AI-SUPPORTED MECHANISTIC REASONING IN PHYSICS EDUCATION: INVESTIGATING STUDENTS' EXPLANATIONS OF CORE ELECTROSTATIC CONCEPTS IN A NEURON AXON – RC CIRCUIT MODEL

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Understanding scientific phenomena in physics requires more than applying formulas; it requires explaining the causal mechanisms underlying physical processes. In science education literature, such explanations are described as mechanistic reasoning. Mechanistic reasoning involves identifying the entities and their properties within a system, and the interactions among them that collectively produce observable outcomes [1]. Rather than relying solely on mathematical relationships, mechanistic explanations articulate the causal processes that link physical concepts. With the rapid development of generative artificial intelligence (AI) tools, new learning environments have emerged that may support students' reasoning processes. However, it remains unclear whether interactions with AI systems foster deeper mechanistic reasoning or simply encourage answer-seeking behaviors. Investigating how students construct mechanistic explanations while interacting with AI therefore, represents an important research problem in physics education. The purpose of this study is to examine the mechanistic explanations of first-year undergraduate students in AI-supported learning environments and to contribute to the physics education literature by analyzing how freshmen construct causal explanations of physical phenomena. The study is situated within the interdisciplinary freshmen science course at Sabancı University. This course aims to equip students with basic Physics, Biology, and Chemistry concepts. The study focuses on students' reasoning about core electrostatics concepts such as; electric field, potential and energy associated with the field, and work, in the context of modeling the neuron axon with simple electric circuits. By analyzing students' written explanations, AI interaction logs, and interview data, the study aims to reveal how students develop causal explanations of physical processes and how AI interactions influence these reasoning patterns. The study employs an explanatory sequential mixedmethods. Participants are undergraduate students enrolled in the above mentioned science course. Data is collected at multiple stages of the instructional sequence, including before and after lectures. In the final stage, students participate in an AI-supported reasoning session designed to encourage mechanistic explanations. Students' explanations are analyzed using a mechanistic reasoning coding framework adapted from Russ et al. (2008), which identifies key mechanistic elements such as entities (e.g., ions and electric field), interactions (electric force), and outcomes (changes in electric potential across the membrane).

[1] R. S. Russ, R. E. Scherr, D. Hammer, J. Mikeska (2008). Recognizing mechanistic reasoning in student scientific inquiry: A framework for discourse analysis developed from philosophy of science. Science education, 92(3), 499-525.