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# Course Description

Professional geoscientists often need to communicate complex science ideas to non-experts such as stakeholders, students, and policymakers. Foundational knowledge of learning theories and practical strategies for effective instruction will benefit geoscience students regardless of future career path. This course will introduce students to theories that provide a framework for how people learn science and outline strategies for development and assessment of geoscience lessons. Emphasis will be placed on aligning instruction with defined standards or objectives and practical applications of educational frameworks.

## Course Objectives

1. Apply learning theories to inform our understanding of student learning in the context of geoscience
2. Evaluate existing geoscience educational resources using criteria grounded in learning theory, accessibility principles and alignment with educational standards
3. Justify instructional design decisions in terms of content and pedagogy by synthesizing learning theory and practical constraints
4. Create assessments that measure understanding of content at multiple cognitive levels and provide feedback

## Reading List


- Francek, M. 2012. A Compilation and Review of over 500 Geoscience Misconceptions. *International Journal of Science Education*. https://doi.org/10.1080/09500693.2012.736644
- Handelsman, J., Miller, S., and Pfund, C. 2007. *Scientific Teaching*. WH Freeman Publishing. ISBN 1-4292-0188-6 (Chapters 2 & 3)
- Kirby, K. 2008. 'Easier to Address' Earth Science Misconceptions. Retrieved from https://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html
- Lynne, P. (2024). Understanding Bloom's Taxonomy. In: Reading and Writing Successfully in College: A Guide for Students. Retrieved from https://rotel.pressbooks.pub/readwritesuccess/chapter/understanding-blooms-taxonomy/
- McConnell, D.A., Chapman, L., Czajka, C.D., Jones, J.P., Ryker, K.D., & Wiggen, J. (2017). Instructional Utility and Learning Efficacy of Common Active Learning Strategies. Journal of Geoscience Education 65(4), 604-625. https://doi.org/10.5408/17-249.1
- National Research Council (2005). *How Students Learn: Science in the Classroom*. The National Academies Press. Retrieved from https://doi.org/10.17226/11102. (Chapter 1)
- Scott, C.L. (2015). The Futures of Learning 2: What kind of learning for the 21st century? Education Research and Foresight Working Papers. UNESCO. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000242996
- St. John, K (Ed.) 2018. *A Community Framework for Geoscience Education Research*. National Association of Geoscience Teachers. Retrieved from http://commons.lib.jmu.edu/ger_framework/15
- TIDeS Teaching Materials. 2025 https://serc.carleton.edu/tides/teaching-materials/index.html
- Wiggins, G., & McTighe, J. (2005). *Understanding by Design, 2nd edition*. ASCD Publishing. ISBN 1-4166-0225-9. https://doi.org/10.14483/calj.v19n1.11490. (Chapter 1)

# 12-week outline

| Topic | Learning Objectives | Reading Assignments |
|---|---|---|
| Week 1: Course Overview | | **N/A** |
| Week 2: Active Learning | **1** | **Reading:** Handelsman Ch. 2: Active Learning and/or McConnell et al. (2017)<br>**Lecture:** Cognitive and affective domains; Active learning strategies; Constructivism<br>**In-class activities:** Discussion, Jigsaw, Minute Paper |
| Week 3: Backward Design | **1, 2** | **Reading:** Learning by Design Ch. 1: Understanding by Design<br>**Lecture:** SMART objectives; Introduction to backward design<br>**In-class activity:** evaluating and re-writing learning objectives |
| Week 4: Student-centered learning | **1** | **Reading:** How Students Learn Ch. 1: Introduction<br>**Lecture:** Prior knowledge; Formative assessment, Metacognition; Conceptual Understandings<br>**In-class activity:** Venn diagram |
| Week 5: Mastery Learning, Assessment | **1, 2** | **Reading:** Lynne Understanding Bloom's Taxonomy and/or Handelsman et al. Ch. 3<br>**Lecture:** Cognitive levels<br>**In-class activity:** Matching assessments and objectives to cognitive level |
| Week 6: Evaluating alignment, Alternative assessments | **2, 4** | **Reading:** Summary page for TIDeS Unit 3 and Unit 5 and/or Handelsman et al. Ch. 3<br>**In-class activity:** Choose a unit within the TIDes curriculum. Choose 2 objectives for that unit and evaluate the alignment of assessments and activities related to those. Then, come up with another style of assessment based on Handelsman et al. Ch. 3 |
| Week 7: Sharing evaluations | **2, 3** | **Reading:** N/A<br>**In-class activity:** Groups finalize and present their evaluations of TIDeS assessment, including the justification for effectiveness using at least 2 theories |
| Week 8: Rubrics for assessment | **4** | **Reading:** Kirby (2008) or Francek (2012), and Handelsman et al. Ch. 3<br>**Lecture:** Summative & formative assessments, scaffolding, rubrics<br>**In-class activity:** Students (or groups) choose a misconception and write an outcome, assessment question, model answer and rubric |
| Week 9: Sharing Misconception Assessments | **1, 2, 3, 4** | **Reading:** N/A<br>**In-class activity:** Students complete assessment questions created by others in the class, then grade assessment responses using model answer and rubric. Class reflects on characteristics of good open-ended questions and creation of rubrics that can adequately differentiate responses. |
| Week 10: Twenty-first century skills: Learning and Innovation | **1, 2, 3** | **Reading:** Summary page of TIDeS Unit 3.3 and/or Scott, C.L. (2015)<br>**Lecture:** Critical thinking, inquiry and problem-solving<br>**In-class activity:** Discussion about critical thinking, analysis of questions on student worksheet for TIDeS Unit 3.3. |
| Week 11: Twenty-first century skills: Life & Career skills | **1, 2, 3** | **Reading:** Scott, C.L. (2015)<br>**Lecture:** Metacognition, communication, teamwork, career skills<br>**In-class activity:** Using think-pair-share to reflect on metacognition and teamwork |
| Week 12: Twenty-first century skills in a learning activity | **1, 2, 3** | **Reading:** Scott, C.L. (2015)<br>**In-class activity:** Students outline learning activities that align with outcomes, assessment, model answer and rubric created in week 8. Learning activities must incorporate and justify inclusion of at least 2 21st century skills |

Return to 12-week outline

# Daily Learning Objectives and Lesson Plans

## Week 1: Course Overview

### Description of Learning Activities

This is an introductory day, as many students will still be registering.

Potential activities include: reviewing necessary books, putting students into groups, gathering preliminary data on students' interests, goals, and prior experience.

### Assessments

**Pre-assessment.** This assessment may include a variety of questions depending on instructor's goals. Often, one goal is to understand student conceptions of teaching, what their prior school experiences were like, etc.
Options include:

1. Contextual information, e.g., where they are from,
2. Attitudes and beliefs about teaching

If students do not attend class the first day, they can be asked to complete the survey on their own time before class. The survey can also be administered as a post-survey at the end of the course.

Example questions for contextual information (open-ended questions):

1. Describe your secondary school experience:
    a. How many people were in your science class?
    b. What did the teacher typically do during class?
    c. What did the students typically do during class?
    d. How could you tell when you understood the material being presented?
    e. Describe an excellent teaching in 3 words.

Questionnaire with example questions for attitudes and beliefs about teaching:

1. University Teaching Beliefs Questionnaire. https://www.tesl-ej.org/ej27/a1app1.html
    a. From: G.J. Gorsuch. 2003. The Educational Cultures of International Teaching Assistants and U.S. Universities. Teaching English as a Second or Foreign Language 7(3). Available from: https://www.tesl-ej.org/ej27/a1.html#app1bak

# Week 2: Introduction to Scientific Teaching (constructivism, active learning)

## Course objectives addressed:

1. Apply learning theories to inform our understanding of student learning in the context of geoscience

*Specific objectives for Week 2:*

- Identify cognitive and affective factors that influence learning
- Differentiate between active learning strategies
- Explain why active learning strategies are examples of constructivist teaching philosophy

## Readings or Pre-Class Assignment

- Handelsman Ch. 2: Active Learning, and/or McConnell et al. "Instructional utility and efficacy of active learning"

## Description of Learning Activities

1. (10 mins) Begin class with a discussion: Think about excellent teachers you have had. What characteristics made them effective?
2. (10 mins) Instructor follows-up discussion with class share-out and categorization of responses into cognitive and affective factors, e.g.
    - Affective→ instructors who make students feel cared for, important, like what they are learning is important, like students are capable of success. Some structural/logistical components may be here, e.g., organization, clear expectations can help students feel supported.
    - Cognitive→ instructors challenge students, provide clear examples, scaffold learning, fair exams, good at explaining concepts, etc. Some structural/logistical components may be here also, e.g., clear expectations, structures that made learning easier.
3. (5 mins) Instructor explicitly defines affective and cognitive domain. Then, instructor reveals that students just participated in an active learning exercise. Students are asked to reflect on assigned reading to identify what type of active learning exercise it was (*brainstorming*)
4. (25 mins) Jigsaw activity on active learning techniques.
    a. Teacher places students into 5 "expert" groups, where **students summarize the active learning strategy and identify cognitive and affective factors that may help students learn**. **Each should write down the groups' conclusions.** *(Note 1: all active learning exercises included appear in both McConnell and Handelsman text, except option 5). (Note 2: Limit group size to 5 students. If there are 6 or more students in each group, break up into smaller groups and have 2 per topic. For example, if there are 25 students in the class, you will have 1 group for each category. If there are 100 students in the class,* you will 20 group As, 20 group Bs, etc, each with 5 students.
        A. Concept Maps
        B. Case studies and Problem-Based Learning
        C. Think-pair-share
        D. Minute Papers

E. Decision Making (Handelsman) or Peer Instruction (McConnell)

b. After 5-10 minutes of discussion, students will transition to new groups, 5 per group, with 1 representative from each "expert" group. Students will share their summaries and identified cognitive and affective factors. Make as many groups as necessary based on the size of the class.

5. (10 mins) Instructor defines constructivism (a learning theory asserting that learners actively construct their own knowledge and understanding of the world through experience, reflection, and social interaction, rather than passively receiving information). Then, students are asked to complete a minute paper (short writing prompt students should be able to answer in 1-2 minutes that they turn in at the end of class) "Choose one of the active learning strategies discuss in class and explain how that strategy is aligned with constructivist theory."
6. Students submit minute papers as they leave class.

## Assessments

- Student identification of active learning activity "brainstorming"- *ungraded*
- Jigsaw part 1: students summarize an active learning strategy and identify affective and cognitive factors associated with them, then explain their findings to others in Jigsaw part 2. - *ungraded*
- Minute paper in which students demonstrate understanding of constructivism and relate to active learning strategies – *ungraded*

# Week 3: Scientific Teaching: Course and Standards-based Alignment,

## Course objectives addressed:

1. Apply learning theories to inform our understanding of student learning in the context of geoscience
2. Evaluate existing geoscience educational resources using criteria grounded in learning theory, accessibility principles and alignment with educational standards

### *Specific objectives for Week 3:*

- Explain how "backward design" can be used to develop an aligned lecture or course
- Evaluate learning objectives using criteria of "SMART" objectives, and revise objectives to meet "SMART" criteria if needed.
- Identify assessments and learning activities that align with "SMART" objectives

## Readings or Pre-Class Assignment

- Learning by Design Ch. 1: Understanding by Design

## Description of Learning Activities

1. (5 minutes) Students revise their reading by working in small groups (3-4 people) to draw a concept map of the three components of the backward design process. Each student should draw a concept map.
2. (10 minutes) Instructor presents slides describing "SMART" objectives (specific, measurable, achievable, relevant, timely) and provides examples of "not as good" objectives and revised objectives that better match the "SMART" criteria.
3. (5 minutes) The instructor presents a slide with a "not as good" outcome and asks students to revise the outcome in their groups.
4. (10 minutes) Student groups share how they revised the objectives by writing their revision on the board or speaking out. Intructor provides feedback to the class as a whole.
5. (15 minutes) The instructor hands each group a "good" pre-printed learning outcome (or finds another way to distribute). Then the instructor helps as needed as student groups:
    a. Identify an assessment that aligns with that learning outcome, with enough detail to see how assessment is achievable (e.g., not just "we'll ask a test question, but what that question would be).
    b. Identify how an active learning activity (from last class) could be used to help students achieve outcome using assessment.
    c. Write these down under their concept map from the start of class
6. (15 mins) Students hand the pre-printed learning outcome back to instructor. If possible, switch groups around and give students the opportunity to share what their last group developed. Then, instructor hands each group a new "good" outcome and they repeat the exercise. The instructor helps as needed.
7. Students hand in their papers as they leave class.

## Assessments

- Concept map- ungraded
- Revision of learning objectives- ungraded
- Identification of aligned assessments and learning activities

# Week 4: Student-Centered Learning

## Course objectives addressed:

1. Apply learning theories to inform our understanding of student learning in the context of geoscience

*Specific objectives for Week 4:*

- Explain how prior understandings are related to constructivism
- Compare and contrast learner-centered, knowledge-centered, and assessment-centered classroom environments
- Explain how formative assessments and metacognition are used in learner-, knowledge-, and assessment-centered classroom environments.

## Readings or Pre-Class Assignment

How Students Learn: Science in the Classroom Ch. 1: Introduction (pp 1-20).

## Description of Learning Activities

1. (15 minutes) Students revise their reading by working in small groups, discussing these two ideas:
    a. How is the excerpt from "Fish is fish" related to the idea of constructivism?
    b. Use the excerpt from "Fish is fish" to differentiate between factual knowledge and conceptual understanding.
2. (15 minutes) Instructor leads a class discussion based on students sharing out their answers from the first activity, and shares slides on constructivism and factual knowledge vs. conceptual understanding if needed.
3. (15 minutes) Instructor presents students with a Venn diagram divided into 3 overlapping circles: learner-centered, knowledge-centered, and assessment-centered. Students are presented with a series of terms from the reading and asked to place each idea or phrase somewhere on the Venn diagram. Make sure students know that ideas do not have to be evenly distributed across the Venn diagram. Each group then needs to write 1 sentence justifying their placement of each.
    a. Student objectives and mastery achievement metrics are clearly defined *(knowledge-centered, though answers may vary if well justified)*
    b. *A focus on student's backgrounds, cultural abilities and abilities (learner-centered, though answers may vary if well justified)*
    c. Students are provided with teamwork and collaboration opportunities *(all three, though answers may vary if well justified)*
    d. Formative assessments *(all three, though answers may vary if well justified)*
    e. Opportunities to receive feedback *(all three, though answers may vary if well justified)*
    f. Metacognition (*all three, though answers may vary if well justified)*
4. (15 minutes) Instructor presents slides on formative assessment and metacognition. Students to share rationales for where they placed those two terms on the last activity.
5. Students hand in their Venn diagrams and justifications as they leave.

## Assessments

- Student answers to initial discussion questions- ungraded
- Completed Venn diagram with justifications

# Week 5: Mastery Learning and Assessment

## Course objectives addressed:

1. Apply learning theories to inform our understanding of student learning in the context of geoscience
2. Evaluate existing geoscience educational resources using criteria grounded in learning theory, accessibility principles and alignment with educational standards

### *Specific objectives for Week 5:*

- Differentiate between the cognitive levels of Bloom's Taxonomy and identify objectives that align with cognitive levels.
- Determine the cognitive level of assessments
- Evaluate the alignment between objectives and assessments

## Readings or Pre-Class Assignment

Lynne: Understanding Bloom's Taxonomy and/or
Handelsman Ch. 3: Assessment

## Description of Learning Activities

1. (15 minutes) Instructor shows a slide with 4-6 geoscience-related learning objectives. Students work in small groups to match each outcome with a cognitive level.
2. (15 minutes) One student from each group writes on the board to indicate which level they identified for each objective. For larger classes or no whiteboard, find another method for soliciting answers. Then the instructor talks through any discrepancies and provides feedback. Note: it is possible to justify more than one cognitive level for some of the objectives.
3. (15 minutes) Each group is provided with one assessment and the objectives it is intended to measure. Students read through the assessment and evaluate the cognitive level.
4. (15 minutes) Student groups then evaluate the alignment between the objectives and the assessment. Student either write a justification for their alignment, or a proposed revision of the outcome or assessment to improve alignment.
5. Students submit their written work at the end of class

## Assessments

- Students matching of objectives and cognitive level- ungraded
- Discussion of cognitive level justifications
- Evaluation of alignment between objectives and assessments

# Week 6: Evaluating alignment, Alternative assessments

## Course objectives addressed:

2. Evaluate existing geoscience educational resources using criteria grounded in learning theory, accessibility principles and alignment with educational standards
4. Create assessments that measure understanding of content at multiple cognitive levels and provide feedback

## Readings or Pre-Class Assignment

Summary page for TIDeS Unit 3 and Unit 5 and/or Handelsman et al. Ch. 3

## Description of Learning Activities

1. (25 minutes) Students work in groups. Each group chooses a unit within the TIDes curriculum to focus on. They will focus on 2 objectives for that unit and evaluate the alignment of assessments and activities related to those objectives.
2. (20 minutes) Students prepare a brief presentation of what they worked on. This could be on 3-4 slides, or an oral presentation, or a poster, depending on supplies available. The presentation should include:
    a. Identifying title and objectives of the unit they focused on
    b. Briefly describing how those outcomes were assessed and taught, including identification of active learning techniques that were utilized to teach the objectives
    c. An evaluation of the cognitive and content-based alignment of the materials with a justification based on what we've learned in class
3. (15 minutes) If time remains, students will begin outlining a student-centered, formative assessment that could replace or supplement the ones already included in the unit. Students can refer to Handelsman et al. Ch. 3 for ideas. This could be included in the presentation if everyone has time to complete this step.

## Assessments

- Students' presentations of TIDeS analysis (next class period)
- Students' outline of an assessment to replace /supplement one already included (next class period)

# Week 7: Sharing evaluations

## Course objectives addressed:

2. Evaluate existing geoscience educational resources using criteria grounded in learning theory, accessibility principles and alignment with educational standards
3. Justify instructional design decisions in terms of content and pedagogy by synthesizing learning theory and practical constraints

## Readings or Pre-Class Assignment

No reading; finalize evaluation of TIDeS activity summary and evaluation of alignment

## Description of Learning Activities

1. (15 minutes) Groups finalize their presentations their evaluations of TIDeS assessment, which include:
    a. Identifying title and objectives of the unit they focused on
    b. Briefly describing how those outcomes were assessed and taught, including identification of active learning techniques that were utilized to teach the objectives
    c. An evaluation of the cognitive and content-based alignment of the materials with a justification based on what we've learned in class
    d. (If they had time to complete this) their proposed new or supplemental assessment
2. (45 minutes) Groups present their work to either the whole class or to a subset of groups, depending on the number of students in the class.

## Assessments

- Group presentation of evaluation (develop rubric)

# Week 8: Rubrics for assessment

## Course objectives addressed:

4. Create assessments that measure understanding of content at multiple cognitive levels and provide feedback

## Readings or Pre-Class Assignment

Francek or Kirby, and/or Handelsman et al. Chapter 3.

## Description of Learning Activities

1. (10 minutes) Instructor shares slides on summative vs. formative assessments and scaffolding conceptual understanding through active learning and formative assessment.
2. (10 minutes) Instructor leads students in a discussion on rubrics based on Handelsman Ch. 3, focusing on tying rubric to outcomes, and assessing both progress and outcomes
3. (15 minutes) If students did not get to create an alternative or supplemental formative assessment for the TiDES unit they present on, they can do that during this class period. Students can reference Handelsman et al (2008) for ideas. Instructor can provide guidance and support.
4. (35 minutes) Instructor explains next assignment, and students complete these steps:
    a. Students (individually or in groups) choose a misconception from either the Kirby website or the Francek paper. They will write a learning outcome based on the misconception.
        i. For example, if the misconception is “The Earth’s interior is magma,” the outcome could be “Students will be able to identify the state of matter of each of the Earth’s internal layers.”
    b. Students will write an open-ended assessment question to determine if students have met the outcome.
        i. For example, using the outcome above, the assessment question could be, “Draw a diagram of Earth’s interior layers, label layers and the state of matter of each.”
    c. Then, they will write a model answer and create a rubric to grade the question.

## Assessments

- Assessment created to replace /supplement one already included (if not done in pervious class)
- Student’s outcome, aligned assessment, and model answer/rubric

# Week 9: Sharing Misconception Assessments

## Course objectives addressed:

1. Apply learning theories to inform our understanding of student learning in the context of geoscience
2. Evaluate existing geoscience educational resources using criteria grounded in learning theory, accessibility principles and alignment with educational standards
3. Justify instructional design decisions in terms of content and pedagogy by synthesizing learning theory and practical constraints
4. Create assessments that measure understanding of content at multiple cognitive levels and provide feedback

## Readings or Pre-Class Assignment

No reading; finalize misconception outcome, assessment, model answer and rubric if needed

## Description of Learning Activities

1. (10 minutes) Students (or groups) finalize their model answer and rubric. Then, they will write their question on 2 pieces of paper (or index cards). *Note: it is a good idea to number or otherwise label the assessments from each group.
2. (20 minutes) The instructor collects the 2 copies of the assessment questions from each student or group. Do not collect the model answer and rubric at this time. Then, the instructor passes out the assessments to other students (or groups), so that each person (or group) has 2 questions to answer. They will be given ~5 minutes to answer each question and then return responses to the instructor. The instructor returns the questions to the student (or group) who wrote that question.*
    * For very large classes, an alternative method for handing out and returning questions may be needed. This is a scenario in which students may need to work in groups rather than individually. Or the class could be split into smaller sections and assessments could be distributed among the smaller sections to make it easier to hand out and return assessments.
3. (15 minutes) Now, assessment responses will be graded based on the rubric. Either the student/group who wrote the question, model answer, and rubric can grade it, or you can distribute all materials to another group for grading.
4. (15 minutes) Instructor will lead class discussion to reflect on activity, focusing on the need to be specific when writing open-ended questions if there are specific answers they want to elicit from those answering the question. Discussion may also include the need to iteratively revise rubrics if the rubrics do not adequately differentiate between different quality responses.
5. Instructor either:
    a. Collects student materials (outcomes, assessments, model answers/rubrics, assessment responses), OR
    b. Asks students to revise their assessments and/or rubrics based on the feedback and responses they got.

## Assessments

- Outcomes, assessments, model answers/rubrics, assessment responses
- Class discussion
- (If assigned), revision of assessment and/or rubric

# Week 10: Twenty-first century skills: Learning and Innovation

## Course objectives addressed:

1. Apply learning theories to inform our understanding of student learning in the context of geoscience
2. Evaluate existing geoscience educational resources using criteria grounded in learning theory, accessibility principles and alignment with educational standards
3. Justify instructional design decisions in terms of content and pedagogy by synthesizing learning theory and practical constraints

## Readings or Pre-Class Assignment

TIDeS Unit 3.3 summary page, Scott, C.L. (2015)

## Description of Learning Activities

1. (20 minutes) Instructor give discussion prompt: What is critical thinking? How can educators assess critical thinking skills? Instructor indicates that students can think of examples as well as definitions. After 10 minutes of discussion, students are asked to contribute answers in a whole-class share out. Instructor can highlight higher order thinking skills, interdisciplinarity, real-world problem solving, and (if it comes up) inquiry level (how much control students have in choosing the questions, methods, and data analysis for things they are studying)
2. (30 minutes) Instructor shares lecture slides defining problem-based learning and inquiry learning. Then, student groups answer these four questions regarding TIDes Unit 3.3, specifically looking at the "unit_2.2_in-class_worksheet"
    a. Which questions do you think require students to use critical thinking skills? Find 2-3 examples and explain why you think they require critical thinking.
    b. Look at the levels of inquiry described in the lecture slides. Are any questions asked at a higher inquiry level than confirmation? Justify your answer.
    c. How do you think questions about real-world connections and applications (e.g. #16 and #17) impact student affect: motivation, interest, value placed on learning, if at all?
    d. Do you think this activity would be effective at meeting objectives and engaging students?
3. (10 minutes) Reflection: Class share-out, particularly focusing on question "d."

## Assessments

- Discussion on critical thinking
- Students' answers to 4 questions analyzing TIDeS activity

# Week 11: Twenty-first century skills: Life & Career skills

## Course objectives addressed:

1. Apply learning theories to inform our understanding of student learning in the context of geoscience
2. Evaluate existing geoscience educational resources using criteria grounded in learning theory, accessibility principles and alignment with educational standards
3. Justify instructional design decisions in terms of content and pedagogy by synthesizing learning theory and practical constraints

## Readings or Pre-Class Assignment

Scott, C.L. (2015)

## Description of Learning Activities

1. (15 minutes) Instructor starts by asking a question as a think-pair-share. This activity is based on this resource, instructor please reference this source for more information.
    a. (individually): Which is heavier, air at 32˚C and muggy, or air at 32˚C and dry.
    b. (in pairs or small groups): Students share their answers and have to justify how they arrived at their answer.
    c. Do not do the group share-out at this point. Instead, instructor provides the basic data of the atomic weights of hydrogen, nitrogen, and oxygen and ask them to use that information in their response.
    d. (in pairs or small groups): Student re-evaluate their answers and justifications to incorporate new information.
    e. (group share out): Students share how and if their answers changed after being presented with new information.
2. (20 minutes) Instructor shares slides to introduce idea of metacognition, and the idea of self-regulated learning. They show figure highlighting sought-after geoscience career skills (from Viskupic paper) that include autonomy, which can be achieved through self-regulated learning. Slides include information on digital literacy, and intrapersonal skills such as communication and teamwork.
3. (10 minutes) Instructor guides students in reflecting on how group work and communication changes learning, by asking students for feedback on how working in pairs or groups changed their ability to think-though the initial question (if at all), and if it changed their ability to communicate their answer.
4. (15 minutes) Student discussion based on the UNESCO reading: How do you think teamwork skills are related to interdisciplinary and intercultural competence? Follow this up with a whole-class share out and reflection.

## Assessments

- Think-pair-share answers part e: how metacognition and communication helped them re-assess their answer
- Discussion about group work, communication and teamwork

# Week 12: Twenty-first century skills in a learning activity

## Course objectives addressed:

1. Apply learning theories to inform our understanding of student learning in the context of geoscience
2. Evaluate existing geoscience educational resources using criteria grounded in learning theory, accessibility principles and alignment with educational standards
3. Justify instructional design decisions in terms of content and pedagogy by synthesizing learning theory and practical constraints

## Readings or Pre-Class Assignment

Scott, C.L. (2015)

## Description of Learning Activities

1. (10 minutes) Instructor explains the activity, and students spend the rest of the class period working on it (see next step).
2. (50 minutes) Students have generated an outcome, aligned assessment, model answer, and rubric to go with their chosen misconception from week 8. Today, they will work in their groups to outline an instructional sequence that uses active learning and models at least 2 twenty-first century skills and then write a brief justification for why and how they are used.
   If desired, students can present these materials during the final exam period, while other students critique and give feedback.

## Assessments

- Aligned outcome, assessment, model answer, rubric, and aligned teaching activity that models at least 2 twenty-first century skills, with a justification of how and why they are used.