George Mason University
College of Education and Human Development

EDUC 547: Scientific Inquiry and the Nature of Science

Instructor:	Dr. Erin E. Peters Burton, NBCT
Date and Time:	MW 4:30-7:10 (June 2 -July 16)
Class Location:	Thompson 1017
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Course Description

Incorporates advanced understanding about scientific knowledge in K-12 classrooms. Builds fundamental knowledge of scientific inquiry and the nature of scientific knowledge and skills to weave this knowledge explicitly in curriculum. Focuses on developing inquiry-based lessons for students to investigate science and assessing student understanding of science and the nature of science.

Course Format

The delivery of this course is designed to reach two major goals:

1. To learn a deeper meaning of Scientific Inquiry (SI) and the Nature of Science (NOS)
2. To develop, implement, and assess Scientific Inquiry and the Nature of Science in secondary classrooms

We will begin by participating in an activity that reveals ideas about scientific inquiry and the nature of science, then we will use these ideas to delve deeper into the concepts of SI/NOS. Following instruction on the aspect of scientific inquiry and the nature of science, teachers will incorporate their understanding of SI/NOS into their teaching and will report the planning, implementation and assessment back to the group. Reporting the results of implementation and assessment of SI/NOS will not be treated as an endpoint, but rather as a reflection with the group so the activities can be enhanced and shared with other teachers.

Relationship to Program Goals and Professional Organization

EDUC 547 is designed to enable science education leaders to use strategies to implement and evaluate school change in science teaching and learning. Students need knowledge of effective instruction in science as well as vehicles for change so that they can be a catalyst for school improvement in mathematics. The course was developed according to the position statement of the National Science Teachers Association (NSTA) and the joint position statement of the National Council for Accreditation of Teacher Education (NCATE) and the National Science Teachers Association (NSTA) on Standards for Science Teacher Preparation.

These position statements indicate that the core knowledge expectations in science education include:

- Understand the historical and cultural development of science and the evolution of knowledge in their discipline.
- Understand the philosophical tenets, assumptions, goals, and values that distinguish science from technology and from other ways of knowing the world.
- Engage students successfully in studies of the nature of science including, when possible, the critical analysis of false or doubtful assertions made in the name of science.
- Understand the processes, tenets, and assumptions of multiple methods of inquiry leading to scientific knowledge.
- Engage students successfully in developmentally appropriate inquiries that require them to develop concepts and relationships from their observations, data, and inferences in a scientific manner.

Additionally, this course was designed with a vision for accomplished teaching, as indicated by NBPTS Science Standards for Early Adolescence (http://www.nbpts.org/userfiles/File/ea_science_standards.pdf) and Adolescence and Young Adulthood (http://www.nbpts.org/userfiles/File/aya_science_standards.pdf) the Five Core Propositions of the National Board for Professional Science Teaching:

- Proposition 1: Teachers are Committed to Students and Their Learning
- Proposition 2: Teachers Know the Subjects They Teach and How to Teach Those Subjects to Students
- Proposition 3: Teachers are Responsible for Managing and Monitoring Student Learning.
- Proposition 4: Teachers Think Systematically about Their Practice and Learn from Experience.
- Proposition 5: Teachers are Members of Learning Communities.

Readings

- Will be provided electronically by the instructor on the Blackboard site.
- Because this course is flexible to the needs of the teacher candidates, other articles/handouts than the ones indicated on this syllabus may be distributed in class or posted on-line at the course website.
- It is expected that the readings assigned for the class will be completed before the class meeting.

Learning Outcomes and CEHD Core Values

Students will:	**CEHD Core Value**
Build knowledge in the historic, philosophical and social factors that have influenced the development of scientific knowledge	Social Justice Innovation
Be able to categorize lessons along the continuum of scientific inquiry	Ethical Leadership
Build a repertoire of science teaching and assessment strategies in scientific inquiry and the nature of science by reading, writing, observing, participating in, and reflecting on the teaching and learning of science;	Research-Based Practice Collaboration
Develop strategies to help students become scientifically literate, think critically and creatively, understand the nature of science, and see the importance of science as a way of knowing;	Social Justice Innovation Collaboration Research Based Practice Ethical Leadership
Utilize a professional learning community to improve lesson planning, implementation and assessment.	Collaboration Ethical Leadership Research-Based Practice
Construct more cohesive science units that focus on science as a way of knowing	Research-Based Practice Innovation

College Expectations and University honor Code

The Graduate School of Education (GSE) expects that all students abide by the following:

Students are expected to exhibit professional behavior and dispositions. See gse.gmu.edu for a listing of these dispositions.

Students must follow the guidelines of the University Honor Code. See http://www.gmu.edu/catalog/apolicies/#TOC_H12 for the full honor code.

Students must agree to abide by the university policy for Responsible Use of Computing. See http://mail.gmu.edu and click on Responsible Use of Computing at the bottom of the screen.

Students with disabilities who seek accommodations in a course must be registered with the GMU Disability Resource Center (DRC) and inform the instructor, in writing, at the beginning of the semester. See www.gmu.edu/student/drc or call 703-993-2474 to access the DRC.

Grading

Since this is a graduate level course, high quality work is expected on all assignments and in class. Attendance at all classes for the entire class is a course expectation. All assignments are due at the beginning of class on the day they are due. Graded assignments that are late will automatically receive a ten percent grade reduction (one full letter grade lower).

Assignments	*Points*
Concept mapping (check #1)	20
Concept mapping (final)	20
Clinical interview questions	10
Clinical interview report	50
Presentation Part 1	100
Presentation Part 2	100
Online discussions	150
Class participation (consultations)	50
Total Points:	500

Policy on Incompletes

If circumstances warrant, a written request for an incomplete must be provided to the instructor for approval prior to the course final examination date. Requests are accepted at the instructor's discretion, provided your reasons are justified and that 80% of your work has already been completed. Your written request should be regarded as a contract between you and the instructor and must specify the date for completion of work. This date must be at least two weeks prior to the university deadline for changing incompletes to letter grades.

Grading Scale

A = 93-100%
A- = 90-92%
B+ = 88-89%
B = 80-87%
C = 70-79%
F = Below 70%

Assignments

Science education research shows that frequent assessment of small amounts of material is most effective for learning science. Therefore, in this class formal and informal assessment will be continuously provided on assignments and class activities. Assessment is used as a tool for information that informs both learning and teaching, so this two-way communication loop is necessary for optimal learning.

1. Concept maps

The materials learned in this course tend to take a metacognitive approach. That is, the nature of science is a way of knowing the world, rather than a set of facts. Capturing this knowledge can be elusive, so to keep track of progress in the course, we will be using concept maps as a tool for displaying knowledge. Teachers will design their own concept maps and add to their maps after each class as a way of reflecting on what they have learned. The format of the concept map is up to the teacher, but it should be an effective means of communication about nature of science knowledge. There will be a formative assessment check on the concept map (see calendar for the date). The formative map should represent all of the information learned in the course at the time of the check. A final concept map will be turned in on the last class. This map should represent all of the knowledge learned during the course.

2. Clinical Interview

In this assignment, you will find an adolescent to interview about scientific inquiry and the nature of science. The purpose of this assignment is for you to gain experience in a one-on-one setting to understand individual student ways of knowing. You will be given more detailed instructions in class, but overall the task is to be completed in the following sequence:

1) For concepts about the **nature of scientific knowledge,** write two easy questions, two moderately difficult questions, and two more difficult questions that are all related and lead up to a “big idea”. Note the easy questions should get at the student’s understanding of the concept from past experience that may or may not be the product of schooling. The questions can be about the nature of science without context or can be contextualized within a content area. However, the questions MUST be eliciting ideas about the nature of science from the adolescent.
2) Audio tape an adolescent answering the questions and you probing for more understanding of the cognition of the student.
3) Writing a 3-4 page paper of the description of what occurred, an analysis of the learning of the anonymous student, and a reflection on what you learned.

3. Class Presentations

A major goal of this course is to enable teachers to incorporate more nature of science knowledge and scientific inquiry processes into their classes in an explicit and reflective way. To reach this goal, teachers will pair up to plan a lesson with explicit, reflective nature of science instruction and will present the objectives and assessment of the lesson and the ways they incorporate nature of science and scientific inquiry in their classes to their peers. Peers will conduct a "consultation" with the pairs of teachers, revealing and discussing strengths and weaknesses of their classroom activities. To prepare for the first presentation, teachers will bring any student materials needed for peers to understand the lesson's intent and assessment. During the second presentation, teachers will bring lesson plans and Template 1 along with any revised student materials. The teachers will then teach the course in a 40 minute block. Templates found at the end of this syllabus should be used to provide framework for the other teachers about the lesson.

4. Online Discussions

A portion of this class will be conducted online in order to facilitate the incorporation of the new information about the nature of science into classroom lessons. In order for this component of the class to be successful, all teachers need to participate in the online sessions. The sessions may be a discussion about a reading that was posted, comments on an online system of lessons, or suggestions for a posted lesson.

5. Class Participation

Learning depends on the active engagement of the participant and frequent checking by the instructor as to the progress of the learner. Smaller assignments will be given as necessary in class in order to inform your learning and my teaching. Part of the class participation is providing feedback to peers when they present their lesson plans incorporating the nature of science (otherwise known as the consultations).

Students who are not in the teaching profession will be given the opportunity to do an alternative assignment that is approved by the instructor.

Instructions for Class Presentations

Criteria for Selecting Work to Share

Not all lessons and student work are conducive to a presenting for this assignment. Lessons that generate the most productive discussions are usually inquiry lessons or assignments where students express their ideas on their own. A multiple choice assessment is not as appropriate for this type of discussion because it is difficult to ascertain students' understanding of phenomena with a forced answer format. Some questions to guide teacher choice of lessons follow:

- Do you have a question that your colleagues could help you resolve?
- Is the work easily viewable for your colleagues?
- Does the work represent one aspect of the nature of science?

- Will the assignment and student work generate an interesting conversation among your colleagues?

Consider that sometimes your “best” work may not generate conversations to find creative approaches to teaching and learning, so bringing in a lesson that needs some improvement may also be an option.

Materials for Presentation Part 1

The presenting teachers should bring enough copies of the following items:

- The assignment materials that are to be given to the students
- Template 1

Also please prepare to talk about the objectives (both content and NOS) of the lesson

The Presentation-Part 1

The presentation should begin by having the presenting teacher pair or group explain an overview of the expectations of the lesson that was designed to teach content and emphasize ONE aspect of the nature of science. Teachers will hand out the student assignment and assessment materials for discussion by peers. The purpose of this discussion is to improve the explicit, reflective nature of science instruction. To aid in this discussion, we will identify the objectives for the content and the nature of science and the assessment plans for the content and the nature of science. Other issues such as possible reasons for misconceptions come out of the discussions. The presentation should always end on a positive note, focusing on the achievements of the teacher pair. This presentation is expected to take 20 minutes including discussion.

Materials for Presentation Part 2

The presenting teacher should bring enough copies of the following items:

- A revised version of what has been planned for the class (Template 1)
- A lesson plan of the presented lesson with expectations
- Revised class activity for all members of the groups to be “students”
- Any additional supporting materials needed for the lesson
- After Presentation 2 – Template 2 filled out individually

The Presentation-Part 2

The presenting teachers should pass out Template 1 and the full lesson plan. As the presenting teachers explain the outline and lesson plan, the group can ask clarifying questions. Part 2 of the presentation of the lesson is to actually teach the lesson to the group. In doing so, the partners will implement the 40 minute lesson that was refined during the consultation with the group. At the end of the 40 minutes, we will conduct a discussion about how the NOS aspect was taught explicitly and reflectively and the connection of the aspect to the content. The lesson will be videotaped in order to refer to portions of the lesson. Following this, the teacher pair will **individually** fill out a reflective template (#2) and turn in to the professor.

Template #1
Teacher Information Worksheet

1. What aspect of the nature of science did you choose for this assignment? Why did you make this choice?
2. To complete the assignment, what should students know about the nature of science?
3. What would you accept as evidence that students understood that aspect of the nature of science?

Template #2
REFLECTION

➢ What does this work tell you about how well a student understands the nature of science? Are they free to express complete thoughts?
Which piece of work would you rate below? And why? • Exceeds expectations – • Meets expectations – • Does not yet meet expectations –
Does the assessment of the student work fairly reflect the nature of science objectives of the assignment?

What adjustments would you make to the assignment based on the consultation?
What adjustments would you make to the assessment based on the consultation?

Schedule
(Plans may change according to student needs)

Date	Class topics and Assignments Due
June 2	**Prior Knowledge and Overview** • Why teach science? • What is scientific inquiry and how is it related to the nature of science? • What do we know from research about how SI/NOS should be taught? • How do we go about assessing SI/NOS?
	Before class please read: Syllabus
	Class Activities: Requirements of the Course Forethought form Views of Science and Education (VOSE) Pre-Test VNOS-B Pre-Test Overview of Scientific Inquiry and the Nature of science ➢ Understanding Science: How Science Really Works http://undsci.berkeley.edu/ http://riaus.org.au/articles/consilience-in-science/#!
	Assignments Due: *None*

Date	Class topics and Assignments Due
June 4	**Building Knowledge of SI/NOS** • How is classroom inquiry different from scientific inquiry? • What concepts about the scientific enterprise are appropriate for secondary students?
	Before class please read: Readings about SI and NOS ➢ Inquiry and the National Science Education Standards *http://www.nap.edu/openbook.php?record_id=9596&page=1* *Read Chapters 1, 3 and 4*

	➢ Next Generation Science Standards http://www.nextgenscience.org/next-generation-science-standards ➢ Peters, E. E. (2006). Connecting inquiry and the nature of science. *The Science Education Review, 5* (2), 37-44. *(available on Blackboard site)* ➢ McComas, W. F. (1998). *The principle elements of the nature of science: Dispelling the myths.* http://coehp.uark.edu/pase/TheMythsOfScience.pdf. ➢ Peters, E. E. (2006). *Why is teaching the nature of science so important?* (available on Blackboard) ➢ Project 2061 – The Nature of Science http://www.project2061.org/publications/sfaa/online/chap1.htm ➢ Ault, C. R. & Dodick, J. (2010). Tracking the Footprints Puzzle: The Problematic Persistence of Science-as-Process in Teaching the Nature and Culture of Science. *Science Education, 94,* 1092-1122.
	Class Activities: Models of the nature of knowledge Examples of de-contextualized nature of science activities The role of de-contextualized NOS activities Nature of knowledge and ways of knowing
	Assignments Due: *Respond to questions about readings on the Discussion Board (Building Knowledge about SI & NOS)*

June 9	**Explicit and Reflective NOS Instruction** • What do we know from educational research about the most effective ways to teach NOS? • Why is NOS difficult to translate into classroom practice?
	Before class please read: • Peters-Burton, E. E. (2013). Self-regulated learning as a method to develop scientific thinking. In I. M. Saleh and M. S. Khine (Eds.), *Approaches and Strategies in Next Generation Science Learning*. Hershey, PA: IGI Global. (available on blackboard)

	➢ Peters, E. E. (2012). Developing content knowledge in students through explicit teaching of the nature of science: Influences of goal setting and self-monitoring. *Science & Education, 21(6)* 881-898.
	Class Activities: Self-regulated learning processes Card Sort Parallels to explicit and reflective approaches to teaching NOS MPI-S Magnets unit
	Assignments Due*:* ➢ *Be prepared to discuss readings in class* ➢ *Consider who will be in your group to present*

June 11	**What constitutes empirical evidence?** • What makes empirical evidence different from other forms of evidence?
	Before class please read: About Implications of Heroic Science Stories ➢ Milne, C. (1998). Philosophically correct science stories? Examining the implications of heroic science stories for school science. *Journal of Research in Science Teaching*, *35*(2), 175-187. Read about scientific approaches in making claims in a class activity ➢ Lawson, Anton E. (1999). A Scientific Approach to Teaching About Evolution & Special Creation". *The American Biology Teacher*, 61 (4), 266-274. **Please try out the following web-based activities for this class:** Evidence to make claims in student activities ➢ National Institutes of Health, (2005). Doing Science: The Process of Scientific Inquiry. http://science.education.nih.gov/Supplements/NIH6/inquiry/default.htm. Evidence to support ideas in science ➢ Differences between models and empirical evidence http://www.skepticalscience.com/empirical-evidence-for-global-warming.htm Perform a student activity that requires empirical evidence to make claims ➢ The World IS really flat! http://www.indiana.edu/~ensiweb/lessons/flaterth.html

	Class Activities: Reactions to Readings and Online Discussion Generating empirical evidence in the classroom Contextualized NOS lesson
	Assignments Due: ➢ *Clinical interview questions – draft* ✓ *Responses to questions on Discussion Board (Using Evidence in Scientific Reasoning)*
June 16	**Scientific knowledge is durable, but also tentative** ✓ How tentative is scientific knowledge?
	Before class please read: Lesson demonstrating tentativeness ➢ AAAS Science NetLinks – Abrupt Climate Change http://www.sciencenetlinks.com/lessons.php?Grade=9-12&BenchmarkID=1&DocID=323 How do scientists handle flux in major concepts? ➢ http://arstechnica.com/science/news/2006/10/5609.ars Different meanings of tentativeness ➢ http://physics.weber.edu/johnston/research/!TheMultipleMeaningsOfTentativeScience_IHPSTfi.PDF Dealing with tentativeness when teaching science ➢ http://www.actionbioscience.org/education/allchin2.html
	Class Activities: Plate Tectonic Theory Case Study – FAST3 Textbook series Dino-Data Performance SRL questions – learning about NOS
	Assignments Due: ✓ *Concept Map Check #1* ✓ *Check in on Clinical Interview Report*
June 18	**Laws and Theories** • What is the difference between theories and laws?
	Before class please read: McComas, W. F. (2003). A Textbook Case of the Nature of Science: Laws and Theories in the Science of Biology. *International Journal of Science and Mathematics Education 1*(2), 141-155. (Reprint found on blackboard).

	Class Activities: 3 Groups will do Presentation #1 Perform an online lesson that explicitly illustrates Theory ➢ AAAS Science NetLinks – Comparing Theories: Lamark and Darwin http://www.sciencenetlinks.com/lessons.php?Grade=9-12&BenchmarkID=10&DocID=0
	Assignments Due: ✓ *Reponses to questions on Discussion Board (AAAS Science NetLinks – Comparing Theories: Lamarck and Darwin)* ✓ *2 groups will present Presentation Part 1*
June 23 Class starts late	**Scientific Habits of Mind** • What habits of mind do scientists adopt?
	Before class please read: Barber, B. (1961). Resistance by scientists to scientific discovery. *Science*, *134*, 596-602. Answer questions on the Blackboard site about this lab: ➢ http://www.teach-nology.com/worksheets/science/phy/lab1/ (Is this lab teaching laws, theories, neither or both?)
	Class Activities: 4 Groups will do Presentation #1 Perform a lesson illustrating scientific habits of mind ➢ AAAS Science NetLinks – The Mozart Effect http://www.sciencenetlinks.com/lessons.php?Grade=9-12&BenchmarkID=12&DocID=36 Perform online lesson illustrating how scientists strive for accuracy ➢ Opinion surveys http://www.sciencenetlinks.com/lessons.php?Grade=9-12&BenchmarkID=12&DocID=451 Self-Reflection form for Learning NOS Forethought form for teaching NOS
	Assignments Due: ✓ *2 groups will present Presentation Part 1* ✓ *Responses to questions on Discussion Board (Laws and Theories in the classroom)*

June 25 Class starts late	**How do social and historical factors influence scientific knowledge?**
	Before class please read Mendelsohn, E. (1977). The Social Construction of Scientific Knowledge. E. Mendelsohn, P. Weingart and R. Whitley (Eds.) *The Social Production of Scientific Knowledge. Sociology of the Sciences*, Vol I, 3-26. Boston: D. Reidel Publishing Company Read how to incorporate more issue based lessons in science ➢ http://www.actionbioscience.org/education/lewis.html
	Class Activities: 3 Groups will do Presentation #1 Perform activity to show historical change in scientific values ➢ Women in Medicine: Past and Future http://www.sciencenetlinks.com/lessons.php?BenchmarkID=1&DocID=115 Discussion of the use of history of science in class Joy Hakim's *The Story of Science*
	Assignments Due: ✓ *Respond to questions in the Discussion Board (Socially-Based Issues in Science)* ✓ *2 groups will present Presentation Part 1*
June 30	**In what ways are scientists creative?**
	Before class please read Holton, G. (1995). Chapter 4 Imagination in Science from *Einstein, history and other passions.* New York: Addison-Wesley. Listen to a portion of PRI's Creativity in Science series Death Ray (it is at the top of the list on the right) http://castroller.com/podcasts/PriScienceAnd/1312948 Plastics http://castroller.com/podcasts/PriScienceAnd/1312949 Biomimicry http://castroller.com/Podcasts/PriScienceAnd/2218598

	Class Activities: Online Discussion on creativity in science Online Discussion on creativity in the classroom
	Assignments Due: ✓ *Final Clinical Interview Report*
July 2	**How do you teach NOS explicitly and reflectively while still teaching science content?**
	Before class ➢ Prepare for Presentation #2
	Class Activities: 2 groups will present Presentation Part 2 Groups presenting will fill out the Performance form after presenting
	Assignments Due: ✓ *Template #2 for people who presented* ✓ *Performance form due for people who presented* ✓ *Respond to questions on Discussion Board (Greatest Discoveries in Science)*
July 7	**How do you teach NOS explicitly and reflectively while still teaching science content?**
	Before class ➢ Prepare for Presentation #2
	Class Activities: 2 groups will present Presentation Part 2 Groups presenting will fill out the Performance form after presenting VNOS post-test
	Assignments Due: ✓ *Template #2 for people who presented* ✓ *Performance form due for people who presented*
July 9	**How do you teach NOS explicitly and reflectively while still teaching science content?**

	Before Class: ➢ Prepare for Presentation Part 2
	Class Activities: 2 groups will present Presentation Part 2 Groups presenting will fill out the Performance form after presenting VOSE
	Assignments Due: ✓ *Template #2 for people who presented* ✓ *Performance form due for people who presented*
July 14	**How do you teach NOS explicitly and reflectively while still teaching science content?** **Measurement of growth in NOS knowledge**
	Before class ➢ Prepare for Presentation #2
	Class Activities: 2 groups will present Presentation Part 2 Groups presenting will fill out the Performance form after presenting Card Sort Self-Reflection form for Teaching NOS Class Evaluation
	Assignments Due: ✓ *Template #2 for people who presented* ✓ *Performance form due for people who presented* ✓ *Final concept map*

Nature of Science and Scientific Inquiry Lesson Plan Rubric
Name of Students____

Unacceptable (0 points)	**Needs Work (1 point)**	**Developing (2 points)**	**Proficient (3 points)**
A. Guiding Question(s): The goal of your lesson should be inquiry oriented. Students' attention should be focused on answering one or two key questions based on empirical evidence. Remember that teacher simply asking lots of questions does not an inquiry lesson make.			
Guiding question(s) not included	Guiding question(s) are included but are not appropriate to student inquiry and/or very poorly worded.	Guiding question(s) are included, are appropriate, but poorly worded.	Guiding question(s) are included, appropriate, and well worded.
B. Student Performance Objective(s): What, more specifically, are the students expected to know and be able to do at the end of the lesson? Include content knowledge, intellectual skills, and dispositions as appropriate. Your objectives should have readily observable behaviors or performance tasks. Students must be made aware of day-to-day objectives. Objectives should include BOTH content objectives and nature of science objectives.			
Poorly written objectives; written more like teacher goals; not performance-based; or not provided. Only NOS or only content objectives are provided.	Objectives are a mix of teacher goals and student performance-based tasks; objectives exhibit poor word choice and uses terms such as "understand" or "able to" for performance task. Only NOS or only content objectives are provided.	States unit's major and minor science content and intellectual process skills objectives using observable behaviors. Includes both NOS and content objectives	Developing plus includes due consideration for student dispositions. Includes both NOS and content objectives.
C. Science Content and Standards: List here the order of science content as it will be taught as well as the corresponding Virginia Standards of Learning.			
Fails to include alignment table between student activities and Virginia SOLs.	Includes a table showing alignment between some student activities and SOLs, but not all.	Includes a table showing alignment between major and minor student activities and SOLs.	Developing plus includes National Science Education Standards A-L in alignment table as appropriate.
D. Alternative Conceptions: List here any alternative conceptions (preconceptions that students might bring to this subject matter and misconceptions that they might develop) as a result of studying the content of this lesson. Be certain to cite your reference(s).			
Little to no consideration for alternative conceptions.	Lists only a very limited array of students' alternative conceptions; doesn't not cite reference(s).	Lists a good variety of preconceptions and misconceptions that students have in relation to subject	Developing plus links various alternative conceptions to specific classroom activities.

		matter of unit. Clearly referenced.	
E. Instructional Approach(es): Indicate which active learning strategies you will employ in this inquiry lesson such as discovery learning, interactive demonstration, inquiry lesson, inquiry lab, hypothetical inquiry, problem/project based learning, case study, discussion, etc. Good inquiry-oriented lessons also will include activities from each of the three following categories: individualized, small group, and whole group.			
More emphasis on didactic teaching; less emphasis on students constructing understanding from experiences; little to no consideration for student groupings.	A roughly equal mix of teacher-centered and student-centered pedagogy; equal emphasis on transmitting knowledge and discovering knowledge; some consideration for student groupings, but does not show planning required to use them effectively.	Provides a detailed overview of diverse and effective teaching procedures that are student student-centered; addresses classroom atmosphere and student management; explains how a variety of diverse student groupings will be used to construct meaning from science experiences and develop dispositions for further inquiry and learning.	Developing, and clearly includes use of formal cooperative learning strategies.
F. Focus of NOS aspect: Research demonstrates that to teach NOS effectively the lessons must be both explicit for the students AND allow the students to be reflective about their scientific thinking. Indicate how your lesson addresses both explicit and reflective NOS activities.			
Fails to provide explicit or reflective NOS instruction.	Provides either explicit or reflective NOS instruction but not directly connected to the content in the lesson.	Provides either explicit or reflective instruction but not both. Connected with the content in the lesson.	Provides both explicit and reflective instruction that is directly connected to the content of the lesson.
G. Checking for Understanding: How will you as teacher determine if the student performance objective(s) for the day's lesson has been achieved? How will you assess the objectives in an informal though meaningful manner?			
No consideration shown for student comprehension or no review of lesson's student performance objectives.	Reviews the lesson objects for students, but teacher conducts summary of student learning without involving students.	Reviews the lesson objectives for students, but does a poor job of eliciting students' input or alternative conceptions; provides some of the summary for the students.	Reviews the lesson objectives for students, and does a good job of eliciting students' understanding in relation to the lesson's student performance objectives including

			alternative conceptions.
H. Extensions/Homework: Explain how you will teach explicitly about the nature of science, its unifying concepts, the philosophy of science, issues of science and technology and/or the processes of science during your lesson. What projects or homework activities will you assign to your students to help them internalize and better understand the intended learning of this lesson?			
No consideration given to any form of extension; no homework suggested.	Only extension or homework given, not both.	Gives both extension and homework information, but is a bit sketchy.	Gives both extension and homework information, and provides enough detail about the extension work that anyone could teach it given the information provided.
I. Materials and Safety: What materials will you need to teach your lesson? Do any of your materials represent a safety hazard? If so, what precautions will you take to protect your students?			
No consideration given for the use of materials.	Makes very limited use of instructional materials; no mention of safety considerations.	Make considerable use of only a limited amount of instructional materials; notes safety precautions as appropriate.	Uses a variety of material resources to conduct lesson including such things as demonstrations and/or simulations to provide for multiple modes of learning as appropriate; notes appropriate safety precautions if appropriate.
J. Backup Plan: No lesson plan should be written without considering the possibility that students will complete their tasks faster than expected. Every lesson plan should, therefore, include meaningful back up activities. The backup plan should not consist of having students work on an assignment intended for homework.			
No consideration given for activities that can be used to fill extra time in a meaningful fashion.	Uses homework for a back-up plan.	Provides an insubstantial or meaningless activity as a back-up plan.	Makes excellent use of extra time to introduce valuable and meaningful extension activities (e.g., NOS case studies) .