EDFS 456: Teaching Strategies for Science and Mathematics

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Required Science Texts: Rutherford & Aldredge, Science for all Americans & Benchmarks
Chiapetta, E. & Koballa, T., Science Instruction in the Middle and Secondary Schools

Required Math Texts: NCTM, Curriculum and Evaluation Standards for School Mathematics

Course Intent

EDFS 456 is designed to unify science and mathematics content and thought with teaching practices that emphasize equity of outcome with high content expectations for all. The planned weekly sessions emphasize the natures of science and mathematics through the use of the laboratory, community, technology and research. Overall this course is designed to guide and develop the skills necessary to effectively teach secondary science and/or mathematics. You will be required to analyze, synthesize and evaluate all the theoretical education work you completed in previous education courses and put it to practical use for this course. Then you will apply the theory and practice in a classroom with a practicing teacher.

Objectives

I. As a science teacher you will:

A. Perform science as inquiry
   1. ask questions
   2. plan and conduct investigations
   3. use appropriate tools and techniques to gather data
   4. think critically and logically about relationships between evidence and explanations
   5. construct and analyze alternative explanations
   6. communicate scientific arguments and explanations
   7. understand scientific inquiry by the ability to identify and communicate a problem and to design, implement and evaluate a solution

B. Use the content of Science and Technology:
   1. distinguish between natural objects and objects made by humans
   2. use your ability to understand the strengths and limitations of technology and technological design
   3. understand the relationship between science and technology

C. Develop understanding about Science in Personal and Social Perspectives:
   1. types of resources
   2. changes in environment(s)
   3. local challenges

D. Use the History and Nature of Science:
   1. science as a human endeavor

E. Gain the ability to plan an inquiry-based science program for the public school students:
   1. develop a framework of year long and short term goals for the students with which you will be working
   2. select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of the students
   3. select teaching and assessment strategies that support the development of student understanding and nurture a community of science learners
   4. work together as colleagues within and across disciplines and grade levels
II. As a mathematics teacher you will:

A. understand the importance of the NCTM’s Principles and Standards for School Mathematics
B. learn and practice techniques used to implement the NCTM’s standards and the South Carolina Standards in Mathematics in Grades 7-12 both within the present day middle and secondary school curriculum
C. develop and practice way of effectively using and adapting different methods of instruction, including cooperative learning and working with instructional aids including technology and manipulatives to meet the needs of all students in mathematics in both block and traditional class schedules
D. learn how to use the learning cycle approach to develop lesson plans that are performance based and incorporate manipulatives, visual aids, technology and multicultural aspects of mathematics in order to teach math to all children
E. learn how to develop multiple assessment strategies to assess 7-12 students’ understanding of mathematics and to provide performance data that can be used for formative and summative purposes
F. learn about the opportunities for professional growth in mathematics education through membership and active participation in the many professional organizations for mathematics educators so that learning is seen as a life-long process

III. As a science or mathematics teacher you will:

A. Guide and facilitate learning:
   1. focus and support inquiries while interacting with students
   2. orchestrate discourse among students about scientific and mathematic ideas
   3. challenge students to accept and share responsibility for their own learning
   4. recognize and respond to student diversity and encourage all students to participate fully in learning
   5. encourage and model the skills of inquiry, as well as curiosity, openness to new ideas and data, and skepticism that characterize science.

B. Engage in the ongoing assessment of your own teaching and of the students’ learning:
   1. use multiple methods and systematically gather data about student understanding ability
   2. analyze assessment data to guide teaching
   3. guide students in self-assessment
   4. use student data, observations of teaching, and interactions with colleagues to report student achievement
   5. know the naïve theories and misconceptions most children have about scientific, mathematical and technological phenomena and help children build understanding

C. Design and manage learning environments that provide students with the time, space, and resources needed for learning science and mathematics:
   1. structure the time available so that students are able to engage in extended investigations
   2. create a setting for student work that is flexible and supportive of scientific inquiry
   3. ensure a safe working environment
   4. make the available science tools, materials, media, and technological resources accessible to students
   5. identify and use resources outside the school
   6. engage students in designing the learning environment

D. Develop communities of science and math learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science and mathematics learning:
   1. display and demand respect for the diverse ideas, skills, and experiences of all students
   2. enable students to have a significant voice in decisions about the content and context of their work and require students to take responsibility for the learning of all members of the community
   3. nurture collaboration among students
   4. structure and facilitate ongoing formal and informal discussion based on a shared understanding of the rules of scientific discourse
   5. model and emphasize the skill, attitudes, and values of scientific inquiry
**Classroom Format**

The class runs for three hours once a week. Plan to attend all sessions for the entire time. There are no formal breaks. If you must miss one session please inform me and either get the notes and handouts from a classmate or see me. It is imperative that you regularly attend and participate in class. You can lose up to 2 letter grades for failure to attend and participate. The activities and pedagogies are not something that you can read and learn. You will fail the course if you fail the practicum portion of the course. Science students must also pass the safety test with a 92%.

The materials assigned are to be read before arriving in class. This will allow you time to think about the ideas you are about to experience. It will also help you to understand that the words on the page do not come alive until you do them. There are weekly discussions that will assist with the reading and understanding process that will be due through the D2L discussions. These are due weekly prior to attending class.

**Assignment for science students only:**

**Safety Test**

A test covering laboratory safety will be conducted. Students must attain a 92% or higher on this test for satisfactory completion. Students scoring lower than 92% will be required to retake the exam.

**Assignment for math students only:**

**Mathematics as a language**

You will write and teach a lesson that utilizes your knowledge of the language of mathematics that expressly assists others in learning this language.

**Assignments to be completed by all**

**Practicum experience**

(see attached guidelines)

- **Laboratory Write Up** The formal written plan will be on D2L. Your plan will be produced for the laboratory that you chose from within your content area and anticipated teaching area. Choose one that your practicing teacher is interested in reviewing. (Science Students)
- **Manipulative based lesson plan**
  You will write a lesson plan to teach a specific concept in mathematics manipulative. You will test your lesson plan by teaching your peers in class. The level of this lesson plan must be 9th grade algebra or higher. (Math Students)
- **Inquiry lesson of level 1 or higher**
  (see attached guidelines you will submit 3 written plans)

**Final Paper**

Write a documented description of the nature of science and mathematics.

- **Sources should include:**
  - Your journal record kept during practicum and after each class
  - Articles from class
  - Excerpts/thoughts from SFA/Benchmarks and CESforSM
  - Excerpts/thoughts from your textbook

- **Your paper should answer the following questions:**
  1. What ideas caused you to feel dissonance with regard to the way you believed science/math and science/math teaching worked for you or did not work for you during your school years?
  2. What ideas caused you to feel resonance with regard to the way you believed science/math and science/math teaching worked for you or did not work for you during your school years?
  3. What does your resonance and dissonance inform you about your beliefs about science/math teaching and learning?
  4. What were the pedagogies used? (Use very detailed descriptions)
  5. What match/mismatch(s) developed among your personal beliefs and your beliefs about the teaching and learning of science/math?
  6. Write a final section explaining how what you have learned this semester will look in your new classroom.
Summary of assessment

Attendance and Participation (graded via attendance & online discussions) 20 pts
Math as a language (Math only) 10 pts
Safety Test (Science only) 10 pts
Textbook reading confirmation (Quiz, Participation, etc) 10 pts
Integrated lesson plan 10 pts
Practicum experience (Time sheets, Teacher evaluation) 20 pts
  Inquiry lesson plans--3 10 pts
  Videotape of your teaching an inquiry lesson 10 pts
  Manipulatives lesson plan (Math) or Laboratory write-up (Science) 10 pts
Final paper 10 pts

The total possible points are 110. All School of Education grading policies will be followed with regard to assignment of a letter grade. All School of Education honor codes will also be followed.

Class attendance and participation

Each student is to attend class regularly and on time. It is imperative that you participate in large and small group discussion and activities. The method(s) of teaching that you will be learning are different from methods that you have learned in other courses so your participation is mandatory. I record your attendance and participation after each class session. You can lose up to two letter grades by failing to attend and participate.
<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Questions to ponder</th>
<th>Science Readings</th>
<th>Math Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 27th</td>
<td>Introduction Practicum Requirements Cube Activity Adolescent development</td>
<td>What does it mean to teach for all? What are students like in the age range I plan to teach? What do adolescent characteristics have to do with the way I teach? What does the brain research say?</td>
<td>Text 1, 2</td>
<td>Text 1</td>
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<tr>
<td>September 3rd</td>
<td>Inquiry—Level 2 and 3 Pretzel Pretzel debriefing Rolling down a hill</td>
<td>What is the nature of inquiry in your discipline? How did I learn that? What is an inquiry level? How do I get the resources to teach using inquiry methods?</td>
<td>Text 4 Benchmark 1</td>
<td>NCTM pp 1-12 Text 2</td>
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<tr>
<td>September 10th</td>
<td>Soils lab Soils debriefing Cooperative learning</td>
<td>What makes a lesson relevant to a student’s everyday life?</td>
<td>Text 3 Benchmark 10</td>
<td>Text 3</td>
</tr>
<tr>
<td>September 17th</td>
<td>Collaborative learning Attribute blocks</td>
<td>What does the literature say? How does it work? Why does learning work more effectively and efficiently with integrated lesson plans?</td>
<td>Text 5 SFA 10</td>
<td>Text 3</td>
</tr>
<tr>
<td>September 24th</td>
<td>Laboratory management and techniques Create microscale lab Geo/Alg using Tech</td>
<td>What is microscale? How do I handle these materials? How do I know my students learned? What do I need to know to be safe in the lab?</td>
<td>Text 12 SFA 1</td>
<td>Text 5</td>
</tr>
<tr>
<td>October 1st</td>
<td>Safety test Develop manipulative lesson plan Inquiry level 3 Tangrams Inquiry Beads</td>
<td>How do I match the nature of my discipline with my teaching?</td>
<td>SFA 13 NCTM Standard 1</td>
<td>Text 4</td>
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<tr>
<td>October 8th</td>
<td>Peer Coaching Field notes Reflective teaching Questioning techniques</td>
<td>What is peer coaching, etc.? How do I take field notes? Ethics in the classroom? What do I need to know about questioning?</td>
<td>Text 8 NCTM Standard or Reasoning and disposition</td>
<td>Text 6</td>
</tr>
<tr>
<td>October 22nd</td>
<td>Teaching ELL’s</td>
<td>Write lesson plans</td>
<td>Text 9 Benchmark 3,11</td>
<td>Text 7</td>
</tr>
<tr>
<td>October 29th</td>
<td>Present lessons</td>
<td>Using a rubric to check amounts of teacher/student action</td>
<td>Text 7 SFA 12</td>
<td>NCTM remaining standards Text 8</td>
</tr>
<tr>
<td>November 5th</td>
<td>Using your interests to help you Voice lesson</td>
<td>What do I have to do to team teach a lesson? What is available? Why should I choose this?</td>
<td>Text 10</td>
<td>Text 9</td>
</tr>
<tr>
<td>November 12th</td>
<td>Team teaching Create team lesson Probeware</td>
<td>What is it like to work with teachers from other disciplines??</td>
<td>Text 11</td>
<td>Text 10</td>
</tr>
<tr>
<td>November 19th</td>
<td>Create integrated plan</td>
<td>How does all of this tie together? What makes teaching so complex? How do I keep from losing my mind?</td>
<td>Text 13 Benchmark 7</td>
<td>Text 11</td>
</tr>
</tbody>
</table>
1. **Practicum Experience**

The practicum experience consists of a minimum of **50 hours**. Students are required to keep a **practicum log** including date, time, teacher, and lesson description. You must **teach 3 lessons** that your teacher approved. You must **videotape one** of these lessons and submit it to the course instructor.

2. **Videotape and analysis**—Tape a class that you designed an inquiry lesson for, use all the criteria discussed during the semester and evaluate your effectiveness at teaching science/mathematics in a manner consistent with your beliefs about the nature of science/mathematics.

Below are some fundamental questions you can ask of each lesson to assist in identifying the science and mathematics during a teaching session. Always supply descriptive evidence to support your answer(s)!

A. **Content**

1. Does the lesson allow students to explore events, concepts, issues and themes from multiple perspectives?
2. Are the perspectives broad enough so that the students don’t end up inadvertently creating new stereotypes of different groups?
3. Does the lesson/unit reflect the lives of the students? Is it meaningful to them?
4. Is it in-depth enough to meet the rigorous standards that give them the opportunity to advance in a career or profession?

B. **Instructional Strategies**

1. Does the teacher hold high expectations for all students?
2. Are a variety of pedagogy and learning activities provided?
3. Are the 5 e’s (or another learning cycle lesson plan) present in the teacher’s actions?
4. Does the pedagogy match the content?
5. Is the teacher tactful when working with the students?

C. **Assessment**

1. Are assessments done using a variety of techniques--written, oral, portfolio, performances, projects, observations, etc?
2. Are assessments on going, formative and summative?
3. Do the assessments match the learning?
4. Do the assessments continue the learning or stop the learning?

Following your inquiry lesson you will complete a written self-evaluation on the lesson. The following questions should be answered:

1. What about your lesson was effective? Why? How do you know?
2. What about your lesson was ineffective? Why? What is your evidence?
3. How would you change your lesson if you taught it again? Explain.
4. Describe the general student response to your lesson.
5. Describe student success on your assessments of the lesson.
3. Inquiry Lesson Plans (3)—Write an activity that teaches about the nature of science/math for use in your classroom.

Explain the components of the nature of science/math that you are teaching. You must use one of the learning cycle lesson plan formats. As part of this class, thinking about teaching and learning is an essential element of observation. Observation means to examine, monitor, scrutinize, perceive, in-depth answer to the basic question, “What is happening here?”

These observations then will be used to assist you, the teacher, in discerning the learning that is occurring. This means you will be constantly diagnosing, (meaning to analyze, assess, determine, probe, solve, understand) what the learner is doing as well as what the teacher is doing.

We are asking you to complete these observations in various settings. You will observe in this class, in other classrooms, and in general living situations. To assist you in this endeavor we are providing you with two general outlines as a place to begin, as a class we will expand the outline and you as an individual may also chose additional ideas to include as your are observing.

The first outline is about what I call a lesson plan. To others the outline is a way of thinking about teaching and learning in a classroom. The reason we are going to use this outline is that teachers who use this form of thinking about teaching and learning tend to get results with ALL students. One of our goals for this institute is to ensure that participants have access to methods that assist with learning for all. The format in the education literature is the learning cycle. The lesson plan format can take many forms. The form we will use for this institute is named the 5 e’s. The model is not linear even though it looks that way on paper. Excellent teachers who get results repeat or loop back through any of the 5 e’s as many times as necessary to achieve their goal. This format is useful in 15-minute situations and in yearlong in-depth studies.

The 5 e’s are engage, explore, explain, expand and evaluate. It is not and should not be thought of as equivalent to any of the behaviorist lesson plans that you are more likely familiar with. You will want to explore this idea of a non-behaviorist lesson plan in depth and challenge your assumptions and ours about what it means to teach in a non-behaviorist way and what results you can achieve. We want you to challenge your assumptions about “who” can learn “what” via which methods. We want you to challenge your assumptions about using only one lesson plan format.

We want you to enjoy the idea that your are being asked to think and think deeply about that same question, “What is happening here?” every time you see this model in practice, including when you use the model. We want you to look at yourself through these same lenses. We want you to know that it is not always comfortable to do these tasks. We want you to know that we are each learning from each other, just as you are learning from us. Ask questions, raise issues, gain a positive belief set about what our children in South Carolina can and will do if we challenge them.
### 5 e’s approach to teaching and learning:

<table>
<thead>
<tr>
<th>Teacher Behavior</th>
<th>Student Behavior</th>
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<tbody>
<tr>
<td><strong>Engage</strong></td>
<td><strong>Engage</strong></td>
</tr>
<tr>
<td>- create an interest in topic/lesson</td>
<td>- show interest in the topic/lesson</td>
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<tr>
<td>- raise questions</td>
<td>- ask questions, answer questions</td>
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<tr>
<td>- elicit what children know about the topic</td>
<td>- tell what they know about the topic</td>
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<tr>
<td>- cause curiosity</td>
<td>- be curious</td>
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<tr>
<td><strong>Explore</strong></td>
<td><strong>Explore</strong></td>
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<tr>
<td>- encourage children to work together</td>
<td>- work together to solve problems</td>
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<tr>
<td>- observe and listen to the children</td>
<td>- think freely about the topic</td>
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<tr>
<td>- ask questions to extend thinking</td>
<td>- record observations and ideas</td>
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<tr>
<td>- make sure children have supplies</td>
<td>- listen critically to others’ ideas</td>
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<tr>
<td><strong>Explain</strong></td>
<td><strong>Explain</strong></td>
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<tr>
<td>- have children explain in their own words</td>
<td>- explain possible solutions to others</td>
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<tr>
<td>- have children define in their own words</td>
<td>- use observations and data in word explanations</td>
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<tr>
<td>- use children’s previous experiences and understandings to explain concepts</td>
<td>- listen critically to others’ explanation</td>
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<tr>
<td>- provide formal labels after children have described the concept</td>
<td>- compare to personal explanation</td>
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<tr>
<td><strong>Expand</strong></td>
<td><strong>Expand</strong></td>
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<tr>
<td>- encourage children to apply and extend learnings to new situations</td>
<td>- apply new learning in new but similar situations</td>
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<tr>
<td>- remind children to think of alternatives</td>
<td>- think of alternatives</td>
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<tr>
<td>- expect children to use formal labels</td>
<td>- use the new formal labels</td>
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<tr>
<td>- ask “What do you think about...” &amp; “Why”</td>
<td>- make reasoned conclusions</td>
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<tr>
<td>- record additional observations and explanations</td>
<td>- discuss investigations and conclusions with peers</td>
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<tr>
<td><strong>Evaluate</strong></td>
<td><strong>Evaluate</strong></td>
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<tr>
<td>- observe and record as children apply what they know</td>
<td>- have children draw, write, speak, &amp; show new learnings</td>
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<tr>
<td>- look for evidence that children have changed their thinking and understanding of new learnings</td>
<td>- demonstrate reasoning</td>
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<tr>
<td>- encourage children to self-evaluate</td>
<td>- evaluate own progress and learning</td>
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<tr>
<td>- ask open-ended questions to assess</td>
<td>- answer open-ended questions</td>
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<tr>
<td>- make sure the evaluation looks like the learning</td>
<td>- make sure the evaluation looks like the learning</td>
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</table>