Integrating the Nature of Science into Content-Based Science Courses

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Overview

- **Defining the Nature of Science (NOS)**
- **Review of NOS Research**
- **Pragmatic Issues of Integrating NOS Aspects**
- **Non-Controversial NOS Aspects**
- **Integrating the Nature of Science**

  Creativity & Imagination

Nature of Science

The values and assumptions inherent to the development of scientific knowledge and the scientific enterprise.

Lederman, N. & Zeidler, D. (1987). *Science Education*, 71(5), 721-734.

Meichtry, Y. (1993). *Journal of Research in Science Teaching*, 30(5), 429-443.

Nature of Science

“It includes aspects of history, sociology, and philosophy of science, and has variously been defined as science epistemology, the characteristics of scientific knowledge, and science as a way of knowing.” (p. 1)

Bell, R. L. *Teaching the Nature of Science: Three Critical Questions*. www.ngsp.com/Portals/0/downloads/SCL22-0449A_AM_Bell.pdf (accessed 13 OCT 2010).

Review of Research

Assumptions about Learning the Nature of Science in Content-Based Science Courses

Assumption I:

Students will learn the Nature of Science merely through participation in science activities.

Assumption II:

Students will learn the Nature of Science through historical illustrative examples.

Review of Research

Through an implicit instruction approach, it is unlikely students will learn what teachers do not intentionally teach by simply engaging in science activities or by exposure to historical episodes.

Abd-El-Khalick, F., & Lederman, N. G. (2000). The Influence of History of Science Courses on Students' Views of Nature of Science. *Journal of Research in Science Teaching, 37, 1057-1095.*

Khishfe, R. & Abd-El-Khalick, F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching, 39, 551–578.*

Sandoval, W. A., & Morrison, K. (2003). High school students' ideas about theories and theory change after a biological inquiry unit. *Journal of Research in Science Teaching, 40(4), 369-392.*

Review of Research

- **Students' NOS views are best developed in content-based science courses.**

  Ackerson et al. (2000). *Journal of Research in Science Teaching*, 37(4), 295-317.

  Southerland et al. (2003). *Journal of Research in Science Teaching*, 40(7), 669-691.

- **NOS instruction must be built into the course curriculum.**

  Abd-El-Khalick, & Lederman. (1998). *Science Education*, 82(4), 417-437.

Review of Research

. . . it cannot be overemphasized . . . that NOS instruction is best undertaken in the context of science content courses. However, NOS instruction is almost nonexistent in the agendas of the mostly traditional science content courses offered in disciplinary departments. (p. 313)

Akerson et al. (2000). *Journal of Research in Science Teaching*, 37, 295-317.

Model Offered by NOS Researchers

Explicit-Reflective Approach

1. Pre-treatment – where students are made aware of their own views.
2. Purposeful activities undertaken to render students dissatisfied of their naïve views.
3. Science instruction that facilitates construction of the intended NOS concept.
4. Structured NOS reflective component.

Abd-El-Khalick, F. (2001). *Journal of Science Teacher Education*, **12**, 215-233.

Pragmatic Issues

- **Managing competition between science content and NOS content.**
- **What is a practical and effective way to incorporate NOS learning into content-based science courses?**
- **What aspects of the Nature of Science are suitable concepts to be addressed in first-year college chemistry courses?**

"Non-Controversial" Aspects

- **Scientific knowledge is tentative.**
- **Scientific knowledge is empirically based.**
- **Partly the product of human inference, creativity, and imagination.**
- **Affected by both social and cultural factors.**
- **Observation and inference are distinct.**
- **Scientific laws and theories are distinct forms of scientific knowledge.**
- **There is no universal recipe-like method for doing science.**

Lederman, N. et al. (2002). *Journal of Research in Science Teaching*, 39, 497-521.

Creativity & Imagination

Research Instrument

View of Nature of Science Questionnaire –*VNOS formC*

Lederman, N. et al. (2002). *Journal of Research in Science Teaching*, 39, 497-521.

Creativity & Imagination

Research Instrument

Naive	Informed
Creativity and imagination are used but only at the beginning of an experiment to come up with an idea.	Creativity and imagination are used throughout the entire scientific process.

Lederman, N. et al. (2002). *Journal of Research in Science Teaching*, 39, 497-521.

Creativity & Imagination

Establishing a Baseline

"Does one semester of 1st year college chemistry, without any intervention, lead to more informed views regarding creativity & imagination?"

Participant Demographics

Gender	Female: 76% (62)	
	Male: 24% (38)	
Race/Ethnicity	African-American: 85% (81)	
	White: 8% (16)	
Class Level	Freshman 51% (27)	Sophomore 28% (24)

( ) denotes TSU distribution

Procedure

Beginning of Semester:

Survey administered to 80 students.

1st and 2nd weeks of class in Recitation.

Eleven students voluntarily participated in semi-structured interviews during weeks 3 and 4.

End of Semester:

Survey administered to 62 students

14th and 15th weeks in Recitation.

Six semi-structured interviews during weeks 15 and 16.

Categorization of Students' Responses

	Beginning	End
Informed	10	6
Naïve	45	45
Not Categorized	25	11

Percent Categorized as Informed

Beginning	End	Significance		
		df	χ^2	p-value
18 (n = 55)	12 (n = 51)	1	0.850	0.235

Comparison between Studies

Pre-instructional Views

	TSU	Akerson et al.
Creativity/Imagination	18 %	24 %

Akerson, V. et al. (2000), *Journal of Research in Science Teaching*, 37, 295-317.

Advance Organizers

- An instructional strategy that facilitates the learning of new material by helping the learner relate new material (about to be encountered in an instructional activity) to previous knowledge.
- Brief presentation of the most general ideas of a subject.
- Serves as a bridge between what is known and what is to be learned.

Ausubel, D. et al. (1978). *Educational Psychology: A Cognitive View* (2nd Ed.). New York: Holt, Rinehart & Winston.

Research Questions

- Are advance organizers capable of affecting change with respect to students' views regarding the role of creativity and imagination in scientific investigations?

- Is there a difference between the manner of communication of the content within the advance organizer with respect to altering students' NOS conceptions?

Manner of Communication

Definite Explication:

Both the NOS attribute and the specific result of instruction are explicitly communicated to the learner.

Indefinite Explication:

The NOS attribute is explicitly communicated as a learning outcome, but the specific result of instruction is implicit and possesses some degree of ambiguity.

Advance Organizer (control)

Analysis of a Calcium Supplement

Calcium, in the form of calcium phosphate, makes up a large part of the mineral matter of bones and teeth. An inadequate supply of calcium in the diet of growing children results in poor skeletal development. Pregnant women who do not consume enough calcium may experience a softening of the teeth and bones. Older women need a large amount of calcium in the diet to offset calcium loss in bones, a condition known as osteoporosis.

A well balanced diet rich in dairy products and leafy vegetables usually provides an individual with all of the calcium they will need. However, it is quite often the case that people are unable to supply enough calcium through their diet to satisfy their needs. Because of this, calcium supplements are available at many drug and health stores. The calcium in these tablets is usually in the form of a salt: typically calcium carbonate or calcium lactate.

Your group will be given a calcium supplement in the form of $CaCO_3$. Your project will be to determine the mass of Ca^{2+} in a single tablet of the calcium supplement. Your value must contain at least 3 significant figures. You will have two lab periods to complete the activity.

Make sure you have read Chapters 1 - 4 of your text before coming to lab next week.

Advance Organizer (definite explication)

As you perform this activity you should become aware of the following:

- You are using more creativity and imagination than what you typically encounter in a general chemistry laboratory activity.
- Creativity and imagination are necessary components of science.
- Creativity and imagination come into play in all stages of science: planning/design, data collection, and after data collection.

Advance Organizer (indefinite explication)

As you perform this activity reflect on the following questions:

- Are you using more creativity and imagination than what you would expect from a general chemistry laboratory activity?
- Do you think creativity and imagination are necessary components of science?
- If creativity and imagination are used, during what stages of the activity did your creativity and imagination come into play: planning/design, data collection, after data collection?

Instrument

View of Nature of Science Questionnaire –*VNOS formC*

Lederman, N. et al. (2002). *Journal of Research in Science Teaching*, 39, 497-521.

Participants

First-semester general chemistry students

	Gender		Ethnicity	
Beginning of semester: n = 235				
	Female	68%	AA	82%
	Male	32%	White	10%
			Other	7%
End of semester: n = 136				
	Female	65%	AA	84%
	Male	35%	White	10%
			Other	6%

Procedure

Beginning of Semester:

Administer *VNOS – Form C*

Interview a small sample of student volunteers

Mid-semester:

Administer Treatment

Lab: advance organizer on creativity and imagination

Students Conduct Normal Course Activity

End of Semester:

Administer *VNOS – Form C*

Interview a small sample of student volunteers

Results

	% Informed			Stat. Anal.		
Treatment	Begin.	End	Δ%	X^2	df	p
Definite	18 (n=61)	18 (n=40)	0	0.005	1	0.94
Indefinite	17 (n=57)	35 (n=37)	106	3.757	1	0.05
Control	17 (n=36)	21 (n=28)	24	0.234	1	0.63
No Lab	35 (n=26)	10 (n=20)	-71	3.765	1	0.05

Conclusions

- The use of advance organizers can facilitate change in students' NOS views.
- Indefinite communication of the NOS aspect via advance organizers is more effective than definite communication.
- Even though indefinite explication led to an increase in the number of students possessing more informed views, 65% still possessed naïve views regarding Creativity and Imagination. Cannot expect full change from a single instructional activity.

Future Research

- Repeat study with a structured reflection component.
- Expand scope of the research to include other NOS concepts
- Explore in more detail the role of the instructional environment
- Begin coupling instructional strategies

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