


Chapter 2

Student–Created Generative Artificial Intelligence (GenAI) Physics Simulations: A Build, Refine and Learn (BRaL) Framework for Conceptual Understanding

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ABSTRACT

This chapter presents a pedagogical framework that aims to enhance physics teaching method from high school level to early college by enabling students to create interactive simulations with the help of generative AI tools which are large language models-powered. The BRaL framework recognizes learners as model builders who can develop and refine simulations without programming skills. This framework ensures students learn physics instead of merely remembering it. They create their own models, then take a break to reflect on what they're thinking, and test their arguments against theory and data. The framework has three stages and it includes educators and AI guidance to students on how to design diagrams, conduct virtual experimentation, and identify errors with clear assumptions. Hooke's law simulation as a case study presented in the chapter and depicts how students transition from simple idealized problems to harder, more complex ones.

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INTRODUCTION

New developments in Generative Artificial Intelligence (GenAI) are changing the way students learn science. Generative AI tools, such as large language models (e.g., ChatGPT), may be of immense value for physics learning, as they simulate the process of a human tutor explaining challenging concepts, answering questions and providing feedback, and directing inquiry through conversation in natural language (Ding & Li, 2023; Leon, 2024). In this study, we examine the innovative Build, Refine and Learn method in which students can develop substantive understanding of core physics concepts by building their own physics simulations with GenAI, followed by furthering their understanding by means of continuous feedback and experimentation.

This process aligns well with constructivist approaches- students learn deeply when they actively build and refine their own thinking by creating a mental model (El Fathi et al., 2025; Xavier & Oliveira, 2024). Recent research highlights how bringing students into the process—actually having them create and review models—boosts their understanding and sharpens their problem-solving skills (Magana et al., 2024). GenAI as a creative partner enables students to do genuine modeling and simulation without the need for programming; thus, they can focus their cognitive resources on physics reasoning rather than coding syntax (Robledo-Rella & Toh, 2024; Hamerski, 2024; Aligato & Saligumba, 2025).

The Build, Refine and Learn method in science education is a solution for the two major problems that have been identified. Firstly, it allows students to generate simulations (not only users) which is a technique based on Papert's constructionism (learning-by-making) and contemporary model-based learning theory. Secondly, it reduces the technical challenge: GenAI “coders” facilitate simulation authoring which implies that students can execute their ideas in code through natural language prompts (El Fathi et al., 2025; Mukherjee & Le, 2025; Xavier & Oliveira, 2024).

GenAI lets students turn their mental models into working simulations fast, without forcing them to learn programming first. They can focus on thinking like physicists: figuring out how to represent a system, choosing the right variables and laws, testing their models. No more getting stuck on code. The real work becomes about understanding physics, not wrestling with syntax errors.

This chapter presents the pedagogical framework for learning by creating and refining models, understanding the importance of mental models and simulations in grasping physics concepts, and explaining how GenAI-supported student-created simulations facilitate learning. We establish the educational worth of carefully planned virtual experimentation using standard representational conventions and provide examples of how repeated build-and-refine cycles (led by teachers or AI

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