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AUTHOR Shotwell, R. Allen
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ABSTRACT

Although the goal of science courses for non-majors should be to increase the scientific literacy of students, many such courses become watered down versions of courses in the major and do not provide enough depth to make science meaningful to students. At the Wabash Valley Region campus of Ivy Tech State College, in Indiana, a project was undertaken to modify a physical science course for non-majors from the traditional survey format to a series of focused issues in science from physics, chemistry, atmospheric science, and astronomy. For each area, background information was provided through lectures and students then formed groups charged with the tasks of gathering more information about the topic; discussing current, related scientific thinking; and determining what sort of actions should be taken as individuals and as a society to respond to the topic. Sample topics included hazardous waste disposal, nuclear terrorism, the greenhouse effect, and extraterrestrial life, and groups were required to make presentations and write summaries of their work. The course sought to minimize traditional lecturing, foster collaborative learning, and strike a balance between informing students and asking them to find information for themselves. In evaluations, student responses were more positive than in traditional courses. Materials on course objectives; the course syllabus and outline; and sample course materials, including an experiment and an exam on nuclear terrorism, are appended. (BCY)

Scientific Literacy: A Non-Traditional Approach to Science for Students Outside of Technical Fields

By

R. Allen Shotwell
Ivy Tech State College, Indiana

Paper presented at the National Institute for Staff and Organizational Development Conference on Teaching and Leadership Excellence (Austin, TX, May 26-29, 1996).

Scientific Literacy: A Non-Traditional Approach to Science for Students Outside of Technical Fields

1996 National Institute for Staff and Organizational Development (NISOD) Conference on Teaching Excellence

R. Allen Shotwell
Ivy Tech State College

May 28, 1996

Abstract.

Most degree programs outside of technology/science areas require an elective in the science area. Because of the background of these non-technical students, the traditional courses in the "hard sciences" such as physics and chemistry are not popular and are generally replaced with more generic science courses. Although technically fulfilling the required elective, many of these courses are of a survey nature or tend to become watered down versions of courses required for majors. Students often become disenchanted with science because the course do not have enough depth to make them meaningful.

The goal of science courses for non-majors should be an attempt to improve the scientific literacy of the students. It is impossible to train them in any sort of depth in survey course, but it is also a fairly accepted concept that the role of science in our society is more important than ever before and that in order to function correctly and to think critically everyone needs to have a strong grasp of the essentials of science. Unfortunately, most science electives for non-majors consist of rote memorization of facts, equations and numbers with perhaps some history of science or current topics thrown in. Little or any information about the mechanics of science or its goals are presented.

At Ivy Tech State College -Wabash Valley Region, the course SCI 111 Physical Science falls into the category of a science course for non-technical majors. The original course syllabus called for "...a minimal mathematical introduction to physical concepts and theories...in the fields of physics, chemistry, earth science and astronomy." This general description has been used as a lead in to a course focused on scientific literacy.

Beginning in the Fall Semester of 1995, the Physical Science course was modified from the traditional survey coverage of the broad areas of science to a series of focused issues in science from physics, chemistry, geology and meteorology. For each area some background area was provided in a lecture form. Student's were then formed into groups and charged with the tasks of

- gathering more information about the topic
- discussing the current scientific thinking about the subject
- determining what sort of actions they should in their personal lives to respond to this knowledge

- determining what actions should be taken by society in response to this knowledge

They were required to make a presentation to the class about their concepts and also to write a summary of their major points.

Structure of the Course.

The course was structured around four physical sciences - physics, chemistry, atmospheric science and astronomy. An introductory unit on general scientific thinking and methods made up the fifth unit. The four units on the physical sciences were covered in roughly three week (four hours per week) blocks. The introductory unit and time for tests and reviews used the remainder of the sixteen week semester.

Each unit was built around a current topic related to the area of science in question. The topic was chosen for its relevance to the student's lives or how well it lent itself to illustrating the concepts of the scientific area in question and to the general processes and procedures used in science. Table 1 lists the topics used for each unit for the fall, spring and summer semesters of 1996.

Table 1 Topics Used

Semester	Chemistry	Physics	Atmospheric Science	Astronomy
Fall 1995/96	Hazardous Waste Disposal	Nuclear Terrorism	Greenhouse Effect	Extraterrestrial Life
Spring 1996	Hazardous Waste Disposal	Nuclear Terrorism	Ozone Layer	Dark Matter
Summer 1996	Acid Rain	Nuclear Terrorism	Greenhouse Effect	Dark Matter

Each unit began with a lecture on the fundamentals of t e science involved with a concentration on the concepts related to the major topic to be covered. The lecture may take one or two class periods (two hours each) and was concluded with a brief introduction to the major topic.

After the lectures, students, in work groups of two or three, went to the library to research the major topic area. The covered traditional library resources such as books and periodicals but concentrated on the CD ROM databases of articles and on the internet. Students were instructed to obtain a minimum of ten resources related to the topic and to turn in a list of these ten at the next class session.

After the library research, the student work groups discussed the information they discovered and isolated five major concepts/facts that they found most important. These five were described for the class and summarized on the chalkboard. The class as whole then discussed the information each group obtained looking for trends and facts. After the discussion, students were asked to write a "position paper" that 1)described the topic, 2) discussed the current research and ongoing projects related to this topic and 3)stated their opinion regarding the topic. The opinion section was to answer a question posed to the class as a whole such as "What should we do about acid rain?".

Each unit ended with a test review and then a test which covered both the fundamentals of the area discussed in the lecture and the major topic information. Some

units would also include hands on labs/demos. These were designed to illustrate a specific point about the fundamentals covered in lecture or to demonstrate some principle related to the major topic.

Teaching Techniques.

The course was taught with certain pedagogical strategies in mind. The first was to minimize the lecture keeping it brief, to the point and in segments of no more than forty minutes. Since the class meet in two hour blocks, this meant lectures included 10 or 15 minute breaks when the were to last the whole class period.

The second strategy was to foster collaborative learning as much as possible. The students worked in groups to research the topic, present their findings and discuss the results. They took two out of the four tests as a group receiving the same grade for all the members of the group. They were encouraged to help each other through the papers, trading ideas and techniques and even proofreading each others papers. In two of the semesters, groups were formed by the students and remained fairly stable throughout the course. In one semester, the instructor randomly formed the groups and changed them for each unit.

The final strategy was to attempt a balance between informing students and asking them to find out for themselves. This last was a tough goal to achieve since too much one way leads to students feeling that they are lost and not learning and too much the other makes them revert to passive learning and lose their interest in the subject. The principles of problem based learning were used to help in this process. Students were presented with the basic concept of the major topic and then asked to find out the answers and to answer the question "What do you think?".

Results, Conclusions and Future Projects.

The results of the course can only be accurately judged in terms of student response at this point. In the spring semester, students completed an anonymous evaluation of the course using the SUMMA instrument from ACT. Their responses were compared to the those of students enrolled in the same course taught in the traditional way by other instructors, those enrolled in the same course taught in the traditional way by myself, to the general institutional average for instructors and to the national average for two year college faculty. The results are described in Appendix 1 Overhead Displays for Presentation

The student interest and enthusiasm for the course was much stronger (or at least more strongly expressed) than when the course was taught with more traditional methods. In addition, I had the satisfaction of students who had finished the course coming to me in subsequent semesters to discuss current events involving science and even going so far as to describe how they dug up more information on these areas after reading something in the paper or seeing it on television.

The class structure itself will continue to evolve as new ides come to mind and some techniques prove less than ideal. Ivy Tech State College will begin outcomes assessment of science during the 1996/97 school year and it is hopped that these data will help to evaluate the success of the course as well.

Appendix 1
Overhead Displays for Presentation
(includes summaries of evaluations and student comments)

Scientific Literacy

A Non-traditional Approach to Science for Students Outside of Technical Fields

R. Allen Shotwell

Instructional Chair/Science and Math

Ivy Tech State College

Terre Haute, IN

The Standard Science for Non-Technical Majors

- Students avoid physics, chemistry or any science perceived as hard or math intensive
- Students all take the one lab science course that is "easiest" (usually physical or earth science)
- Course is either watered down or survey type with little meaningful content

Why do I need to know this become a _____?

A) It helps you to learn to think critically.

B) Suppose you run into (name a situation) as a (name a career), then what?

C) If you want to be a college graduate, you need to know a few things.

D) You don't

E) None of the above.

Scientific Literacy

- In order to function in today's society and order to interpret and react to today's issues you need to be scientifically literate.
- Literacy doesn't necessary mean becoming a scientist
- Understand scientific thinking and methods, analyze data, know were to find out more.

SCI 111 Physical Science

- A series of focused subjects in the physical science
- Must investigate, interpret, and come to a conclusion
- Must articulate this process verbally and in writing
- Must have a grasp of the basic concepts of the subject

Course Content and Methods

(see syllabus)

Course divided into major subjects.

Each subject includes lecture, research, discussion, experiment, position paper and test.

Groups are used in discussion, research, experiment and some tests.

Paper topic is narrowed from discussion.

Reactions

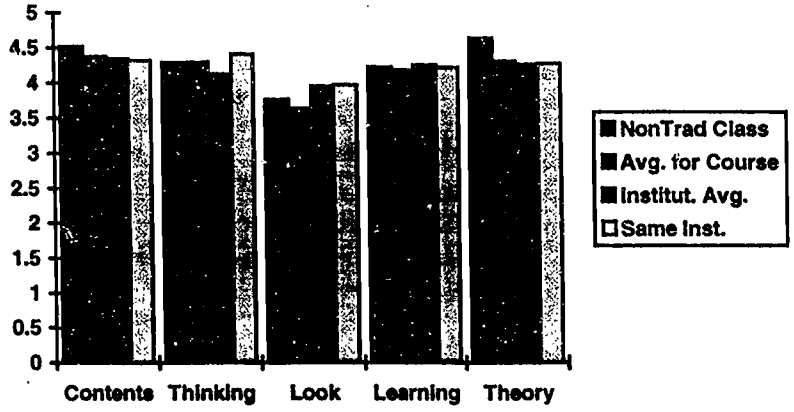
I didn't think I would enjoy this class, but I'm finding out a lot of useful information.

[The instructor] makes learning Physical Science fun.

[The instructor] does allow a lot of class participation and experiments which allows me to learn more. He turns an otherwise boring subject into something interesting.

[The instructor] is a good teacher. I am an [Administrative Office Technology] major, and I don't understand why I have to take this class. It is a very good class, for those who need it.

I like the instructor, but I still can not figure out why [this course] is required. I personally don't like science.



NonTrad Class - Class discussed in lecture.

Avg. for Class - Average for all sections of class.

Instit. Avg. - Average for Institution

Same Inst. - Same class taugh by same instructor without non-traditional approach.

Contents: The contents of the assignments contributed to my understanding of the subject.

Thinking: The instructor's presentation often causes me to think in-depth about the subject.

Look: During the term, I looked forward to attending this class.

Learning: In this course, I am learning much.

Theory: The instructor relates underlying theory to practice.

Appendix 2
Course Syllabus and Outline

SCI 111

Physical Science

Course Outline and Syllabus

Spring Semester 1996

Allen Shotwell

Course Name: *Physical Science*

Course Number: *SCI 111*

Credit Hours: *3*

Contact Hours: *4 per week (64 total)*

Meeting Times: *Monday and Wednesday 1:00 - 2:50 p.m.*

Instructor: *Allen Shotwell*

Instructor Contact Information: *(812)299-1121 or 1-800)-377-IVTC ext. 376*
M-F 8:00 a.m. - 4:45 p.m.
Office is in the front of the building behind the receptionist.

Course Description: *A minimal mathematical introduction to physical concepts and theories demonstrating knowledge of current applications and developing trends in the fields of physics, chemistry, earth science and astronomy. Presents an introduction to science and scientific thinking for the non-scientist and provides a view of science as it relates to society and the world around us.*

Course Objectives:

1. Demonstrate skill in analyzing situations based on observation.
2. Understand the natural laws, facts and theories of the physical world.
3. Work in teams.
4. Draw reasonable conclusions from quantitative data and communicate the results to others
5. Use the basic principles of science to interpret and form opinions of topics that affect everyday life and society as a whole.
6. Explain the concepts of scientific thinking and methods and use them to analyze problems

Textbook: *An Introduction to Physical Science (7 ed.) by Shipman, Wilson and Todd available in the Ivy Tech bookstore.*

The following information describes the philosophy, structure and progress of the course. Because each class is different, it is possible that some items described may be changed during the course of the semester. All changes will be communicated to you in writing as they occur.

COURSE STRUCTURE

Course Syllabus

Week#	Meeting Day	Topics	Activities
1	First	Course Orientation An introduction to science	Lecture
	Second	The Scientific Method	A mini science problem
2	First	Analysis and Interpretation of data. Research and publishing.	Lecture
	Second	Fact finding and resources	Resource search
3	First	Test Review	Lecture
	Second	Test #1	Test
4	First	An introduction to Physics and modern physics.	Lecture
	Second	The atom and the nucleus	Lecture/Worksheet
5	First	Nuclear Terrorism	Lecture
	Second	Nuclear Terrorism	Resource search
6	First	Opinions on terrorism	Group presentation/ discussion
	Second	Summary/Test Review	Lecture
7	First	Test #2	Test*
	Second	An Introduction to Chemistry Toxic Waste	Lecture
8	First	Toxic Waste	Resource Search
	Second	Opinions on Toxic Waste	Group presentation/ discussion
9	First	Summary/Test Review	Lecture
	Second	Test #3	Test*

10	First	An introduction to Atmospheric Science The Greenhouse Effect	Lecture
	Second	The Greenhouse Effect	Resource search
11	First	Opinions on Greenhouse Effect	Group presentation/ discussion
	Second	Summary/Test Review	Lecture
12	First	Test #4	Test*
	Second	An introduction to Astronomy The Space Program	Lecture
13	First	The Space Program	Resource Search
	Second	Opinions on the Space Program	Group presentation/ discussion
14	First	Summary/Test Review	Lecture
	Second	Test #5	Test*
15	First	An introduction to Geology Fossil Fuels	Lecture
	Second	Fossil Fuels	Resource Search
16	First	Opinions on Fossil Fuel Usage	Group presentation/ discussion
	Second	Catch up and last test/puzzles due.	

*Paper and resource list due.

Evaluation and Assignments

The following activities are assigned and used to determine a grade for the course. Please review them carefully.

Tests: There will be about six tests for the course. Tests will alternate between individual and group. Individual tests involve each person completing the test individually. Group tests are completed in groups of three or four and one copy is turned in for the whole group. In both cases, tests will be closed book with no notes or other resources allowed.

Papers: About four papers will be required for this course. Each paper will be between two and five pages and will be written individually. The papers will be of a position format - you will summarize the topic, describe current thinking and then put forth your position (or opinion) on the subject. Papers are graded based on grammar, spelling, punctuation, thoroughness and presentation.

Puzzles: Four or five puzzles or logic problems will be assigned during the course. These puzzles are intended to help you develop logic and thinking skills. Puzzles are completed in groups of three or four. Puzzles are based on right answer (100%) or a percentage determined by method of solution if the answer is wrong.

Resource Lists: For each topic/paper, you will be asked to compile a list of resources that can be used to learn more about the subject. The list should have a minimum of ten items with enough information about each to locate them and with a description of each resource including its usefulness. Resource lists can be compiled in groups but must be turned in individually. Lists are based on all or nothing criteria.

Each assignment is given the weight listed below.

Tests	35%
Papers	30%
Puzzles	15%
Resource Lists	20%

Final grades are based on the following scale.

90 - 100%	A
80 - 89%	B
70 - 79%	C
60 - 69%	D
below 60%	F

No grades are dropped and no assignments are curved.

Attendance Policy: Any student who misses twelve classes in the first twelve weeks will be dropped from the course).

Paper Evaluation Sheet

Spelling (one percentage point per word)	5%___
Grammar (two percentage points per mistake)	10%___
Punctuation (one percentage point per mistake)	5%___
Presentation (is the paper legible and neat?)	10%___
Works Cited (are all resources cited and given credit?)	10%__

Thoroughness

Did the paper describe all pertinent info?	15%___
Did the paper describe all current ideas?	15%___
Were the descriptions thorough enough to make them understandable?	15%___
Was the opinion expressed backed up by facts and clear arguments?	15%___

Additions to the Syllabus
SCI 111 Spring 1996
January 22,1996

Attendance Policy

Please be aware that you will also be withdrawn from the course if you miss three weeks in a row any time before the twelfth week of class.

Make ups

Tests - you have up to two weeks to make up a test. It is your responsibility to schedule a make up test with the instructor. If you miss a group test, you will have to make it up as an individual test.

Papers - papers will not be accepted beyond one week late.

Puzzles - all puzzles are due by the last day of class in the semester.

Resource lists - resource lists will not be accepted beyond one week late.

In-class work - any activities (for a grade or otherwise) besides those mentioned above cannot be made up.

SCI 111

Physical Science

Course Outline, Syllabus and Grading Policies

Summer Semester 1996

Course Name: *Physical Science*

Course Number: *SCI 111*

Credit Hours: *3*

Contact Hours: *64 (4 per week for 16 weeks)*

Meeting Times: M, W, R 1:00 - 2:30

Classroom: E103

Course Description: *A minimal mathematical introduction to physical concepts and theories demonstrating knowledge of current applications and developing trends in the fields of physics, chemistry, earth science and astronomy.* Concepts and theories will be presented in a series of focused subjects from each field. Subjects are chosen for their relevancy to society and our personal lives.

Course Objectives:

1. *Demonstrate skill in analyzing situations based on observation.*
2. *Understand the natural laws, facts and theories of the physical world.*
3. *Work in teams.*
4. Draw reasonable conclusions from quantitative data and communicate the results to others using the tools of scientific analysis (graphs, charts tables, etc.).
5. Discover the scientific principles behind issues affecting society and use these principles to evaluate the issues.
6. Understand the role of experimentation in science and practice the principles of the scientific method.

7. Use the resources of a library, the internet and other sources to determine the background information about topics in science.

Textbook: *Physical Science*, Faughn, Chang and Turk, 2 ed.
(Available in the Ivy Tech State College Bookstore)

Instructor: *Allen Shotwell, (812)299-1121 or 1-800-377-IVTC, Office in front of building (under dome) behind the switchboard.*

THE FOLLOWING INFORMATION MAY CHANGE DEPENDING UPON THE PROGRESS OF THE COURSE. YOU WILL BE PROMPTLY NOTFIED OF ANY CHANGES WHEN THEY OCCUR.

Course Outline and Order of Topics

Week #	*Chapter*	*Topics*
1	1	An Introduction to Science, rules and regulations of the class, History of Science The Scientific Method How does science work? A mini science experiment
2***	Ch. 1	Graphs, charts and scientific data. Research and information sharing. Review Test #1
3 & 4***	Ch. 21- 24	Astronomy Principles The Dark Matter Problem Test #1

5*** & 6	Ch. 18 -20	Earth Science Global Warming and the Greenhouse Effect Review and Test#2
7 & 8	Ch. 12-14	Nuclear Physics Nuclear Terrorism Review and Test #3
9&10	Ch. 15 -17	Chemistry Acid Rain
11		Review and Test #4

***Your instructor will not be on campus for the following dates: 5/27, 5/29, 6/10, 6/12, 6/13, 6/17, 6/19, 6/20

The first two dates will be used for outside the classroom work (the class will not meet formally).

The remainder of the dates will be covered by a substitute instructor.

Classroom Activities, Experiments and Assignments

Lecture - Each focus area will begin with a lecture by the instructor. The lecture is designed to outline the background information for the class and to provide a starting point for their discussions.

Group Work - Following the lecture, class groups will perform four tasks

(1) Investigate the subject by obtaining more materials from various sources.
(2) Discuss the subject and the materials found.
(3) Present their findings to the class

Tests- formal written tests will be given at the end of each unit.

Experiment - Some principles of the focus area will be demonstrated by an experiment.

Assignments and Evaluation

GROUP INVESTIGATION OF TOPIC - the group will use the resources of the library and the internet to discover more about the topic. The materials they gather (or a list of the references) will be turned in for evaluation. The grade of the materials will be an all or nothing grade (you did it or you didn't do it).

GROUP PRESENTATION/DISCUSSION - Each group will make a presentation or participate in a discussion of their progress and the information they have obtained during the class times set aside for them. Evaluation will be an all or nothing (you did it or you didn't do it).

POSITION PAPER- the position paper will be word-processed/typed, will have proper spelling/grammar and will in include a list of references as well as an indication of how they are used the paper (footnotes/end notes). Grades will based on these criteria and on the content of the paper. Each paper will have a different slant - describe, argue for or against, express you opinion, etc.

TESTS - tests will be written and closed-book. Each test will include short answer sections covering the basic facts of the subject and an essay section describing your findings on the subject.

EXPERIMENTS - experiments will be evaluated on the thoroughness in performing the task, precision and accuracy of results, presentation of results.

Final Grades

Each of the assignments described above has the following weight

Group Work	
Investigation of topic	15%
Presentation	10%
Written Summary	25%
Tests	40%
Experiments	10%

Final grades are based on the following scale

90 - 100	A
80 - 89	B
70 - 79	C
60 - 69	D
0 - 59	F

Policies for Late Submissions and Make Ups

Students are expected to attend classes as scheduled and as part of the instructional process of the class. However, if absences do arise, the following policy will be used.

1. TESTS - You have two weeks to make up a test you have missed. It is up to the student to contact the instructor about scheduling a time for the make up. The instructor will not remind the student. If you miss a group test, you will have to complete it on your own.

2. EXPERIMENTS - Due to their nature, labs can not be made up.

3. RESOURCE LISTS AND PAPERS - The resource lists and papers can be up to one week late (with appropriate penalties).

4. ABSENCES, EMERGENCIES, ETC. - It is the student's responsibility to find out what was missed during an absence. This includes announcements of tests, changes in assignments, etc. To help offset unforeseen emergencies, ONE LAB will be dropped when the final grade is calculated. TEST GRADES WILL NOT BE DROPPED.

5. COLLEGE ATTENDANCE POLICY - If a student misses 12 or more classes or two consecutive weeks within the first 8 weeks of the semester, he or she will be withdrawn from the class.

Appendix 3
Sample Course Materials

- A "Mini" Science Experiment used in the introductory unit to illustrate some principles of the scientific method.
- Sample Test on Nuclear Terrorism

SCI 111

Experiment #1

A Mini Science Problem

Introduction

As a way of seeing how the scientific process works, students will explore a question in physics - how gravity works. The experiment is "mini" because the information available on the subject is provided in this hand out along with the methods for experimentation and analysis of data.

You will work together in groups of three or four to determine your answers and submit one document per group. The document should answer all questions given and include all data you have gathered.

The Question

Does the weight of an object affect how fast it falls?

What other sicentists say (paraphrased).

The speed of an object depends on the amount of force that is applied to it. [For falling objects, the force is from the weight of the object so heavier objects should fall faster.]

Aristotle, 384 - 322 B.C.

At a given location on earth and in the absence of air resistance, all objects fall with the same uniform acceleration.

Galileo Galilei, 1564 - 1642

Every particle in the universe attracts every other particle with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between them.

Isaac Newton, 1642 - 1727

The Theory (this is your theory - what do you think?)

_____

_____

_____

The Experiment

Using the objects, scales and stop watches provided, time objects you drop and record how long they take to hit the floor (Hint: You may need one person to time and one to drop. Objects may have to fall pretty far before you can measure the time). Record all objects dropping from the same height. Record your information in the table below - make sure to describe each object in the first column so that you can remember what it is.

Table 1

	Weight	Time
Object _____		
Object _____		
Object _____		
Object _____		
Object _____		

Analysis

Attached to this handout is a sheet of graph paper. Once everyone finishes their measurements, the instructor will lead you through the analysis.

Your Conclusions

Part I Definitions (5 points each) Give a brief definition of the following.

1. Fusion

2. Radioactive Isotope

3. Alpha

4. Binding Energy

5. Neutron

6. Atom

7. Electron

8. Beta

9. Nuclear Force

10. Unstable Nucleus

Part II Short Answer (20 points each) Provide a short, but complete, answer to the following questions.

1) Describe the structure of an atom. Include in your discussion, the particles, their names and their locations within the item. Also, describe what makes the nucleus of an atom unstable and what the result of unstable nuclei is.

2) Describe why nuclear weapons in the former Soviet Union are a source of worry. Include in your description, the reasons why nuclear weapons in Russia are considered to be susceptible to theft. Also, make sure to include a discussion of any examples of theft of nuclear materials you know of.

3) Describe what is needed to make a nuclear weapon and how this is tied to nuclear power plants in countries such as North Korea and Iraq.