"What greater or better gift can we offer the Republic than to teach and instruct our youth?"
Cicero

George Mason University
College of Education and Human Development
Secondary Education Program

EDCI 473:001 Teaching Science in the Secondary School
Fall Semester, 2010

Instructor:	Dr. Stephen Burton
Date and Time:	(August 29 – December 10) Tuesdays 7:20-10 pm
Class Location:	Robinson A Room 412
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Office Hours:	By appointment

Text Resources

- Herr, N. (2008). *The sourcebook for teaching science: Strategies, activities and instructional resources (Grades 6-12).* San Francisco: Jossey-Bass.

Online Resources

- National Research Council (1996). *National science education standards*. Washington, DC: National Academy Press. Available online at http://www.nap.edu/openbook.php?record_id=4962

- Commonwealth of Virginia (2010). *Standards of Learning for Virginia Public Schools.* Richmond, Virginia. Retrieved on August 14, 2011 from http://www.doe.virginia.gov/testing/index.shtml

- Commonwealth of Virginia (2003). *Science Standards of Curriculum Framework Guides.* Retrieved on August 14, 2007 from http://www.pen.k12.va.us/VDOE/Instruction/sol.html#science.

- National Science Teachers' Association. *Science Class* newsletter. Retrieved on August 14, 2007 from http://www.nsta.org/publications/enewsletters.aspx.

- American Association for the Advancement of Science (1993). *Benchmarks for Science Literacy*. Retrieved on August 14, 2007 from http://www.project2061.org/tools/benchol/bolframe.htm.

- McComas, W. F. (1998). *The principle elements of the nature of science: Dispelling the myths.* Retrieved on August 14, 2007 from http://coehp.uark.edu/pase/TheMythsOfScience.pdf.

- Peters, E. E. (2006). *Why is teaching the nature of science so important?* Retrieved on August 14, 2007 from http://www.vast.org/content/File/v1n1/linkedwhole.pdf.

- American Chemical Society (2007). *Educators & Students page.* Retrieved on August 14, 2007 from http://www.chemistry.org/portal/a/c/s/1/educatorsandstudents.html.

- American Chemical Society (2003). *Safety in Academic Chemistry Laboratories Accident Prevention for Faculty and Administrators*. (800 227-5558) Free single copies or online: http://membership.acs.org/c/ccs/pubs/sacl_faculty.pdf

- U.S. Government Printing Office (2007). *Code of Federal Regulations.* Retrieved on August 14, 2007 from http://www.gpoaccess.gov/cfr/index.html.

- U.S. Department of Labor (2007). *Occupational Health and Safety Administration.* Retrieved on August 14, 2007 from http://www.osha.gov/.

- American National Standards Institute (2007). *American National Standards Institute Homepage.* Retrieved on August 14, 2007 from http://www.ansi.org/.

- Maryland Public Schools (2007). *Legal Aspects of Laboratory Safety.* Retrieved on August 14, 2007 from http://mdk12.org/instruction/curriculum/science/safety/legal.html.

Other articles/handouts will be distributed in class or posted on-line at the course website. (Your GMU email address is required for communication with the course instructor and for using Blackboard!)

Course Materials Online

The Blackboard site can be found at http://mymasonportal.gmu.edu. Use the same login as your GMU email. Materials will be added throughout the semester based upon needs from the course.

Course Description

EDCI 573 is the first course in a two-part sequence of science methods courses for pre-service and provisionally licensed science teachers. The course is designed to build fundamental knowledge of science teaching and learning including standards-based curriculum design and research-based teaching strategies. 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 science, implement lessons in a high school classroom, observe students learning, and evaluate their teaching and student outcomes. Field experience is a required part of this course.

Goals

The pre-service and provisionally licensed teacher will:

- Build a repertoire of science teaching and assessment strategies by reading, writing, observing, participating in, and reflecting on the teaching and learning of science; RESEARCH-BASED PRACTICE; SPA STANDARDS 1, 3, 5, 6, 8, 10
- 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; ETHICAL LEADERSHIP; INNOVATION; SPA STANDARDS 2, 3, 4
- Plan standards-based (local, state, and national) units of science study including daily lesson plans for students that reflect research in effective science teaching and learning; RESEARCH-BASED PRACTICE; SPA STANDARD 5, 6, 8, 10
- Construct science lessons that include alignment of objectives, activities, and assessments that address the needs of a variety of student populations including English language learner, special needs students, and gifted and talented students; ETHICAL LEADERSHIP; SPA STANDARDS 8, 10
- Learn about science laboratory safety and plan teaching activities that highlight safety; ETHICAL LEADERSHIP; SPA STANDARD 9
- Work collaboratively with peers to teach and discuss science and science teaching. COLLABORATION; SPA STANDARD 10
- Incorporate environmental sustainability into teaching paradigms and into daily life. SOCIAL JUSTICE; SPA STANDARD 4

Relationship to Program Goals and Professional Organizations

EDCI 573 is the first course in a two-course sequence of science methods courses for students seeking a secondary school teaching license in earth science, biology, chemistry, or physics. The course builds on students' knowledge of their subject matter. The course focuses on the teaching of science as called for by the state and national science standards and as outlined by the National Council for Accreditation of Teacher Education (NCATE), the National Science Teachers Association (NSTA), and the Interstate New Teacher Assessment and Support Consortium (INTASC). EDCI 573 builds a repertoire of science teaching and assessment strategies to facilitate student learning.

Nature of Course Delivery

A variety of teaching strategies will be used to explore the themes of the day. All students will continuously analyze and evaluate teaching strategies, as well as science content, processes, and ways of knowing in science.

Sustainability at GMU

George Mason University is focusing on making our community "greener" and reducing the impact on the environment. This course will contribute to this effort in the following ways. I hope that you will create other ways to contribute to contribute to this effort.

- Handouts will be available electronically through the Blackboard platform
- You should consider reducing waste in your teaching practice (ex: unnecessary paper) and in developing your unit plan
- Incorporate teaching sustainability in the content of your lesson plans (for example, human's role in reducing their impact on the environment.) Think about what the next generation needs to know about "greening".

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.

Field Experience Signup

The State of Virginia requires a number of hours of field work before you can do your internship. You will acquire 15 of those hours during this class. The university will place you in the field if you are not already teaching. EVERYONE needs to register on the website even if you are teaching, so that GMU has a record of where/when everyone did this 15 hours of field work.

The website to sign up is **http://cehd.gmu.edu/endorse/ferf.**

Learning Objectives:	Assessment:
A student will be able to consistently write measureable objectives	**Lesson Plan 3**
A student will be able to develop assessments aligned with measureable objectives	**Lesson Plan 3**
A student will be able to design a lesson in which students are actively engaged and follow a student-centered theory	**Lesson Plan 3**
A student will be able to use assessment data to evaluate student achievement of objectives	**Lesson Plan 3**
A student will be able to design a lesson in which students will learn characteristics of the nature of science	**Lesson Plan 3**
A student will be able to examine student achievement of objectives to evaluate and modify their lessons	**Microteaching Reflection Paper**
A student will be able to describe the safety issues and solutions for lessons	**Lesson Plan 3, Safety Assignment**
A student will be able to organize curriculum topics to build integrated student knowledge	**Planning Project**
A student will be able to explain the characteristics of the nature of science in context of actual science.	**Nature of Science Assignment**
A student will be able to be reflective about their own teaching and the teaching of others based upon evidence.	**Microteaching Reflection Paper, Field Experience Paper**

Grading

Since this is a graduate level course, high quality work and participation is expected on all assignments and in class. **Attendance at all classes for the entire class is a course expectation. For each unexcused absence, the course grade will be reduced by 5% points.** All assignments are graded. Each graded assignment will be assessed using a scoring rubric which will be handed out before the assignment is due. Approximately half the rubrics will be based on fulfilling the specified criteria for the project and half the rubric will be based on the quality of work. The rubrics are available on the Blackboard website at the beginning of the

semester. 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).

Assessments	Points	Due Date
Nature of Science Assignment	10	September 27th
Lesson Plan 1	5	October 4th
Lesson Plan 2	5	November 1st
Planning Project	10	November 15th
Safety Assignment	10	November 22nd
Lesson Plan 3	20	November 29th
Microteaching Paper	15	December 9th
Field Experience Report	20	December 9th
Professionalism	5	

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 a *major* percentage 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.

Feel free to submit assignments either electronically or as a hard copy. Considering the length of the Unit Plan it may be a good idea to submit it on disk, as two copies are required.

Some assignments ask for two copies to be submitted. One copy will be placed in the class collection for use by future students. If you choose, you may delete or otherwise conceal your name on the second copy of submitted assignments.

All written assignments are to be word-processed. Please use standard 12 point font (don't use "Chiller" or other poster font) and make your margins 1" on each side. All assignments should be double spaced and in APA format (check apa.org for more details). Make each project something that you will actually use in teaching.

1. Lesson Plans

The core goals of the class include:

- Write measurable objectives
- Write valid and reliable assessments
- Align assessments with the objectives
- Use data from the assessments to inform instruction
- Align activities with objectives and assessments
- Identify appropriate activities from a diverse repertoire of teaching methodologies

In this class, you will learn to write lesson plans that have appropriate objectives, activities, and assessments. You will be achieving these goals in a developmental way: (1) taking a poor lesson and improving it (5 points), (2) writing a lesson plan with a group with lots of support from the instructor (5 points), and (3) writing a lesson plan with a group with no instructor feedback (20 points). Detailed instructions for accomplishing these goals will be given in class. The lesson plan format and rubric can be found in this syllabus.

2. Microteaching

Research shows that the most effective teachers inform their practice by analyzing and reflecting on their teaching. Toward the end of the semester, you will work with a classmate to teach a 40 minute lesson that you have constructed with a partner. You will be videotaped so you have evidence to draw from for the analysis part of this assignment.

During the first 5 minutes of the lesson you will give an **overview** (orally and visually presented) of your lesson plans including standards and which part you are about to teach. For 30 minutes engage your classmates in **hands-on science** as if they were students at the grade level you teach. You will also need to assess the achievement of the objectives with some type of assessment that is aligned with the objectives. For the last 5 minutes, tell the class what **effective science teaching strategies** (orally and visually presented) you just demonstrated. This lesson will be **videotaped** for you. After you teach the lesson, you will review the videotape, and write a **5 page paper** that **describes** the teaching and learning goals you had for the lesson (about 1 page), **analyze** the lesson in terms of effectiveness using your assessment (about 3 pages), and **reflect** on improvements needed and successful events in the lesson (about 1 page). We will share highlights of the micro-teaching experiences on the last class.

3. The Planning Project

The **Planning Project** is a two-part project that includes an **annual plan and quarterly projects**. This project supports the massive planning effort that you have in getting your year started. For a class you are or will be teaching, plot on monthly planning schedules/calendars the science units of study including weekly topics. Then develop integrated quarterly projects that your student will do.

The **annual plan** is an outline of your plans for the year. For each science unit of study, indicate the length of time you predict that each unit will take and break that unit/time span into

weekly science topics. For example, a five-week unit on the five senses may have as weekly topics - sight, sound, taste, smell, and touch. **The annual plan outlines what you will teach, not how you will teach**. To get started, take monthly planning schedules/calendars and label each month, day, and school holiday. Then, indicate the science units and weekly topics you plan to cover on the monthly schedules. To assist you with this project consult school division, state, and national standards, content text books, and the Virginia Science Standards of Learning Curriculum Framework.

For the **four quarterly projects**, you will design a student project for each quarter that provides students with a unifying experience for the quarter. The projects should relate to the topics being studied during each quarter and should include a variety of learning strategies such as individual research papers or group presentations. For the projects, consider including science that is relevant to the social studies theme for the year, science that will enhance learning on a field trip, science fair projects (check out the *Students and Research* book for ideas), science demonstrations, and/or major science events of the year such as an eclipse. One of the topics should incorporate a sustainability project. While choosing topics, think big ideas!

4. Safety Assignment

A **Safety Plan** is necessary for the health and safety of your students and yourself, as well as, for legal reasons. You will put together a science safety portfolio which will include:

- A list of **safety rules/procedures** and a **safety contract** for the parents and students to sign and date (front and back of one page – ready to distribute to students). You may find the Flinn Scientific supply catalog helpful. The company is well known for their safety equipment and accompanying lessons.
- Analyses of science classroom safety cases (which will be given in class)
- A lesson analysis that requires you to look at three labs and analyze each lesson for safety, identifying the major aspects (one lab will be with animals a second will use chemicals and the third lab will be an earth science or physics lesson with materials).
- A safety related assignment that engages students and teaches the importance of safety in the science classroom (post the safety related assignments you identify on the blackboard site for other to use. You can then copy all of the assignments onto a flash drive for future use in your classroom. These lessons make wonderful "emergency lesson plans."
- Active maintenance of safety equipment in a science classroom (which will be performed in class).
- Analyses of science classroom safety cases (which will be given in class) - You are responsible for writing a half page reflection to each of the cases. Each reflection will be evaluated using the following rubric. You are required to earn an "acceptable" level of performance for each case. If an acceptable level is not earned, you may re-do the reflection.

  Case #1: Texas high school student dies of injuries sustained in alcohol fire. He was trying to refill the lamp while it was still lit

  Case #2: You have been given some snake skins. You would like to use them in class.

  Case #3: A student brought in an iguana to share.

  Case #4: You will be using balloon projectiles in class.

5. Nature of Science and Scientific Inquiry Assignment

Provide a product (lab write up, paper, presentation, poster) of an example where you think that you show that you have done scientific inquiry specifically in your certification field (biology, chemistry, earth science, physics). Provide a written reflection highlighting how your experience has assisted you in addressing the 9 core nature of science ideas (see table below). Further, describe in relative detail how you developed and used at least 10 of the science process skills (see table below). Finally, explain whether you feel that you might apply scientific inquiry in your classroom to teach a science concept.

NATURE OF SCIENCE

1. Science cannot answer all questions
2. Science employs multiple methods and types of reasoning that share many common factors, habits of mind and norms
3. Science produces, demands, and relies on empirical evidence
4. Scientific knowledge is tentative, durable, and self-correcting
5. Laws and theories are related but distinct kinds of scientific knowledge and play central roles
6. Science is a creative endeavor
7. Social, historical and cultural factors play a role in the construction of scientific knowledge
8. Science and technology are not the same but impact one another
9. Science has a subjective element

SCIENCE PROCESS SKILLS

- Classification – describes patterns in nature and is a human construct
- Measurement – standardized and reproducible way of collecting empirical evidence
- Observation – description of the natural world intended to be free from interpretation
- Analysis – interpreting empirical evidence
- Synthesis
- Using hypotheses to make predictions
- Generating falsifiable questions
- Finding appropriate resources/information/data to evaluate questions
- Generating falsifiable hypotheses
- Using models as a way to examine phenomena
- Identifying patterns
- Generating investigations and ability troubleshoot
- Dissemination of knowledge
- Generating inferences

6. Field Experience

The purpose of the field experience is to provide you with the opportunity to (1) connect the goals of EDCI 573, science education theories, concepts and research findings to

classroom/school practice, (2) to study and practice in a variety of classroom/school communities, and (3) to promote critical, self-reflection about your current and future teaching practice.

Your field experience should focus on two or more of the following:

1. the teaching process and teacher practices
2. implementing specific lesson plans
3. preparing and testing instructional materials with diverse learners
4. students' learning styles
5. student-student and student-teacher interactions
6. planning, implementing, and evaluating specific assessment instruments with diverse learners
7. teaching and learning with technology
8. students' behavior in a specific teaching/learning context
9. specific classroom management strategies
10. teacher interaction with students with special needs
11. teacher interaction with non-traditional students

You are required to observe and log-in a total of 15 hours, spread over the semester. During your field experience, you are required to keep detailed field notes, a log sheet indicating dates, times, subject area, grade levels, teachers' or principals' signatures and collect any relevant data.

At the end of your field experience, you are required to analyze your field notes as well as any other relevant data you collected and prepare a Field Experience Report. Your Field Experience Report must be between 4-5 pages in length excluding cover page, references and appendices. Your report must describe and discuss:

- your guiding study question,
- background and context of the class,
- procedure/method for how you took notes,
- how you made sense of your notes to find the themes you are writing about,
- summary of findings, and
- implications for your practice.

When possible you could volunteer as a science fair judge at a local science fair (more relevant in the spring than fall) as part of your 15 hours of field observation (not to exceed 3 hours). Keep your field notes in a file at home, and please be ready to provide them to the instructor if they are requested.

7. Professionalism

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. Your participation in these assignments is essential to valuable class discussions and will help to "chunk" the large assignments into smaller, more attainable learning goal. Your classmates depend on your comments to extend

their learning. Attendance for each class is necessary – please contact the professor BEFORE any absence.

DAILY LESSON PLAN

Date: **Subject:**
Title (optional)
Describe the lesson in one phrase.

Grade Level
Identify the grade level at which the lesson is aimed.

Virginia Standards of Learning
List the SOL Curriculum Framework Science Benchmarks that the lesson addresses – write the SOL in full so it can be compared with the objectives.

Science Content Objectives
Write a statement that describes the science content that students should know, be able to do, or value at the completion of the lesson (not activities students engage in during the lesson). Objectives must:

- be written with the form – "A STUDENT WILL BE ABLE TO…"
- be a measurable student outcome.
- be matched to the appropriate benchmarks/goals.
- guide the development of the assessment and lesson procedure.

Nature of Science Objectives:
Write a statement that describes the Nature of Science content that students should know, be able to do, or value at the completion of the lesson (not activities students engage in during the lesson). For the nature science characteristics and process skills, refer to McComas 2004. Objectives must:

- be written with the form – "A STUDENT WILL BE ABLE TO…"
- be a measurable student outcome.
- be matched to the appropriate benchmarks/goals.
- guide the development of the assessment and lesson procedure.

Materials and Setup
List all materials needed to teach the lesson including:

- how many/how much of each.
- the source of supplies not available at typical stores (Meijer or Target).
- how materials will be prepared, distributed, and managed throughout the lesson.

Safety
Describe applicable chemical, electrical, biological, and general safety precautions, disposal procedures, and required safety equipment (goggles, aprons, gloves, etc.).

Requisite Knowledge/skills for students
Describe the critical content knowledge (beyond the obvious) students should already possess for this lesson to be successful.

Procedure
Describe class activities pointing out what students and teacher does during the lesson in enough detail to guide other teachers. Lessons may span one or more class meetings. Give time estimates (in minutes) for Engage, Explore, Explain, and Elaborate.

Engage:
An activity (questions, demonstration, video clip, etc.) that captures the students' interest and elicits students' prior knowledge related to the concepts in the lesson.

- Aligns with lesson objectives
- List questions that the teacher can ask during the activity to:
  - Generates interest and curiosity
  - Raises relevant questions
  - Assesses current knowledge
  - Exposes misconceptions

Explore:
Student-centered activities designed such that students collect evidence to answer scientific questions including how the teacher will facilitate the explorations.

- Aligns with lesson objectives and "Engage"
- Activities are student-focused, hands-on, inquiry-based, and often done in groups
- Students make observations, collect data, hypothesize, predict, discuss
- Includes possible questions to probe, guide, and redirect students' thinking or work

Explain:
Activities to help students articulate findings based on their evidence and connect their findings to scientific explanations. This may include, but is not limited to, sharing and justifying hypotheses, formalizing definitions, whole-class sharing, consulting resources to help explain observations, questioning other students, etc.

- Aligns with lesson objectives, "Engage" and "Explore"
- Students discuss results of "Explore" activities in their own terms
- Student analysis and explanation based on their evidence
- Provides grade-appropriate scientific explanations and vocabulary

Elaborate (Apply, Extend):
Activities that allow students to apply scientific concepts, skills, and vocabulary to new situations. Examples are additional questions, considering alternative hypotheses or contexts, or related explorations.

- Aligns with objectives, "Engage," "Explore" and "Explain"
- Possibly modify and improve conceptual understanding
- Large and small group discussions are key elements.

Evaluate:
Formative and summative assessment to determine if students have met the learning objectives of this lesson. This process occurs potentially at every stage of 5 Es and **not** just at the end.

Identify evaluation activities within your procedure. Provide a detailed description of varied methods used to collect data about students' understanding of the concepts and skills the students should gain (or change) through the lesson.

- Data collected will help determine if objectives were achieved by the students.
- Assessments will be incorporated throughout the lesson.
- Include opportunities for students to evaluate their own work and learning.
- Provide detailed descriptions of the assessments being used (e.g., questions, performance, products, etc.).
- Include answer keys, grading rubrics, or other criteria you will use to evaluate whether students have met the objective(s).

References

Provide a complete list of science and teaching sources you used in your lesson plan including books, journals, web sites, personal communications cited in APA format (Wisconsin, n.d.). These correspond to in-text citations including the author and publication year in parentheses. Please refer to model lessons for examples.

All lesson plans are expected to be the original work of the student. Any resources used must be cited. Furthermore, if you quote a definition or passage, you must fully explain its significance to your work, *in your own words.* Failure to do so is considered plagiarism and will be handled according to university policies.

Integrated Science Lesson Plan Scoring Rubric

Element	Distinguished	Proficient	Insufficient	Unacceptable
Content Objectives	All objectives are clearly measurable Science content is at the appropriate level Objectives are written beyond the knowledge level of blooms	Some objectives are clearly measurable Science content is at the appropriate level	None of the objectives are measurable	Objectives Absent
Nature of Science Objectives	All objectives are clearly measurable Nature of Science identified is appropriate for the lesson Objectives are written beyond the knowledge level of blooms	Some objectives are clearly measurable Nature of Science identified is appropriate for the lesson	None of the objectives are measurable	Objectives Absent
Materials and setup	A complete inventory of needed materials including the source of supplies not available at typical stores. A detailed description of how materials will be prepared, distributed, and managed.	Inventory is nearly complete and sources are provided. The description of how materials will be prepared, distributed, and managed is provided but lacks minor details.	Inventory is appreciably incomplete and sources are lacking. The description of how materials will be prepared, distributed, and managed is incomplete or lacking.	No inventory. No sources. No description of how materials will be prepared, distributed, and managed
Safety	Describe applicable chemical, electrical, biological, and general safety precautions, disposal procedures, and required safety equipment (goggles, aprons, gloves, etc.).	Safety must be addressed at the proficient level or the lesson will be rejected. In the case of no safety issues, this must be clearly stated in the lesson.		
Requisite Knowledge	Clearly and Completely Describe the critical content knowledge (beyond the obvious) students should already possess for this lesson to be successful.	Description of critical content knowledge is nearly complete and is clearly stated.	Description of critical content knowledge is appreciably incomplete and is unclear.	Lacks a description of requisite knowledge.
Procedure	Clearly describe class activities specifying what students and teacher does during the lesson in enough detail to guide other teachers.	Adequately describe class activities specifying what students and teacher does during the lesson in enough detail to guide other teachers.	Poorly describe class activities, lacking what students and teacher does during the lesson in enough detail to guide other teachers.	Lacks description of class activity and the roles of teachers and students. Other teachers at a loss, classroom management hopeless.

Engage	A clear and complete description of the activities and questions that accomplishes all of the following: Generates interest and curiosity Raises relevant questions Assesses current knowledge Exposes misconceptions	A good description of the activities and questions that accomplishes most of the following: Generates interest and curiosity Raises relevant questions Assesses current knowledge Exposes misconceptions	An incomplete description of the activities and questions that accomplishes only one or two of the following: Generates interest and curiosity Raises relevant questions Assesses current knowledge Exposes misconceptions	Uninteresting, poorly designed activity that does not raise relevant questions, assesses current knowledge, or identifies misconceptions.
Explore	A clear complete description of Activities that are student-focused, hands-on, inquiry-based, and often done in groups. Students do many of the following: make observations, collect data, hypothesize, predict, discuss. Includes numerous questions to probe, guide, and redirect students' thinking or work	A good description of Activities that are student-focused, hands-on, inquiry-based, and often done in groups. Students do at least three of the following: make observations, collect data, hypothesize, predict, discuss. Includes some questions to probe, guide, and redirect students' thinking or work	An incomplete description of Some activities are not student-focused, hands-on, inquiry-based. Students do one or two of the following: make observations, collect data, hypothesize, predict, discuss. Lacks questions to probe, guide, and redirect students' thinking or work	Teacher directed, lacks inquiry, passive, and no guidance of students by questioning.
Explain	Clearly and completely describes how teacher will facilitate students discussing results of "Explore" activities in their own terms Clearly and completely describes how the teacher will facilitate student analysis and explanations based on their evidence Provides grade-appropriate scientific explanations and vocabulary	A good description of how teacher will facilitate students discussing results of "Explore" activities in their own terms A good description of how the teacher will facilitate student analysis and explanations based on their evidence Provides good grade-appropriate scientific explanations and vocabulary	An incomplete description of how teacher will facilitate students discussing results of "Explore" activities in their own terms A poor description of how the teacher will facilitate student analysis and explanations based on their evidence Inadequate grade-appropriate scientific explanations and vocabulary	Lacks description of how teacher will facilitate students discussing results of "Explore" activities in their own terms Lacks a description of how the teacher will facilitate student analysis and explanations based on their evidence Lacks grade-appropriate scientific explanations and vocabulary

Elaborate (Apply / Extend)	Clearly and completely describes activities that will encourage students to apply scientific concepts, skills, and vocabulary to new situations as well as possibly modify and improve conceptual understanding. Includes activities for large and/or small groups.	Description of activities is not clear; however the activity is sound and seemingly effective and includes activities for small and/or large groups.	Description is neither clear nor complete OR it is complete and clear but is not sound nor seemingly effective.	Activities do not engender the students to apply scientific concepts to new situations OR none of the descriptions of activities are clear or complete.
Evaluate	Assessments are varied and creative. All assessments measure student achievement of each objective Clear and complete descriptions of the assessments being used (e.g., questions, performance, products, etc. including answer keys, grading rubrics, or other criteria you will use to evaluate whether students have met the objective(s)). Assessments take place throughout the 5 E lesson. Include opportunities for students to evaluate their own work and learning. Clearly and completely describes where, how, and when assessment takes place	Assessments are varied AND Most assessments measure student achievement of each objective AND/OR Most of the descriptions of the assessments being used are clear and complete. Assessments take place throughout the 5 E lesson. Include opportunities for students to evaluate their own work and learning. AND Most descriptions of where, how, and when assessment takes place are clear and complete.	Assessments are not varied OR Few assessments measure student achievement of each objective OR Few of the descriptions of the assessments being used are clear and complete Few assessments occur in the 5 E lesson OR There are few opportunities for students to evaluate their own work and learning. OR Few descriptions of where, how, and when assessment takes place are clear and complete.	Assessments absent OR Assessments do not measure student achievement of each objective OR None of the descriptions of the assessments being used are clear and complete No assessments occur in the 5 E lesson OR There are no opportunities for students to evaluate their own work and learning. OR None of the descriptions of where, how, and when assessment takes place are clear and complete.
References	Provides a complete list of science and teaching sources used in the lesson plan including books, journals, web sites, personal communications cited in APA format. Reference list indicates depth, quality, and variety in resources used.	Provides a complete list of science and teaching sources used in the lesson plan including books, journals, web sites, personal communications cited in APA format.	Provides a list of science and teaching sources used in the lesson plan including books, journals, web sites, personal communications, but some citations may be missing, incomplete or not in APA format.	Reference list is not included or is missing many citations, making authentication of original sources difficult or impossible.
Style	Very clearly written containing only a few grammatical, syntax, and spelling errors.	Clearly written containing some grammatical, syntax, and spelling errors.	Somewhat clearly written containing many grammatical, syntax, and spelling errors.	Unclearly written and riddled grammatical, syntax, and spelling errors.

Alignment	(1) Objectives, (2) engage, (3) explore, (4) explain, (5) elaborate, (6) evaluate/assessments, and (7) scientific explanation are well-aligned, support one another, and tie directly to the benchmark(s).	Five or six of the key elements are aligned with the benchmark.	Four of the key elements are aligned.	Three or fewer of the three key elements are aligned.
Originality	A majority of the content in the lesson plan is original or previously published content is adapted/incorporated in a novel manner.	Some of the content in the lesson plan is original or previously published content is adapted/incorporated in a novel manner.	N/A	None of the content in the lesson plan is original, or adapted in a novel manner.

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.

McComas 2008. Proposal for core nature of science content in popular books on the history and philosophy of science: lessons for science education. In Lee, Y.J. & Tan, A.L. (Eds.) *Science education at the nexus of theory and practice.* Rotterdam: Sense Publishers.

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.

SCHEDULE
(PLANS MAY CHANGE ACCORDING TO STUDENT NEEDS)

Date	Class topics	Readings (due on the listed week)	Work Due (due on the listed week)
August 30	-Syllabus -Student-centered learning -Role of Objectives and Assessment	1. Syllabus 2. Herr pp. 517-528	
September 6	-Nature of Science -How Students Learn Science -A Private Universe	1. Blackboard postings on How Students Learn Science 2. McComas Paper • All documents in Folder 2- Nature of Science (Course Content Button)	1. Measureable objectives
September 13	-Standards of Learning -AAAS Atlas and Benchmarks -Reflection on cookbook and student-centered lesson	1. Herr pp. 496-498 2. Herr pp. 106-142 3. Pendulums	1. Reflection on a student-centered philosophy 2. Review Virginia Standards of Learning for your content area 3. Review National Science Education Standards - both VA SOLs and NSES are found on the links on this syllabus
September 20	-Backwards Design -Assessment	1. Blackboard Postings	1. Objectives and assessments for first lesson plan (team submission) 2. Clinical Interview questions
September 27	-Planning lessons -Organizational Structure 5-E -Pacing Guides -Biomes and Climate	1. Skim *National Science Education Standards* 2. Bloom's Taxonomy handout 3. Herr pp. 517-528 4. Blackboard Postings 5.	1. NOS Assignment
October 4	-Planning lessons	1. Blackboard Postings	1. Lesson Plan 1 with

		2. Herr pp 458-470	aligned Objectives and Assessments (team submissions)
October 11 – No Class – Monday classes meet on Tuesday because of Columbus Day Holiday – Tuesday classes do not meet			
October 18	-Writing Lessons 1. Inquiry 2. Cookbook labs	2. Blackboard Postings 3. Herr pp 458-470	
October 25	-Writing Lessons • Cooperative Learning • Direct Instruction • Demonstrations	1. Blackboard Postings	1. Clinical Interview Paper
November 1	- Planning lessons		1. Lesson Plan 2 with aligned Objectives and Assessments (team submissions)
November 8	-Organizing curriculum – Backwards design revisited		
November 15	-Safety discussion -Microteaching presentations and reflection		1. Planning Project
November 22	Safety (online – no formal class meeting)	Herr pp. 529-547	1. Safety Assignment
November 29	-Microteaching presentations and reflection		
December 6	-Microteaching presentations and reflection		1. Field Experience Report 2. Lesson Plan 3 with aligned Objectives and Assessments (team submissions) 3. Microteaching Paper – (individual submissions)

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