

Bridging Misconceptions and Affective Barriers: A Two-Pronged Approach to Supporting Students Learning Atomic Theory in General Chemistry

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Students Struggle with Atomic Theory

Challenge | General Chemistry students struggle to learn the quantum mechanical model of atoms, often leading to negative outcomes.

There are two contributing factors:

1. **Strong negative affect** in regards to chemistry hindering learning ability.¹
2. **Misconceptions** about atomic structure from high school.¹⁻³

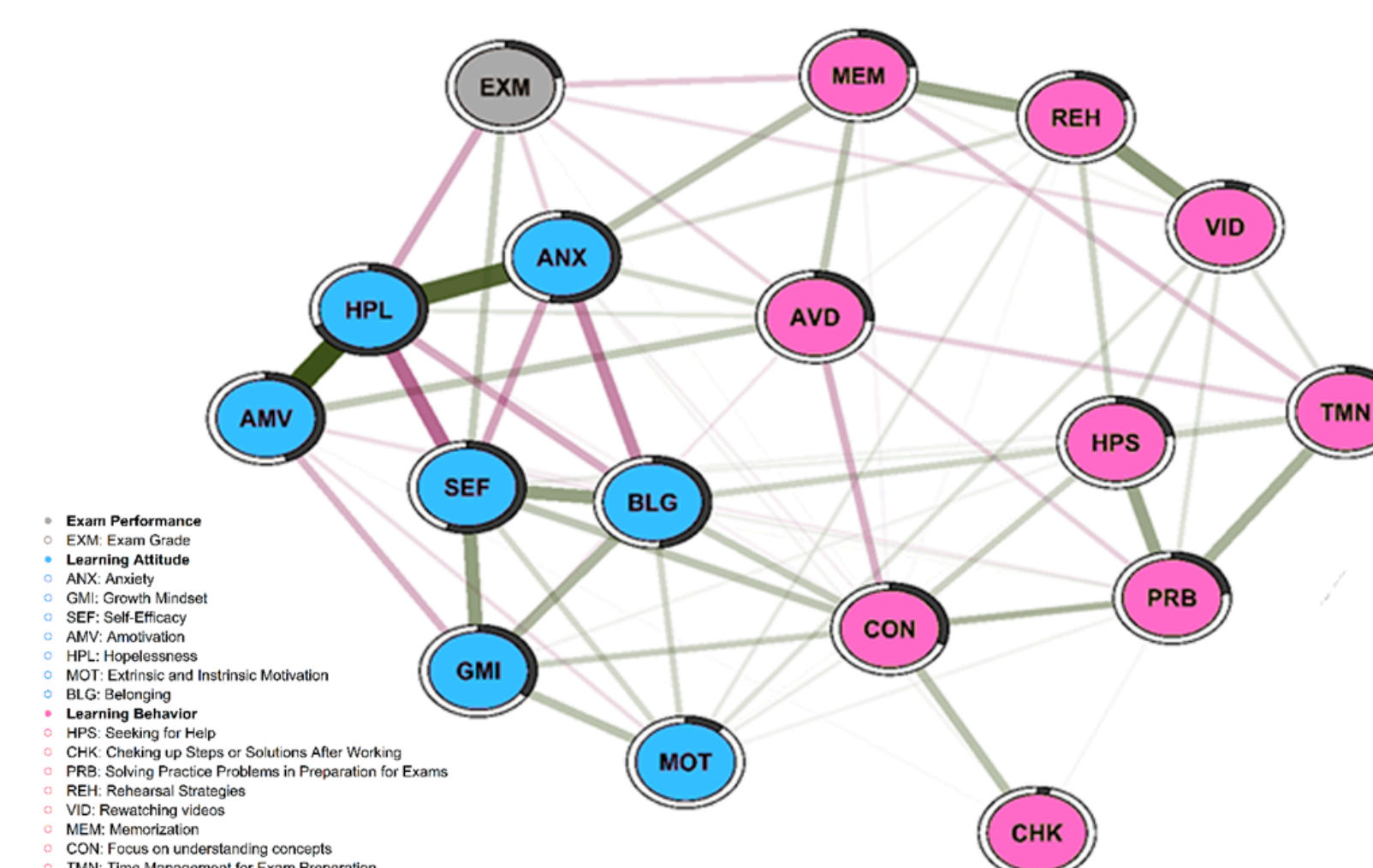
Goals | Improve learning outcomes by addressing negative feelings and emotions and eliminating misconceptions through:

1. A **short-form curriculum** consisting of question-embedded video lessons and brief exercises, based on principles from cognitive-behavioral therapy techniques.
2. A **systematic review of common General Chemistry textbooks** to identify the prevalence of naive conceptions of atomic theory principles.

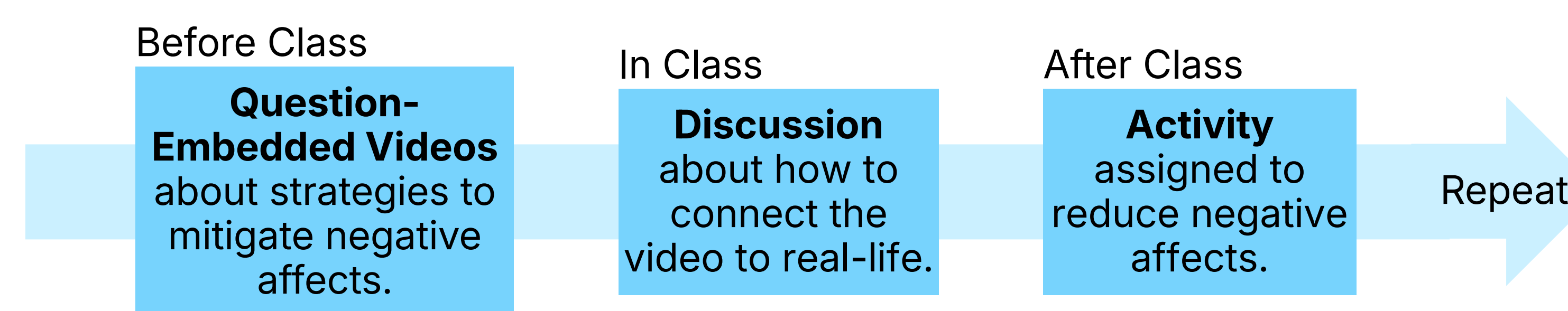
Addressing Negative Affect

Students' outcomes in General Chemistry are correlated with:

- Hopelessness
- Anxiety
- Sense of Belonging
- Avoidance
- Self Efficacy
- Growth Mindset



A novel curriculum targeting affective factors is being developed:



Textbooks Reinforce Misconceptions from the Bohr Model

Why a textbook analysis?

- The **Bohr model** is the main source of misconceptions.¹
- Textbooks could exacerbate and amplify misconceptions if atomic representations are not selected carefully.²

Methods

- Two coders independently recorded each occurrence of an atomic representation with classification and qualities. Discrepancies were resolved through debate (89% Inter-Coder Reliability).

Preliminary Findings

- All included textbooks **failed to explain** the electron's wave behavior clearly, using terminology from the Bohr model for the modern model.
- Frequent use of representations such as the stippled dot diagram may leave a false impression that electrons exist as particles.
- Many books alternated between interpreting electrons as waves and as particles, possibly causing confusion.

Textbook Information			Characteristics	Representations												
Author	Title	Edition (Year)	Prevalent Limitations	Overall Style	Bohr Model	Bohr Energy Level Diagram	H Emission Spectra	Bohr Model Equation	3D Boundary	Electron Cloud Slice	Stippled Dot	Electron Configuration	Energy Level Diagram	Ψ^2 Graph	$\Psi^2 r^2$ Graph	Non-H Em. Spectra
Zumdahl, et al.	Chemistry	10th (2017)	Lack of emphasis on wave functions. Enforcement of Bohr conceptions throughout the text.	N/A	@	@	@	@	@	@	@	@	@	@	@	@
Brown, et al.	Chemistry: The Central Science	14th (2017)	Lack of emphasis on wave functions, phases, and periodic trends. Enforcement of Bohr conceptions throughout the text.	N/A	@	@	@	@	@	@	@	@	@	@	@	@
Tro	Chemistry: A Molecular Approach	6th (2022)	Alternation between the wave and particle explanations of an electron. Enforcement of Bohr conceptions throughout the text.	Frequent use of analogy.	@	@	@	@	@	@	@	@	@	@	@	@
Gilbert, et al.	Chemistry	6th (2020)	Alternation between the wave and particle explanations of an electron.	Emphasis on history.	@	@	@	@	@	@	@	@	@	@	@	@

Future Avenues: Atomic Theory Game

Interactive simulations and gamification promote understanding, improve behavior, and increases scores.⁴⁻⁵

We are developing an **interactive atomic simulation game** to facilitate understanding whilst mitigating negative affects. It will have two modes:

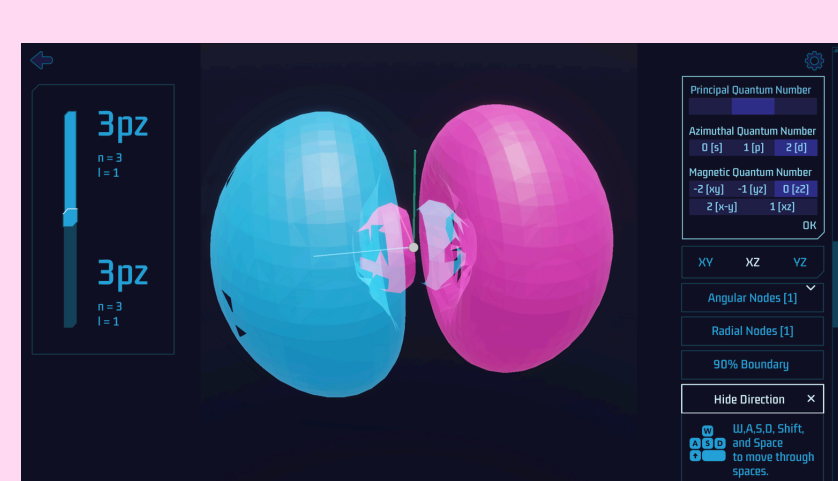
Campaign Mode

- Ideal for students learning for the first time.
- Interactive guided lessons and activities with various integrated simulations.



Playground Mode

- Ideal for instructors and in-class demonstrations.
- Various customizable simulations to demonstrate different atomic features.



References

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