LEARNING IN THE LABORATORY

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Overview

- Operationally define laboratory instruction
- Address its criticisms and potential
- Review styles of laboratory instruction
- Integrated course design
- Backward design

Operational Definition

Classical:

A form of practical work taking place in a purposely assigned environment where students engage in planned learning experiences . . . [and] interact with materials to observe and understand phenomena (Some forms of practical work such as field trips are thus excluded). (p. 4)

-- Hegarty-Hazel, E. (1990). Overview. In E. Hegarty-Hazel (Ed.), The student laboratory and the science curriculum. London: Routledge.

Operational Definition

Contemporary:

Laboratory experiences provide opportunities for students to interact directly with the material world (or with data drawn from the material world), using tools, data collection techniques, models, and theories of science. (p. 3)

-- National Research Council (2006). America's lab report: Investigations in high school science. Washington, DC: The National Academies.

Criticisms

Cook-book

Unproductive

Confusing

Emphasis on lower-order cognition

Unrealistic in its portrayal of science

Ineffective towards conceptual change

Potential

Concept Formation:

- science content
- nature of science

Literacy:

- scientific
- information
- quantitative

Skill Development:

- scientific reasoning
- intellectual
- problem-solving
- manipulative
- organizational

Potential

"The job of lab of course is to provide the experience of doing science. While the potential is rarely achieved, the obstacles are organizational and not inherent in the laboratory teaching itself. That is fortunate because reform is possible and reform is cheap. Massive amounts of money are not required to improve most programs; . . .

M. Pickering (1980, p. 80). Cited in Byers and Eilks (2009, p.12).

Potential

what is needed is more careful planning and precise thinking about educational objectives. By offering a genuine, unvarnished science experience, a lab course can make a student into a better observer, a more careful and precise thinker, and a more deliberate problem solver. And that is what education is all about."

M. Pickering (1980, p. 80). Cited in Byers and Eilks (2009, p.12).

Traditional vs. Non-Traditional Dichotomy

Traditional Conceptualization

Pre-lab

Activity

Post-lab

Expository, Cook-book, Recipe

SYNONYMOUS

Non-Traditional Conceptualization

Inquiry

Discovery

Problem-based

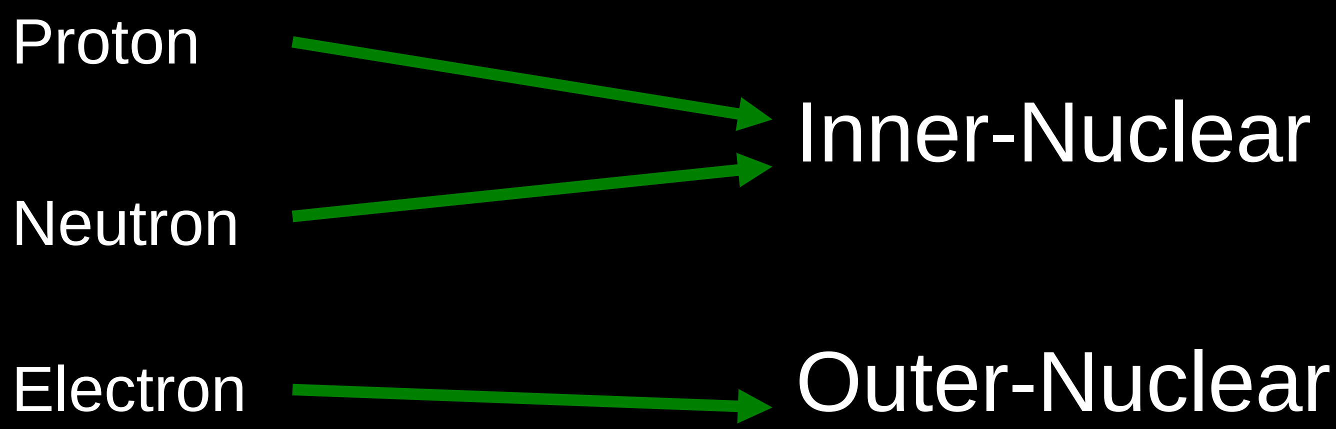
NOT SYNONYMOUS!

Issues with Dichotomous Modes of Thought

Limits our understanding
Relationships become over simplified
Key properties are lost
Constrains our potential

[Need quote from Gould or from my paper]

Consider Sub-atomic Particles



Review of Laboratory Styles

Style	Procedure	Thinking	Outcome
Expository	Given	Deductive	Known
Inquiry	Not Given	Inductive	Unknown
Discovery	Given	Inductive	Known*
Problem-based	Not Given	Deductive	Known*

Maximizing Student Learning in the Laboratory

1. Move away from relying on a single strategy

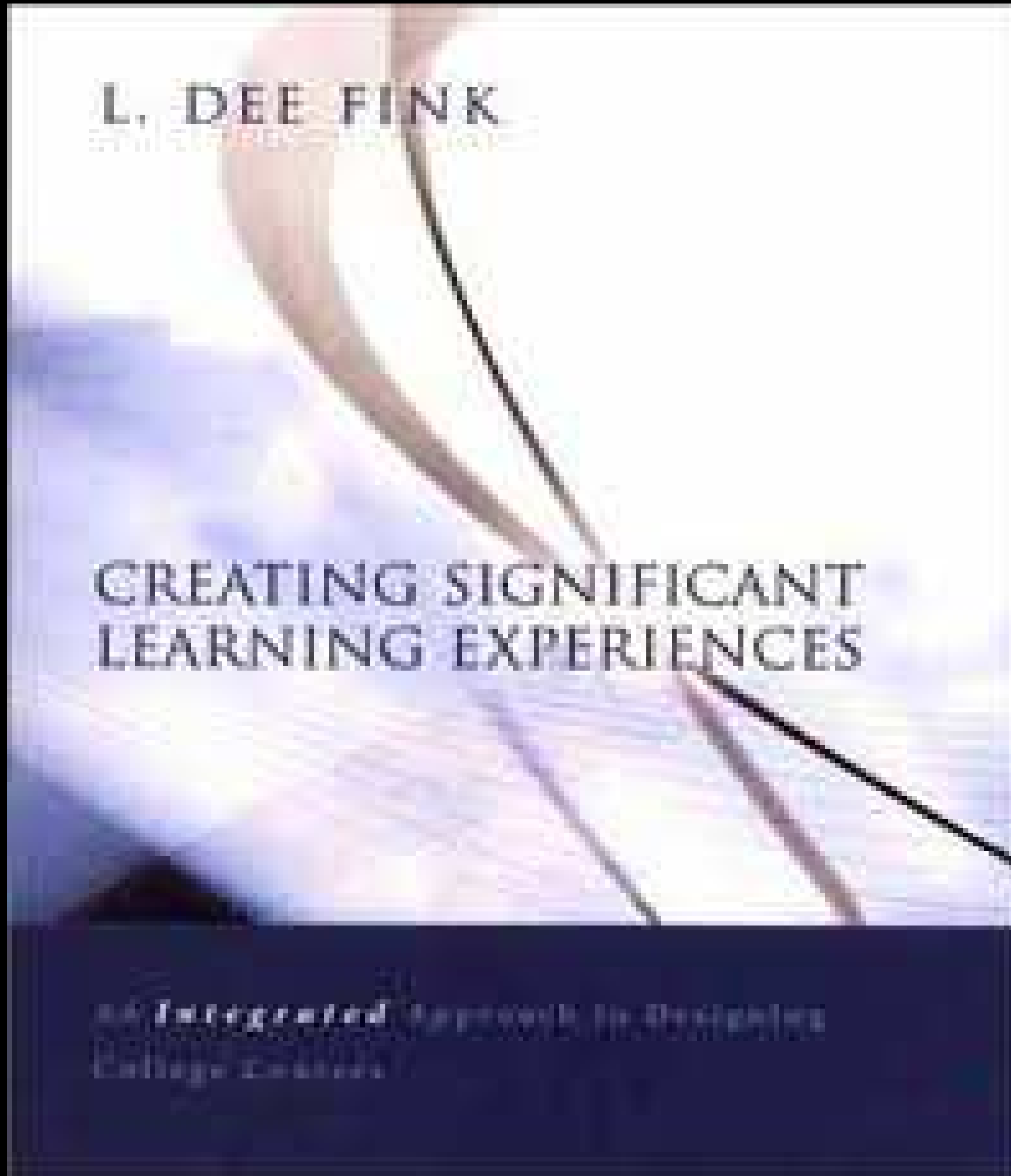
2. Greater emphasis on identifying learning outcomes

3. Directly linking outcomes with the appropriate assessment

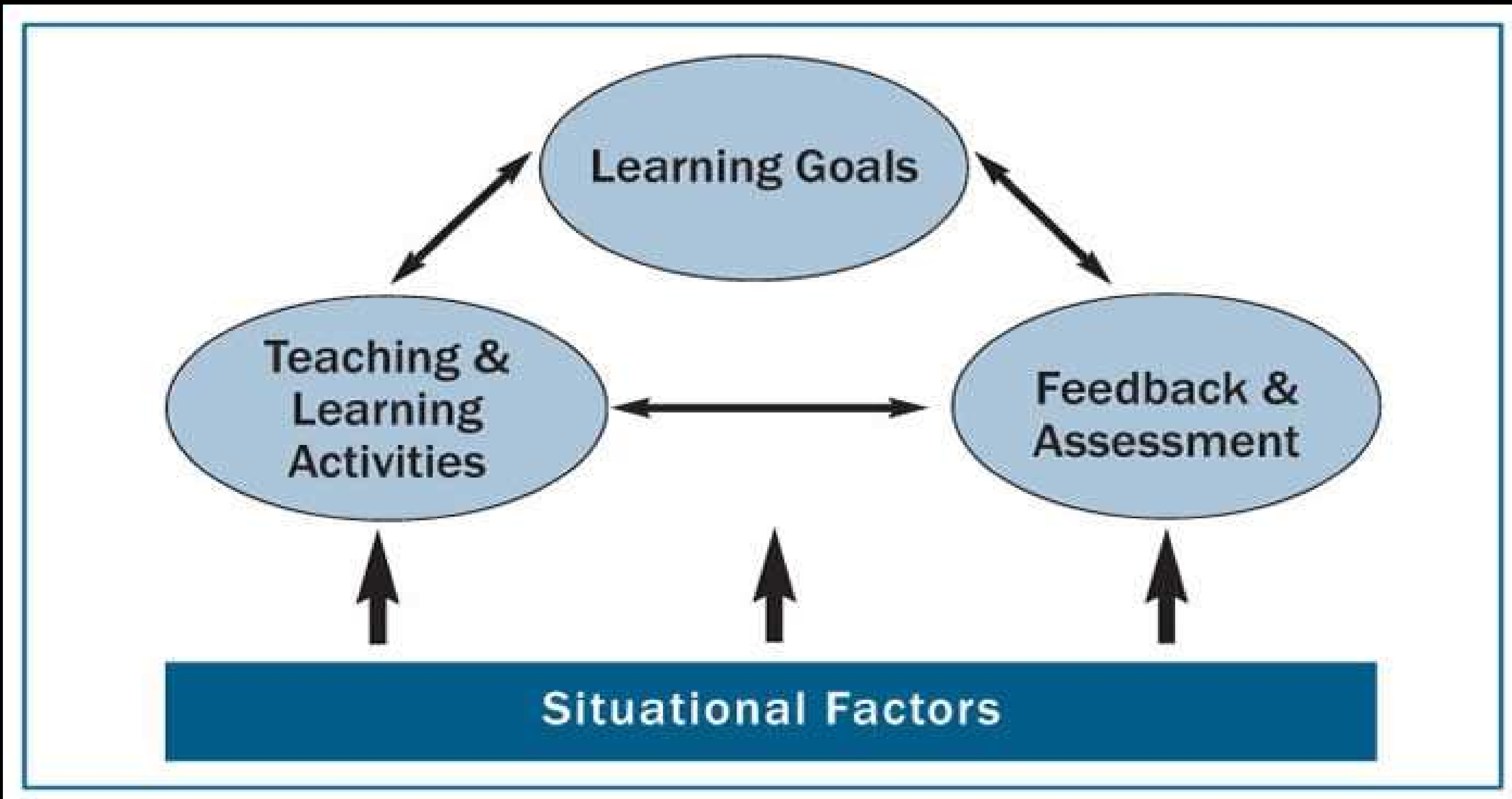
Maximizing Student Learning in the Laboratory

"The key [to getting the most out of the laboratory] experience is not only to identify desired learning outcomes for practical work but to ensure that these are directly linked to assessment" (p. 89)

– Bennett et al. (2009).


L. DEE FINK
CREATING SIGNIFICANT
LEARNING EXPERIENCES
Integrated

Integrated Course Design



– Fink, D. (2003). Creating significant learning experiences. San Francisco: Jossey-Bass.

Learning Goals

What should students learn in the laboratory?

Bottom-up perspective

What do **YOU** want your students to get from this experience, that will still be there and be of value years after the experience is over?

Fink's Six Dimensions of Learning Goals

1. Foundational knowledge
2. Application
3. Integration
4. Human dimension
5. Caring
6. Learning how to learn

Foundational Knowledge

Knowing and Understanding:
Developing the necessary knowledge base and deep understanding of the concepts and principles associated with a subject to a degree that allows one to offer explanations and predictions.

Chemistry contexts:

Remember nomenclature rules	Know elemental names and symbols
Describe/explain laws	State why a substance is/is not a metal
Describe manipulative technique	State/explain a theory

Application

Learning how to engage in some new kind of action, which may be intellectual physical, or social. This includes thinking, communicating, and manipulating objects.

Chemistry contexts:

Problem solving	Manipulating laboratory materials
Writing reports	Presentations
Evaluating data	Deducing conclusions from the data

Integration

Being able to see and understand the connections between different things such as ideas, academic disciplines, people, and realms of life.

Chemistry contexts:
Addressing energy in the context of biology

Relating the properties of waves and particles to electrons

Learning a new procedure from another student

Realizing chemistry's social, political, economical, environmental ramifications

Human Dimension

Having the opportunity to learn about one's self and about others.

Chemistry contexts:
Chemistry is challenging and one's performance in it will affect his or her self-image and self-esteem.

Realize that chemistry (and all of science) is a truly human endeavour.

Introduce students to the culture of the discipline.

Learning how to be a productive member of a lab group.

Caring

Develop certain feelings about a particular subject or learning experience: specific interests will have emerged and various values will have become even more important to them.

Chemistry contexts:
Develop a curiosity about chemical phenomena.

Develop more positive attitudes about chemistry.

Develop an interest in the history of chemistry and of particular chemists.

Appreciate the impact chemistry has had on the development of mankind.

Learning How to Learn

Learn about the processes of learning

- *Learn how to be a better student*
- *Learn how to inquire*
- *Learn how to be a self-directing learner*

Chemistry contexts:
Develop meta-cognitive problem-solving skills

Develop inquiry skills

Conduct long-term open-ended scientific investigations

What do **<u>YOU</u>** want your students to get from the laboratory experience, that will still be there and be of value years after the experience is over?

The answers to this question are your foundational goals.

Foundational Goals

Major goals that serve as the basis of the curriculum. These are the goals on which instructional activities are based and are the primary foci for assessment.

Chemistry examples:

Concept construction/development	[Foundational Knowledge]
Develop specific manipulative skills	[Application]
Develop scientific reasoning skills	[Application]
Understand that chemistry is a human endeavour	[Human Dimension]
Appreciate the societal impacts of chemistry	[Caring]
Conduct long-term open-ended scientific investigations	[Learning how to Learn]

How do You Know Students are Achieving Your Goals?

Characteristics of Goals:

- *Tend to be broad*
- *Oftentimes vague*
- *Usually cannot be measured*
- *Their achievement is often inferred*

Outcomes

Measurable pieces of evidence that we use when inferring whether or not our goals are being achieved.

Characteristics of Outcomes:

- *Derived from goals*
- *Describe a student performance/disposition that is measureable*
- *Only one behaviour per outcome statement*
- *A single outcome or a collection of outcomes may be used to infer goal achievement*

Backward Design

Traditional design of laboratory experiences:

Activity → Assessment → Outcome →(?) Goal

Backward design of laboratory experiences:

Goal → Outcome → Assessment → Activity