Towards an AI-Augmented Textbook

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Textbooks are a cornerstone of education, but they have a fundamental limitation: they are a one-size-fits-all medium. Any new material or alternative representation requires arduous human effort, so that textbooks cannot be adapted in a scalable manner. We present an approach for transforming and augmenting textbooks using generative AI, adding layers of multiple representations and personalization while maintaining content integrity and quality. We refer to the system built with this approach as Learn Your Way. We report pedagogical evaluations of the different transformations and augmentations, and present the results of a a randomized control trial, highlighting the advantages of learning with Learn Your Way over regular textbook usage.

Keywords: Personalized learning, generative education, content transformations

1. Introduction

Recent advances in generative Artificial Intelligence (Gen-AI) have the potential to revolutionize education, but this potential is yet to be realized in full. It requires a responsible, multidisciplinary approach to weave together learning science and cutting edge technology. In this work, we focus on a central aspect of the current learning journey: exploring textbook material. Traditionally, every school selects several textbooks that are meant for use by all learners. The textbooks, by definition, are inflexible and not adaptive, as it is impractical to manually create a version for every audience, and certainly not one that would adapt to individual user needs. Here we argue that in the age of Gen-AI, this notion of a flexible and personalized textbook is in fact within reach. Specifically, we show how textbooks can be transformed into a richer and more personalized form, while maintaining the integrity of the original content, and adding layers that promote effective learning.

Our textbook augmentation approach takes as input a textbook segment or chapters and uses them as the basis for extensive generated content, practice and evaluation. Our approach rests on two key concepts that underlie the corresponding augmentations of the original content: multiple representations and personalization. We propose a two step AI generation scheme whereby the original text is first personalized, and then transformed into a range of presentation forms and assessment components. A key desiderata in this process is that content is adequately aligned with the source and curriculum, and that the presentation is engaging and pedagogically effective. We implement our approach in an experimental learning experience that we call Learn Your Way.

We begin with the pedagogical observation that learning can be more effective when the experience is adapted to the characteristics and needs of the learner [see 1, 2, for a review of personalization approaches]. Learn Your Way is thus designed to first re-generate the original textbook content, based on specific learner attributes. In addition, Learn Your Way generates assessment opportunities for the learner which serve to create a signal about their progress, reflect personalized feedback to the learner, and influence subsequent steps.

The value of multiple representations of content has been studied in learning science [e.g., see 3]. For example, dual coding theory [4] suggests that multiple representations have the advantage of forging links between different encodings of the same concepts, thus reinforcing the corresponding mental conceptual structures. Learn Your Way is therefore augmented with multiple views of the

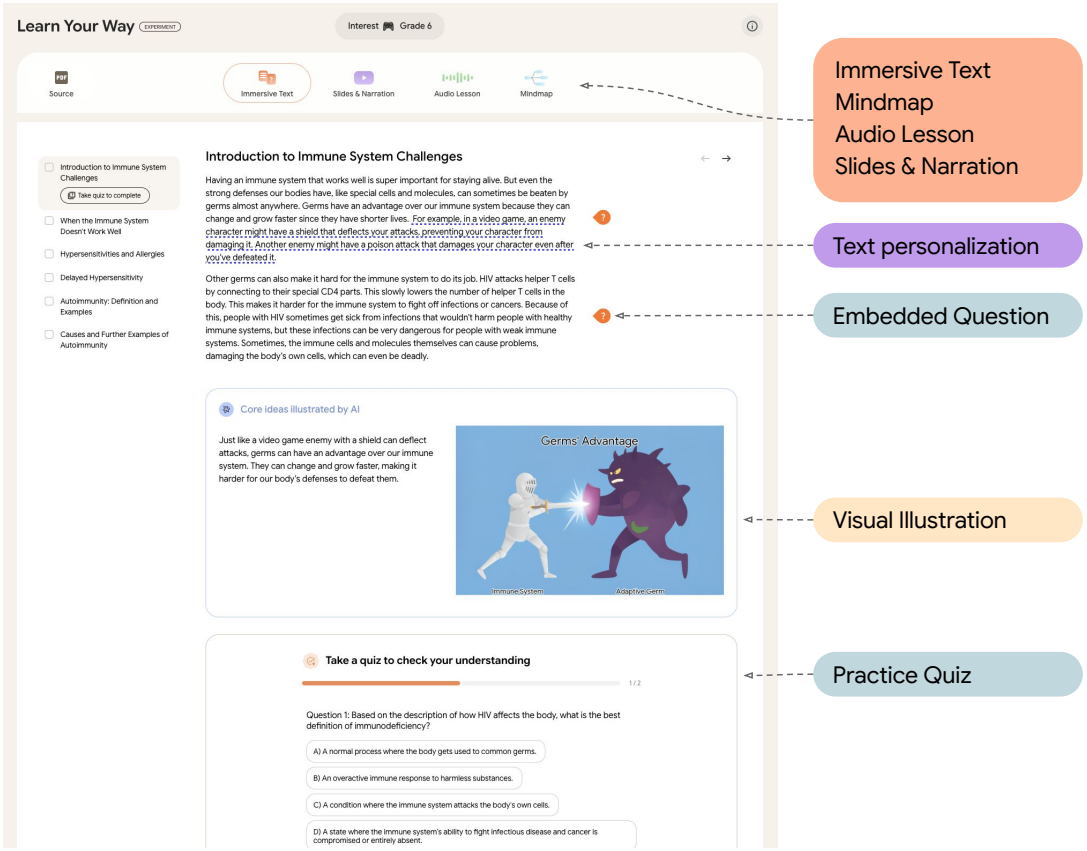

Figure 1 | An example of the Learn Your Way learning experience. Centerpiece is the "Immersive Text" view, that shows the source material (OpenStax's *Disruptions in the Immune System* content) transformed to 6th grade level and adapted for a personal interest in gaming. The Immersive Text contains various generative add-ons such as personalized examples, embedded questions, and more. At any given time, the learner can also switch to alternative views of the entire material such as narrated slides or an audio lesson, which are also personalized.

material (audio lessons, narrated slides, and mind maps), which learners can interact with and choose from. Providing these options is in line with the view that personalized systems should also be adaptable, offering learners agency to decide on their learning path [5–7]. It is also motivated by theories of self-regulated learning (SRL) [8] and visible learning [9] that acknowledge the importance of supporting learners with cognate control of their learning process.

Figure 1 shows the central Learn Your Way view, demonstrating how personalization and multiple representations come together. The resulting AI-augmented textbook provides the learner with a personalized and engaging learning experience, while also allowing them to choose from different modalities in order to enhance understanding. In the next sections we describe each of the components in Learn Your Way, along with an evaluation of the pedagogical merit of each one. Finally, we report the results of a randomized controlled study showing that learning with our personalization and multiple representations Learn Your Way system can improve learning efficacy compared to a standard Digital Reader over the same material. Taken together, our results demonstrate the potential to re-imagine the medium of a textbook in the age of generative AI.

2. Textbook Augmentation via Personalization and Multiple-Views

We assume source-of-truth material which is defined by the learner's curriculum and learning goals. For simplicity, think of a section in a textbook, although the source-of-truth can be a more complex collection of knowledge and skills to be delivered. Our goal is to explore how transforming the source material can increase content engagement and efficacy. Gen-AI offers four key opportunities in this context. First, it can generate such content for any material the learner is interested in. Second, it can do so while adapting to the specific attributes and needs of the learner. This is in contrast to the generation of personalized learning material by human educators, which is a much longer process and is impractical to do at scale. Third, AI can be used to generate different representations of the material, including visualizations and audio-based formats, which are known to further enhance the efficacy of learning [3, 4]. Finally, AI can generate formative assessment elements tailored to the learner, allowing them to monitor and regulate progress. As [10] notes, formative assessment is a critical driver of learning, and in particular self-regulated learning.

Our textbook transformation and augmentation follows a two step approach. In the "Text Personalization" stage, we rewrite the material to match specific personal attributes of the learner. Then in the "Content Transformations" stage, we create multiple views of the rewritten material. These allow the user to choose their own learning path, interleaving complementary representations of the same conceptual structures. Figure 2 demonstrates this process, showing two different personalization transformations, that results in different views. Unless otherwise noted, all transformations and augmentations described below rely directly on Gemini 2.5 Pro, a leading model for education [11], without additional fine-tuning.

2.1. Text Personalization

As explained above, our approach first transforms the original text into a more personalized form. A key choice in this process is what specific attributes of the learner should be personalized to. For simplicity, we focus on two key attributes: grade-level and personal interests. There are of course many additional attributes to consider on the path towards more comprehensive personalization.

Personalization to Grade Level.
Adaptation of the material to match the reading grade level of the learner is a core transformation that provides the basis for all other transformations that follow. The text is generatively adapted, with the goal of matching the Flesch-Kincaid Grade (FKG) [12, 13] for that level, while maintaining factuality and coverage of the material. This is known as re-leveling and is part of Gemini 2.5 Pro core education capabilities. See [11], Section 2.2 for an evaluation.

Personalization to Interests.
The Learn Your Way experience asks the learners, in addition to the grade level, for their personal interests. Currently, for simplicity, the learner is asked to select one of several common interests (e.g., sports, music, food). This information is then used to rewrite the original text, making it more relatable. This also serves the purpose of mapping new knowledge to existing conceptual networks used by the learners, thus making learning more effective. As [14] notes: "individuals' existing knowledge serves as a base for subsequent learning and performance". Their review further argues that "prior knowledge guides readers' comprehension of written language". Our Gen-AI rewriting is done in a focused manner, by first selecting parts of the text that are particularly amenable to personalization, and then replacing only these parts with an AI-rewritten personalized version. This has the added advantage of highlighting the personalized text, thus informing the learner that it has been specialized to their interests. See example in Figure 2 for Newton's third law example, rewritten for two different interests: basketball and art.