Learning Task Inventories (LTIs) in Introductory Organic Chemistry

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ORGANIC CHEMISTRY I AT WLU

• first organic chemistry course
• required for many Year 2 Science students
• prior to 2010 → primarily lecture based
• starting in 2010 → “blended” approach
• course enrollment

2003 79
2004-09 138
2010 211
2011-12 302
WHY LTIs?

- blended learning: start with learning objectives

Your ability to predict chemical reactivity of organic compounds and illustrate mechanisms by which reactions occur is highly dependent on your ability to visualize and represent the chemical structures of organic compounds and to explain the effect that structure has on reactivity. By the end of this course, you should be able to:

- **describe** and **illustrate** the structure of atoms and the nature of bonding between atoms in organic compounds;
- **evaluate** the effect that bonding has on the 3-D shape, stability, properties and reactivity of organic compounds;
- **assess** the consequences of 3-D shape, conformational mobility and stereochemistry on structure and reactivity of organic compounds;
- **provide** the chemical structures of reactants, reagents or products required for or predicted by a given chemical reaction;
- **solve** and/or **depict**, using the curved arrow formalism (a.k.a. arrow pushing), the mechanisms by which organic reactions occur.

- “What do we have to know...?”

- develop self-monitoring, metacognitive skills

TYPICAL LEARNING TASK INVENTORY

**Learning Tasks for Chapter 6. An Overview of Organic Reactions**

After covering the material from this chapter, you should be able to:

- **name, describe** and recognize examples of the four common types of organic reactions
- **distinguish** between symmetrical bond breaking/making (radical) mechanisms and unsymmetrical bond breaking/making (polar) mechanisms, and **illustrate** how each type occurs using curved arrows
- **name, describe** and illustrate, using curved arrows, the three mechanistic steps involved in the radical halogenation of alkanes
- define nucleophile and electrophile, identify molecules, and atoms within molecules, that are capable of acting as either or both, and use curved arrows to show the movement of electron density when nucleophiles and electrophiles react (IMPORTANT AND ON-GOING TASKS IN THIS COURSE FROM THIS POINT ON)
- define \( \Delta G^\circ \) and \( \Delta G^\circ \) for a given reaction, or for a particular mechanistic step in a reaction, and sketch an energy diagram given information regarding the sign and magnitude of \( \Delta G^\circ \) and \( \Delta G^\circ \)
- **describe** the relationship between \( \Delta G^\circ \) and \( K_{eq} \) and between \( \Delta G^\circ \) and the rate of a particular step in a reaction
- define exergonic and endergonic, and, given an energy diagram, describe a reaction, or an individual mechanistic step of a reaction, as exergonic or endergonic
- given an energy diagram, locate starting materials, transition states, intermediates and products, and **identify** the rate-limiting step
- for the acid-catalyzed addition of water to ethylene, **draw** a detailed arrow-pushing mechanism and an energy diagram labeled with the rate-limiting step and the locations and structures of transition states and intermediates
- **determine** the differences between common laboratory reactions and biological reactions
IMPLEMENTATION OF LTIS

2010
- released as pdfs through CMS

% of Students Accessing LTIs by Chapter

Chapter

1  2  3  4  5  6  7  8  9

% Students

0  10  20  30  40  50  60  70  80

 IMPLEMENTATION OF LTIS

2011
- converted to required surveys in CMS

“State Dr. MacNeil’s middle name and date of birth.”

“Select 1 if you are reading this question.”
LTI RESEARCH DESIGN

2012
- 293 students (94%) in ‘Orgo 1’ recruited
- randomly divided into 5 treatment groups
- completed introductory and end-of-term surveys and 9 weekly LTIs

<table>
<thead>
<tr>
<th>Condition</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTI</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Prompt</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Quiz</td>
<td>X</td>
<td>X</td>
<td>✓ (no feedback)</td>
<td>✓ (part. feedback)</td>
<td>✓ (full feedback)</td>
</tr>
<tr>
<td>Survey</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

PARTICIPANTS
- 293 participants
- 186 females (69%); 82 males (31%)
- 233 2nd year (86%); 37 3rd, 4th year (14%)
- course required (87%); course optional (13%)
ATTITUDES AND EXPECTATIONS

Positive Feelings Toward Organic Chemistry

% of students

<table>
<thead>
<tr>
<th>Response</th>
<th>% of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>strongly disagree</td>
<td>6</td>
</tr>
<tr>
<td>disagree</td>
<td>20.1</td>
</tr>
<tr>
<td>neutral</td>
<td>26.9</td>
</tr>
<tr>
<td>agree</td>
<td>35.4</td>
</tr>
<tr>
<td>strongly agree</td>
<td>37.6</td>
</tr>
</tbody>
</table>

Agree/Strongly Agree <50%

- I look forward to this course.
- I think organic chemistry is fascinating.

ATTITUDES AND EXPECTATIONS

Negative Feelings Toward Organic Chemistry

% of students

<table>
<thead>
<tr>
<th>Response</th>
<th>% of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>strongly disagree</td>
<td>1.5</td>
</tr>
<tr>
<td>disagree</td>
<td>13</td>
</tr>
<tr>
<td>neutral</td>
<td>7.8</td>
</tr>
<tr>
<td>agree</td>
<td>45.7</td>
</tr>
<tr>
<td>strongly agree</td>
<td>32.3</td>
</tr>
</tbody>
</table>

Agree/Strongly Agree 78%

- The thought of organic chemistry gives me anxiety.
- I am fearful of this course.
ATTITUDES AND EXPECTATIONS

Will I learn a lot? I don’t know but I’m going to try!

<table>
<thead>
<tr>
<th>Response</th>
<th>% of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>strongly disagree</td>
<td>6%</td>
</tr>
<tr>
<td>disagree</td>
<td>11%</td>
</tr>
<tr>
<td>neutral</td>
<td>22%</td>
</tr>
<tr>
<td>agree</td>
<td>35%</td>
</tr>
<tr>
<td>strongly agree</td>
<td>54%</td>
</tr>
</tbody>
</table>

Agree/Strongly Agree ~80%!

Results:

- I believe I will learn a lot of important information in this course.
- I plan to utilize all learning materials provided for this course.
- I believe I will need extra support (e.g., SI, practice tests) to do well in this course.
EFFECT OF LTIs

Final Exam Average Grade vs Condition

- ANOVA: differences not significant
- ANCOVA: # of LTIs completed is significant

The more LTIs a student completes, the higher the student’s final exam grade.

FEEDBACK FROM STUDENTS

- perceived effect of LTIs

What impact did LTIs have on each of the following?
FEEDBACK FROM STUDENTS

- perceived effect of LTI quizzes

What impact did LTI quizzes have on each of the following?

<table>
<thead>
<tr>
<th>Impact</th>
<th>Awareness of what I did or did not know</th>
<th>Ease of learning the material</th>
<th>Contribution to my final grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>large impact</td>
<td>49.5</td>
<td>56.9</td>
<td>53.8</td>
</tr>
<tr>
<td>small impact</td>
<td>38.2</td>
<td>18.7</td>
<td>19.7</td>
</tr>
<tr>
<td>no impact</td>
<td>12.3</td>
<td>24.4</td>
<td>26.4</td>
</tr>
</tbody>
</table>

% of students

FEEDBACK FROM STUDENTS

Did completing weekly LTIs have an effect on study time?

<table>
<thead>
<tr>
<th>Time</th>
<th>YES</th>
<th>NO</th>
<th>NOT SURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midterm</td>
<td>17.5</td>
<td>71.7</td>
<td>10.8</td>
</tr>
<tr>
<td>Final</td>
<td>15.9</td>
<td>74.5</td>
<td>9.6</td>
</tr>
</tbody>
</table>

% of students

Did your study habits change as a function of using the LTIs?

<table>
<thead>
<tr>
<th>Change</th>
<th>In this course</th>
<th>In future courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>19.6</td>
<td>74.2</td>
</tr>
<tr>
<td>no</td>
<td>80.4</td>
<td>25.8</td>
</tr>
</tbody>
</table>

% of students
FEEDBACK FROM STUDENTS

Would you recommend using the LTIs in future offerings of this course?

% of students

- 72% would recommend
- 28% would not recommend

FEEDBACK FROM STUDENTS

- open-ended responses

“HELPED ME FOCUS”

“MORE FEEDBACK”
CONCLUSIONS

- LTI conditions did not have a significant effect on final exam grades
- # of LTIs completed was a significant predictor of final exam grades even after controlling for prior learning
- students feel that LTIs improve “awareness” or “focus” but do not think this translates to improved study habits or grades

FUTURE WORK

- directly measure metacognitive skills at beginning and end of course
- explore effect of LTI frequency on improvement of metacognitive skills
- hold interviews to gain insight into how students are using the LTIs
- develop scaffolding that supports other aspects of self-regulated learning
ACKNOWLEDGEMENTS

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- Robyn Glover and Patrick Smith