an overview of students' perception towards the three SDL tools, i.e., Textbooks, Perplexity AI, and Google Search, where students responded to a structured Likert-scale questionnaire on six aspects: ease of access, reliability, engagement Level, clarity of explanation, time efficiency, and helpfulness for SDL. Traditional textbooks were rated with the highest reliability (4.8±0.4) and clarity of explanation (4.7±0.6), confirming their historical strength in presenting accurate and systematically organized information. They were also rated high for overall helpfulness in SDL (4.5 ± 0.5) but slightly lower in engagement (3.8 ± 0.9) and time efficiency (3.9 ± 0.8), which is potentially a consequence of the amount of time required to progress through long chapters.

On the contrary, Perplexity AI was considered very engaging (4.6 ± 0.7) and time-saving (4.6 ± 0.6), indicating that its interactive format and quick turnaround time were desirable for students. It also performed well on ease of access and overall helpfulness, though it was slightly lower in reliability (4.1 ± 0.8) than the textbooks, which may reflect students' uncertainty in AI-generated content.

Google Search scored low in all tested dimensions, especially regarding reliability (3.6 ± 0.9). Students reported that navigating the vast quantities of mixed-quality material surfacing in commercial sites and non-academic blogs was challenging. Nonetheless, it was relatively easy to access (4.2 ± 0.7) and moderately helpful for SDL (4.1 ± 0.6).

In general, Table 2 presents a summary of each tool's strengths and limitations from the learner's viewpoint. Textbooks are still the most sure and concise, but Perplexity AI is becoming a strong SDL tool and is especially appreciated for its engaging and time-saving features. Google Search is far less popular, as there is a debate about content quality.

Figure 3 shows a radar chart of the students' average scores for the six parameters using the three SDL tools. Textbooks were considered the most reliable and transparent, consistent with their long-standing academic utility. Perplexity AI was more engaging and time-efficient than the others, indicating its attractiveness for rapid interactive learning. Google Search was seen as easy to find but less dependable. Table 2 underscores the synergies between the two approaches. It illustrates how the traditional resource and its AI companion bring different advantages, all of which can be merged for more powerful self-directed learning.

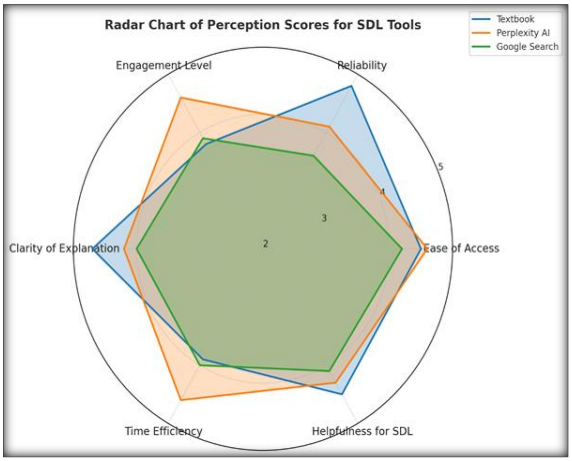


Figure 3: Radar Chart of Perception Scores for SDL Tools

DISCUSSION

This comparative interventional study assessed the efficacy and perception of students towards three SDL tools, namely textbooks, Perplexity AI, and Google Search, in first-year MBBS students learning specific topics in Physiology. Although all three instruments performed similarly in the post-test with no significant differences, textbooks achieved the highest mean score over the sessions. The topic-wise approach showed mixed results across topics, and Perplexity AIperformed the best for the surfactant session (perhaps because of the availability of visual aids). On the perception surveys, there were also differences, with textbooks being the highest in reliability and clarity, Perplexity AI in engagement and time efficiency, and Google Search being the lowest in reliability.

These results comply with previous studies indicating the importance of traditional textbooks for organized, dependable course material in medical education.[14] While (AI-based) techniques such as Perplexity have emerged relatively recently, our findings are consistent with those of Lademann*et al*. (2025) and Gandhi*et al*. (2023), who concluded that AI tools increase participation and decrease cognitive load by simplifying complex data.[15.16] However, these resources might not have the same depth and peer-reviewed quality checks as textbooks. Consistent with this finding, Wang*et al*. (2023) also found that Google Search can easily provide fast and ready access to information with no filtering or content relations, and the quality of content was also uneven, particularly for those who were novice in their evaluation of source credibility.[17] This specific benefit of AI on Surfactant is consistent with Ohlsson et al.'s (2023)results, where multimedia and visual simulations contribute to better comprehending dynamic physiological processes.[18] This indicates that the best teaching effect may be achieved when hybrid SDL strategies are matched with the nature of the topic.

The strength of this study is its comparative design, which uses quantitative (performance) and qualitative (student feedback) results to provide a broader view of the tool's effectiveness. The rotation of tools across groups reduced content bias. First-year MBBS students, who are new to SDL, can benefit from learning various tools that help scaffold basic learning.

Limitations of the study

This study is not without limitations. The immediate assessment may not indicate long-term retention or conceptual use, and the absence of blinding and the dependence on self-reported data might result in response bias. Additional investigation is needed to address long-term learning outcomes, curriculum incorporation, and the ethical implications of incorporating generative AI in medical education.

This research shows that while conventional textbook text content is a solid performer as an SDL resource, AI-based tools such as Perplexity have unique engagement and time efficiency advantages. Even Google Search, which is extremely popular, requires curation because the quality of its information is heavily shifted. Educators may incorporate AI-based resources with traditional materials to enable flexible, learner-focused approaches.

CONCLUSION

This study compared the efficacy of traditional textbooks, Perplexity AI, and Google Search as resources in SDL for MBBS students in a few selected physiology topics. Although the general academic performances across the three groups of students were not significantly different, various subject-related differences and perception data provided interesting information. Textbooks were rated mostfor reliability and clarity, validating their role as a basic medical educational tool. However, Perplexity AI showed significant strengths in engagement and time spent, suggesting its use as a complementary tool in current learning settings. About information quality, Google Search, even though widely used, demonstrated information quality variations and was perceived as having the least reliability.

The results of this study recommend that educators consider incorporating a blended learning approach, in which traditional educational resources are combined with AI-based tools. By doing so, content accuracy can be provided and engagement maintained while catering to various learning preferences. Faculty development should involve instruction on the appropriate and ethical use of generative AI tools in medical education. Curriculum planners should also consider adding organized SDL modules, where learners can navigate different learning environments under the facilitator's guidance.

In future studies, it is necessary to investigate long-term retention of knowledge learned with AI assistance and make the transition to clinical practice. Further qualitative studies on student experiences and their ethical views on AI in education will provide additional insights into the impact of AI on educating the future medical workforce.

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