ChemDraw for iPad in organic chemistry courses

Layne A. Morsch  University of Illinois Springfield
Michael Lewis  Saint Louis University
Hans Keil  PerkinElmer
Patrick Diller  McGraw-Hill Education

March 18, 2013
Mobile Technology in Undergraduate Chemistry Courses
247th ACS National Meeting
Dallas, TX
Course Overview UIS

- Began teaching from iPad fall 2012
- Taught using a lecture plus problem solving format for Summer and Fall
- Teaching with a flipped course model Spring 2014
- Pilot in summer class with 18 students continued in Fall semester with 59 students
- Currently using with 40 students
Classroom Use

- Summer – iPads loaned from Perkin Elmer
- In class problem solving
- Summer - Exam questions
- Student groups studying outside class
- In class problems encourage attendance
ChemDraw Structures, Mechanisms and Syntheses

Students were asked to:

- Draw a structure with 5+ carbons that would be water soluble
- Draw the enantiomer and a diastereomer of a structure
- Draw the product of an E1 elimination reaction
- Draw the mechanism of an $S_{N}2$ substitution reaction
- Write out a several step synthesis
Flick-to-Share

- I use Flick-to-Share to create a class group
- I can send Flicks to the whole class
- They can work out the problem and flick the result back to me
- Students that have iPads can Flick to each other while studying
Instructor iPad

Student iPad

draw the mechanism of this SN2 reaction
<table>
<thead>
<tr>
<th>Flick Sent By</th>
<th>Share Date</th>
<th>File Details</th>
<th>File Shared</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:Imorsc1@uis.edu">Imorsc1@uis.edu</a></td>
<td>02/24/2014 09:23:01</td>
<td>ChemDraw.cdxml - chemical/x-cdxml</td>
<td>Download</td>
</tr>
<tr>
<td><a href="mailto:Imorsc1@uis.edu">Imorsc1@uis.edu</a></td>
<td>03/03/2014 09:37:34</td>
<td>ChemDraw.cdxml - chemical/x-cdxml</td>
<td>Download</td>
</tr>
<tr>
<td><a href="mailto:Imorsc1@uis.edu">Imorsc1@uis.edu</a></td>
<td>03/03/2014 09:36:02</td>
<td>ChemDraw.cdxml - chemical/x-cdxml</td>
<td>Download</td>
</tr>
<tr>
<td></td>
<td>02/26/2014 09:28:36</td>
<td>ChemDraw.cdxml - chemical/x-cdxml</td>
<td>Download</td>
</tr>
<tr>
<td></td>
<td>03/03/2014 09:46:10</td>
<td>ChemDraw.cdxml - chemical/x-cdxml</td>
<td>Download</td>
</tr>
<tr>
<td></td>
<td>02/24/2014 09:32:54</td>
<td>ChemDraw.cdxml - chemical/x-cdxml</td>
<td>Download</td>
</tr>
<tr>
<td></td>
<td>02/24/2014 09:33:18</td>
<td>ChemDraw.cdxml - chemical/x-cdxml</td>
<td>Download</td>
</tr>
<tr>
<td></td>
<td>02/26/2014 09:28:22</td>
<td>ChemDraw.cdxml - chemical/x-cdxml</td>
<td>Download</td>
</tr>
<tr>
<td></td>
<td>03/03/2014 09:45:41</td>
<td>ChemDraw.cdxml - chemical/x-cdxml</td>
<td>Download</td>
</tr>
<tr>
<td></td>
<td>03/03/2014 09:45:45</td>
<td>ChemDraw.cdxml - chemical/x-cdxml</td>
<td>Download</td>
</tr>
</tbody>
</table>
Improved Learning Environment

- 100% engagement in problem solving
- Students learn to draw more accurate mechanisms
- Students gain extensive experience with ChemDraw
ChemDraw for iPad Fall Student Survey | Top Findings

Survey distributed December 11, 2013 (n=15)

<table>
<thead>
<tr>
<th>Working Well +</th>
<th>Pain Points -</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Easy to draw structures, overall</td>
<td></td>
</tr>
<tr>
<td>• Builds better comprehension of course material though group practice</td>
<td></td>
</tr>
<tr>
<td>• Helps with learning &amp; error correction</td>
<td></td>
</tr>
<tr>
<td>• Prof can easily review students work in class</td>
<td></td>
</tr>
<tr>
<td>• Needs effective group sharing options</td>
<td></td>
</tr>
<tr>
<td>• Drawing and sharing takes up class time</td>
<td></td>
</tr>
<tr>
<td>• Considerable learning curve to start drawing</td>
<td></td>
</tr>
<tr>
<td>• Perception of it working inconsistently</td>
<td></td>
</tr>
</tbody>
</table>
Use and satisfaction of ChemDraw for iPad in class has improved with recently added drawing and text tools.

Flick-to-Share not sending to >15 students at a time still impedes use in class, with students.

Plans to increase the use of ChemDraw for iPad in class with a ‘flipped classroom’ structure in Spring.

“ChemDraw for iPad continues to allow me to force students to engage and give them better feedback on their structures.”

“Sorting Flicks by name, date comes in really handy. Makes it easier to grade.”

Working Well +
• Engaging students in real time
• Sorting received Flicks
• Reviewing student work in class

Pain Points −
• Cannot send to a group of students at a time
• Cannot remove people from a group
**Student Evaluation Details | University of Illinois**

**University of Illinois Springfield 16 Weeks of Use, December 2013 (n=15)**

<table>
<thead>
<tr>
<th>Ease of Drawing Structures</th>
<th>Perceived Efficiency</th>
<th>Overall Satisfaction</th>
<th>Perceived Usefulness</th>
<th>Ease of Sharing Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5.7</strong></td>
<td><strong>5.8</strong></td>
<td><strong>5.1</strong></td>
<td><strong>5.5</strong></td>
<td><strong>3.8</strong></td>
</tr>
<tr>
<td>1 Low</td>
<td>High</td>
<td>1 Low</td>
<td>High</td>
<td>1 Low</td>
</tr>
<tr>
<td><strong>7</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Easy after learning curve
- Simple, good design
- Helps with correction
- Helps students understand materials

- Easier, quicker than paper
- Easy after learning curve
- Clean and precise structures
- Helps with correction
- Takes a lot of time to draw

- “It was hard to get at first, once you do it is easier.”
- “Now that I have plenty of practice I really enjoy and think ChemDraw is a great thing.”
- “The buttons are simple and self-explanatory so it’s hard to make mistakes.”
- “It’s easy and it helps students understand bonds and structures.”

- The app allows drawing structures & reactions quickly and accurately.”
- “Awesome to have this program especially since it would let you know if something wasn’t quite right.”
- “They are cleaner and more precise than writing them by hand.”
- “It takes a lot of time to draw structures depending on the complexity.”
- “If you don’t have a lot of experience with using it then it’s hard to go fast.”

- “It was a little difficult to grasp however it does make drawing structures less intimidating.”
- “Works well the majority of the time however every once in a while there are glitches”
- “Sometimes things don’t send & it does not work for the Flick-to-Share.”
- “I’ve enjoyed the added practice with using ChemDraw to work problems in class.”
- “Simple and easy to use as compared to online version.”

- “It’s nice to be able to do them as a class together and the talk about the reactions and what was wrong.”
- “Practice is essential and this allows for more practice and use.”
- “More useful if I was able to receive things from my professor.”
- “It is useful for drawing structures but sometimes takes too long.”
- “Easy as long as there was only one or two people to share the structures with.”

- Easy if sharing w/individuals
- Students not receiving Flicks
- Takes time to receive Flicks
- Works inconsistently

- “It was easy for me to share with the instructor but when the instructor would try to share with us, most of the students wouldn’t receive anything.”
- “When the instructor sent mass flicks I wouldn’t receive them, yet I logged into Flick and would receive if just sent to me.”
- “I never, during the whole semester using it, got a structure from anyone else.”
- “Annoying waiting forever to receive Flicks from the professor.”
- “Easy as long as there was only one or two people to share the structures with.”
## Student Evaluation Details | iPad Ownership

### Currently own and use iPad in class (n=4)

*These students rated the app higher in overall satisfaction*

<table>
<thead>
<tr>
<th>Ease of Drawing Structures</th>
<th>Perceived Efficiency</th>
<th>Overall Satisfaction</th>
<th>Perceived Usefulness</th>
<th>Ease of Sharing Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>5.0</td>
<td>5.3</td>
<td>5.3</td>
<td>3.3</td>
</tr>
<tr>
<td>1 Low Low</td>
<td>1 Low High 7</td>
<td>1 Low High 7</td>
<td>1 Low High 7</td>
<td>1 Low High 7</td>
</tr>
</tbody>
</table>

### Currently borrow iPad for use in class (n=11)

*These students rated the app higher overall in ease of drawing structures and efficiency*

<table>
<thead>
<tr>
<th>Ease of Drawing Structures</th>
<th>Perceived Efficiency</th>
<th>Overall Satisfaction</th>
<th>Perceived Usefulness</th>
<th>Ease of Sharing Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.8</td>
<td>6.1</td>
<td>5.0</td>
<td>5.5</td>
<td>4.0</td>
</tr>
<tr>
<td>1 Low Low</td>
<td>1 Low High 7</td>
<td>1 Low High 7</td>
<td>1 Low High 7</td>
<td>1 Low High 7</td>
</tr>
<tr>
<td>University of Illinois Springfield</td>
<td>16 Weeks of Use, December 2013 (n=15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>--------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of Drawing Structures</td>
<td>Overall Satisfaction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.7</td>
<td>5.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Low</td>
<td>1 Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High 7</td>
<td>High 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Usefulness</td>
<td>Ease of Sharing Structures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>3.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Low</td>
<td>1 Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High 7</td>
<td>High 7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>University of Illinois Springfield</th>
<th>6 Weeks of Use, July 2013 (n=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Drawing Structures</td>
<td>Overall Satisfaction</td>
</tr>
<tr>
<td>5.1</td>
<td>5.0</td>
</tr>
<tr>
<td>1 Low</td>
<td>1 Low</td>
</tr>
<tr>
<td>High 7</td>
<td>High 7</td>
</tr>
<tr>
<td>Perceived Usefulness</td>
<td>Ease of Sharing Structures</td>
</tr>
<tr>
<td>4.6</td>
<td>4.3</td>
</tr>
<tr>
<td>1 Low</td>
<td>1 Low</td>
</tr>
<tr>
<td>High 7</td>
<td>High 7</td>
</tr>
</tbody>
</table>
ChemDraw for iPad Fall Student Survey | Top Findings

Survey distributed December 11, 2013 (n=15)

1. ChemDraw for iPad was seen by the students as largely easy to use, after an initial learning period.

2. Lack of Flick-to-Share working effectively with groups of 15+ students at a time impedes use in class as well as student satisfaction with the app. Multiple students reported frustration in not receiving ‘Flicks’.

3. Students who borrowed iPads for use in class (n=11) rated ChemDraw for iPad higher, on average, in ease of use, usefulness, and perceived efficiency than students who used their own iPads in class (n=4).

4. Average ratings for all usability measures increased, with the exception of ease of sharing structures, across the surveys distributed at 6 weeks of use (summer) and 16 weeks of use (winter).
Implementation at SLU

- The iPads were used in a four-week Organic II course with 26 students during the summer of 2013.
- Questions were asked of the students that involved structure/reaction/mechanism drawing.
- Students emailed structures to the instructor.
- Credit (~1.5% of the overall grade) was attached to participating.
- Answers were shared and discussed.
- Flick-to-Share was not used due to the short duration of the course.
  - Getting everyone enrolled quickly.
  - Lack of a quick way to organize the student files.
Student Use and Perception

• The students reported liking the use of the technology; they thought it added to their overall learning experience.

• This corresponded to class participation. Almost every student submitted structures when asked.
  – Even though they still got credit for submitting by the end of the day.

• Student attendance was much higher than usual for summer course.
Student Performance

- The ACS standardized exam for Organic Chemistry was given at the end of the course, as it was for the same course the previous summer.
- The students who used the iPads scored 6/70 higher; this corresponds to an improvement of 17 percentile points.
- The only policy difference between the summer 2012 and summer 2013 courses was the iPad implementation.
### Student Evaluation Details | Saint Louis University

#### 1 Week of Use (n=21)

<table>
<thead>
<tr>
<th>Ease of Drawing Structures</th>
<th>Overall Satisfaction</th>
<th>Perceived Usefulness</th>
<th>Ease of Sharing Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.4</td>
<td>5.5</td>
<td>6.0</td>
<td>6.1</td>
</tr>
<tr>
<td>1 Low High 7</td>
<td>1 Low High 7</td>
<td>1 Low High 7</td>
<td>1 Low High 7</td>
</tr>
</tbody>
</table>

- **Ease of Drawing Structures**: 5.4
  - After playing around with it… it is very easy to figure out and use.”
  - Good for basic structures.”
  - Tapping with finger is much easier than clicking and dragging.”
  - It is slower then drawing by pen and paper.”

- **Overall Satisfaction**: 5.5
  - Overall the app is very user friendly.”
  - I am able to save important reactions and use the documents like flashcards.”
  - It is helpful, but it takes some adjustments to use the app correctly and it has a few features that could be improved.”

- **Perceived Usefulness**: 6.0
  - It’s nice to have because it makes participating in examples easier.”
  - It aids my learning experience.”
  - Helpful for sharing and checking work but I find it easier and quicker to just use pen and paper.”

- **Ease of Sharing Structures**: 6.1
  - Amazingly easy and perfect!”
  - Easy with the direct email link.”
  - Email is fine, but can get cluttered in the inbox. Sending multiple files at once from a gallery is better.”
  - Would enjoy a network to sign in through classes and have a group Dropbox type thing.”
“It’s nice to have because it makes participating in examples easier.”

“It is very useful, but still need to take notes on paper.”
Difficulties

- Slower to draw reactions/mechanisms than freehand
- Manual analysis of responses
- Note Taking
Newest Version

- Increase # and type of arrows
- Text Tool
- Group Flick
- Export to PNG or PDF that students can include in lab reports or papers
- Sorting of Flicks received

- Addition of periodic table that allows creation of any molecular formula
- Templates that include:
  - Newman, Haworth, Fischer projections
  - Bicyclics, sawhorse, chair structures

These intentions may change without notice as we respond to customer requirements.
Future Development

Additional templates
- Biochemistry – amino acids, DNA/RNA
- Apparatus

More closely integrate into the classroom setting
- More pilots, more learning
  - Gann Academy (high school), Boston University
- ChemDraw Web
  - Wider usage for “lap top generation”

These intentions may change without notice as we respond to customer requirements.
Acknowledgments

- Hans Keil, PerkinElmer Business Line Leader, Personal Applications
- Dr. Phil McHale, PerkinElmer Product Manager
- Patrick Diller, McGraw-Hill Education
- Robin Smith, PerkinElmer R&D Leader
- Jennifer McCormick, User Experience
- Kara McElwrath, UIS Assistant Director of Client Services