

Research Symposium

Directed or Random? Student Reasoning About Diffusion Across Physiological Contexts

Zach Kam, BS¹, Maya Shah, Jasmine Parker, Issac Gollapalli

¹ College of Osteopathic Medicine, Michigan State University

<https://doi.org/10.51894/001c.164398>

Spartan Medical Research Journal

Vol. 11, Issue 2, 2026

46

BACKGROUND

Random molecular motion underlies diffusion, chemical reactions, and gas exchange, yet many students explain diffusion primarily as particles moving “from high to low concentration.” Rather than treating this as a misconception, we adopt a dynamic systems perspective informed by Knowledge-in-Pieces and Resources frameworks to examine how students coordinate knowledge resources when reasoning about diffusion.

METHODS

We administered three parallel diffusion questions (animal, plant, and nonliving contexts) to 197 students enrolled in an introductory human physiology course at a large R1 public university. Students predicted the location of a labeled oxygen molecule before and after equilibrium and explained their reasoning. Using knowledge analysis with team-based coding (90% interrater reliability), we identified common knowledge resources and patterns in their coordination. Multinomial regression assessed effects of context and GPA on reasoning type.

RESULTS

Fourteen common knowledge resources were identified and organized into six reasoning patterns. The most prevalent pattern was “High to Low” reasoning (51%), in which students relied on concentration gradients to explain molecular behavior. Twenty-one percent coordinated gradient reasoning with random motion after equilibrium, while only 2% used exclusively random motion reasoning. Question context did not significantly impact reasoning type. Across GPA levels, “High to Low” reasoning predominated, although higher-GPA students were somewhat more likely to coordinate gradient and random motion resources.

CONCLUSIONS

Students’ reliance on “High to Low” reasoning reflects its strong cueing priority in diffusion contexts. Instruction should therefore focus on helping students coordinate productive gradient reasoning with molecular-level random motion rather than replacing existing ideas. A resources-based approach may better support mechanistic understanding of diffusion.

Accepted: June 15, 2026 EDT. Published: July 31, 2026 EDT.



This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CCBY-4.0). View this license's legal deed at <http://creativecommons.org/licenses/by/4.0> and legal code at <http://creativecommons.org/licenses/by/4.0/legalcode> for more information.