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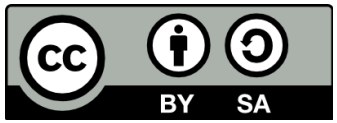
Author(s): Ginger Shultz, Grace Winschel, Renata Everett



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Deconstructing a Puzzle Using Writing and Technology

Ginger Shultz, Grace Winschel, and Renata Everett
University of Michigan

Image courtesy of wilhei55
http://www.flickr.com/photos/wilhei/109403331/

MELO$_3$D

Michigan Education through Learning Objects Project

http://openmi.ch/melo3d

MELO3D coordinators: *Brenda Gunderson and Nancy Kerner*
USE Lab Research Specialist: *Steve Lonn*
Open Education Coordinator: *Emily Puckett-Rodgers*

MELO$_3$D

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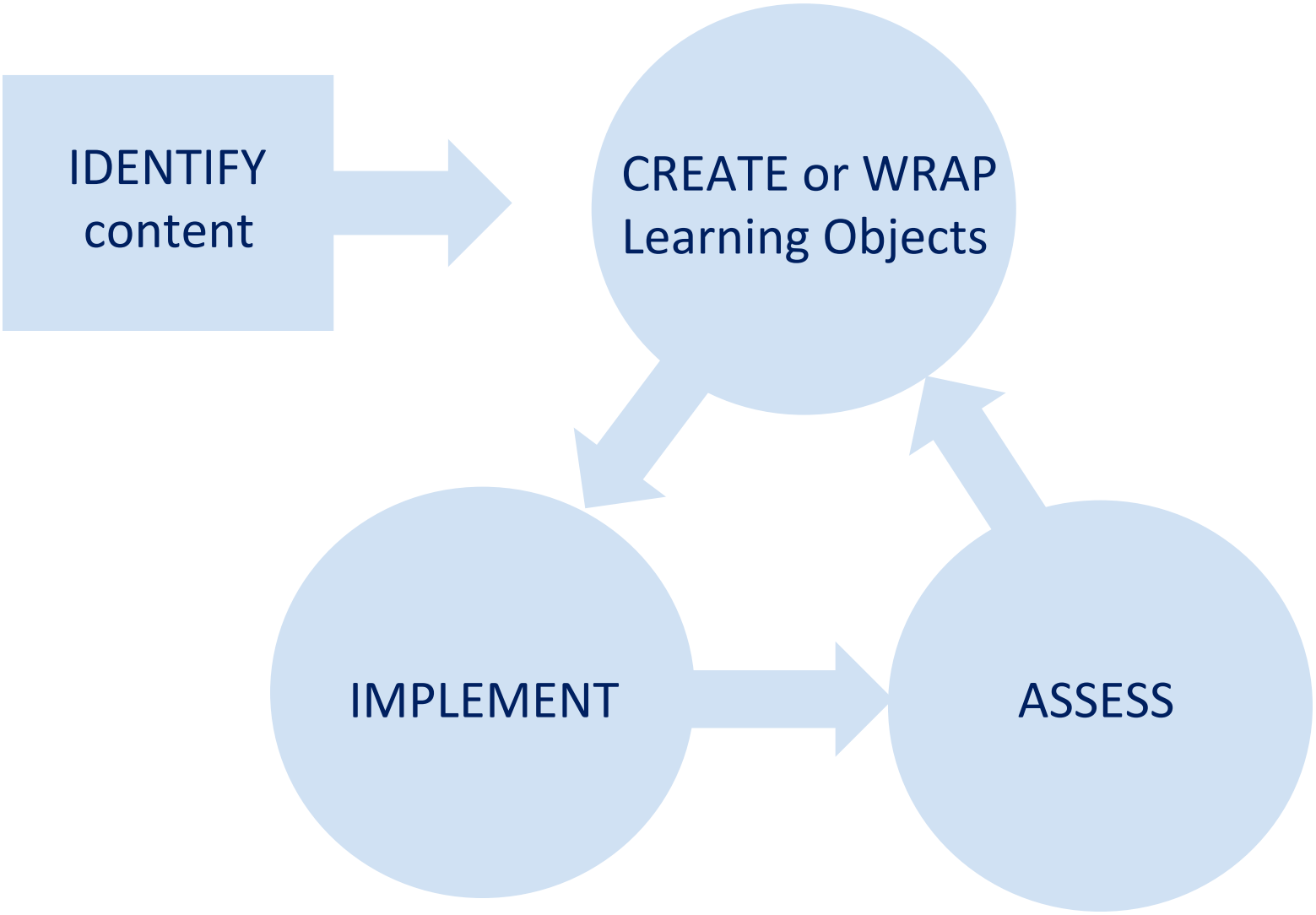

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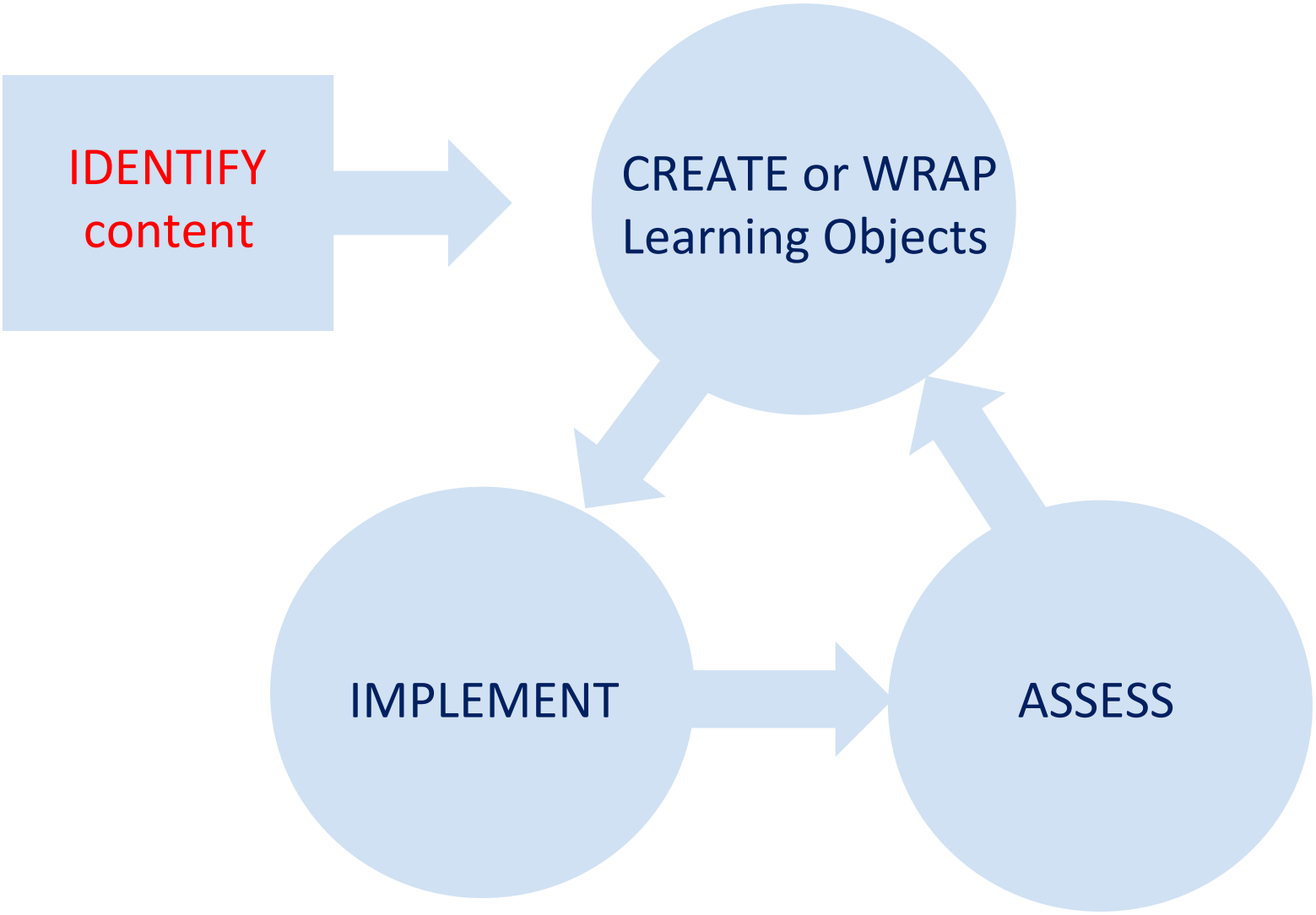


Identify Content

30 TAs
850 students
1 instructor
4 hour lab session
1 hour lecture

Image courtesy of Evelyn Saenz
http://www.flickr.com/photos/evelynsaenz/6812427231/

Chemistry 216

Identify Content

"The Synthesis and Characterization of Carbonyl Compounds"

- Lab Techniques
- Chemistry (i.e. reaction mechanisms and stoichiometry)
- Lab Report Writing
- Characterization Methods

Chemistry 216

Identify Content

"The Synthesis and Characterization of Carbonyl Compounds"

- Lab Techniques
- Chemistry (i.e. reaction mechanisms and stoichiometry)
- Lab Report Writing
- Characterization Methods – Spectroscopy

Spectroscopy

Identify Content

The study of the interaction of light with matter…

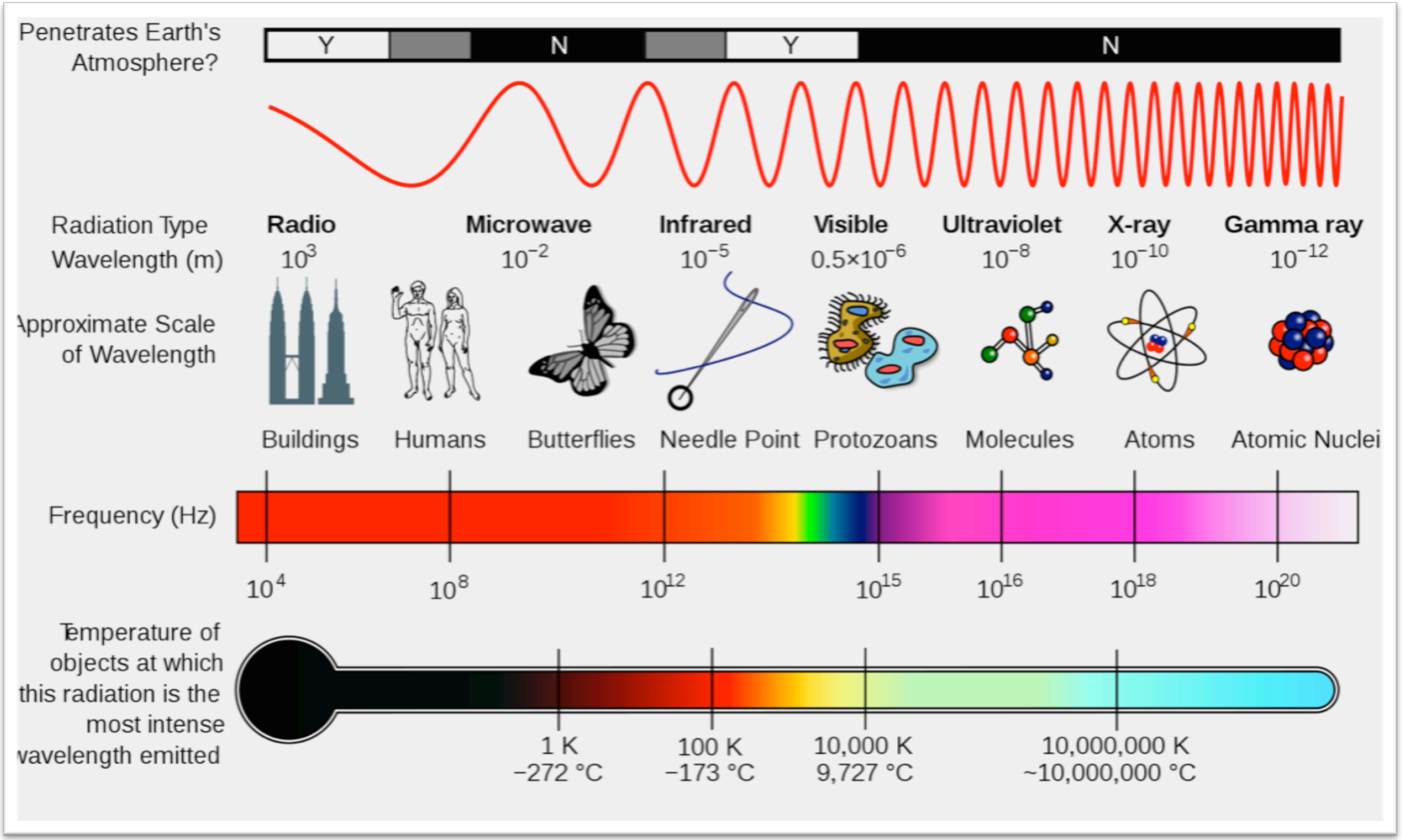
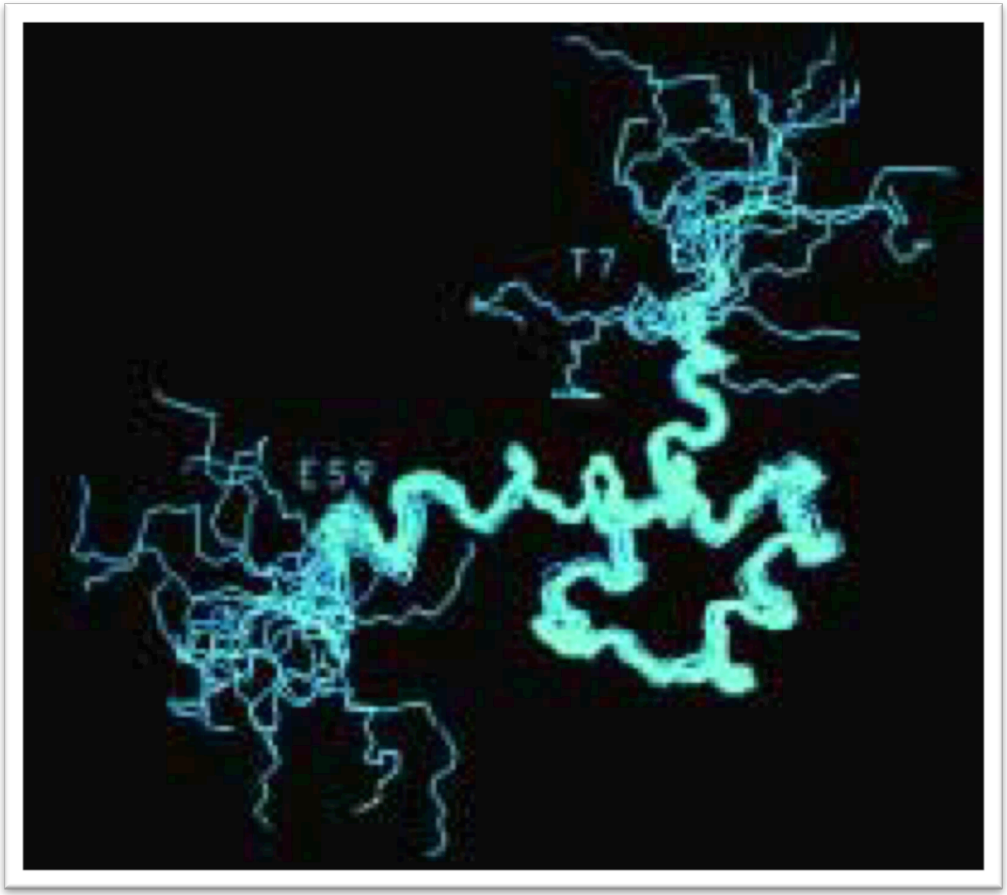


Image courtesy of Inductiveload, NASA
http://en.wikipedia.org/wiki/File:EM_Spectrum_Properties_edit.svg

6 Nobel Prizes (to 8 people) have been awarded for work in NMR (Nuclear Magnetic Resonance) spectroscopy 1943 -2003 Chemistry, Physics, Medicine:



The Nobel Prize in Chemistry 2002
John B. Fenn, Koichi Tanaka,
*Kur*t Wüthrich

NMR structure of the
Antennapedia homeodomain
(polypeptide)
from *Wüthrich*
Nobel Lecture December 2002

http://www.nobelprize.org/nobel_prizes/chemistry/laureates/2002/index.html

U-M acquires cutting edge technology to care for children with brain tumors

1.5 Tesla Magnetic Resonance Scanner at Mott Childrens Hospital

https://www.mottchildren.org/news/1434um-technology-for-children-with-brain-tumors?rendermode=previewnoinsite

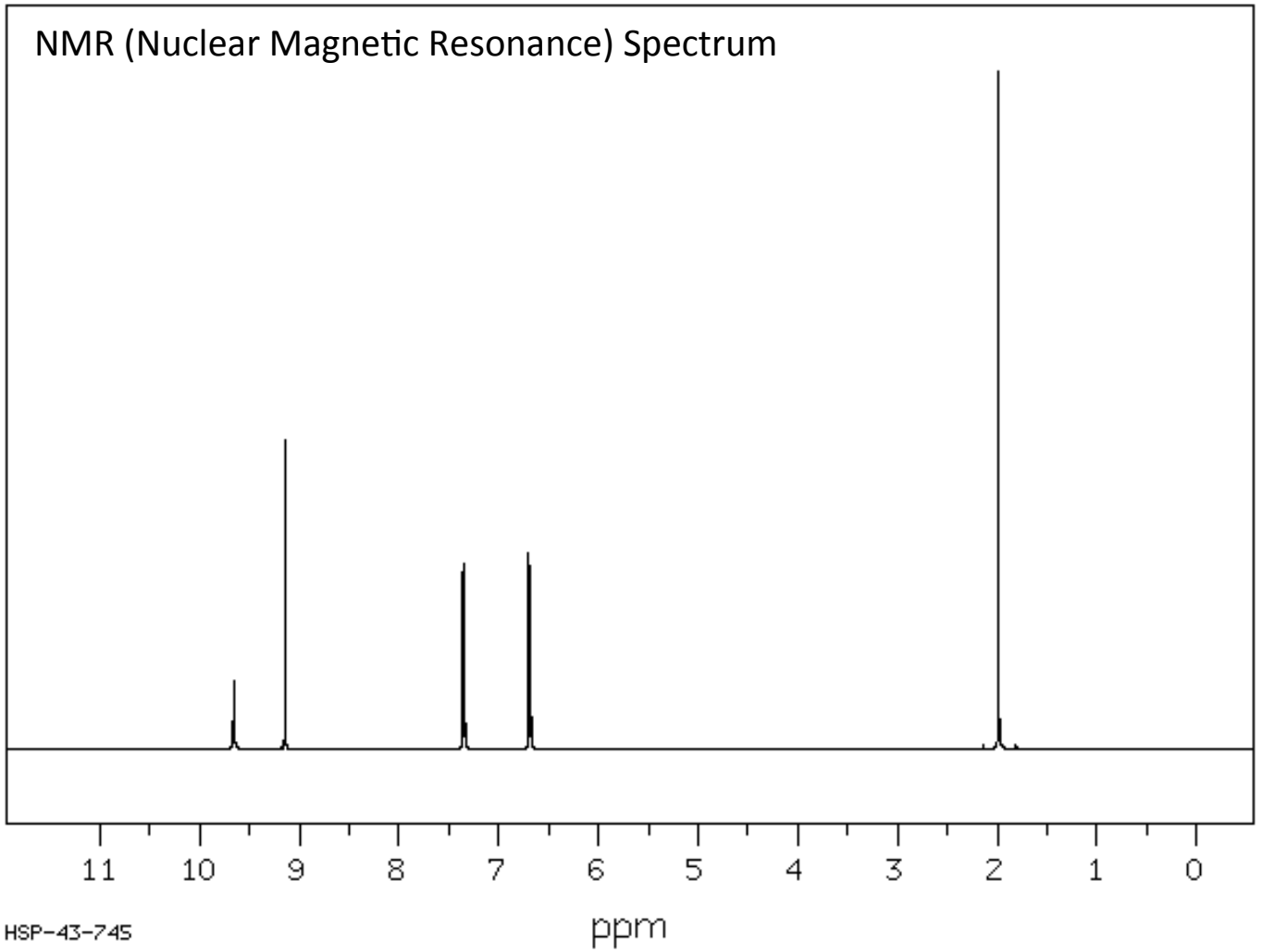
MRI - Magnetic Resonance Image

http://www.memorylossonline.com/glossary/magneticresonanceimaging.html

Spectroscopy

Identify Content

Used in organic chemistry to elucidate the structure of small molecules

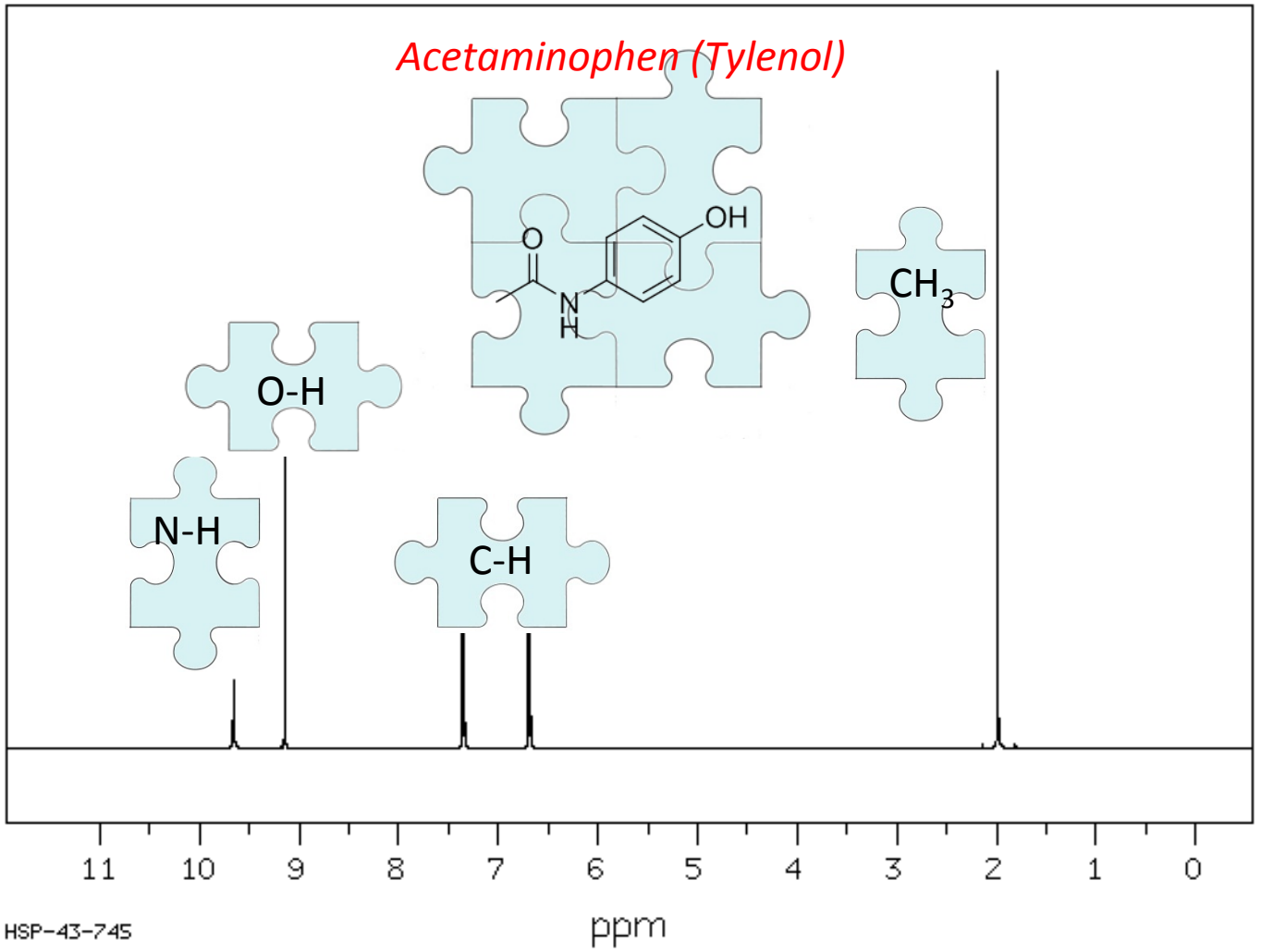


 Spectrum obtained from SDBS website: http://riodb01.ibase.aist.go.jp/sdbs/cgi-bin/direct_frame_top.cgi

Spectroscopy

Identify Content

Used in organic chemistry to elucidate the structure of small molecules



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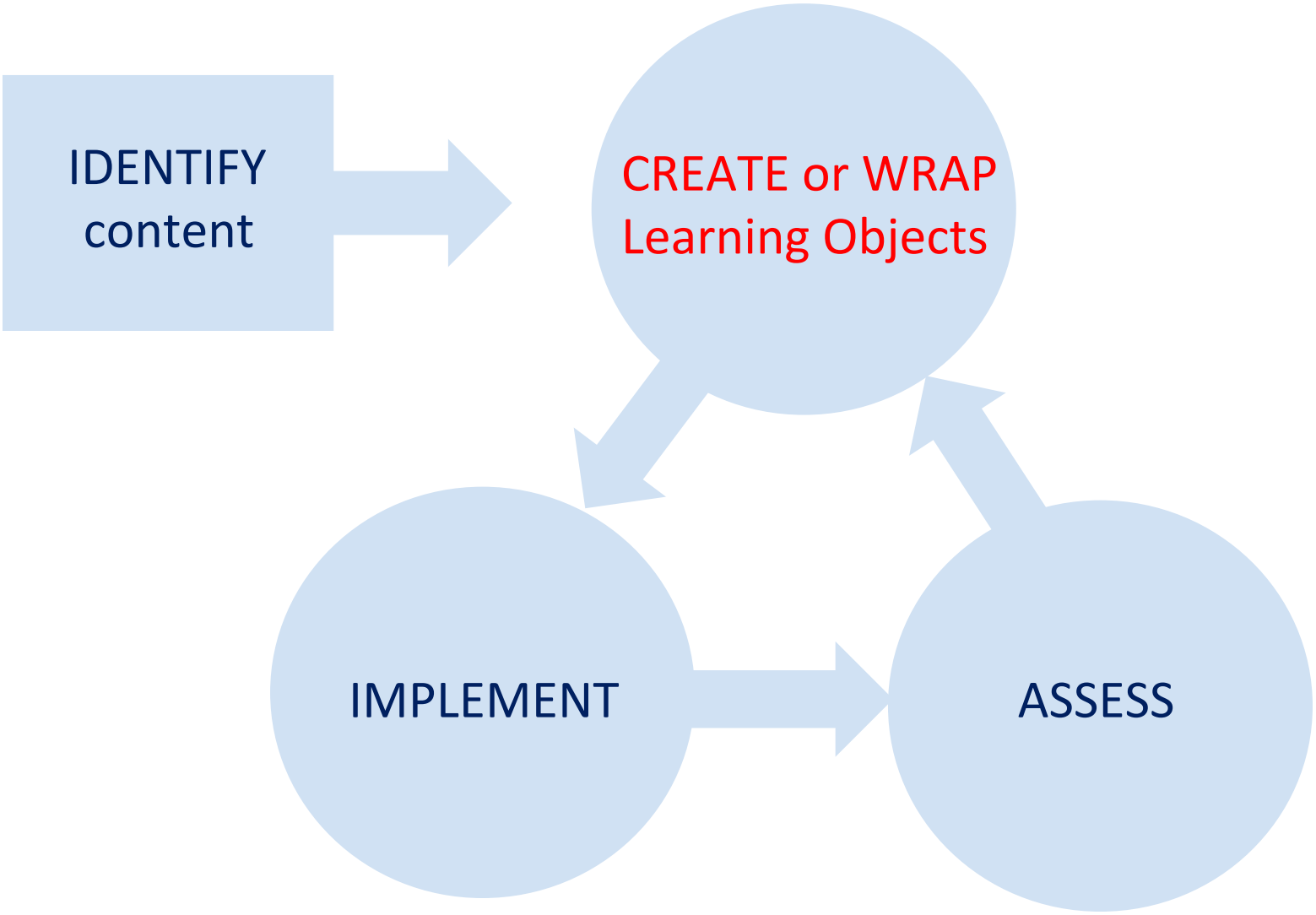
MELO$_3$D

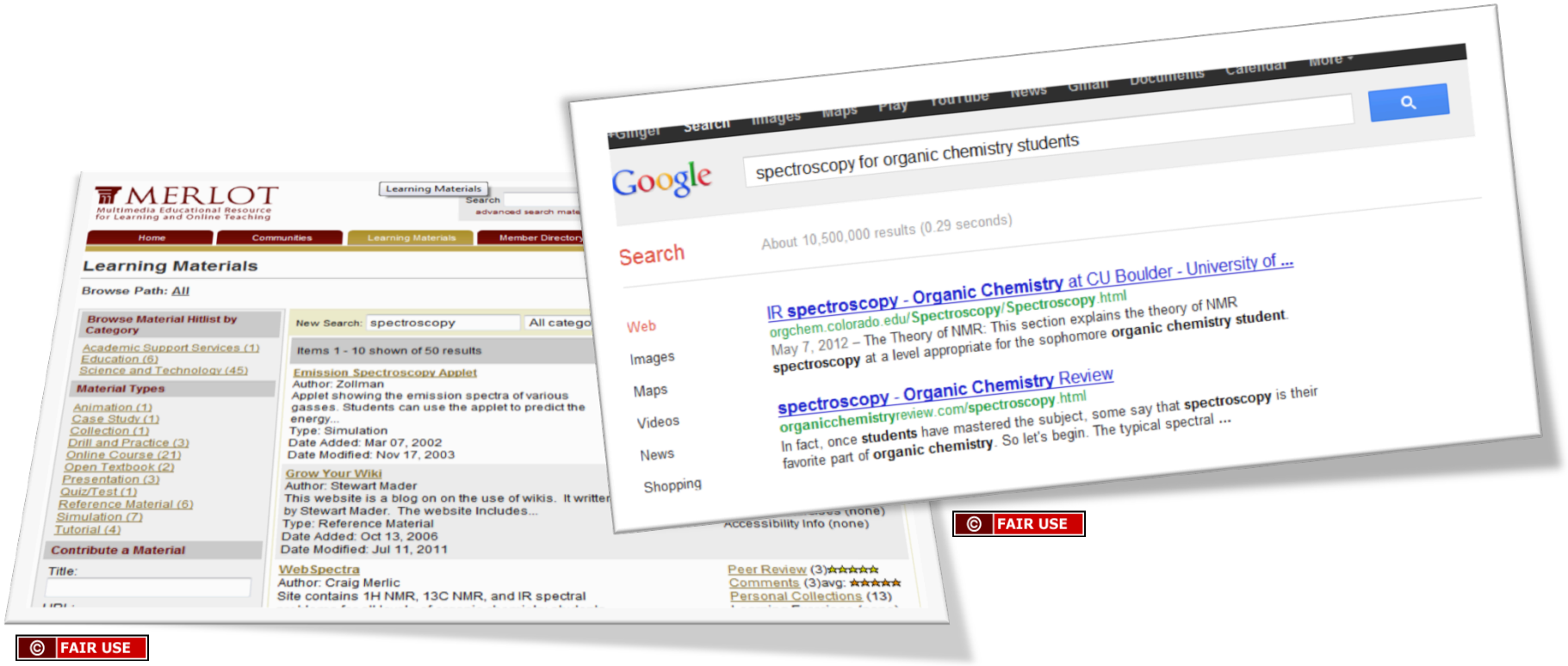
Michigan Education through Learning Objects

http://openmich/melo3d



Existing Spectroscopy LOs

Create or Wrap LOs

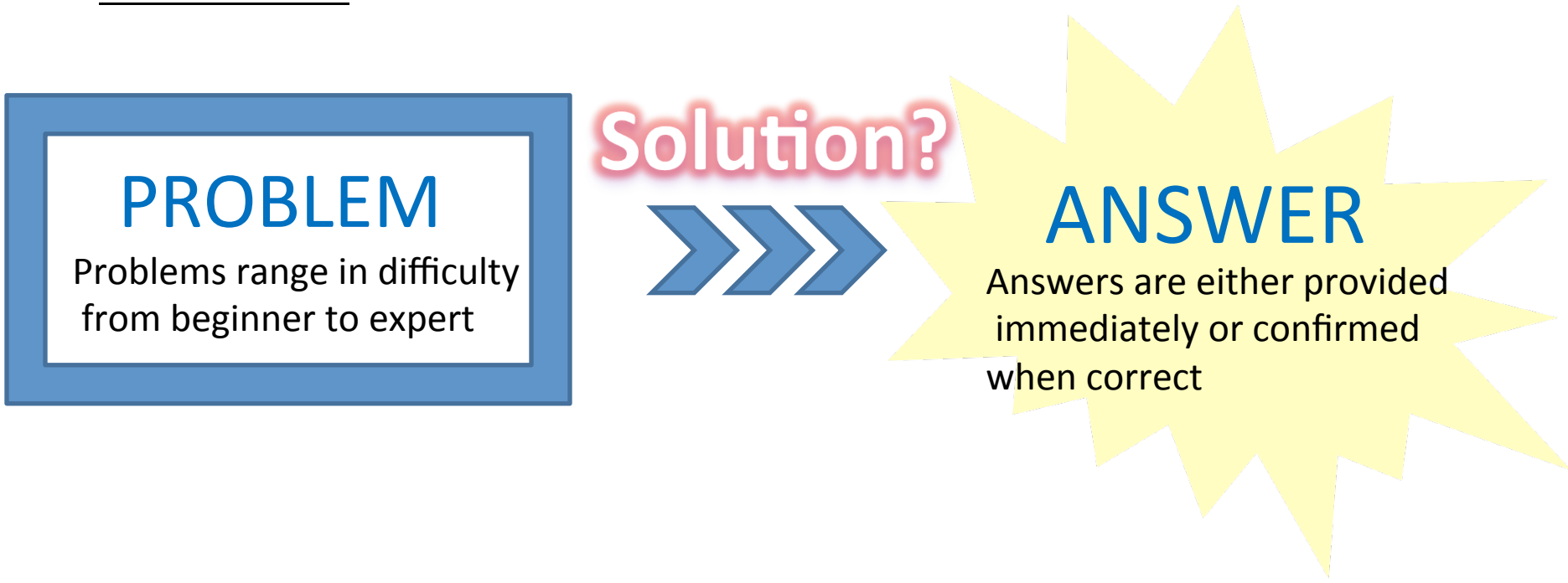


An extensive search revealed a wealth of Spectroscopy Learning Objects that range significantly in difficulty and focus.

Existing Spectroscopy LOs

Create or Wrap LOs

- All offer practice beyond what is offered in an typical organic chemistry textbook
- A few sites allow the student to interact with the spectrum (zoom in on peaks etc.)
- Most Organic Chemistry focused Spectroscopy LOs provide an answer, but not a solution.



How do we elucidate the problem solving process using technology?

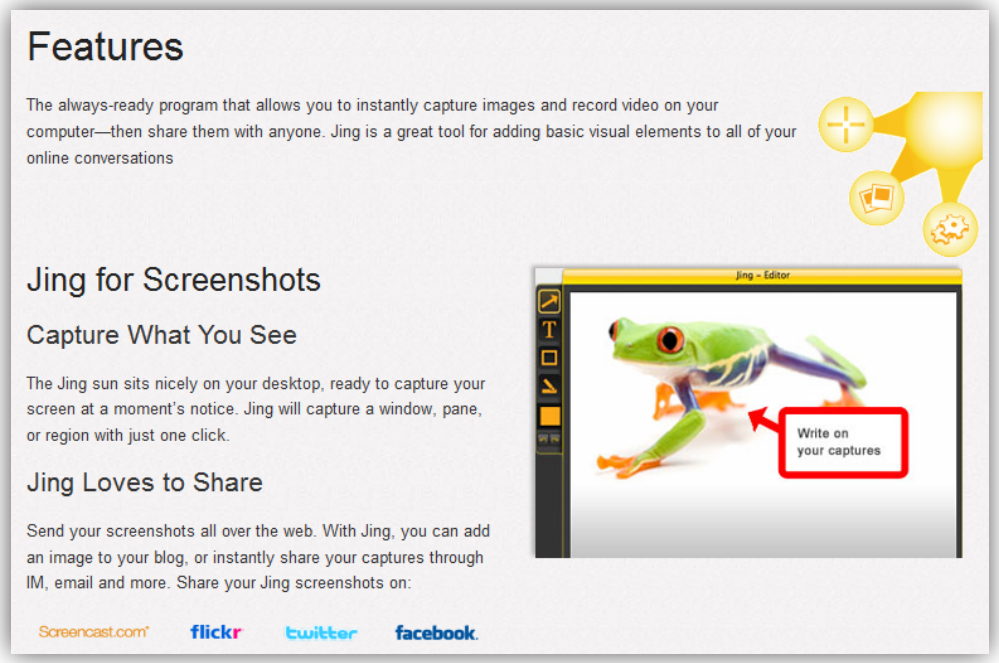
Pedagogically "wrap" a set of existing spectroscopy learning objects

1. Use JING to provide students with a tutorial given by an expert problem solver – How does an expert solve this?

2. Use "Documented Problem Solution" writing to increase student metacognition of spectroscopy problem solving process – How do I solve this?

3. Use Voicethread to facilitate small group discussion of spectroscopy problems – How do my peers solve this?

Technology - Jing



http://www.techsmith.com/jing-features.html

Current Educational Research Indicates that Successful Spectroscopy Problem Solvers…

1. Use a consistent approach
2. Draw molecular fragments during intermediate stages of the problem solving process
3. Do a complete analysis of the data
4. Checked their final answer against the spectrum

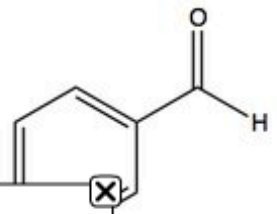
Cartrette, D.P. and Bodner, G.M. "Non-Mathematical Problelm Solving in Organic Chemistry" J. Res. Sci. Teach. (2010) 47, 6, 643

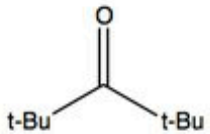
Voicethread

Create or Wrap LOs

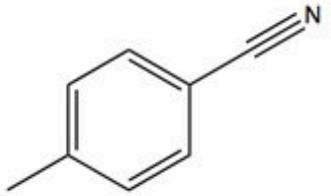
menu **Discussion 1; Final Week (1/3)**

Chose one of the compounds below and explain what you would expect it's H-NMR and C-NMR would look like. How many unique signals? What is the splitting in the H-NMR? Where would you expect the peaks to be in the spectrum? If someone has already commented on one structure, chose another. If they are all taken, look at the other analyses your peers have provided and determine whether you agree or disagree.

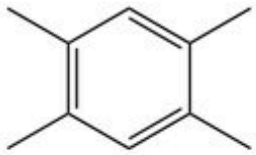




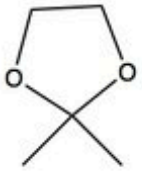
B



C



D



E

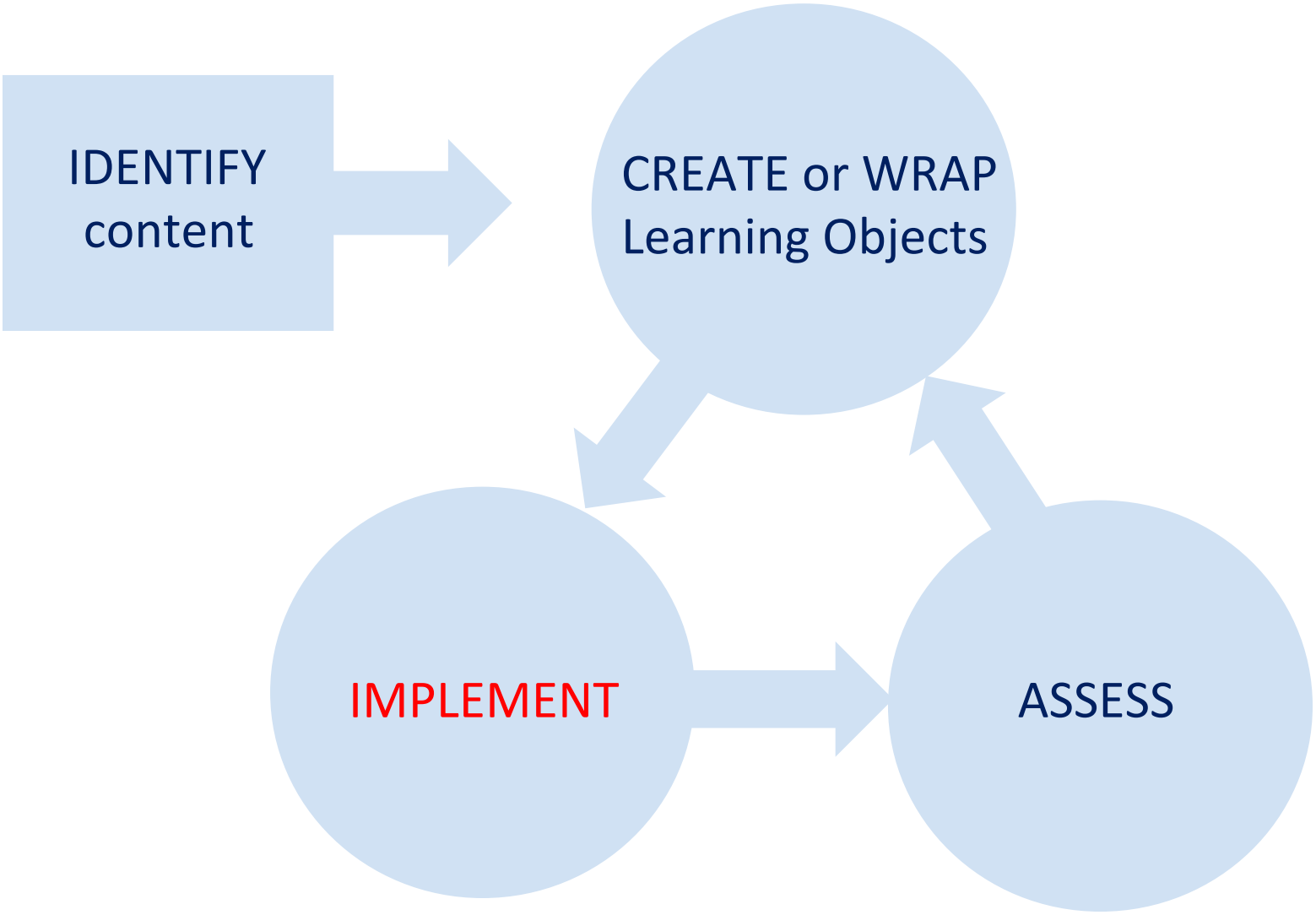
The H-NMR for molecule D would have two unique signals, one at 0.9 ppm and one at 5.3 ppm and the C-NMR would have three unique signals. The signal at 0.9 ppm would be highly integrated, whereas the other signal would not be quite as integrated. The signal at 0.9 ppm is also more shielded, thus representing the CH3 group, while the other signal is less deshielded due to the pi bonds in the ring. The signal at 5.3 ppm would represent an internal hydrogen atom. The splitting for the signal at 0.9 ppm would be a doublet because there is only the one neighboring hydrogen, thus according to the n+1 rule this would be a doublet. The splitting for the signal at 5.3 ppm would be a quartet because using the n+1 rule and the three neighboring hydrogens, it would be split into a quartet. Magnetic anisotropy due to the ring could also potentially be moving the signals more downfield.

comment

MELO$_3$D

Michigan Education through Learning Objects

http://openmich/melo3d



Small Scale Trial

Implementation - Fall

Course enrollment is 359

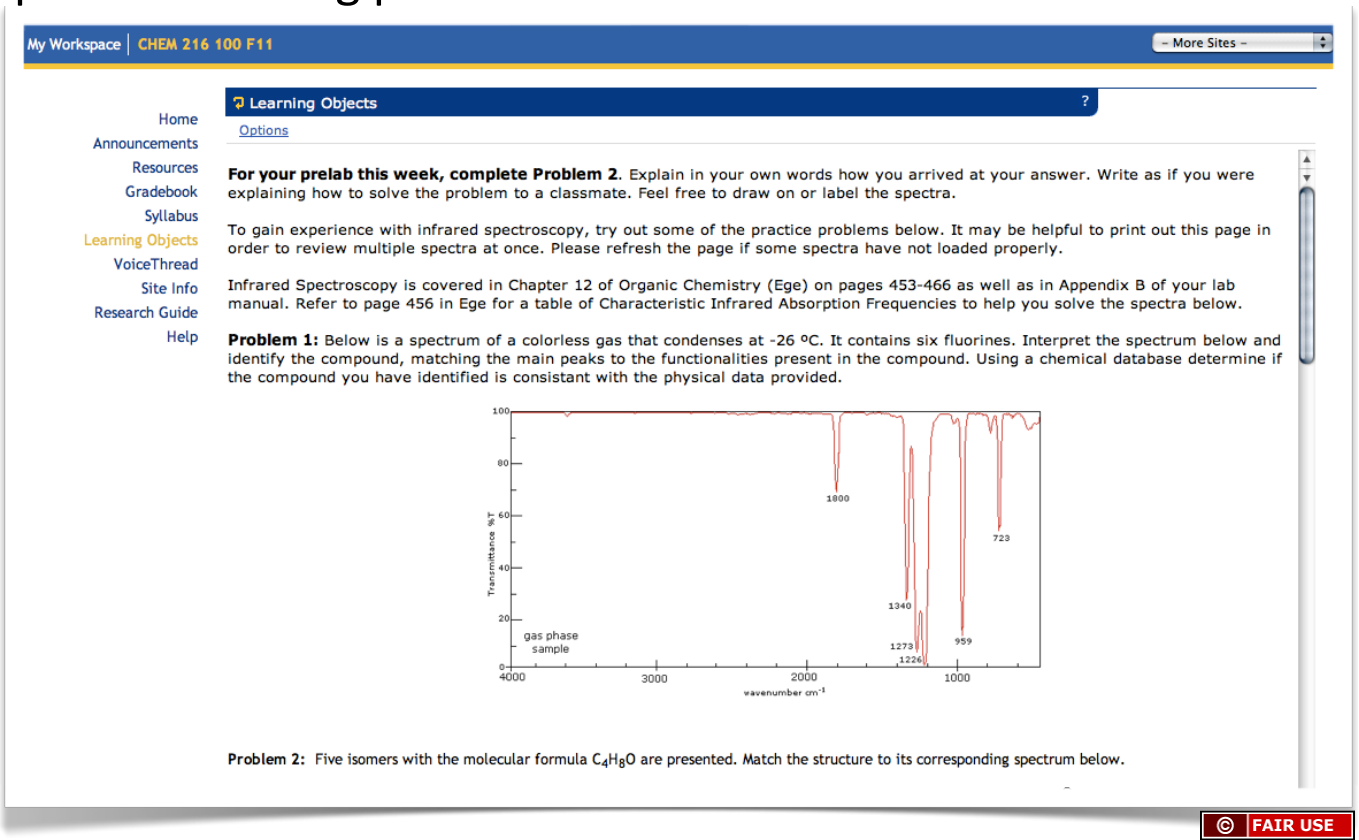
3 lab sections (47 students)

Supported by 3 TAs

Pedagogical Design LO - Framework

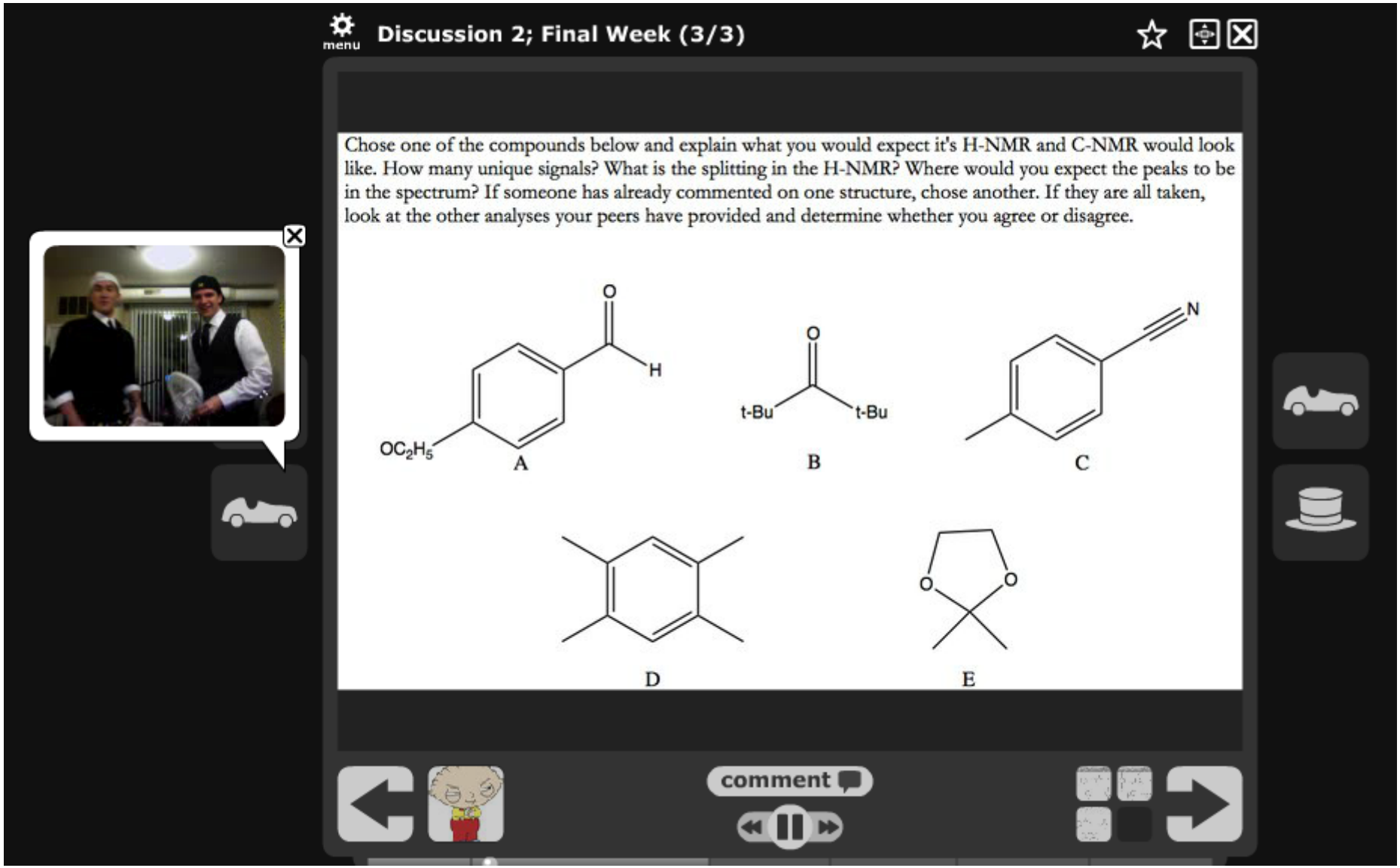
Create or Wrap LOs

- Each week students complete a set of spectroscopy problems
  - Students watch a short tutorial created by a TA, who demonstrates how to solve the problem
  - Students solve several similar problems
  - For one problems students write a narrative description of their problem solving process



Voicethread

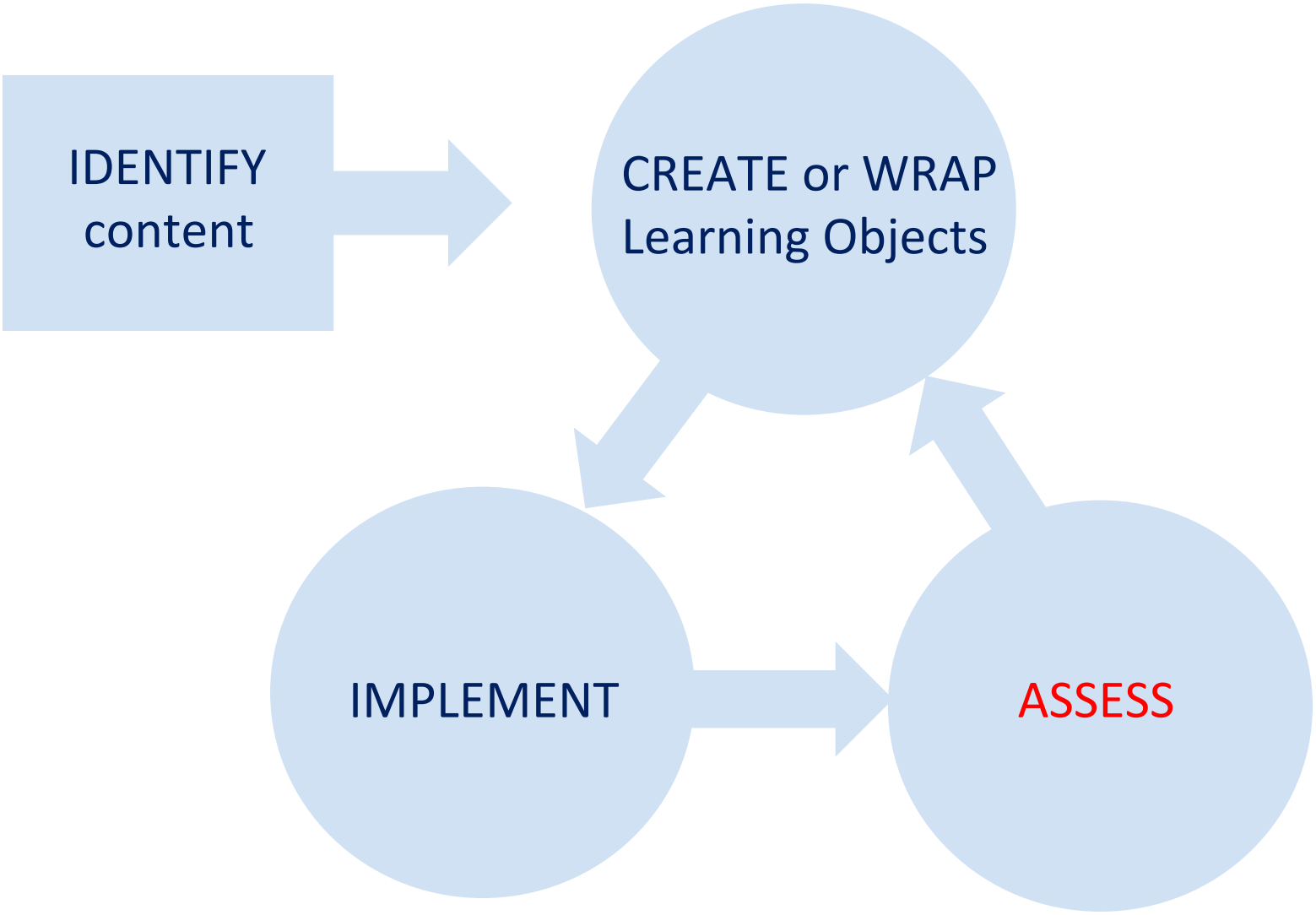
Implementation - Fall



$MELO_3D$

Michigan Education through Learning Objects

http://openmich/melo3d



Course Exams

Exam 1 (Infrared spectroscopy)

1. Problem (lower degree of difficulty)
    - LO students (8/8) and non-LO students (7.3/8) performed similarly
2. Problem (higher degree of difficulty)
    - LO students performed better (10/12 pts) than non LO (6.9/12 pts)
    - non-LO N= 331 LO students N = 48

Exam 2 (NMR spectroscopy)

1. No real difference observed ..

*Suspect TA dependence

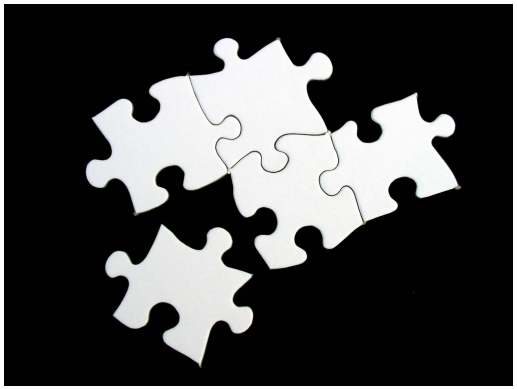
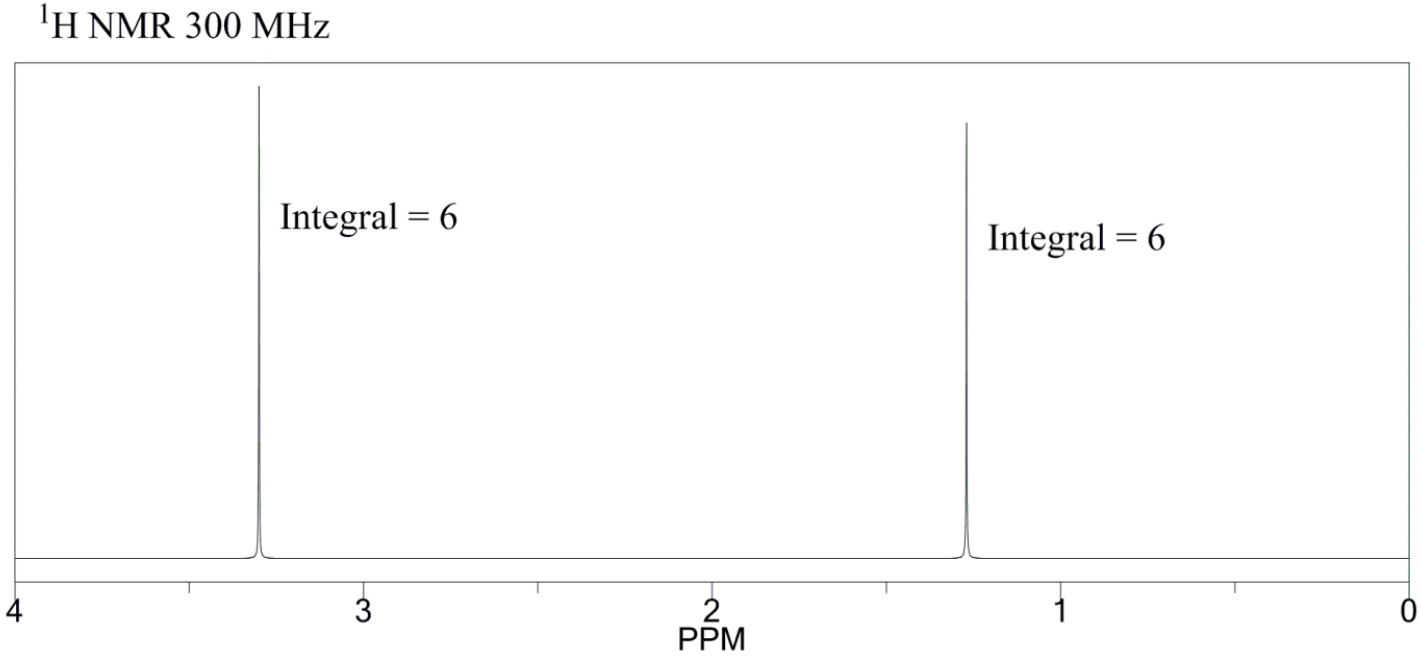


Image courtesy of wilhei55
http://www.flickr.com/photos/wilhei/109403331/

NMR Probe

Assessment - Fall

1. Draw the structure of a molecule with the formula $C_5H_{12}O_2$ that corresponds to the following NMR spectrum.



2. Explain, in your own words, how you arrived at your answer. Write as if you were explaining how to solve the problem to classmate. Feel free to draw on or label the spectrum above.

Answer	LO Response	LO %	Non-LO	Non-LO %
Did not attempt	6	13	19	13
Attempted, incorrect	11	23	61	43
Attempted, correct	30	64	61	43
Total	47	100	141	100

A greater percentage of students who used the learning objects attempted the problem and obtained a correct answer

NMR Probe - quantitative

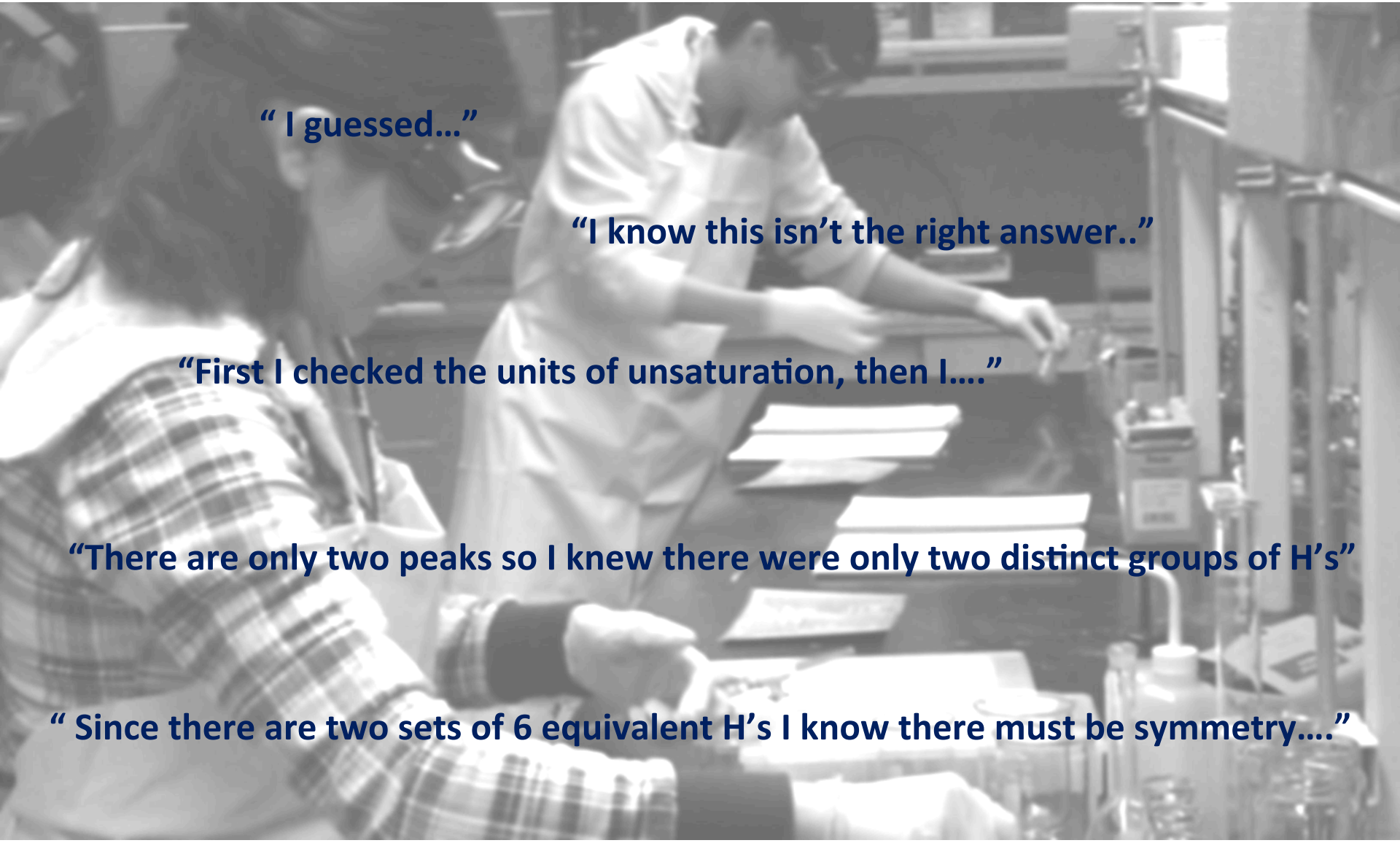
Assessment - Fall

Written Explanation	LO Response	LO %	Non-LO	Non-LO %
Did not explain	8	17	40	28
Explained Poorly	14	30	67	48
Explained Well	25	53	34	24
Total	47	100	141	100

A greater percentage of students who used the learning objects attempted to provide a written explanation and of those more provided a well written explanation

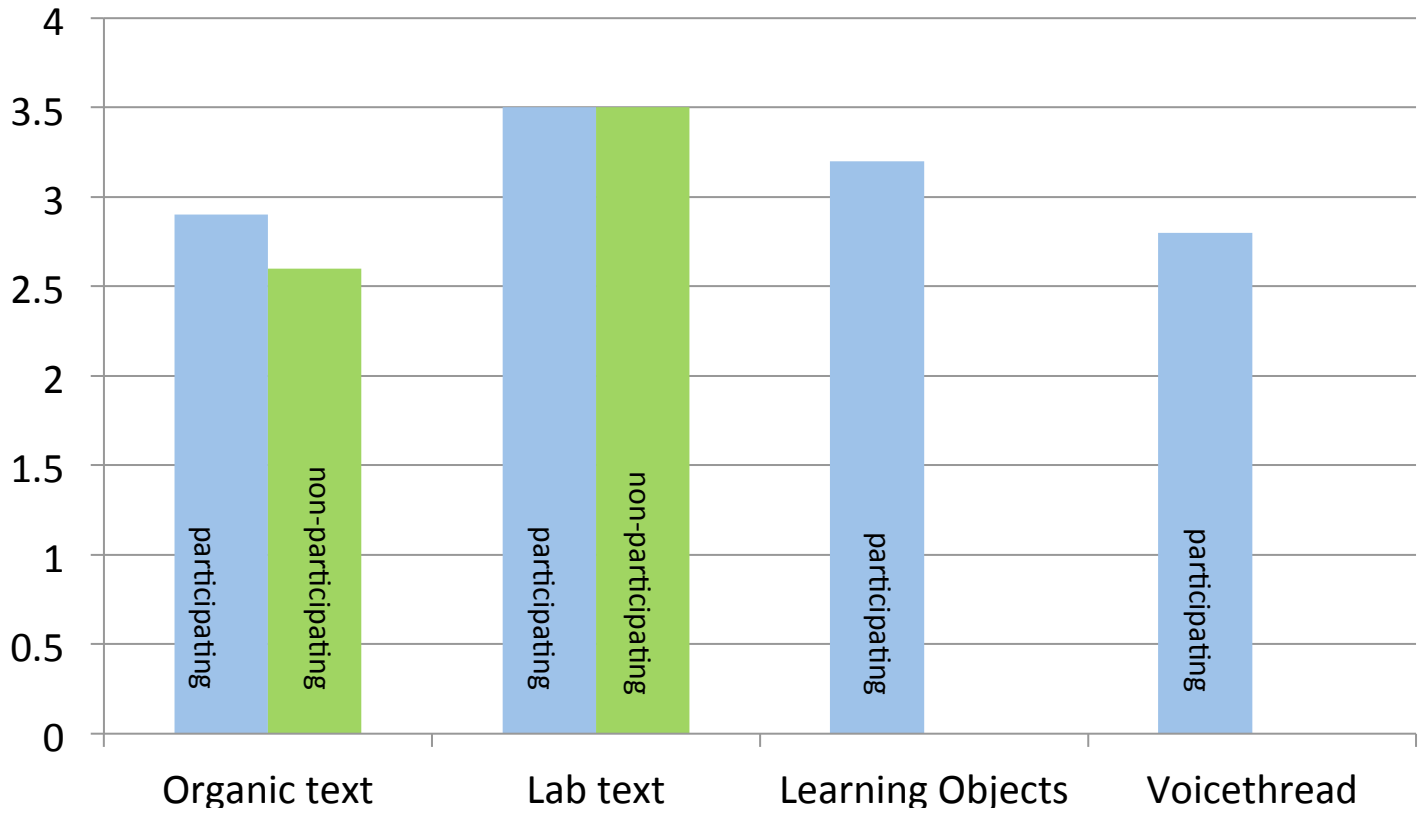
NMR Probe - qualitative

Assessment - Fall



Student Resources Survey

Assessment - Fall



Students regard the LOs as more useful learning resources than their organic text

Student Comments

"I thought the VoiceThread and learning objects were incredibly useful, and helped prepare me for the exam. The feed back from them were also helpful, and helped me know what to study. The only way they could be improved would be to maybe have immediate feedback."

"It forced me to practice IR and NMR when I would have otherwise neglected to do so, which was helpful. VoiceThread should be required to be video because it forces you to explain it out loud, which takes more understanding than simply writing it."

"The learning objects were generally useful in getting me to think about IR and NMR spectra and to study them in advance….They could be improved by having access to answers afterwards."

"It was useful to see what other students had written in the discussion.."

Learning Objects/Voicethread:

Average of 230 hits a week - only 47 students have access

665 hits the week prior to exam 1
612 hits the week prior to exam 2

VoiceThread:

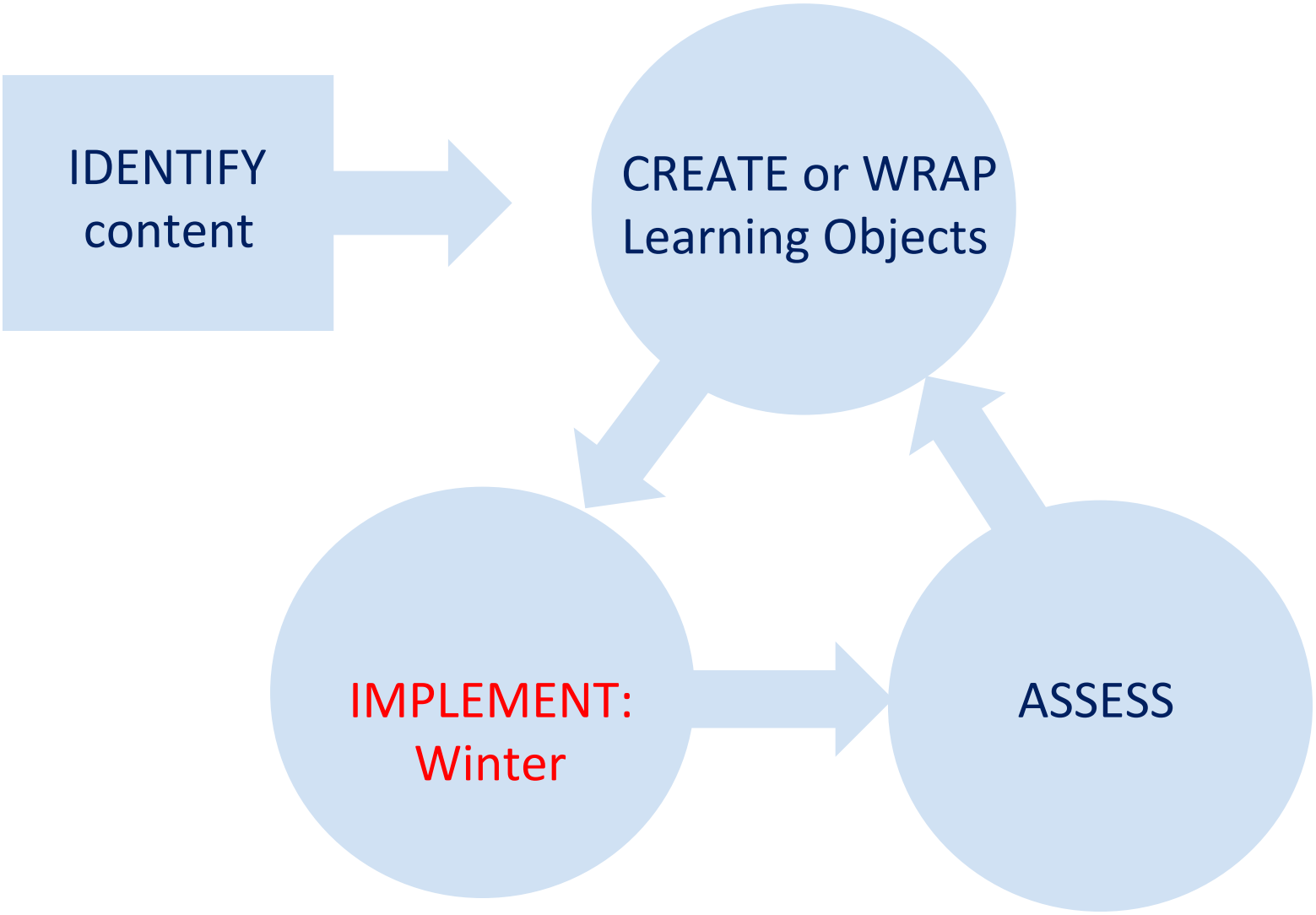
During the last week of class:

Discussion 1: 16 comments: 119 hits
Discussion 2: 17 comments: 72 hits
Discussion 3: 15 comments: 91 hits

MELO$_3$D

Michigan Education through Learning Objects

http://openmich/melo3d



Scale Up

Implementation - Winter

Course enrollment is 796

(3 lecture sections, 52 lab sections, 27 TAs)

269 students participated

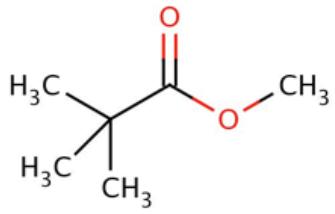
(1 lecture section, 19 lab sections, supported by 19 TAs)

Learning Objects

Implementation

Week 2: Problem 2: Week 2 problems can be found here for reference.

Calculating units of unsaturation with the molecular formula reveals only one unit of unsaturation. This could be a ring, an alkene or a carbonyl. Looking at the IR spectrum, the first thing you likely noticed is a strongly absorbing carbonyl peak in the center of the spectrum. Carbonyl stretching at 1737 cm^{-1} and C-O stretching at 1194 cm^{-1} and 1166 cm^{-1} are consistant with an ester functionality. Lack of C-H absoprtion above 3000 cm^{-1} indicates no C-C unsaturation, which makes sense. The ester is what gives this compound its one unit of unsaturation and the ester contains both of the oxygens, so determining the rest of the structure is mostly trial and error. You likely drew out many different linear or branched esters. By checking their physical properties, you would have determined that the compound is methyl 2,2-dimethylpropanoate, shown below.



revision for winter term - solutions to all problems are provided after they are collected

Week 1: Problem 4: Week 1 problems can be found here for reference.

a) Which compound contains an aromatic ring?

C-H alkene stretches show up with medium intensity around 3080-3020 cm^{-1}.
C-H alkene bending shows up with strong absorptions between 1000-675 cm^{-1}. C=C aromatic stretches show up around 1680-1450 cm^{-1} with variable intensity.

Using this data, we can propose 3, 6, or 7 has an aromatic ring.

b) Which compound would be reduced by $NaBH_4$ (in EtOH/NaOH)?

You know that $NaBH_4$ reduces most carbonyls like ketones and aldehydes, though typically not amides, carboxylic acids or esters.

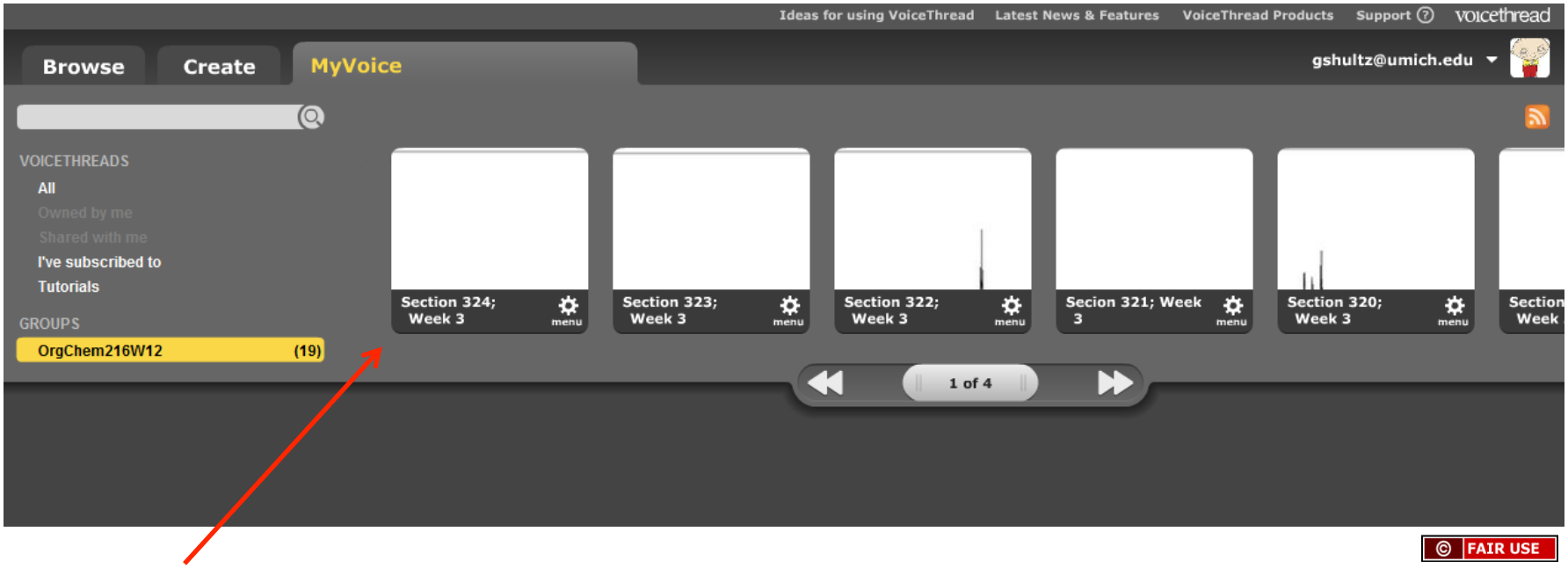
You should be looking for spectra with a carbonyl peak. These would be:

Voicethread

Implementation

Scale Up required changes in:

1. Site Access
2. Organization



1. Students were organized by lab section and alphabetically in groups of 6

2. TA's were tasked with monitoring student participation

MELO$_3$D

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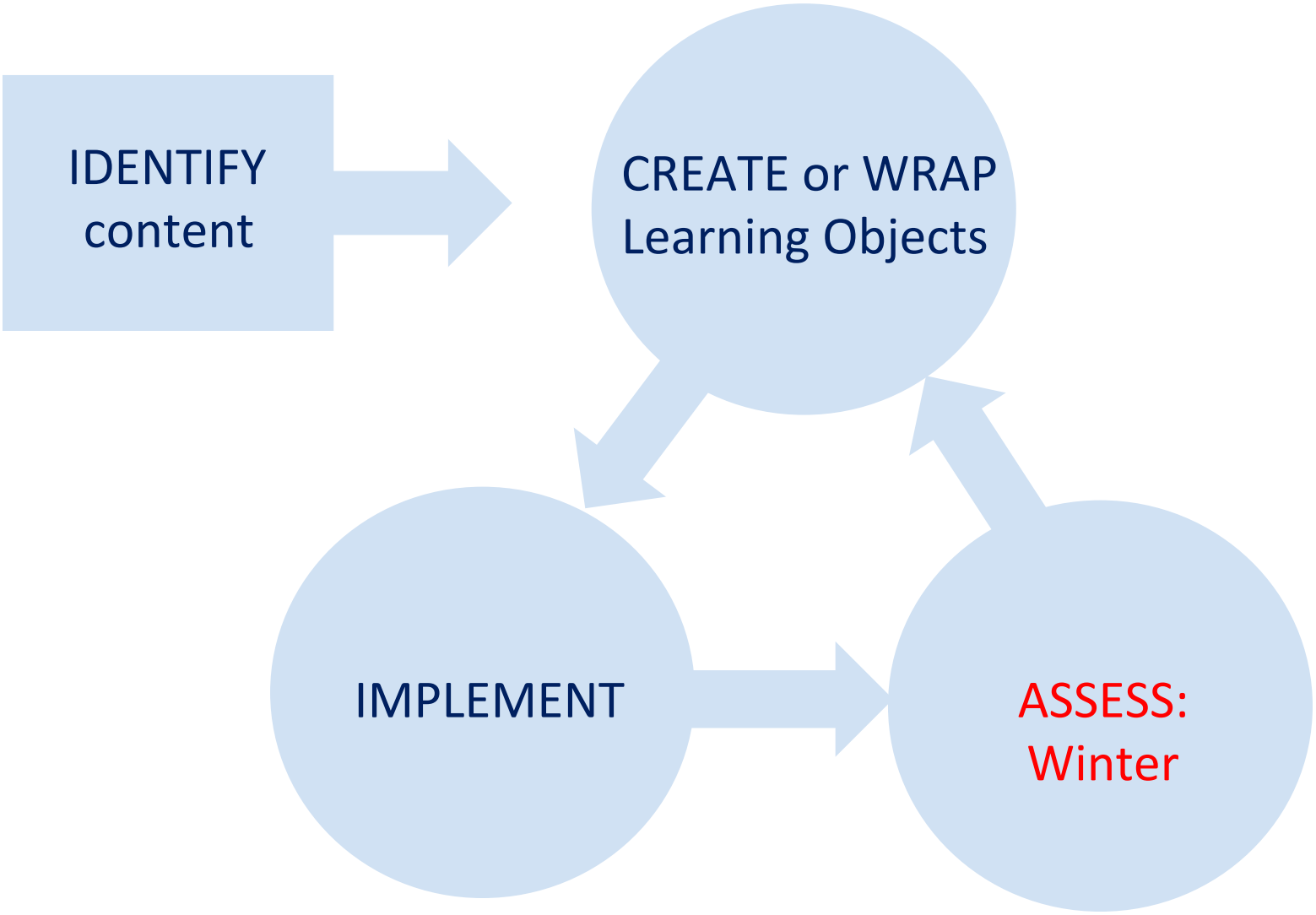
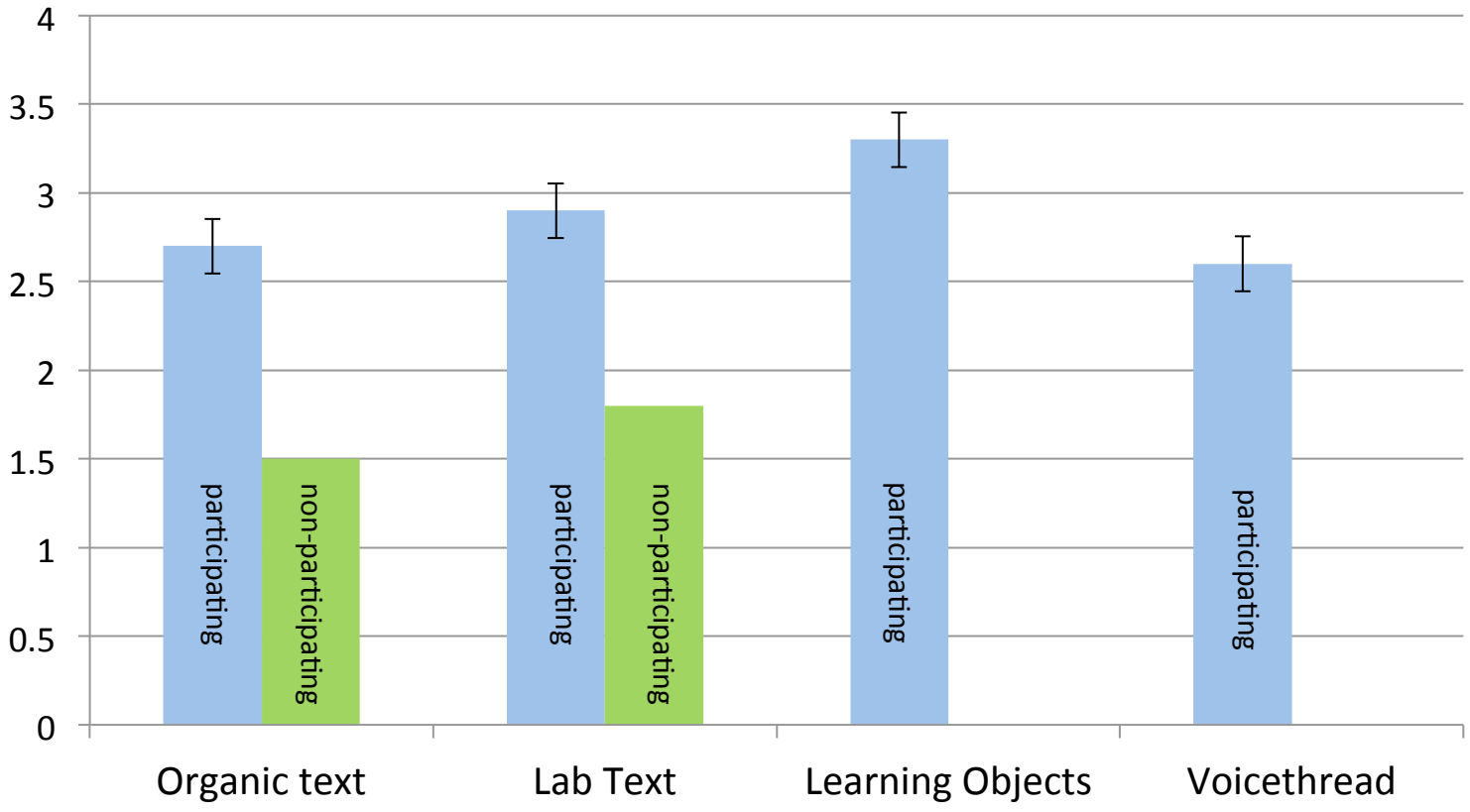


Exam and NMR probe

- No difference is observed between the performance of participating and nonparticipating students on either Exam or the NMR probe
- Correlation to log data indicates a relationship between exam performance and number of hits
- Significant differences observed between lab sections indicate that there may be a TA dependence

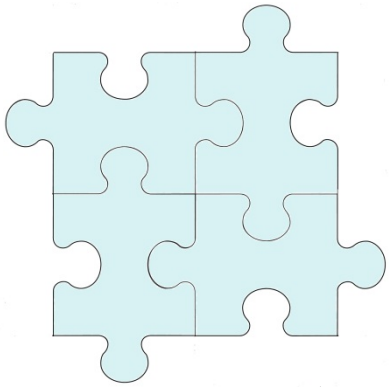
Student Resources Survey – Winter Term



Students regard the LOs as more useful learning resources than either of their Organic texts

Important Lessons

- Benefits of Writing and/or Voicethread Discussion
- Scale up Issues
  - Delayed start on Voicethread
  - TA & students compliance
- Future Plans
  - Will continue to use wrapped LOs, but will hold off on Voicethread for now



MELO$_3$D

http://openmi.ch/melo3d

Michigan Education through Learning Objects

See also:

"Online Learning Objects: Affecting Change Through Cross-Disciplinary Practices and Open Technologies"

Emily Puckett-Rodgers and Steve Lonn
Thursday 10:10 am Marco Polo 706-707

Funding for MELO3D provided by an LSA-ITC NINI Grant from the University of Michigan