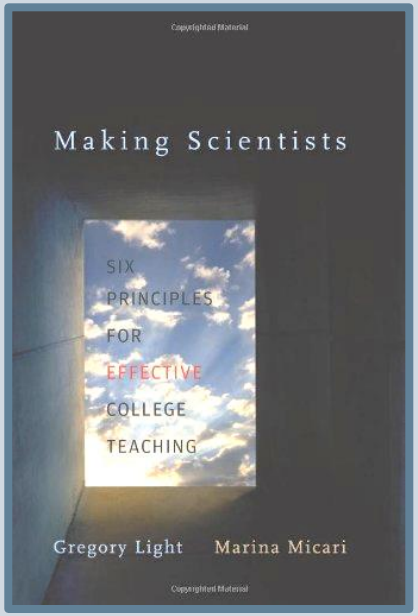

Making Scientists

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Six Principles for Making Scientists

1. Learning Deeply
2. Engaging Problems
3. Connecting Peers
4. Mentoring Learning
5. Creating Community
6. Doing Research

Deep Learning

Learning Methods

- **Surface** – Some students understand learning as simply acquiring and increasing their knowledge and storing methods for reproducing and applying that knowledge, often trough memorization.
- **Deep** – Some students see learning as a transformative experience, aimed at understanding a set of concepts or topics through the construction of meaning and knowledge.
- **Strategic** – A combination of both, aimed at achieving the highest grade.

Deep Learning

Facilitating Deeper Conceptual Learning

- Go beyond teaching content. Engage students during class through questions, problems and group activities.
- Provide forums for students to share ideas with each other and studios for students to discover and build knowledge through problem-based activities; authentic, realistic projects; and exercises that challenge their misconceptions and prompt them to bring diverse ideas together.

Deep Learning

Activity (Think-Pair-Share)

Provide a few assignments (currently used or proposed) that require students to go beyond surface learning (memorization) and encourages deep learning.

Engaging Problems

Problem Based Learning (PBL)

- Problems reflecting real-world situations
- Students discussing the process cooperatively among themselves
- Students being appropriately guided by someone who knows the problem
- Students applying this new knowledge to the problem and evaluating their learning

Engaging Problems

Developing Engaging Problems

- Kindle interest: Create problems that reflect authentic, real-world scientific issues and that feel meaningful to students.
- Reveal relevance: Design problems that students can see are important to progress in the course and connected to issues in the world.
- Connect knowledge: Build into problems opportunities for students to seek new knowledge and apply it.

Engaging Problems

Developing Engaging Problems (cont.)

- Engage discussion: Develop for a group-learning context problems that will engender discussion and debate.
- Probe misconceptions: Design problems that, if solved incorrectly, should challenge assumptions and/or reveal basic misconceptions students might have.
- Promote critical thinking: Construct problems with several approaches or alternative solutions, or which require making connections between multiple concepts.

Engaging Problems

Activity (Think-Pair-Share)

Provide a few engaging problems (currently used or proposed) that enforce the attributes of “Problem Based Learning (PBL)”.

Connecting Peers

Enhancing Group Dynamics

- Stress collaboration rather than competition
- Provide support and leadership
- Keep learning groups relatively small (i.e., 5-7 group members)
- Help learning groups develop ground rules for participation
- Ensure learning groups have clear goals

Connecting Peers

Encourage Engagement with Problems

- Create diverse learning groups (i.e., perspectives, experiences)
- Allow peer leaders to provide “scaffolding”
- Create learning groups that dig deep into problems
- Ensure the group – not just group leader – is actively engaged in problem-solving
- Provide groups with high-quality material that prompt engaged discussion

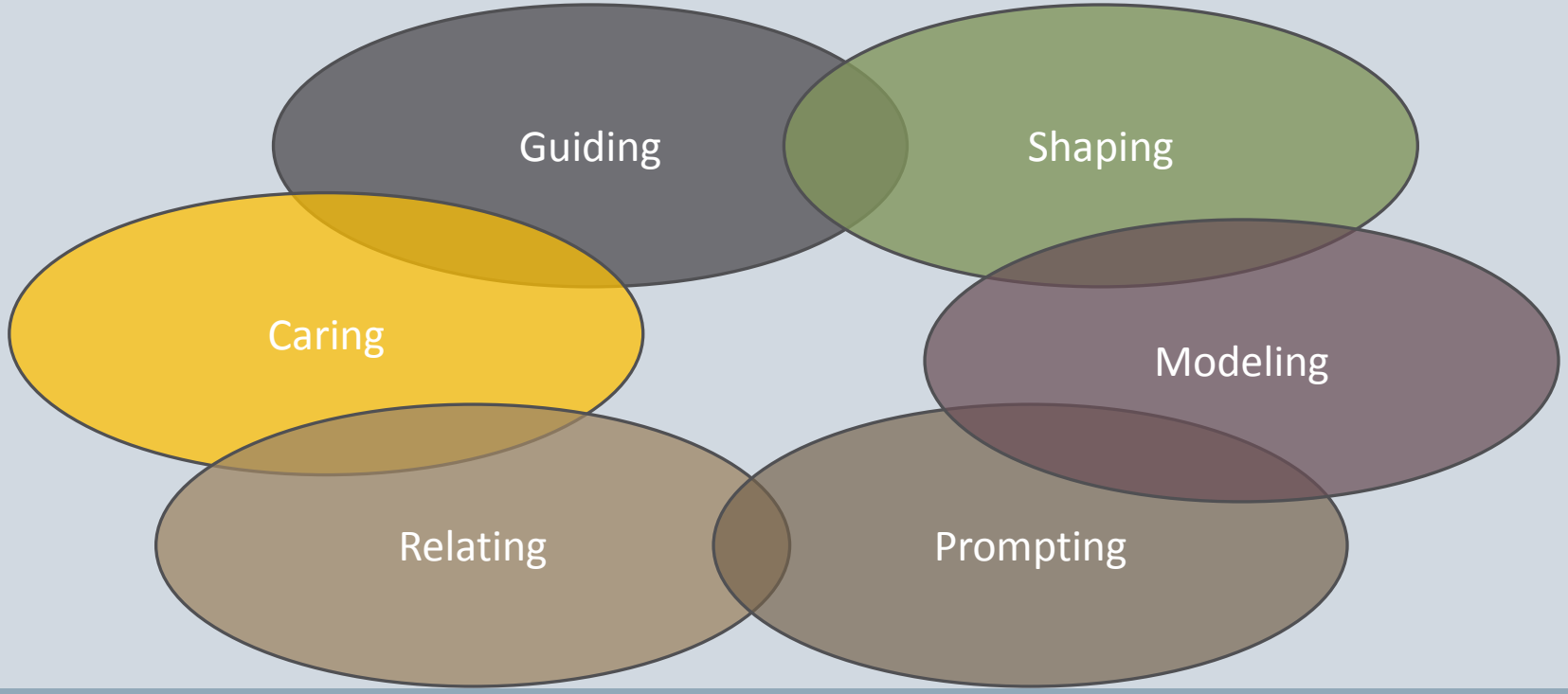
Connecting Peers

Activity (Think-Pair-Share)

Suppose you don't have "money" or "time", what *small change* could you make in your course (or in a course lesson) this semester to *connect* your students?

Mentoring Learning

Six Critical and Interrelated Components of Mentoring for Peer-Facilitated Learning



Mentoring Learning

Learning Goals for Peer Mentors/Facilitators:

- Develop understanding of contact and how to facilitate students' learning that content
- Become familiar with pedagogical theory and research
- Gain knowledge of small group dynamics
- Gain facilitation skills
- Develop inquiry skills by engaging research in practice
- Reflect on practice and develop self-evaluation skills

Mentoring Learning

Activity (Scenario)

If you were asked to train peer tutors in your department during a one-day, 3-hour session during the 1st week of the semester, how would you structure the session?

Creating Community

"Scientific research is a social act. It is not a solitary struggle between nature and the human mind, as accounts of the heroic scientist would lead us to believe, but instead entails relations within a community of scientists and a community of minds seeking recognition and consensus."

-Daryl Chubin and Edward Hackett

Peer Review and U.S. Science Policy (1990)

Creating Community

Important Levels of Community

- Group membership
- Group influence
- Fulfillment of needs
- Emotional connection

McMillan and Chavis (1986)

Creating Community

Community Members

- Undergraduates
- Facilitators
- Senior Facilitators
- Graduate Students
- Faculty

Creating Community

Benefits to the Community

- Seeing the Big Picture
- Demystifying the Faculty
- Assessing Informal Wisdom
- Acquiring Tacit Knowledge and Skills
- Navigating Science

Creating Community

What can faculty do?

1. Hold group office hours.
2. Encourage students to take advantage of regular office hours.
3. Hold and go to recitation.
4. Answer questions virtually.
5. Require study groups.
6. Share a meal.
7. Let students learn about faculty research.
8. Keep the class current.
9. Have students do the work.
10. Bring in topical guest speakers.

Creating a Community

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Activities: (1) Describe the characteristics of your learning community? (2)Add 6 more activities to the list above.

Doing Research

"My brain is open."
-Paul Erdos
Mathematician

Objectives:

- To have students experience science the way that scientists do.
- To engage students in the scientific process.

Doing Research

Science Experience

1. Challenging problems
2. Engaged peers
3. Helpful mentors
4. Lively discussion
5. Community

Doing Research

Student Research Process

1. Identify a problem
2. Write a research proposal for funding
3. Work in small groups led by the facilitators
4. Complete the proposal and research within two semesters.

Doing Research

Activity

What are the first steps in phrasing your research question? Describe how you would teach your students to do this.

Learning Activities…

Summary

Six Principles for Making Scientists

1. Learning Deeply
2. Engaging Problems
3. Connecting Peers
4. Mentoring Learning
5. Creating Community
6. Doing Research

How can you use these six principles to transform your students in your teaching and/or research?

"What do I mean by an effective education in science? I believe a successful science education transforms how students think, so that they can understand and use science like scientists do."

-Carl Wieman

Nobel Laureate (2001)

For more information about the Gateway Science Workshop

Light, G. and Micari, M. (2013). *Making scientists: Six principles for effective college teaching*. Cambridge, MA: Harvard University Press.

Website: http://www.northwestern.edu/searle/programs-events/undergrad/group-study/gsw/

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The Lamar Laboratory

The Stone Laboratory

You!