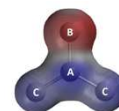


# Polar or Nonpolar: Student decision-making when offered sequential or simultaneous exemplars with and without electrostatic potential maps

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## BACKGROUND: MOLECULAR POLARITY

Key concept for structure-property relationships

Difficulty with molecular polarity<sup>1-7</sup> and structure-property relationships<sup>8-12</sup> more generally. Why?

- Complex: depends on bond polarity and 3-D symmetry
- Heuristics: students often only consider a *single* aspect in making polarity decisions; functional reduction<sup>3</sup> or one-reason decision making<sup>13</sup>
- Prior content knowledge: requires students to first predict Lewis structure and molecular geometry

## RESEARCH QUESTIONS

To what extent:

- Will an **array of exemplars** of generic polar and nonpolar molecules, with or without electrostatic potential maps (EPMs), aid students in predicting and/or describing aspects of molecular polarity?

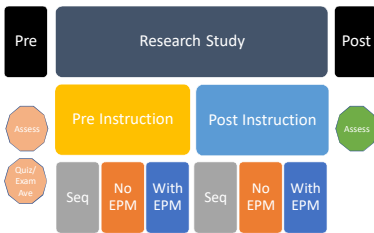


- Does **timing** with respect to direct lecture instruction about molecular polarity influence study results?
- Does study participation influence **long-term** student retention and/or understanding of molecular polarity?

## EXPERIMENTAL STUDY DESIGN

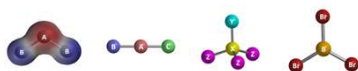
	Sequential	No EPMs	With EPMs
Block 1	Test molecules, feedback	View array exemplars	View array exemplars
Block 2	Test molecules, feedback	Test molecules, feedback	Test molecules, feedback
Block 3	Test molecules, feedback	View array exemplars	View array exemplars
Block 4	Test molecules, feedback	Test molecules, feedback	Test molecules, feedback
Block 5	Test molecules, NO feedback	Test molecules, NO feedback	Test molecules, NO feedback

## OVERALL STUDY DESIGN



## METHODS

- Spartan molecular modeling software to generate molecule images
- Qualtrics survey software for online administration
- Subjects: from ~600 CHEM 403: General Chemistry I students
  - Two lecture instructors
  - Before and after direct lecture instruction

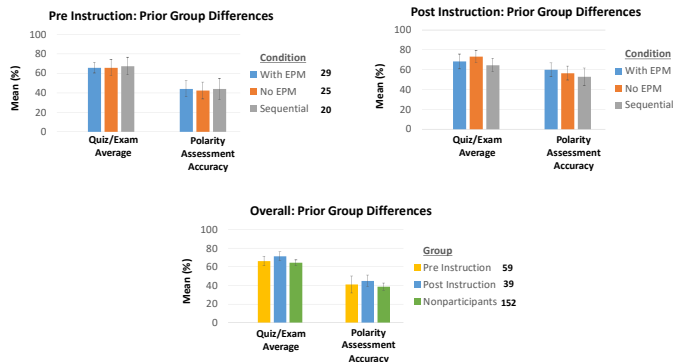


## POLARITY ASSESSMENT

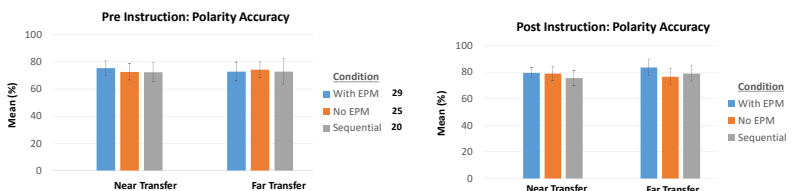
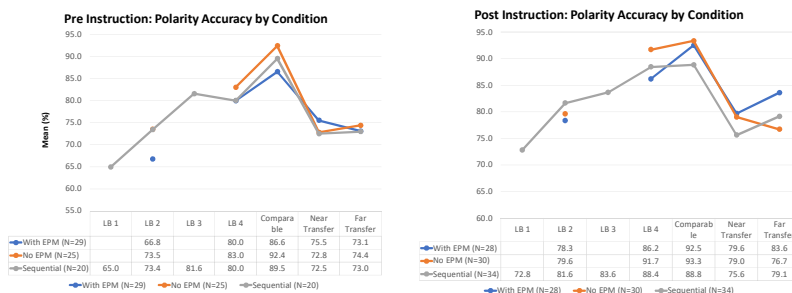
10 question molecular polarity quiz given at the start of CHEM 403, immediately before the study, and again at the start of CHEM 404.

CS <sub>2</sub>	OF <sub>2</sub>	H <sub>2</sub> CO	CH <sub>2</sub> Cl <sub>2</sub>	CCl <sub>4</sub>
O <sub>2</sub>	HCN	NF <sub>3</sub>	H <sub>2</sub> Se	H <sub>2</sub> C=CH-CH <sub>3</sub>

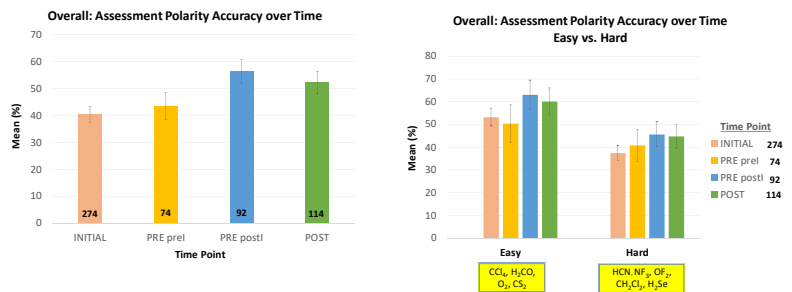
## RESULTS: PRIOR GROUP DIFFERENCES



## RESULTS: POLARITY ACCURACY BY CONDITION



## RESULTS: ASSESSMENT ACCURACY OVER TIME



## RESULTS: SUMMARY

- Generally **only minor differences** between all groups on data collected **prior** to the study (Quiz/Exam average, Polarity Assessment Accuracy)
- Generally **only minor differences** between all three treatment groups (With EPMs, No EPMs, Sequential) on Polarity Accuracy (Near Transfer, Far Transfer)
  - Perhaps EPM group benefits most from polarity direct instruction?
- Overall Polarity Assessment results over time show direct instruction responsible for **~10% increase** in accuracy, but still generally **barely better than chance** by General Chemistry II
- Overall Polarity Assessment results over time show direct instruction **more effective for easy** (~10% increase) vs. **hard** (~5% increase), those requiring Lewis structure and VSEPR
- All students show **very low average accuracy** (~30%) for propene
- Generally **only minor differences** between all three overall groups (Pre Instruction, Post Instruction, Nonparticipants) on Post Assessment Accuracy

## FUTURE WORK

- Continue to analyze quantitative and qualitative data from Fall 2018 and Spring 2019
- Develop and test efficacy of **Molecular Polarity Intervention** based on cognitive psychology and what we've learned:
  - Timing **after** direct lecture instruction
  - Add in **definitions** of polar and nonpolar molecules
  - Higher quality feedback** to describe why molecules are polar or nonpolar
  - Mix transfer** molecules into learning blocks
  - Use **interleaving** to scaffold students in developing competency in gradually going from 3D to 2D to molecular formulas throughout learning blocks

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