Technology Tools to Enhance the Synergy between Active Learning and Assessment

Examples from Geological Sciences and Engineering Courses

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Small to Medium Enrollment Course

Merging Active Learning & Assessment

Course:
Geology 130, undergraduate
Required for geology & geophysics majors

Enrollment:
Traditionally - 11 to 20 students
This semester - 30 students

Course goals: focus on three major skills categories
Technical skills (basic professional)
Scientific skills (research-focused)
Personal skills (lifelong learning)
Gallery Walks
Stimulating Active Inquiry in Classroom

Starting Point
Group Engagement
Individual initiatives

Gallery Walks
Replacing “telling/being told about” with “doing”

Informal support from the instructor
Gallery Walks
Major Instructional Benefits

Use of real-world problems

Stimulates classroom interactivity

Collaboration in a non-threatening environment

Clarification of concepts introduced in lecture
Gallery Walks
How final output traditionally looks like

... good learning materials soon forgotten when hanged on the lab’s walls!
Gallery Walks

Can technology “save the day”?

Convert the Gallery Walks posters in Wiki entries (now Google Sites)

Figure 1: What is the original question? You need to tell the reader what this topic is about.

Endmember Feldspar Components in the Ternary System An-Ab-Or

Anorthite: CaAl$_2$Si$_2$O$_8$

Albite: NaAlSi$_3$O$_8$

Orthoclase: KAlSi$_3$O$_8$

A brief explanation of these components is needed.

Exchange Components in the Ternary Feldspar System

Exchange Components used to describe compositional variation among these three phases: Na$_{1+x}$, Al$_x$Ca$_{1-x}$

Can you provide an example as to how these exchange components would operate? A brief discussion that one is a “coupled exchange” where two elements with different charges on two different crystallographic sites must exchange at the same time to maintain charge balance.
Welcome to IMP - The Wiki for Igneous and Metamorphic Petrology

Introduction

The IMP is being created as an active learning resource for the Geology 130 Igneous and Metamorphic Petrology community at the Missouri University of Science and Technology. The primary focus will be collaborative knowledge creation focused on but not limited to topics covered by the Geology 130 curriculum. The purpose of this lab wiki is to provide a space for augmenting curriculum and addition of new content.

1.2 Wiki IMP Guidelines & Responsibilities

1.2.1 Content Accuracy

1.2.2 Make a Difference by Making a Contribution

1.2.3 Location. Location. Location.

1.2.4 Avoid Disharmony

1.2.5 Offensive Material

1.2.6 Vandalism

1.3 Meet the "PIT Crew"

1.4 Walk the Walk

1.5 ROTW - Rock of the Week

1.6 The Lab Connection
Wikis for Gallery Walks

Structure of instructional activities

- Introduce the PIT crew
  - Warm-up activity in Wiki environment
  - Takes place before first Gallery Walks

- Gallery Walk’s Wiki page

- Peer & Instructor Formative Assessment

- Wiki Classroom Presentation

Mengchu Xiao

Favorite Element: **Carbon**

My favorite element is carbon, because carbon is a complicated chemistry element. Carbon exists in our lives everywhere, and carbon was discovered many years ago, since then carbon has been used to find organic matter. Many different series of carbon compounds make the foundational things in our lives.

Favorite Mineral: **Quartz**

Because quartz, which is widely found, quartz is an important mineral in our studies, it has different colors, such as amethyst or rose quartz. Also quartz is used for our watches; it has many purposes.

Favorite Rock: **Granite**

Granite is a kind of igneous rock that is formed below the surface by magma, and the main components are feldspar and quartz. C develop different mineral particles, making its color beautiful, the color and luster can maintain one hundred years because of its gr addition to being used as advanced architectural decorative halls and grounds, and granite still is the first choice for an outdoor sci

I first became interested in Geology

I can remember when I visited a museum. There was a part of exhibition about rocks, and when I listened to the guard who introduc

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One student from each group will present the main points for the entire class
# Wiki Grading Rubric

## The Range of Skills

### Geology 130 – Gallery Walk

#### Wiki Posting Topic:

#### Group Name and Members:

<table>
<thead>
<tr>
<th>Category</th>
<th>Scoring scheme</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organization of Content</strong></td>
<td>content is well organized and easy to navigate. Headings are appropriate and informative. Bulleted lists are used to group material as necessary.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Content is organized using some heading. However, the overall organization can places.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>The content is somewhat logically organized. Bullets are needed.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The material presented is disorganized, follow or to find information.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Technical Skills</strong></td>
<td>The entire content of the Wiki posting correctly applies principles presented in lecture to solving and interpreting the Gallery Walk problem in a manner that is easy to follow and understand on your own.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>With a few minor exceptions the content of the Wiki posting correctly applies principles presented in lecture to solving and interpreting the Gallery Walk problem in a manner that is easy to follow and understand on your own.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Half of the content of the Wiki posting incorrectly applies principles presented in lecture to solving and interpreting the Gallery Walk problem creating some confusion with regard to the material and topics covered in lecture.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The content of the Wiki posting incorrectly applies principles presented in lecture to solving and interpreting the Gallery Walk problem and created significant confusion with regard to the material and topics covered in lecture.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Editing Accuracy</strong></td>
<td>The material presented is full of error-stated limits on both spelling/grammar. Much of the material used is not properly used.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>A maximum of 3 spelling and/or grammar errors or typos. All material used is properly used.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>A maximum of 5 spelling and/or grammar errors or typos. Some material used is not properly used.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The material presented is full of error-stated limits on both spelling/grammar. Much of the material used is not properly used.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Content clarity</strong></td>
<td>All ideas in the Wiki are presented in using proper technical terminology.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>About two-thirds of the ideas in the Wiki are presented in using proper technical terminology.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>About half of the ideas in the Wiki are presented in using proper technical terminology.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>There is no clear and concise idea in technical terminology for the topic or inappropriate use.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Learning potential</strong></td>
<td>The content of the Wiki posting fully and correctly answered the question posed and provided adequate discussion of the topic. This significantly increased my understanding of the topic and principles presented in lecture.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>With one or two exceptions, the content of the Wiki posting fully and correctly answered the question posed and provided adequate discussion of the topic and increased my understanding of the topic and principles presented in lecture.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>More than half of the content of the Wiki posting fully and correctly answered the question posed and provided adequate discussion of the topic. This posting somewhat increased my understanding of the topic and principles presented in lecture but not sufficiently to fully understand the material.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The content of the Wiki posting totally missed answering the question posed and failed to provide a adequate discussion of the topic. This posting did not help to increase my understanding of the topic and principles presented in lecture.</td>
<td>1</td>
</tr>
<tr>
<td>Learning potential</td>
<td>Content clarity</td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------</td>
<td></td>
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</tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>Stated limits on both spelling/grammar. Much of the material used is not prop.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>All ideas in the Wiki are presented in using proper technical terminology for the topic.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>About two thirds of the ideas in the Wiki are clear, concise manner. Proper technical terminology is used, or absent in places, for the topic.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>About half of the ideas in the Wiki are clear, concise manner. Proper technical terminology is used, or absent in places, for the topic.</td>
<td></td>
</tr>
</tbody>
</table>
| 1 | There is no clear and concise ideas and technical terminology for the topic is misappropriately used.
# Grading Rubric Feedback

## Problem 2

<table>
<thead>
<tr>
<th></th>
<th>Team 1</th>
<th>Team 2</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization of content (1 to 4)</td>
<td>3.5</td>
<td>3.3</td>
<td>2.8</td>
</tr>
<tr>
<td>Editing Accuracy (1 to 4)</td>
<td>3.6</td>
<td>3.6</td>
<td>3.3</td>
</tr>
<tr>
<td>Content Clarity (1 to 4)</td>
<td>3.1</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Technical Skills (1 to 4)</td>
<td>3.6</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Learning Potential (1 to 4)</td>
<td>3.1</td>
<td>3.6</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>Final Score (Max = 20)</strong></td>
<td>16.9</td>
<td>17.3</td>
<td>15.6</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td><strong>16.60</strong></td>
</tr>
</tbody>
</table>

**Problem Number 2**

**Organization of content (1 to 4)**

Need a figure caption for the plagioclase crystal. An introduction to the problem is required.

**Editing Accuracy (1 to 4)**

Watch for run on sentences. It is best to write succinct sentences that convey a point.

**Content Clarity (1 to 4)**

Overall good. Terms were used, for the most part, correctly in your explanations. It is good to see the use of full sentences.

**Technical Skills (1 to 4)**

Data points are not plotted on the phase diagram. Open system you can add or subtract.
Quality of Gallery Walks Entries
Impact of Formative Assessment

Sample Initial Gallery Walk

Sample Final Gallery Walk – noticeable improvement
Perceived involvement (t-Test)

Online Exit Survey

Perceived involvement scale

If “1”, the middle of the scale, represents the lecture in this course the Gallery Walks were:

<table>
<thead>
<tr>
<th>(9) important</th>
<th>5 4 3 2 1 2 3 4 5</th>
<th>unimportant</th>
<th>(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) irrelevant</td>
<td>5 4 3 2 1 2 3 4 5</td>
<td>relevant</td>
<td>(9)</td>
</tr>
</tbody>
</table>

(1) Low

5

High (9)

Student attitude (essay questions)

Overall *Gallery Walks* perceived as being significantly more involving than *Wiki*

- Gallery Walks: 6.71 (5.88, p < .01)
- Wikis: 5.88 (NS)
Gallery Walks & Wikis

Identified Strengths – Sample Inputs

“The gallery walks were an additional way for us to learn and be exposed to the material.”

“…[Wikis were] furthering our ability to work with others; the ability to work off campus as a group; allowed us to clarify confusing concepts with peers”

“Working together in groups was excellent practice for the work world. I learned more thinking about these problems and assignments than I do just working out a problem on paper or reading a textbook.”
Gallery Walks & Wikis

Some lesson learned from first implementations

Overloading the student is easy

Currently student workload balanced by transforming homework assignments into Gallery Walk & Wiki problems;
Shifting the Course Culture
Expanding the benefits of online collaboration tools

PIAZZA
Open inquiry forum
- Questions related to major concepts
- Discussions encouraged before lecture

Google Docs
Group-based activity
- Basic questions related to a course topic
- Each group member is the main editor for one question
- Other members can edit and improve
- Graded activity

Qiuzlet
Collaborative virtual flash cards
- Definitions for major concepts
- Test implementation with no graded requirements
Shifting the Course Culture
Integration of collaborative tools and assessment

PIAZZA
Preparation for
Google Docs
Questions expanded & integrated in
Gallery Walks
Problems

Qiuzlet
Collaborative virtual flash cards

Term Exams

Final Exam
Shifting the Course Culture
Students’ choices for first term exam preparation

- Goggle Docs review questions: 4.18
- My lecture notes: 4.07
- Clicker Questions: 3.89
- Tegrity lectures: 3.89
- Quizlet: 3.86
- Gallery Walk problems: 3.75
- My homework assignments: 3.61
Large Enrollment Course

Mixing Assessment & Active Learning

Course:
Geology 220, undergraduate
Required for Geology & Geophysics, Geological Engineers, Mining Engineers, Petroleum Engineers.

Enrollment:
Traditionally – 60 students (other campuses ~10-20)
Last semester - 197 students

Course goals: focus on three major skills categories
Technical skills (basic professional)
Scientific skills (research-focused)
Personal skill (lifelong learning)
Traditional Structure of Activities

- Blackboard
  - Course Communication
  - Platform
- Lecture & Clicker Questions
- Lab & Homework
- Essays & Problems
  - Exam Items
Clicker Questions

...developed & revised during the last 6 years

...integrated in a “clicker strategy” around following instructional goals:

- **Review materials from previous lectures**
- **Introduce a new subject**
- **On-spot assessment of lecture material**
- **Clarify misconceptions**
Clicker Questions

Review materials from previous lectures & readings

Example “refresher” questions

Typically used near the beginning of the course
Clicker Questions

Introduce the subject with a provocative question

**Topic:** “Hydrofracking”
Clicker Questions
Challenging misconceptions with “clicker couplets”

63% correct answers

(a)
During simple shear directions that **parallel** the lines of no finite longitudinal shear have an $S = 1$ and...

- 63% 1. have been affected by deformation
- 95% 2. have not been affected by deformation
- 1% 3. Not sure

82% correct answers

(b)
During progressive simple shear directions that parallel the lines of no finite longitudinal shear....

- 82% 1. have been affected by deformation
- 17% 2. have not been affected by deformation
- 1% 3. Not sure

Pooling without the correct answer

Student discussions

Re-pooling with the correct answer
Clicker Questions

Students’ perception on in-class support

- Helped to pay attention
- Enhanced interactions
- More active
- Helped follow the lecture
Clicker Questions

Students’ perception on outside classroom support

- Assess understanding
- Remember materials
- Motivated me to prepare for lecture

FS06 FS07 FS08 FS09 FS10 FS11

p < .05
Current Structure of Activities

PIAZZA
Course Communication

Lecture &
Clicker Questions

In - Class
Assignments

Lab & Homework

Google Docs
Optional

Multiple-Choices
Items Exams
Tracking the Impact of Clickers

Lecture & Clicker Questions
- Actual clicker questions
- Similar to clicker questions
- Similar to lecture slides

In-Class Assignments
- Questions similar to in-class assignments

Multiple-Choices Items Exams
QXX) In designing a well penetrating thousands of meters below the Earth’s surface through limestone several Body Forces may need to be considered such as Thermal Loading, Gravitational Loading, Electromagnetic Loading, and Displacement Loading. The following data was provided: 1) current depth of the well (z) 1000 meters, 2) Young’s Modulus E for limestone - 5.3x10^4 MPa, 3) Poisson’s ratio (n) of limestone 0.17, 4) Density (r) of Limestone 2.67 g/cm³, 5) acceleration due to gravity (g) 9.8m/s², 6) the age of the limestone (t) 450 Ma “Ordovician”. In order to choose the correct mud weight for this hole the magnitude of the Lithostatic Load in MPa generated by the rock column at the bottom of the hole must be calculated using which of the following equations?

A) \( s_2 = s_3 = \left[ \frac{n}{(1-n)} \right] s_1 \)

B) \( P_z = \frac{1}{E} \left[ (s_z - n(s_x + s_y)) \right] \)

C) \( P_z = \rho g z \)

D) \( S_v = r (E/n) z \)

E) \( S_1 = g z t \)
Sample Exam Questions

Exam question that was an actual Clicker Question

Q7) According to the textbook used in this course, Structural Geology of Rocks and Regions (3rd edition), which of the following choices is the correct definition for the angle theta (θ) as used in stress analysis problems?

A) The acute angle between the stress vector and the pole to the plane.
B) The acute angle between the stress vector and the plane.
C) The obtuse angle between the stress vector and the pole to the plane.
D) The obtuse angle between the stress vector and the plane.
E) The angle between the plane and the pole to the plane.
A Peek into Last Semester’s Dataset

Comparing the results of the exam question that was used an actual Clicker Question

The exam mean score was statistically significant higher than the lecture score:

$$t(203) = -10.40, p < .001$$

But the two means were not correlated.

Coding:
0 – not responded
1 – wrong answer
2 – correct answer
Sample Exam Questions

Exam question similar (covered the same concept) to a Clicker Question

You and a colleague in Australia are working on a report for a gold mining company that is due tomorrow. He sends this figure of a Mohr Circle as an attachment along with a “Good luck I’m hitting the waves mate!” You try every way you can to reach him but no luck. Thanks a lot mate you say under your breath as know you have extra work to do answering the following questions regarding the stress analysis of a fault plane that will be intersected by one of the main mine shafts at depth. At least he told you the scale!

Mohr Circle for Stress. The scale is 10 MPa increments.

... 

Q18) In the report you need to include the value of the Shear Stress acting on this fault plane.

A) 22   B) -22   C) 25   D) 32   E) 60

...
A Peek into Last Semester’s Dataset

Comparing the results of an exam question that was similar (covered the same concept) with a Clicker Question

Means

<table>
<thead>
<tr>
<th>Coding</th>
<th>Clicker question</th>
<th>Exam Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – not responded</td>
<td>1.55</td>
<td>NS</td>
</tr>
<tr>
<td>1 – wrong answer</td>
<td>1.49</td>
<td></td>
</tr>
<tr>
<td>2 – correct answer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Clicker question was a significant predictor for the result on the similar exam question:

\[ \beta = .18, \ t(203) = 2.58, \ p < .05 \]

But explained only a modest proportion of the variance:

\[ R^2 = .03, \ F(1,202) = 6.63, \ p < .05 \]
Course Goals

Technical skills (basic professional)

Scientific skills (research-focused)

Personal skills (lifelong learning)

Google Docs
Optional
Questions / Comments