Using Educational Tools to Foster Active Learning

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Learning is Experiential

- Where is knowledge located?
  - Internal to the knower?
  - External to the knower?
Learning is Experiential

Where is knowledge located?
- Internal to the knower?
- External to the knower?
- In the interactions between the knower and the external world.
Learning is Experiential

- **Equilibration** → Harmonizing internal understanding with external experiences.
  - Assimilation → Fitting new experiences into existing modes of thinking
  - Accommodation → Adapting internal models based on new experiences.

- **Ex:** Even and Odd schemes.
  - Every other number.
  - Amount left over when grouping.
Learning is Experiential

- Empirical Abstraction
- Reflective Abstraction
  - Generalization
  - Coordination
  - Encapsulation
- Pseudo-empirical abstraction: \( \frac{\sin x}{x} \)
Learning is Experiential

- Empirical Abstraction
- Reflective Abstraction
  - Generalization
  - Coordination
  - Encapsulation
- Pseudo-empirical abstraction:
  \[
  \frac{\sin x}{x} = \sin
  \]
Learning is Experiential

“Children have real understanding only of that which they invent themselves.”

- Jean Piaget.
Learning is Experiential

- Classroom experiences are often physical.
  - Manipulatives
  - Lab Assignments
  - Virtual Worlds

- Important Consideration: Are these experiences designed in a way that allows for students to reinvent the core ideas of the course?
  - What is \( \pi \)?
Raising Calculus to the Surface

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Engaging in Multivariable Calculus

- For most students, it is the first serious study of functions of more than one variable.
- Hand-drawn representations are often difficult for students to interpret.

Challenge: Allow students greater access to multivariable functions.
Making Multivariable Functions More Accessible

- Emphasize symbolic representations and two-dimensional sketches
- Utilize Mathematics Software
- Engage meaningfully with three-dimensional objects.
Physical Materials

- Physical Surfaces
  - Made of Transparent Plastic
  - Have a Dry-Erase Finish

- Inclinometer

- Contour Diagrams
  - Have a Dry-Erase Finish
Lab Activities

- Intended to be introductory
- Require student collaboration
- Emphasize measurement
- Engage in a “real-world” context.
- Utilize the surfaces as transitional objects.
- Move students towards mathematizing their experiences.
  - Often completed during whole-class discussion.
Lab Activities

- Multivariable Functions
- Level Curves
- Partial Derivatives
- Gradient Vectors
- Directional Derivatives
- Tangent Plane Approximations
- Lagrange Multipliers
- Optimization
- Accumulation along a Path
- Surface Area
- Volume and Mass
Activity

1) Find the blue dot on your surface. Mark all points on the surface which are located at the same height as the blue dot.

2) Mark all the points on the surface which are \( \frac{1}{2} \) inch above (vertically) the blue dot.

3) Mark all the points on the surface which are \( \frac{1}{2} \) inch below (vertically) the blue dot.

4) At the blue dot, draw an arrow on the surface pointing in the steepest direction.

5) Choose two other points located at the same height as the blue dot and repeat (4) for each point.

Discuss: What relationships do you observe between the lines drawn in items 1-3 and the arrows drawn in items 4-5?
Instrumental Genesis describes the process by which a learner adopts the use of an object.

- **Artifact**: Material object
- **Utilization Scheme**: Actions involving an artifact
- **Instrument**: The artifact and its endowed utilization schemes
- **Instrumentalization**: The development of new utilization schemes to use with the artifact.
- **Instrumentation**: Interactions with the artifact that enhance the user’s understanding of the subject matter
Instrumental Genesis

Instrumentalization

Instrumentation

User

Artifact
The following clip is an example of instrumentalization.

The students are tasked with determining whether the derivative on the surface and the derivative on the tangent plane are the same.
The following clip is an example of instrumentation.

The students are still working on the same task of determining whether the derivative on the surface and the derivative on the tangent plane are the same.
Reflecting on Our Activity

- What instrumentalization activities did your group experience?
- What instrumentation activities did your group experience?
Thoughts on Instrumental Genesis

- There is value in considering the types of schemes your students will be creating when involved in an activity and the ways that those schemes will, in turn, inform their thinking about the subject.

- Have you seen any good/bad examples of instrument use within your discipline?
Learning Spaces

Using iPads to foster collaborative learning
Learning is Social

- Often our “external” experiences are actually interactions with other people.
- This means that knowledge is socially negotiated.
Signs: Publicly displayed statements that carry meaning in the conversation
- Words
- Gestures
- Images

The use of instruments carries many non-verbal signs that you may wish to include in your conversation.
Comparing Laptop vs. iPad classrooms
Comparing Laptop vs. iPad classrooms

What differences do you notice between the two classrooms?
Comparing Laptop vs. iPad classrooms

- What differences do you notice between the two classrooms?

- Laptops add a “picket fence between you and the students.” - Oblinger

- “You’re more likely to help each other when it’s portable and you can see what each other is doing.” - Student
Learning Spaces

- Private Space: Signs available only to the individual.
- Public Space: Signs available to all participants and open for common usage.
Learning Spaces

- We found that instruments that are more conducive to use publicly (iPads) results in a broader range of signs used in the conversation.
- Additionally, students we more likely to share activities with their classmates.
Instrument Use in Collaborative Settings

- How does the instrument lend itself towards being used in different spaces?
- What signs involving the instrument need to be shared with the community?
- How versatile is the instrument?
- Have you seen any good/bad examples of instrument use within collaborative settings?
Thank You!

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