George Mason University
College of Education and Human Development

EDUC 500: SCIENTIFIC INQUIRY AND THE NATURE OF SCIENCE
Spring Semester, 2010

Instructor:	Erin E. Peters, Ph.D., NBCT
Date and Time:	February 3 – May 12 (Wednesdays 3:30-5:30 – every other week online) April 24th from 10-3 pm
Class Location:	TBA – in Stafford Co.
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Office Hours:	By appointment

COURSE DESCRIPTION
Scientific Inquiry and the Nature of Science is a course designed for in-service science teachers who would like to incorporate more understanding about scientific knowledge in their classrooms. The course is designed to build fundamental knowledge of scientific inquiry and the nature of scientific knowledge and skills to weave this knowledge explicitly in curriculum. The course focuses on developing inquiry-based lessons for students to investigate science and assessing student understanding of science and the nature of science. The teachers will plan lessons for students to learn scientific inquiry and the nature of science, implement lessons in a secondary classroom, observe students learning, and evaluate their teaching and student outcomes.

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

Every two weeks we will examine an aspect of scientific inquiry and the nature of science with readings, activities, and discussions. 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 classroom and will report the planning, implementation and assessment back to the group. Because it takes some time to incorporate and assess deep understanding of SI/NOS in classrooms, face-to-face meetings will take place every two weeks. The weeks between the face-to-face meetings will be conducted electronically, where the goal is to reinforce and build more understanding of the implementation and assessment of SI/NOS into the classroom via electronic discussions of activities in the classroom. 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.

READINGS

- Will be provided electronically by the instructor on the Blackboard site.
- Because this course is flexible to the needs of the teachers, 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.

GOALS

The pre-service and provisionally licensed teacher will:

- Build knowledge in the historic, philosophical and social factors that have influenced the development of scientific knowledge
- Be able to categorize lessons along the continuum of scientific inquiry
- 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;
- 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;
- Utilize a professional learning community to improve lesson planning, implementation and assessment.
- Construct more cohesive science units that focus on science as a way of knowing.

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)	10
Concept mapping (check #2)	10
Concept mapping (final)	20
Clinical interview questions	10
Clinical interview report	50
Presentation #1	100
Presentation #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 two formative assessment checks on the concept maps (see calendar for dates). The maps 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

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.
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 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 way. To reach this goal, teachers will present the ways they incorporate nature of science and scientific inquiry in their classes to their peers. Peers will conduct a "consultation" for the teacher, revealing and discussing strengths and weaknesses of their classroom activities. Teachers will be presenting two different lessons at two different times during the semester. To prepare for the presentation, teachers will bring lesson plans and any supporting materials needed for person outside to understand the lesson's intent, implementation, and assessment. Templates found at the end of

this syllabus should be used to provide framework for the other teachers about the lesson. At the end of the semester, all of the templates and lessons will be compiled into a resource book for all of the teachers to share.

4. Online Discussions

Half 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).

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. Since it is important to see the progression of student learning during the lessons, a sample lesson that took more than two days is ideal. 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?
- Do the samples result from more than one or two days of classroom work?
- 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

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

- An outline of what occurred in the class before and after the lesson (Template 1)
- A lesson plan of the presented lesson with expectations
- The assignment materials that were given to the students
- The rubric or assessment scheme the students received
- Three samples of student work with names whited-out for privacy purposes
    - One that exceeds your expectations
    - One that meets your expectations
    - One that does not yet meet your expectations

The Presentation

The presentation should begin by having the presenting teacher explain the population that was taught and an overview of the expectations of the lesson. Then the presenting teacher should pass out Template 1 and the full lesson plan. As the presenting teacher explains the outline and lesson plan, the group can interject clarifying questions. The group should save their comments about the planning and implementation of the lesson for the discussion period. After all members have a clear understanding of the lesson, the presenting teacher passes out the three student work products, but without the labels of exceeds, meets, or does not yet meet expectations.

The group can work independently or collaboratively to examine and comment on the alignment of the planned learning goals with the outcomes in the student products. Often as the group makes a judgment on which student product exceeds, meets, or does not yet meet expectations, issues arise about how well the students learned the intended content. 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 students and the teacher.

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
STUDENT WORK PRODUCTS

✓ 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?

TEMPLATE #3
TEACHER REFLECTION

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
February 3 Face-to-face	**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? Class Activities: Requirements of the Course Overview of Scientific Inquiry and the Nature of science ➢ Understanding Science: How Science Really Works http://undsci.berkeley.edu/ Conducting SI and NOS in the Classroom – online module Part 1 ➢ National Institutes of Health, (2005). Doing Science: The Process of Scientific Inquiry. http://science.education.nih.gov/Supplements/NIH6/inquiry/default.htm. *Assignments Due* ✓ *None*

February 10 Online	**Building Knowledge of SI/NOS** • How is classroom inquiry different from scientific inquiry? • What concepts about the scientific enterprise are appropriate for secondary students? Activities: 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* ➢ 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?* http://www.vast.org/content/File/v1n1/linkedwhole.pdf. ➢ Project 2061 – The Nature of Science http://www.project2061.org/publications/sfaa/online/chap1.htm *Assignments Due:* ✓ *Clinical interview questions (Post on Blackboard site)* ✓ *Respond to questions about readings on the Blackboard site*
February 17 Face-to-face	**What constitutes empirical evidence?** • What makes empirical evidence different from other forms of evidence? Activities: Reactions to Readings and Online Discussion Presentations on Lessons incorporating NOS and consultations 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 *Assignments Due:* • *Presentations (Not everyone will present each time – we will take turns until everyone gets two presentations)*

February 24 Online	**Empirical evidence** • How is evidence used in creating a scientific approach? Activities: Read about scientific approaches in making claims ➢ Lawson, Anton E. "A Scientific Approach to Teaching About Evolution & Special Creation". *The American Biology Teacher*, vol.61, no.4, April 1999, pages 266-274). Perform a student activity that requires empirical evidence to make claims ➢ The World IS really flat! http://www.indiana.edu/~ensiweb/lessons/flaterth.html *Assignments due:* ✓ *Responses to questions on Blackboard site*
March 3 Face-to-face	**Scientific knowledge is durable, but also tentative** • How tentative is scientific knowledge? Activities: Presentations of lessons incorporating NOS and consultations Lesson demonstrating tentativeness ➢ AAAS Science NetLinks – Abrupt Climate Change http://www.sciencenetlinks.com/lessons.php?Grade=9-12&BenchmarkID=1&DocID=323 Discussion ➢ How do scientists handle flux in major concepts? http://arstechnica.com/science/news/2006/10/5609.ars *Assignments Due:* ✓ *Presentations* ✓ *Concept Map Check #1*
March 10 Online	**Scientific knowledge is durable, but also tentative** • How tentative is scientific knowledge? Activities: Read about the different meanings of tentativeness ➢ http://physics.weber.edu/johnston/research/TheMultipleMeaningsOfTentativeScience_IHPSTfi.PDF Read about dealing with tentativeness when teaching science ➢ http://www.actionbioscience.org/education/allchin2.html *Assignments Due:* ✓ *Reponses to questions on Blackboard site* ✓ *Check in on Clinical Interview Report*

March 17 Face-to-face	**Laws and Theories** • What is the difference between theories and laws? Activities: Presentations of lessons incorporating NOS and consultations 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 Discussion about Theory, Law, and Hypothesis ➢ http://ola4.aacc.edu/jsfreeman/TheoryandLaw.htm *Assignments Due:* ✓ *Presentations*
March 24 Face-to-face	**Scientific Habits of Mind** • What habits of mind do scientists adopt? Activities: Presentations of lessons incorporating NOS and consultations 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 a mini-lesson showing how perception can be biased ➢ http://www.indiana.edu/~ensiweb/lessons/percep.html *Assignments Due:* ✓ *Presentations*
March 31 Online	**Theories and Laws** • What is the difference between theories and laws? **Habits of Mind** • What habits of mind do scientists adopt? Activities: 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?) Perform online lesson illustrating how scientists strive for accuracy ➢ Opinion surveys http://www.sciencenetlinks.com/lessons.php?Grade=9-12&BenchmarkID=12&DocID=451 *Assignments Due:* ✓ *Responses to questions on Blackboard*

April 7 No session Spring Break	
April 14 Face-to-face	**How do social and historical factors influence scientific knowledge?** Activities: Presentations of lessons incorporating NOS and consultations Perform activity on False assumptions based on social context that can make trouble in science ➢ http://www.indiana.edu/~ensiweb/natsc.fs.html 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 *Assignments Due:* ✓ *Presentations* ✓ *Concept Map Check #2*
April 21 Online	**Social/Historical factors** Activities: Read how to incorporate more issue based lessons in science ➢ http://www.actionbioscience.org/education/lewis.html Read Chapter 1 of Creativity in Science ➢ http://books.google.com/books?id=00KsMKjXxzYC&dq=creativity+in+science&printsec=frontcover&source=bl&ots=9w9bt_Cjk_&sig=GVmNgNN5JMgHyMPkgvDOth5XZyA&hl=en&ei=7zAYS--xDNDAlAe_u5nsAg&sa=X&oi=book_result&ct=result&resnum=9&ved=0CDoQ6AEwCA#v=onepage&q=&f=false *Assignments Due:* ✓ *Respond to challenges to create issue based and historically based lessons in science on Blackboard*

April 24th Face-to-face 10-3 pm	**Reflection on the Concepts** • SI/NOS connections • Empirical evidence • Tentativeness • Laws and Theories • Habits of Mind Activities: ➢ Presentations and consultations *Assignments Due:* ✓ *Presentations* ✓ *McComas, The Role and Character of Nature of Science in Science Education (available as PDF on Blackboard)*
April 28 Face-to-face	**In what ways are scientists creative?** Activities: Presentations incorporating NOS into lessons and consultations Ideas about incorporating Creativity into Scientific Inquiry ➢ Tobias Creativity PPT ➢ http://74.125.47.132/search?q=cache:Rl8wrUNAM28J:https://www.wpi.edu/News/Events/SENM/tobias.ppt+creativity+in+science&cd=11&hl=en&ct=clnk&gl=us *Assignments Due:* ✓ *Presentations* ✓ *Final Clinical Interview Report*
May 5 Online	**Creativity in science** Activities: Listen to a portion of PRI's Creativity in Science series ➢ http://www.publicbroadcasting.net/dfrw/.jukebox?action=viewPodcast&podcastId=15003 Listen to podcasts ➢ The Death Ray ➢ Plastics ➢ Biomimicry *Assignments Due:* ✓ *Respond to Creativity discussion board on Blackboard*

May 12 Face-to-face	**Wrap up and Celebration of Activities** Activities: ➢ A look back on the progress that was made ➢ Distribution of Lessons incorporating NOS *Assignments Due:* ✓ *Final Concept Map*

"Education is not a preparation for life; education is life itself." - John Dewey

OTHER RESOURCES

Barnekow, D. J. (1998). *Graphic organizers for science.* Portland, ME: J. Weston Walsh.

Bybee, R.W., Powell, J.C., & Trowbridge, L.W. (2008). *Teaching secondary school science: Strategies for developing scientific literacy.* Upper Saddle River, NJ: Pearson.

Cothron, J. H., Giese, R. N., Rezba, R. J. (2005). *Students and Research.* Dubuque, Iowa: Kendall/Hunt.

Hassard, J. (2005). *The art of teaching science: Inquiry and innovation in middle school and high school.* New York: Oxford University Press.

Johnson, D. W. & Johnson R. T. (1999). *Learning together and alone: Cooperative, competitive, and individualistic learning.* Boston: Allyn and Bacon.

Kagan, S. (1994). *Cooperative Learning.* San Clemente, CA: Resources for Teachers, Inc.

Keely, P., Eberle, F., & Farrin, L. (2005). *Uncovering student ideas in science: 25 formative assessment probes.* Arlington, VA: National Science Teacher Association Press.

Llewellyn, D. (2002). *Inquire within: Implementing inquiry-based science standards.* Thousand Oaks, CA: Corwin Press.

National Resource Council. (2005). *How Students Learn: Science in the Classroom.* Committee on *How People Learn,* A Targeted Report for Teachers, M.S. Donovan and J.D. Bransford, Editors. Division of Behavioral and Social Science and Education. Washington, DC: The National Academies Press.

Slavin, R. E. (1995). *Cooperative learning.* Boston: Allyn and Bacon.

Tomlinson, C. A. (1999). *The differentiated classroom: Responding to the needs of all learners.* Alexandria, VA: Association for Supervision and Curriculum Development.

Wiggins, G. & McTighe, J. (1998). *Understanding by design.* Alexandria, VA: Association for Supervision and Curriculum Development.