Course: EDUC 267F: The Development of Scientific Reasoning and Knowledge.

Instructors

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Course Times: Winter Quarter: Friday Jan 13, 20, 27 Feb 3, 10 & 17: 9.30-12.20

Office Hours: By appointment – please e-mail one or other of us or make an arrangement after class.

Course Description

The focus of the second part of the course will be on developing your competence and confidence to teach science. Thus we will spend some time giving you an opportunity to develop your own knowledge of science. The approach to this will be to model some of the practices that you might use with your students and the emphasis will be on developing your ability to help students engage in scientific practices. Thus we will look at what you need to think about when it comes to the eight practices that are a feature of the Next Generation Science Standards (NGSS) for science which are:

1. Asking Questions & Defining Problems
2. Developing and Using Models
3. Planning and Carrying out Investigations
4. Analyzing and Interpreting Data
5. Using Mathematical and Computational Thinking
6. Constructing Explanations & Designing Solutions
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating and Communicating Information

We will also place an emphasis on how the science you might teach can be used to support literacy and numeracy skills as well.

We will begin by looking at the ways in which language in science is difficult and how literacy is central to science. For instance words can have multiple meanings or alternatively the words

can be very unfamiliar. But the difficulties are increased by the fact that ideas in science have to be communicated with diagrams (which are not as straightforward as they might appear to be); with tables and charts (which children have to learn to produce and comprehend); and at a higher level (with symbols which have to be learnt) and mathematics. The difficulty is compounded by the fact that much of science is presented in an unfamiliar way. Fictional text is generally presented as a narrative and this is the genre – both oral and written through which our lives are told and represented. For instance, history is a narrative, albeit contested and with plural accounts; and literature is the embodiment of narrative with it classic genres of romance, irony, tragedy and comedy.

In the case of science, however, the classic genres are much less familiar. Science relies on reports, texts that explain and experimental reports. Some of the writing in science is also argumentative but no text of this nature appears in school textbooks. In addition, much of the writing in science uses the passive tense that can also make the language difficult to appropriate. The simple view of reading sees it as an activity which is simply a process of decoding the meaning of words on the page and assembling their joint meaning. However, reading is really a constructive act and making meaning from texts requires us to link what we already know with what we think the word means in any given context to make sense of it. Teachers are therefore essential to helping students to read a text as only they can help the student appropriate the meaning that resides in the ensemble of words.

Why then, does science make use of such strange and unfamiliar language and how can teachers of science help students to develop an understanding of the linguistic practices of science and non-fiction texts? Drawing from much of the work on the teaching of literacy, we shall look at a range of strategies which can be used to support the reading of science that go beyond filling in the gaps. We will explore these first as an aid to your own understanding of science and then look at how they can be modified or adapted for the classroom. We will also look at the strategies that can be used to support students writing. Here we will focus on features – the audience for whom students write; what does it mean to write in today's world where forms of communication are multi-modal; and how children's writing can be scaffolded.

Next, we will turn to talk and children's questions about the world. Children have many questions about the world. Some are amenable to scientific inquiry and some are not. How do we decide the difference? This in turn leads us onto look at the role of talk in learning. Many theories of learning now place an emphasis on greater use of talk by students for learning. However, how can young children be supported to engage in purposeful talk and what structures and resources are available to support them? Ways of undertaking this work will be explored and, again, a feature here will be on using these approaches to develop your own understanding both of science and the nature of science itself such as concept maps or diagnostic assessments of student understanding. How engaging in talk, in particular argumentation, makes evident the fact that science moves from evidence to explanation to evaluation and is not just a body of pre-ordained facts will be explored. Basic ideas will be examined to show that these are not so self-evident as they are commonly thought to be. Moreover, it is important to know why the wrong idea is wrong as knowing why the wrong ideas are wrong is often as important as knowing why the right ideas are right. What kinds of resources are available to support such work and how can it be implemented in the classroom will be a focus of this work.

In taking this approach, the aim will be to show that the crowning glory of science is not the 'facts' of science but the ideas that help us to make sense of the world. However, often these ideas can appear to be a set of crazy ideas – for instance, that day and night is caused by a spinning Earth rather than a moving Sun, that air has weight, or that the air is full of tiny living organisms called 'germs'. When it comes to electricity, for example, there are many discrete facts one could memorize about the topic. But, the wonderful thing is that science has found that the matter is electrically charged. And, that these charges can be made to move with a battery or a generator. When they move they transfer energy from one location to another enabling us to produce energy in one location and transport it hundreds of miles along a narrow cable.

Throughout this short course, therefore, we will endeavour to do the following:

1. To develop your own understanding of both the content of science you are required to teach and the nature of science. In addition, how these ideas relate to the bigger picture of science that formal schooling aims to develop.

2. To develop your knowledge of the strategies that are needed to teach science. A particular focus here will be on strategies for developing students' knowledge of the language of science.

3. How we can use formative assessment to inform our teaching.

In summary, science does not wear its meaning on its sleeve and understanding science means coming to terms with an unfamiliar language and concepts. Rather than being self-evident common sense, science is really unnatural – whether it be the idea that day and night are caused by a spinning earth, plants get their 'food' from the air, or diseases are carried by small, invisible living microorganisms which we call 'germs' – none of these are obvious. Helping young children to come to terms with these strange but wonderful ideas will be a focus of this course.

Week Outline of Course

Week #	Instructional Goal	Major Activities	Science Activity	Assignment Due	Science Teaching Strategy	Reading
1	• Introduction and Goals & Reviewing Work to date • Explaining Assignments • Goals of the Course	• Introduce Do-It, Talk-it, Read-It, Write-It • Introducing Concept Mapping (Summarizing Activity) • Making Science Relevant: • Activating Student Background knowledge (Concept Map)	• Awesome Science • Beautiful Science • Disturbing Science • The Three Scales of Science • Things you can handle • Too Large to Imagine • Too Small to See • Modeling the Solar System • Investigations with a Syringe • The Ruler and Paper	Need to identify science lesson with CT to be taught in week 5-7	• Concept Mapping • Using Argument in Science (Knowing why the Wrong Idea is Wrong) • Turn and Talk • Listening Triads • Building Models to Explain • Constructing Explanations • Exit Slips • Thick/Thin Questions • Resources to Support Your Learning	Osborne, J., Sedlacek, Q. C., Friend, M., & Lemmi, C. (2016). Learning to Read Science. *Science Scope*, *40*(3), 36-42.
2	• Building a Model for Learning Science • Exploring What it means to teach science	• Modeling the Phases of the Moon	Developing Models Constructing Explanations	Need to identify NGSS performance expectation you will address in your science lesson	Supporting Writing in Science Graphic Organizers – The Freyer Model	Baxter, J. (1989). "Children's Understanding of Familiar Astronomical Events." International Journal of Science Education **11**: 502-513.

Week #	Instructional Goal	Major Activities	Science Activity	Assignment Due	Science Teaching Strategy	Reading
3	• Analyzing and Interpreting Data • Supporting Reading in Science	• The Common Core Literacy Standards for Informational Texts • How are sound produced? • How do we see?	• Collecting Data Sets on Humans (Height, Reaction Time, shoe size, hand size, eye color). • Looking at ways of representing variation	What is the Big Idea?	Pre, During and Post Reading Strategies Questioning the Author	• Reading Assignment 3: Fab Five • Read grade level framework • Find bundles • In class put it together
4	• To develop your knowledge and understanding of electricity and magnetism • To try out some science practices	• Transferring Energy with Light and Sound	How Strong is a Magnet? Communicating Results and Findings.	Identify Practice that will be a feature of your lesson	Communicating Information	Reading Assignment : Talk Science Primer •.
5	• To develop your knowledge and understanding of electricity and magnetism • To try out some science practices	• Using a FOSS Kit • Eliciting your Prior Understanding	Using the FOSS kit Van de Graaf Generator – Constructing an Explanation	• Teaching A Scientific Practice Plan	Predict, Observe, Explain (Radiation Bottles)	Reading Assignment 4: SPACE research report: Electricity
6	• To develop your knowledge about the role of Literacy in Science	Discussing readings • Why is Language Important in Science? • What kind of language activities might we do? • Using adapted primary literature	Tricky Tracks Glass and Tumbler	• Final Assignment is due Feb 27!!	Writing Frames Writing for Difference Audiences Wordsift POMS	Reading Assignment 5: Writing for Learning in Science. Adapted from Wellington, J., & Osborne, J. F. (2001). Language and Literacy in Science Education. Buckingham: Open University Press..

		• Building electric circuits that work • Making an electromagnet • Constructing Explanations for what we see.				

Sessions

For each session, we anticipate that you will spend an additional 3 hours outside the classroom doing the reading, and undertaking the assignments. In addition, there may be one or two short, school-based tasks that we will be asking you to do within the first four weeks of the quarter. These are not assessed and their main purpose is to get some data from children that we can talk about in the session. If you wish, you can collaborate with a fellow student on this. However, it might make sense to show this to your mentor teacher to see if they anticipate any difficulties with undertaking any or all of these school-based tasks.

Session 1: Introduction to Module: Teaching scientific practices Jan 13

Reading: Osborne, J., Sedlacek, Q. C., Friend, M., & Lemmi, C. (2016). Learning to Read Science. *Science Scope, 40*(3), 36-42.

In this session, we will begin by examining what kinds of things scientists do. We will start by thinking about some very simple phenomena and then think about how we can explain them, what we have to do to explain them and what that says about the nature of scientific practices. We will also start to think about what it means to teach science and what strategies we have developed and how to keep a record of these. We will then move to thinking about the teaching of Astronomy (First grade, fifth grade and Middle School), what we have to teach and how it can illustrate some of the scientific practices we have been talking about.

Session 2: Teaching Astronomy: What does it tell us about science? Jan 20

Reading: Baxter, J. (1989). "Children's Understanding of Familiar Astronomical Events." International Journal of Science Education **11**: 502-513.

In this session, we will continue looking at how we might teach some of the basic ideas in astronomy. In particular, we will focus on the need to construct models, either physical or imagined to explain ideas in science. In addition, we will begin to look at how ideas in science must be argued for and the coordination between theory and evidence. In this session, we will finish the work on astronomy by looking at the ways in which we can help students to process informational texts and some of the difficulties they pose for your students. We will also have a chance to reflect on the strategies that we have met so far for teaching science, their function and their value.

Session 3: Light and Sound and Reading in Science Jan 27

Reading: Fang, Zhihui. (2008). Going beyond the Fab Five: Helping students cope with the unique linguistic challenges of expository reading in intermediate grades. *Journal of Adolescent*

and Adult Literacy, 51(6), 476-487.

In this session we will focus on the significance and value of reading in science. We will begin by exploring what makes reading non-fiction texts harder than reading fiction texts using some practical examples and looking at the textbooks that you may use. We will then look at some of the strategies and resources that teachers of science can use to help.

Session 4: Sound and Light: Supporting Talk in Science **Feb 3**

Reading: Sarah Michaels and Cathy O'Conner. Talk Science Primer.
TERC. 2012 http://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

In this session, we will focus on the teaching of electricity and magnetism, beginning by exploring your own knowledge of the area and looking at some of the complexities that can make the area confounding. A particular focus will be on conducting a simple inquiry, how to interpret the results and what the implications are for teaching both this and other topics.

Session 5: Getting to Grips with Electricity **Feb 10**

Reading: Osborne, J. F., Black, P., Smith, M., & Meadows, J. (1991). SPACE research report: Electricity. Liverpool: Liverpool University Press.

In this session, we will begin to look at how providing students an opportunity to talk science is an important means of developing students' knowledge. The session will begin with a discussion of the reading before looking at some typical approaches that can be used in the context of teaching of electricity that support the teaching and learning of science. This will be an opportunity to try these strategies for yourselves and evaluate them.

Session 6: Reading, Talking and Writing in Science **Feb 17**

Reading: **Chapter FIVE: Writing for Learning in Science.** Adapted from Wellington, J., & Osborne, J. F. (2001). *Language and Literacy in Science Education*. Buckingham: Open University Press.

In this session, we will explore the role of writing in supporting learning in science. Traditionally writing in science has been dominated by copying from the board – a device by which the notes of the teacher become the notes of the student without going through the mind of either. Focusing on some of the concepts in the Grade 3 science curriculum, we will examine what strategies can be used to support student writing and how they might assist

Useful Web Sites for You

The Khan Academy – www.khanacademy.org.	This website is useful for explanations of the background science.
The Exploratorium – www.exploratorium.edu	A useful website for lots of ideas and resources about teaching science.
www.goorulearning.org	This is a website that contains a lot of resources to support teaching science and has been written to support teachers.
www.sharemylesson.come	Another website for sharing lessons and materials
Mystery science	www.mysteryscience.org