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The Eclectic Reader for Introduction to Engineering

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The Eclectic Reader for Introduction to Engineering

Abstract

A recently piloted multi-disciplinary introduction to engineering course features not only a sampling of engineering majors, disciplines, and sub disciplines, but also aims to develop the mindsets and skills of well-rounded engineering students through thoughtful liberal arts reading. To this end, a wide range of reading assignments including sci-fi, philosophy, technical articles, and standard introductory texts aims to help freshmen engineering students establish connections between engineering and a larger intellectual world. Each reading is coupled with a note taking exercise, online discussion board, and classroom discussion and activities in support of specific learning objectives. The faculty have enjoyed the breadth of conversations inspired by the readings, and the students have risen to the challenge through gently scaffolded assignments and clearly defined expectations. The use of good literature should meaningfully contribute to student development as engineers and as individuals capable of critical thinking. Appendices provide twenty reading assignments as assigned to the students on the learning management system.

Keywords

Reading, Introduction to Engineering, Liberal Arts

Introduction and Literature Review

As ABET and engineering programs across the country endeavor to shape well-rounded engineers [1], a growing emphasis has been placed on engaging the liberal arts in the engineering curriculum. The liberal arts are widely accepted as key to higher education to the degree they focus students on *how* to think rather than simply *what* to think [2]. Liberal arts particularly help students develop professional identities, soft skills, and engage with other cultures and histories [3] convincing students of the non-neutrality of technology [4]. Yet, the means for integrating liberal arts education into high credit hour, technical engineering programs remains far from a solved problem.

Some engineering educators equate liberal arts with professional skills and hope that general education requirements will provide students with the necessary breadth of critical thinking skills [2]. At the other end of the spectrum, a growing number of schools are offering bachelor's of arts degrees in "Science, Technology, and Society" or minors in urban sustainability and similarly integrated topics [5], [6]. The first approach is often too broad, unfocused, and shallow, while the second aims to create well-rounded critical thinkers without the technical competencies expected by engineering industries. More middle ground options include adding courses in history, ethics, literature or the performing arts with an intentional engineering focus, though these courses challenge the high credit requirements of many engineering programs [5], [7], [8], [9], [10]. Other attempts incorporate liberal arts through guest lectures, course modules, and paired courses, though typically at the cost of some technical depth or breadth [3], [11]. Finally, other schools have leveraged co-curricular and extra-curricular programs, events, and resources to integrate the liberal arts and engineering [12], [13], [14]. The engineering education literature on the topic, in both tone and conclusion, leans toward pessimism; perhaps liberal arts critical

thinking and engineering problem solving are like oil and water: useful in their own applications, interesting in their interactions, but fundamentally unmixable.

One space where the liberal arts are often forced into the engineering curriculum is through non-technical introduction to engineering courses. Where such courses are often taken by non-STEM majors, this approach seeks to bring engineering to the liberal arts course of study [15]. More often, introduction to engineering courses have enough space in their learning objectives to include a lecture, assignment or discussion on a liberal arts topic as considered from an engineering perspective [3]. Introductory classes are indeed an excellent place in the curriculum to engage liberal arts breadth within an engineering context, particularly if students are inspired and equipped to pursue liberal arts resources outside of class [16], [17].

Introductory classes often struggle to engage students outside of the class time. For example, many excellent introduction to engineering textbooks are on the market, yet there are many challenges to textbook selection. A textbook should include all the desired topics of the introductory course [18]; it needs to offer good value for its cost [19]; and it needs to inspire critical thinking rather than just giving the right answer [20]. Finding the "Goldilocks" textbook feels impossible *before* adding liberal arts standards of historical, literary, narrative, and inspirational excellence to the list of requirements. A multi-author textbook might be tempting, but the challenges of writing such a textbook from the blank page are numerous [21]. Even with a good textbook, freshman students are often already overwhelmed by the transition to college, homework for math and science courses, and a slowly dawning realization that college, unlike many high school experiences, will require effort outside the classroom. Reading a textbook for an "easy" introductory course is often the first assignment to skip, particularly where there is no mechanism for assessing completion.

The Problem and The Pedagogy

A recently piloted multi-disciplinary introduction to engineering course features not only a sampling of engineering majors, disciplines, and sub disciplines, but also aims to develop the mindsets and skills of well-rounded engineering students. Three faculty members from three unique engineering disciplines taught the course in a round-robin format; small cohorts of students rotated through one-month modules with each faculty. Modules focused on introducing the opportunities associated with each engineering major offered at the college *and* began to form the habits of mind and communication associated with all engineering disciplines. Furthermore, the faculty brought their own liberal arts interests in philosophy, science-fiction, theology, and lifelong learning to the course, aiming to engage students with a range of resources to shape *how* to think about engineering and the engineers' place in the world.

Rather than attempting to select a singular cohesive textbook for the whole course, or lean on course topics to encourage liberal arts engagement, the faculty selected readings from a wide range of thinkers and authors including both engineers and non-engineers. Rather than trying to merge liberal arts and engineering, students were asked to enter engineering through the lens of literature, history, and philosophy as written by philosophers, historians, and technologists. A wide range of reading assignments including science-fiction, philosophy, technical articles, and standard introductory texts aimed to initiate freshmen engineering students in establishing connections between engineering and a larger intellectual world.

Each reading assignment included similar basic elements. Students were provided learning objectives for a coming class meeting and asked to read a portion of a text while taking handwritten notes. These handwritten notes were then posted as images to a discussion board on the learning management system [17]. When available, the larger text associated with the assignment was also made available. In class, students engaged in quiz-facilitated peer instruction and discussion with the faculty, also while taking notes [22]. Students were assessed for their engagement in the material through in-class quizzes and the required posting of lecture notes to reading discussion boards.

The Eclectic Reader

The following sections summarize the readings for each module. Appendices provide greater details including LMS assignments as implemented in the pilot of a new introduction to engineering course during the fall semester of 2023. Faculty members selected readings based on their own literary interest, connection to class learning objectives, and suitability for introducing engineering concepts. Assignment formats represent the preferences of the unique instructors collaborating on the course.

Electrical and Computer Engineering Module

The electrical engineering faculty chose to lean on a traditional introduction to engineering text to introduce engineering breadth and electrical engineering depth to students. Selection from specific chapters allowed students to focus their reading time and keep the assignment length appropriate for the course load. All reading selections for this module were from Eide, Jenison, Northup and Mickelson's *Engineering Fundamentals and Problem Solving* [23] with more details available in Appendix A.

Mechanical Engineering Module

The mechanical engineering faculty leaned into science fiction short stories to stir students' imaginations. Discussion board post typically asked students to think critically about the reading and offer a defended perspective. Students were asked to read the following stories:

- Isaav Asimov's *Nightfall* [24]
- Ray Bradbury's *The Flying Machine* [25]
- Ray Bradbury's *The Veldt* [26]
- Philip K. Dick's *We Can Remember It For You Wholesale* [27]
- Philip K. Dick's *Do Androids Dream of Electric Sheep?* [28]
- Harry Turtledove's *The Road Not Taken* [29]
- Kurt Vonnegut's *Harrison Bergeron* [30]
- Caroline M. Yoachim's *Welcome to the Medical Clinic at the Interplanetary Relay Station* [31]
- Roger Zelazny's *For a Breath I Tarry* [32]

Students were also asked to research personality tests and the Mars Climate Orbiter [33] with the goal of engaging with other learning and engineering mindsets and skills. Additional details can be found in Appendix B.

Civil and Construction Engineering Module

The civil engineering faculty chose older texts from a wide range of topics to introduce various lifelong learning frameworks and topics. Students were encouraged to read the assigned texts, understanding that they might be confused by the intensity of the literary work. Clear learning objectives, formative quizzes, and peer instruction during class time where key to helping student draw connections between the reading assignments and their development as students and engineers. Consider the range of works written for the popular audience used to stimulate cross-disciplinary thinking:

- Adler and Doren's *How to Read a Book* [34]
- *FE Reference Handbook* [35]
- G.K. Chesterton's *Orthodoxy* [36]
- C.S. Lewis's *Abolition of Man*[37]
- Ralph Peck's *Engineering Judgement* [38]
- Henry Petroski's *To Engineer is Human* [39]
- Polya's *How to Solve It* [40]

Students were directed to specific chapters (see Appendix C) and instructed to spend no more than thirty minutes reading and taking notes. When publicly available, the faculty provided access to the complete works for interested students.

Preliminary Responses

The faculty enjoyed the breadth of conversations inspired by the readings, and the students seemed to rise to the challenge through gently scaffolded assignments and clearly defined expectations. Assessment by faculty observation, note taking assignment grades, and in-class formative quizzes all showed students learned through the readings and discussions. Standard student course evaluation surveys indicated students understood how assignments related to course goals (4.81/5.0), that they learned a lot (4.90/5.0), and that many methods involved them in learning (4.95/5.0). Free responses included appreciation for the range of interesting and engaging topics with some specifically mentioning the reading. Students also mentioned that some of the readings were difficult, but most were fun.

Conclusions and Future Work

During the course pilot, students have been receptive to reading assignments and note taking discussion boards. Faculty have appreciated thought-provoking discussion in the classroom around a broader range of topics and interests. The use of good literature appears to meaningfully contribute to student development as engineers and as individuals capable of critical thinking. Most notably, the assigning of liberal arts-leaning reading has challenged students to engage in their engineering studies as whole people eager to grow and develop in every aspect of their being.

Faculty look forward to increasing standardization in assignments and refining discussion board and in-class discussion prompts to inspire additional critical thinking. Engagement with other faculty (both at the college and through conferences like ASEE) should increase the range of selected texts, pushing further out from the safe space of secondary sources and textbooks. The faculty hope that assignments in reading good resources will inspire students to dig deeper and seek greater connections between engineering, their daily lives, and their other studies.

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Appendix A. The Eclectic Reader
Electrical and Computer Engineering Module

Eide, Jenison, Northup and Mickelson's Engineering Fundamentals and Problem Solving Chapter 1 [23]

Learning Objectives

- Describe and illustrate formative content, comparative analysis, design outcomes, design cycle, societal impacts, and career opportunities for engineering and each of the disciplines and subdisciplines.
- Distinguish "engineer" from "technician" and "scientist".

Instructions

- Read Chapter 1 of "Engineering Fundamentals & Problem Solving" by Eide *et. al.* (pages 1-36). You may skip Sections 1.5.1, 1.5.2, and 1.5.6.
- As you are reading, summarize each major section (e.g. "1.2.1 Scientist") with handwritten notes. Only write as many notes as you need to accomplish all of the Chapter Objectives (listed on page 1). For example: Pretend someone said to you "Explain the role of an engineer in the world", then imagine yourself verbally providing an answer, *and you are allowed to refer to your notes while you give your answer*. That is the appropriate level of note-taking for *this* assignment.

Eide, Jenison, Northup and Mickelson's Engineering Fundamentals and Problem Solving Chapter 2 [23]

Learning Objectives

- Articulate the requirements for professional licensure and success in a future career.
    - Outline the requirements, process, and benefits for professional licensure including the role of an engineering degree program.
    - Explain the difference between an undergraduate and a graduate degree.
    - Articulate the value of accreditation (e.g. ABET).

Instructions

- Read Chapter 2 of "Engineering Fundamentals & Problem Solving" by Eide *et. al.*
- As you are reading, summarize each major section with handwritten notes. Only write as many notes as you need to accomplish all of the Chapter Objectives (listed on the first page of the PDF, page 39 of the book).

Eide, Jenison, Northup and Mickelson's Engineering Fundamentals and Problem Solving Chapter 17 [23]

Learning Objectives

- Describe and illustrate formative content, comparative analysis, design outcomes, design cycle, societal impacts, and career opportunities for engineering and each of the disciplines and subdisciplines.
    - Electrical and Computer Engineering

Instructions

- Read Chapter 17 of "Engineering Fundamentals & Problem Solving" by Eide *et. al.* (pages 1-20 of the PDF, pages 379-398 of the book). You do not need to read the remainder of the chapter.
- As you are reading, take enough notes to answer the following questions:
    - What is *electricity*?
    - How is *current* different from *static electricity*?
    - What is a *circuit*?
    - What is *potential*? What is *resistance*? (...in an electric circuit)
    - What is *Ohm's Law*?
    - What is the difference between a *series* and a *parallel* connection?
    - What is *KVL* and what is it useful for?
    - What is *KCL* and what is it useful for?
- Post a picture of your notes on this Discussion board (below).

Eide, Jenison, Northup and Mickelson's Engineering Fundamentals and Problem Solving Chapter 3 [23]

Learning Objectives

- Practice sustainable engineering problem solving techniques, engineering analysis and design processes.
- Outline and describe the engineering design process for each engineering discipline.

Instructions

- Read Chapter 3 of "Engineering Fundamentals & Problem Solving" by Eide *et. al.*
- As you are reading, summarize each major section with handwritten notes. Only write as many notes as you need to accomplish all of the Chapter Objectives (listed on the first page of the PDF, page 53 of the book).
- Post a picture of your notes on this Discussion board (below).

Eide, Jenison, Northup and Mickelson's Engineering Fundamentals and Problem Solving Chapter 4 [23]

Learning Objectives

- Practice sustainable engineering problem solving techniques, engineering analysis and design processes.
- Explain problem solving strategy in terms of reality, mental models, and mathematical models.
- List major concepts in sustainable engineering solutions.

Instructions

- Read Chapter 4 of "Engineering Fundamentals & Problem Solving" by Eide *et. al.* (Read pages 1-13 of the PDF, which is the same as pages 73-85 of the textbook.)
- As you are reading, summarize each major section with handwritten notes. Only write as many notes as you need to accomplish all of the Chapter Objectives (listed on the first page of the PDF, page 73 of the book).
- Post a picture of your notes on this Discussion board (below).

Eide, Jenison, Northup and Mickelson's Engineering Fundamentals and Problem Solving Chapter 5 [23]

Learning Objectives

- Communicate ideas, engineered solutions, and designs using technical communication skills including oral presentations, written documents, and graphics.
- Present technical data accurately and succinctly using plots and tables.

Instructions

- Read Chapter 5 of "Engineering Fundamentals & Problem Solving" by Eide *et. al.* (Read pages 1-29 of the PDF, which is the same as pages 95-123 of the textbook.)
- As you are reading, summarize each major section with handwritten notes. Only write as many notes as you need to accomplish all of the Chapter Objectives (listed on the first page of the PDF, page 95 of the book).
- Post a picture of your notes on this Discussion board (below).

Appendix B. The Eclectic Reader
Mechanical Engineering Module

Roger Zelazny's For a Breath I Tarry [32]

Learning Objectives

- Evaluate the role of humans and computer in the design process, and discuss the benefits and disadvantages of refusing to accept an impossibility.
- Describe the fixed vs. growth mindset.

Instructions

- Do you agree with Frost's statement in the final line? Make a discussion board post arguing either for or against Frost's opinion.
- The full text of "For A Breath I Tarry" can be found at the following link: http://afrodita.rcub.bg.ac.rs/~alexp/books/forbreat.html

Harry Turtledove's The Road Not Taken [29]

Learning Objectives

- Evaluate the consequences of design decisions many years removed from the original decision.
- Define and describe engineering judgment and how to develop it.

Instructions

- Please read the science fiction short story "The Road Not Taken" by Harry Turtledove:
- https://eyeofmidas.com/scifi/Turtledove_RoadNotTaken.pdf
- Once you are done, please comment on the class discussion board (link below) about one thing in the story that stood out to you or made you think.

Wikipedia account of the Mars Climate Orbiter [33]

Learning Objectives

- Explain why consistent units, clarity of communication, and detailed record-keeping are important in engineering.
- Estimations of engineering quantities and their units.

Instructions

- Consider the following summary of the Mars Climate Orbiter, a spacecraft from 25 years ago (this information has been lifted from Wikipedia). Use the discussion board and describe a situation you have encountered where issues with units have caused a problem. If you have yet to personally encounter a problem involving units, please discuss a time when a miscommunication created a problem.

Caroline M. Yoachim's Welcome to the Medical Clinic at the Interplanetary Relay Station [31]

Learning Objectives

- Discuss the differences inherent in philosophical outlooks underlying design philosophy.
- Follow written and verbal instructions.

Instructions

- Read the science fiction short story Welcome to the Medical Clinic at the Interplanetary Relay Station. The story can be found at the following link:
- https://www.lightspeedmagazine.com/fiction/welcome-to-the-medical-clinic-at-the-interplanetary-relay-station/
- What message do you think the author is trying to convey? Do you think this story does a good job of getting that message across? Write a discussion board post talking about your answers to those two questions.

Philip K. Dick's We Can Remember It For You Wholesale [27]

Learning Objectives

- Identify benefits and disadvantages of potential engineering developments.
- Describe the ethics of the engineering profession.

Instructions

- Would the implementation of "false memories" as an alternative to actual experience be a technology that you would advocate for or oppose? Post a comment on the discussion board defending your answer.
- The full text of "We Can Remember it for you Wholesale" can be found here: https://philosophy.as.uky.edu/sites/default/files/We%20Can%20Remember%20It%20for%20You%20Wholesale%20-%20Philip%20K.%20Dick.pdf

Philip K. Dick's Do Androids Dream of Electric Sheep? [28]

Learning Objectives

- Describe why teams of different personalities and thinking strategies are not only beneficial but often necessary.
- Evaluate team performance using project management, leadership, and team dynamics concepts.

Instructions

- Under what circumstances would you be willing to move to a planet other than Earth? Make a discussion board post with your answer.
- The full text of "Do Androids Dream of Electric Sheep?" can be found here: https://www.larevuedesressources.org/IMG/pdf/dadoes.pdf

Personality Tests

Learning Objectives

- Consider the circumstances which would cause a different decision-making outcome among designers or customers.
- List major concepts in sustainable engineering solutions.

Instructions

- Consider the following personality tests:
  - Myers-Briggs: https://www.16personalities.com/free-personality-test
  - True Color Personality Test: https://www.colorpersonalitytest.net/
  - The Big Five Personality Test: https://www.truity.com/test/big-five-personality-test
- Take two of the tests and make a discussion post about the results. Do the two personality tests you took agree or disagree? Do you think the results are accurate?

Ray Bradbury's The Flying Machine [25]

Learning Objectives

- Contrast the immediate benefits of an emerging technology with its drawbacks.
- Describe the ethics of the engineering profession.

Instructions

- How do you think the negative possibilities of technology should be weighed against their benefits? Is there any specific technology today you believe should be treated more carefully? Make a discussion board post with your answer.

Kurt Vonnegut's Harrison Bergeron [30]

Learning Objectives

- Outline the societal implications of using design in different philosophical manners.
- Explain the importance of life-long learning for engineers.

Instructions

- What message do you think Vonnegut was trying to convey with this story? Make a discussion board post describing your answer.

Isaav Asimov's Nightfall [24]

Learning Objectives

- Identify unsolved engineering problems that are of interest.
- Demonstrate self-directed lifelong learning through reading, interpretation, and synthesis.

Instructions

- What unanswered question in science today would you like to see solved within your lifetime? Make a discussion board post with your answer. The full text to "Nightfall" may be found here: http://www.whitehole.net/storyPages/files/misc/Nightfall.pdf

Ray Bradbury's <u>The Veldt</u> [26]

Learning Objectives

- Identify why short-sighted solutions are often detrimental in longer time frames.
- Explain problem-solving strategy in terms of reality, mental models, and mathematical models.

Instructions

- Can you think of an area in today's society where you are not sure that automation is the correct solution? Make a discussion board post with your answer.
- The full text to "The Veldt" can be found here: https://repositorio.ufsc.br/bitstream/handle/123456789/163728/The%20Veldt%20-%20Ray%20Bradbury.pdf

Appendix C. The Eclectic Reader
Civil and Construction Engineering Module

Henry Petroski's To Engineer is Human Chapter 2 [39]

Learning Objectives

- Describe and illustrate formative content, comparative analysis, design outcomes, design cycle, societal impacts, and career opportunities for engineering and each of the disciplines and subdisciplines.
- Practice sustainable engineering problem solving techniques, engineering analysis and design processes.
- Outline and describe the engineering design process for each engineering discipline.

Instructions

1. Reading Notes (30min)

- *Read* for no more than 30 minutes from Chapter 2 of the provided excerpts from Henry Petroski's *To Engineer is Human* while *taking notes*.
- *Alternatively, listen to To Engineer is Human Chapter 2 on hoopla (free account through County Library).*
    - *Optional 1: listen to To Engineer is Human Chapter 2 while taking notes.*
    - *Optional 2: Listen to To Engineer is Human.*
- *Post* a picture of useful notes from the reading.

2. Lecture Notes (10min)

- *Attend* class *taking notes*.
- *Post* a reply to your own initial post with an updated picture of synthesized notes from the reading and lecture.

G.K. Chesterton's Orthodoxy: Chapter 4 Ethics of Elfland [36]

Learning Objectives

- Practice sustainable engineering problem solving techniques, engineering analysis and design processes.
- Explain problem solving strategy in terms of reality, mental models, and mathematical models.

Instructions

1. Reading Notes (20min)

- *Read* G.K. Chesterton's *Orthodoxy Ethics of Elfland* Common Sense of Fairyland and Logic vs Science (pages 6-14), and Conclusion (page 31) while *taking notes*.
- *Alternatively, listen to G.K. Chesterton's Orthodoxy Chapter 4 on hoopla (free account through County Library).*
    - *Optional 1: Read G.K. Chesterton's Orthodoxy Ethics of Elfland Absurd Limitations of the Materialist and Scientific Fatalism and the Weirdness of Repetition (pages 20-24) while taking notes.*
    - *Optional 2: Read all of G.K. Chesterton's Orthodoxy Ethics of Elfland*
- *Post* a picture of useful notes from the reading.

2. Lecture Notes (10min)

- *Attend* class *taking notes*.
- *Post* a reply to your own initial post with an updated picture of synthesized notes from the reading and lecture.

Ralph Peck's Engineering Judgement: On Being Your Own Engineer, A Man of Judgement, Five Lessons From Five Jobs [38]

Learning Objectives

- Describe the learning process and the learning resources available to the student.
    - Describe the fixed vs growth mindset.
- Demonstrate self-directed lifelong learning through reading, interpretation, and synthesis.
    - Explain the importance of life-long learning for engineers.
- Practice sustainable engineering problem solving techniques, engineering analysis and design processes.
    - Define and describe engineering judgement and how to develop it.

Instructions

1. Reading Notes (30min)

- *Read* for no more than 30 minutes from the provided excerpts from Ralph Peck's *Engineering Judgement* while *taking notes*.
- *Post* a picture of useful notes from the reading.

2. Lecture Notes (10min)

- *Attend* class *taking notes*.
- *Post* a reply to your own initial post with an updated picture of synthesized notes from the reading and lecture.

FE Reference Handbook [35] and C.S. Lewis's Abolition of Man: Chapter 3 [37]

Learning Objectives

- Describe the ethics of the engineering profession.
- Articulate the requirements for professional licensure.
    - Outline the requirements, process, and benefits for professional licensure including the role of an engineering degree program.
- Practice sustainable engineering problem solving techniques, engineering analysis and design processes.
    - List major concepts in sustainable engineering solutions.

Instructions

1. Reading Notes (30min)

- *Read* pages 4-9,12 from the FERH *taking notes*.
- *Read* Chapter 3 from C.S. Lewis's *Abolition of Man* Download Abolition of Man *taking notes*.
    - *Optional: Listen to all of C.S. Lewis's Abolition of Man on hoopla*
- *Post* a picture of useful notes from the reading.

2. Lecture Notes (10min)

- *Attend* class *taking notes*.
- *Post* a reply to your own initial post with an updated picture of synthesized notes from the reading and lecture.

Adler and Doren's How to Read a Book [34] and Polya's How to Solve It [40]

Learning Objectives

- Demonstrate self-directed lifelong learning through reading, interpretation, and synthesis.
    - Explain the importance of reading for life-long learning.
        - Identify terms and procedures through inspectional and analytical reading.
            - Inspect a text.
            - Describe and practice the steps of analytical reading.
        - List the requirements for respectful disagreement.
        - Document learning through written assignments
            - Note taking and journaling
            - Discussion boards
        - Follow written and verbal instructions.

Instructions

1. Reading Notes (30min)

- *Read* at least 20 min from the provided excerpts from Adler and Doren's *How to Read a Book* "Goals of Reading"(7-11), "Reading as Learning" (11-14), and "The Third Stage of Analytical Reading" (163-164) while *taking notes*.
- *Read* the provided excerpts from Polya's *How to Solve It* "Main Divisions, Main Questions" (pages xvi to xvii) while *taking notes*.
- *Post* a picture of useful notes from the reading.

2. Lecture Notes (10min)

- *Attend* class *taking notes*.
- *Post* a reply to your own initial post with an updated picture of synthesized notes from the reading and lecture.