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Perspective

Integrating NotebookLM, Source-Grounded Artificial Intelligence, and Storytelling for Enhanced Physiology Education: A Perspective

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ABSTRACT

Physiology education is often faced with the challenge of engaging first-year medical students since the subject matter is abstract and mechanistic. Traditional teaching may not be able to make physiological mechanisms applicable to daily life, leading to the challenge of retaining and applying such information for the students. Storytelling is quickly gaining recognition as a powerful pedagogical tool that can make physiological principles personal, promote wonder, and make learning easier by placing information in everyday contexts. Nevertheless, it is difficult for teachers to compose scientifically accurate and engaging stories within curricular and time constraints. Google's NotebookLM offers a novel solution to this difficulty. Unlike general-purpose Large Language Models (LLMs) such as ChatGPT, NotebookLM enables users to upload specific documents and generate content based solely on those sources. This minimizes hallucinations and ensures created stories are also compatible with trusted academic sources. In this paper, we report on how the open-source "Anatomy and Physiology 2e" textbook was integrated into NotebookLM to create personalized, context-aware storytelling content for physiology pedagogy. This would enable teachers to create accurate and interesting stories instantaneously, making storytelling integration with lectures or tutorials seamless. Through quoting a trustworthy source, teachers can also be open and scientifically trustworthy. With the improvement of LLMs, it is feasible for tools like NotebookLM to transform physiology teaching by rendering complex mechanisms accessible, memorable, and directly usable for students with the power of narrative, aided by trustworthy sources.

Keywords: Education, Medical, Physiology, Storytelling, NotebookLM, Artificial Intelligence, Competency-based Education

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Introduction

Physiology, the study of functions and processes of living organisms, is fundamental to medical education. Despite its central role, many first-year medical students find the subject abstract, mechanistic, and challenging to connect emotionally or clinically (1). Traditional teaching methods, which emphasize diagrams, definitions, and didactic lectures, often fail to convey the dynamic and integrated nature of physiological systems (2). Storytelling has emerged as a promising pedagogical strategy to bridge this gap. Storytelling has the unique ability to engage, contextualize, and humanize content, making complex ideas more relatable (3). Medical storytelling can facilitate better understanding, improve retention, and encourage early clinical reasoning by situating concepts in meaningful contexts (4). However, creating relevant stories within physiology is not without numerous challenges (5). The microscopic and functional nature of physiological phenomena—such as ion channel opening, hormonal feedback loops, and cardiovascular reflexes—resists intuitive storytelling. Furthermore, instructors may struggle to develop scientifically accurate yet engaging stories within class time and under curriculum constraints (6).

Large Language Models (LLMs) have increasingly been incorporated into the discipline of medical education (7). Such Artificial Intelligence (AI)-based technology allow students to learn sophisticated medical problems by being provided with more concise summaries, participating in interactive question-and-answer sessions, and producing mock clinical encounters (8). Instructors can use LLMs when creating personalized quizzes, case studies, and learning materials and thereby reduce time and enhance personalized learning (9). LLMs have potential benefits for teaching communication skill improvement, ethical reasoning, and clinical decision-making by means of patient interaction simulation (10). Many educators, nevertheless, have issues with the reliability and potential hallucinations provided by LLM chatbots. The latter scenario has serious implications for using such material as educational content without stringent checking and verification (11). In such a background, we describe a tool and resource for which there shall be less likelihood of inaccuracy and hallucinations in generating content for educational storytelling.

Tools and Resources

Google NotebookLM is a specialized LLM developed to interact directly with user-uploaded documents and data (12). The model offers a personalized, context-aware experience setting it apart from more general-purpose LLMs such as GPT-3. Specifically, NotebookLM is created as a personalized research assistant, facilitating users in analyzing, synthesizing, and writing content from their own particular resources. By grounding its responses on the user's own materials, it increases relevance, precision, and efficiency in tasks as summarizing scholarly articles, writing reports, and researching intricate topics. This makes NotebookLM particularly valuable for researchers, students, and professionals seeking AI-powered insights closely tied to their own knowledge base.

Anatomy and Physiology 2e by OpenStax is a free, peer-reviewed, and openly licensed textbook designed for the anatomy and physiology course typically required for biomedical science students (13). Now in its second edition, the book provides comprehensive coverage of the structure and function of the human body, integrating core concepts with real-world clinical applications. As an Open Educational Resource (OER), it is accessible online, downloadable in multiple formats, and adaptable for classroom use, promoting equity and affordability in medical and health science education. This book is licensed under Attribution 4.0 International (CC BY 4.0), which allows users to reuse any content with attribution (i.e., provide credit to the creator) (14).

Methods of Using NotebookLM

To access Anatomy and Physiology 2e within NotebookLM, students have to initially start by downloading the book in PDF. The users have to visit the corresponding site and click on "Download a PDF," and it will download the entire book as a single PDF file, and its entire size will be almost 430 MB. Then they have to upload the file into NotebookLM. For that, they have to visit NotebookLM, click on "Create new," and upload the source file (i.e., the ebook PDF) either by dragging to the upload box marked for upload or by clicking on the "choose file" button for upload. Along with uploading, there is also an environment to select the source from Google Drive. The uploading takes its own time and will create a summary on the page along with giving a title, as in Figure 1.

On this page, there is an option to add more books or source materials by clicking "+Add" under the "Sources." Once uploaded, the model will be able to read and reference the content directly, allowing users to ask specific questions, summarize sections, or generate study aids based on the material.

Creating Materials for Storytelling

Various types of stories can be used to enhance learning of the material of physiology by making abstract material less daunting and more memorable; these groups of stories are listed below:

- **Analogy-based:** Comparisons to everyday scenarios.
- **Clinical case:** Fictional patients to apply physiological principles.
- **Journey/adventure:** Following elements like cells or ions (e.g., a red blood cell's path).
- **Historical:** Key discoveries and the scientists who contributed to the field of physiology.
- **Conflict/problem-solution:** Body's responses to imbalances, e.g., homeostasis during dehydration.
- **Dialogues/dramatized:** Depicting cells/organs interactions.

Analogy-based stories relate physiological ideas to common everyday scenarios (15). For instance, an analogy-based prompt such as *"Create a short analogy-based story (100–150 words) explaining the cardiac conduction system for a first-year medical student"* produces a concise, relatable narrative (Figure 2).

Creating Audio Notes

When an instructor uses storytelling in a classroom setting, control remains with the instructor, and the story is delivered to students. However, in many cases, the syllabus

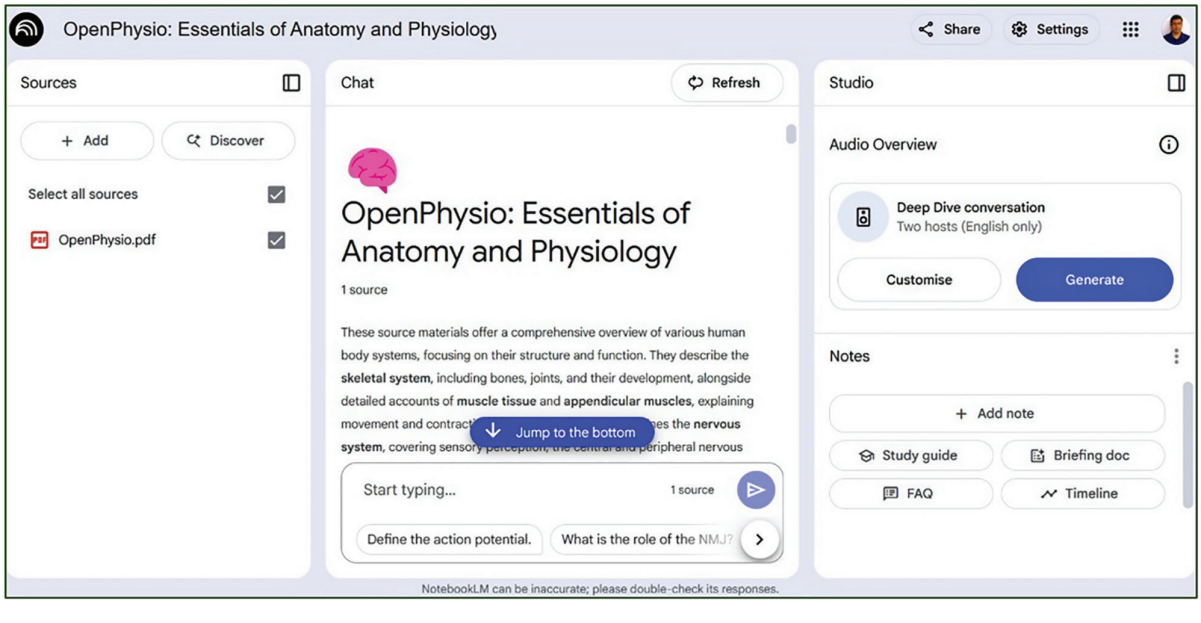

Figure 1: A desktop screenshot of NotebookLM displaying an uploaded ebook

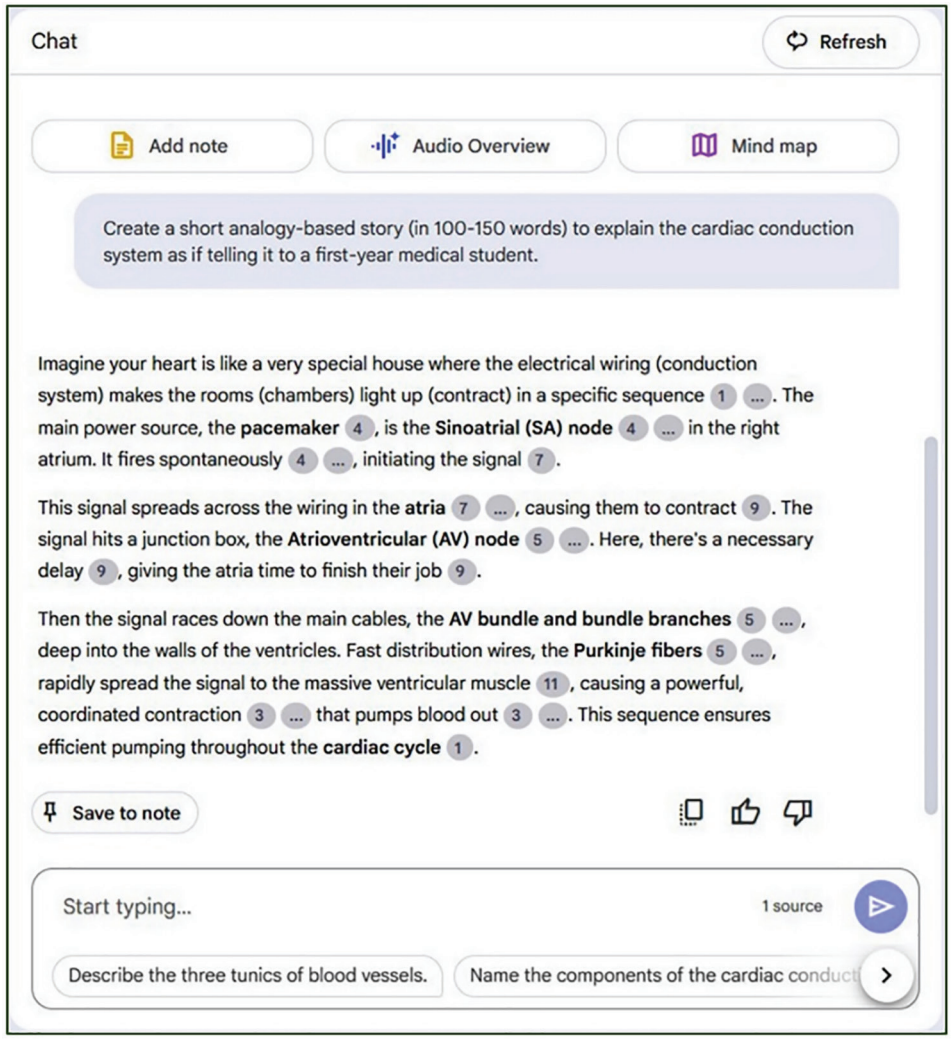

Figure 2: An example of story created in NotebookLM where the text is sourced from the uploaded ebook

is too extensive to cover during class, making it hard to include storytelling because of time constraints (16). In these situations, stories may be used either as material for a flipped classroom or shared with students afterward as additional learning resources (17).

The instructor may copy the storytelling material from NotebookLM and make a PDF to share with the students. In addition, creating an audio note of the content can be more interesting. Audio notes or podcasts can enhance storytelling by bringing a personal and immersive dimension to the narrative (18). Through voice modulation, tone, and pacing, the speaker can convey emotions, emphasize key points, and create a stronger connection with the listener. The instructor can record the matter and share the audio note via various communication channels with the students. If recording audio is challenging for any reason, the Deep Dive feature in NotebookLM can provide assistance (19).

For creating an audio note, the first task is to generate the text of the storytelling session. This may be done in NotebookLM or any other chatbot according to instructors' choice. Now, they should upload the PDF to a new note in NotebookLM. For instance, we uploaded the story of Maya in the notebook (20) as shown in Figure 3. Now, users should go to the option "Customise" and provide instruction to follow. For this example, we instructed to emphasize on pathophysiology of the disease. Now, clicking on "Generate" button will generate the audio with a time gap. For downloading, users should click on

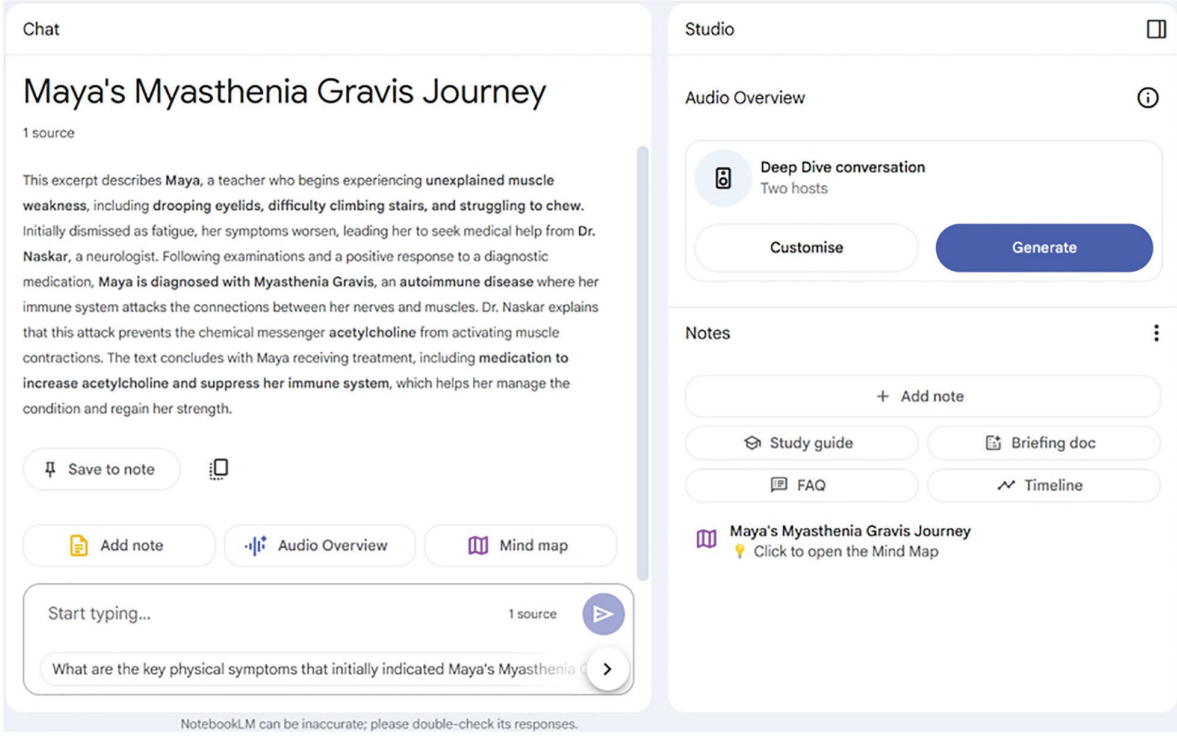

Figure 3: A note on a storytelling text material showing the option to generate deep dive conversation (audio file) and mind map from the uploaded text

the three-dot button appeared with the audio note and an audio file in waveform audio file (WAV) will be downloaded. If the audio is of larger size for sharing, one may try to compress the files from any online converter. For the above example, a WAV file of 26.8 MB was created and it was compressed to 6.15 MB for better sharing in social media (21). However, the quality of the audio may be reduced due to this compression.

Associated Visualization

Flowcharts and mind maps, when used alongside storytelling, significantly enhance comprehension and retention by visually organizing information in a logical and intuitive manner (22, 23). While storytelling engages the listener emotionally and provides context, flowcharts break down processes into clear, sequential steps, and mind maps illustrate relationships between concepts in a non-linear, holistic way. This combination caters to diverse learning styles combining the read/write and auditory types for making complex topics easier to grasp and remember (24).

NotebookLM helps creating a mind map from the uploaded document. To generate it, users need to click on the "Mind map" button. For example, NotebookLM created a mind map for Maya's story that describe the symptoms, diagnosis, pathology, treatment plan, and progress (20). In addition to mind map, many instructors may need to create flow charts. For making flow chart, they can use NapkinAI (https://www.napkin.ai). It makes visually appealing flow chart by analyzing the text input (20).

General-Purpose LLMs and Specified Tools

LLM-based chatbots like ChatGPT and tools like NotebookLM are both built on language models, but they differ significantly in purpose, functionality, and interaction style. Chatbots like ChatGPT, Claude, Perplexity are general-purpose conversational AI designed to engage in a wide range of topics, answer questions, generate content, and simulate dialogue based on its vast pre-trained knowledge (25). It excels in open-ended, real-time interactions, where the user inputs prompt and receives responses

based on patterns learned during its training. While it can generate creative content and explanations, its answers are not tied to user-specific documents unless explicitly provided in the prompt.

In contrast, NotebookLM is a specialized AI tool that combines the power of language models with document-based context. It gives users the choice to upload PDFs, articles, and notes and interact with the AI in the context of the uploaded content. This makes it particularly useful for studying, research, or creating tailored summaries and analyses based on personal or academic materials. Unlike other LLM chatbots that depend on their general training, NotebookLM anchors the response on the uploaded materials and consequently allows for more customized and source-related outputs. This makes it especially suitable for students and educators who want reliable, source-based summaries, explanations, or concept connections. By acting as a personalized AI tutor, NotebookLM enhances academic integrity in using language model ethically (26).

Clicking on the numbers will open the source text for verification (Figure 2). If any text appears important during the chat, it can be saved as a note by selecting the "add note" option for future reference.

Other Applications

In this paper, we discussed how NotebookLM can assist in creating stories for educational use. It is clear that modifying the prompt can lead to different outputs, similar to other chatbots (27). Hence, educators should try different prompts to test which one gives the best responses suited for their needs.

NotebookLM can serve a wide range of educational purposes beyond storytelling. Like all other LLM-based chatbots, learners can quickly generate concise summaries that capture the main ideas (28). This is especially helpful during exam preparation or when reviewing complex topics. It can also assist in note consolidation, allowing students to combine scattered notes from lectures and readings into coherent, organized overviews.

Another significant application is generating questions and conducting self-quizzes. By analyzing the uploaded content, NotebookLM can create custom quiz questions that align with the user's materials, aiding in active recall and formative assessment. Educators can use it to develop teaching aids (9), such as lesson outlines, concept maps, and classroom discussion prompts tailored to their curriculum. Lastly, for research, NotebookLM can help in literature synthesis and identifying thematic patterns, offering a valuable assistant for writing reviews or organizing evidence for academic writing.

Conclusion

The integration of NotebookLM and open educational resources offers a powerful and innovative approach to creating storytelling materials for educational purposes. As the tool interacts directly with the personal content, there is less chance of getting any inaccurate content, and users can always check from there where the output text is sourced. This fusion of storytelling and technology not only makes physiology more accessible and memorable but also promotes active learning, more profound comprehension, and critical thinking.

While NotebookLM offers valuable support for educational and research purposes, it does have certain limitations. Its most significant constraint is that it relies solely on the user-uploaded sources, which means the accuracy and depth of its responses are entirely dependent on the quality and completeness of those documents. If the materials are outdated, poorly written, or limited in scope, the model may generate incomplete information and may deviate from what the user wants. Additionally, it cannot provide real-time data or cross-reference external knowledge beyond what has been uploaded. In contrast, chatbot like ChatGPT can now directly search from the internet and provide links of the source.

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Abbreviations

AI: Artificial Intelligence
LLMs: Large Language Models

Authors' Contribution

HM conceptualized and designed the study, collected the data, visualized the results, conducted a literature search, and prepared the manuscript. SM also conceptualized the study, assisted with the literature search, and reviewed and revised the manuscript. Both authors approved the final version and take responsibility for its content.

Conflict of Interest

The authors declare that there are no conflicts of interest related to the publication of this article.

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Availability of Data and Materials

The authors confirm that the data supporting the findings of this study are available within the article and through the provided links.

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