Automated Text Analysis Facilitates Using Written Formative Assessments for Just-in-Time Teaching in Large Enrollment Courses
Assessment to Reveal Student Thinking

- Large enrollment courses prohibit the use of constructed response assessments
Constructed response assessments

- Allow students to represent their understanding in their own words (Keuchler and Simpkin 2010)

- Give faculty greater insight into student thinking compared to multiple choice assessments (Birenbaum, and Tatsuoka 1987)

- Students treat CR and multiple-choice assessments as different cognitive tasks and prepare for them differently (Stanger-Hall 2012)
Study Population

• 3 sections of Introductory Biology Cell and Molecular Course for Majors

• 4 instructors

<table>
<thead>
<tr>
<th></th>
<th>Section 1</th>
<th>Section 2</th>
<th>Section 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrollment</td>
<td>309</td>
<td>466</td>
<td>302</td>
</tr>
<tr>
<td>% Female</td>
<td>46</td>
<td>58</td>
<td>49</td>
</tr>
<tr>
<td>% First and second years</td>
<td>69</td>
<td>69</td>
<td>67</td>
</tr>
<tr>
<td>Cum GPA at start of term</td>
<td>2.48</td>
<td>2.69</td>
<td>2.52</td>
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Scope of Analysis

• 15 questions
  – Thermodynamics, acid-base chemistry, metabolism, genetics

• Responses collected

<table>
<thead>
<tr>
<th>Pre</th>
<th>Post</th>
<th>Total</th>
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<tbody>
<tr>
<td>8,290</td>
<td>4,387</td>
<td>12,677</td>
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</table>
Timeline:
Feedback Report and Just-in-Time Teaching

Previous week
- Administer Questions Online

Monday morning
- Download Responses, Analyze, Generate Report
- Report sent to Instructor
- Instructors Use Report to Modify Lesson Plan

Monday ~5pm
- Tuesday morning
- Just-in-Time Instruction
Analysis Stream in IBM SPSS Modeler

- Connects text and cluster analyses
- Generates output for feedback report
- Allows rapid analysis of new data sets
monosaccharides involves a hydrolysis reaction which is adding a water molecule. The bonds could be solid making them harder to break by a water molecule.

because it takes a lot of energy to break these bonds.

Breaking the bonds between monosaccharides occurs very slowly at room temperature because the bonds become kinked at room temperature.

Carbohydrate take longer at break down at room temperature due to their hydrogen bonds. The monosaccharides have monomers that prevents them from breaking those bonds.

I think the reaction occurs very slowly because the bonds that are breaking are covalent bonds which are relatively strong.

Because covalent bonds are the strongest and therefore hardest bonds to break.

The normal room temperature does not have enough heat given for the reaction especially for breaking the bond in the string. So the reaction goes very slowly.

This reaction occurs slow at room temperature because the bonds of the carbohydrate need to be broken.
Question

A carbohydrate is composed of a string of covalently linked monosaccharides. Breaking those bonds between the monosaccharides is a chemically spontaneous reaction (ΔG for this reaction is -3.7 kcal/mol). However, this reaction occurs very slowly at room temperature. Why do you think this is so?
This reaction occurs very slowly at room temperature because the reaction is only ~3.7 kcal/mol which is a low reaction.

The activation energy is higher at room temperature so it takes longer for the reaction to proceed.

Because it takes a lot of energy to break these bonds.

The reaction occurs slowly at room temperature because the kinetic energy of the atoms is very low. As you increase the temperature the kinetic energy rises which allows for the atoms to move more quickly and then break apart from each other.
### Feedback Report

<table>
<thead>
<tr>
<th>Cluster 1</th>
<th>Cluster 2</th>
<th>Cluster 3</th>
<th>Cluster 4</th>
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<tbody>
<tr>
<td>Miscellaneous</td>
<td>High temperatures/Activation Energy</td>
<td>Energy to Break Bond</td>
<td>High Temperature to Break Bonds</td>
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<tr>
<td>37.7%</td>
<td>20.9%</td>
<td>28.9%</td>
<td>12.5%</td>
</tr>
</tbody>
</table>

| 0.24 temperature | 0.99 high | 0.88 break | 1.00 temperature |
| 0.13 activation energy | 0.49 temperature | 0.78 bond | 0.95 break |
| 0.02 bond | 0.34 activation energy | 0.33 covalent bond | 0.80 bond |
| 0.01 break | 0.08 bond | 0.29 high | 0.61 high |
| 0.01 covalent bond | 0.04 covalent bond | 0.05 energy | 0.21 covalent bond |
| 0.00 high | 0.01 break | 0.01 temperature | 0.05 activation energy |

### Example Responses

| This reaction occurs very slowly at room temperature because the reaction is only -3.7 kcal/mol which is a low reaction. | The activation energy is higher at room temperature so it takes longer for the reaction to proceed | The reaction occurs slowly at room temperature because the kinetic energy of the atoms is very low. As you increase the temperature the kinetic energy rises which allows for the atoms to move more quickly and then break apart from each other. |

- Example Response 1
- Example Response 2
- Example Response 3
A Comparison of student responses
PRE/POST Instruction

<table>
<thead>
<tr>
<th>PRE</th>
<th>POST</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Misc.</td>
</tr>
<tr>
<td>Misc.</td>
<td>48.6</td>
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<tr>
<td>High Temp/ Activation energy</td>
<td>42.5</td>
</tr>
<tr>
<td>Bond Breaking</td>
<td>39.5</td>
</tr>
<tr>
<td>High Temp/Bond Breaking</td>
<td>45.2</td>
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Instructors response to CR questions and feedback reports

• Created clicker questions and led discussions based on results from feedback report

• Reported that written assessments were particularly important for gaining insight as to why students have struggled continuously with certain concepts

• Proposed future in-class activities to improve student writing skills
Improving the use of automated analysis for JiTT

- Encourage student participation by giving credit for homework assignments

- Allow more time between each assignment and the next class for preparing instructional activities

- Professional development for faculty to help them address concepts that students find challenging
Future Directions

- Communities of Practice
  - Local: groups of faculty within a department/teaching the same course
  - Virtual: faculty across institutions
  - Use the same assessment & share instructional materials
Future Directions

• Web Portal
  – support rapid assessment and feedback
Question Development Cycle

- Predictive Model
- Confirmatory Analysis
- Human Coding
- Rubric Development
- New Question Design
- Data Collection
- Lexical Resource Development
- Exploratory Analysis
- Question Revision