Critical Thinking:
Improving these skills in our students

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Expectations in a typical university course

- Student expectations
  - Job of TA/professor is to provide content, explain, grade
  - Job of student is to memorize, perform tasks, move on
- TA/Professor expectations
  - Help students develop stronger, broader skills using course content as a vehicle
  - Link with skills and knowledge from prior courses
  - Empower students for future challenges
- Mismatch is often a root cause of dissatisfaction

Outline/Goals for Today

- How to focus student's attention on and improve their broader skills
  - Intellectual development / critical thinking (today)
  - Communication, ethics, cultural adaptability…..
- How to embed intellectual development in your course
  - For TAs
  - For people in charge of a course
- Likely student reaction
- Summary

My Background

- Teach large-enrollment (400-600), calculus-based physics to sophomores
  - Mainly pre-engineering students
  - Develop broader, stronger problem-solving skills in students via complex, ill-structured problems

Intellectual development of students (I)

- Core student-beliefs about what is knowledge/learning
  - Hofer's review of Perry scheme and others (handout)

1. Duality
   - all problems are solvable
   - the student's task is *to learn the right solutions*
2. Multiplicity
   - attempts to account for diversity in human opinion
   - often becomes a new certainty of "we'll never know for sure,"
   - what is most important is one's own thinking.
   - arbitrary basis for determining what's right
     - hence an attitude of "do your own thing" or "anything goes"

Adapted from http://www.perrynetwork.org/schemeoverview.html
http://www.cse.buffalo.edu/~rapaport/perry.positions.html

Intellectual development of students (II)

3. Contextual Relativism
   - Propose solutions and support these by reasons;
   - Some solutions are better than others, depending on context.
   - Student's task is to learn to *evaluate solutions*.

4. Commitment
   - Develop and judge possible solutions using both intellectual and ethical considerations
   - Consider choices in the face of legitimate alternatives
   - Integrate knowledge learned from others with personal experience and reflection.

Question

- Discuss these four Perry positions in your group
  (Dualist, multiplicity, contextual relativism, commitment)
  - Do they "ring true" to you about students
  - Estimate the average shift of positions a typical student has during his/her four years at college
    - e.g. from Duality (1) to Commitment (4) is a shift of 3
    1. average shift ~ 1, or less
    2. 1 < average shift < 2
    3. 2 < average shift < 3

Critical thinking

Analysis of what people do who perform regularly at the "Committed" position

Develop and judge possible solutions using both intellectual and ethical considerations

⇒ Large amount of buzz in popular industry, books etc.

⇒ As TAs and Profs: use critical-thinking literature to

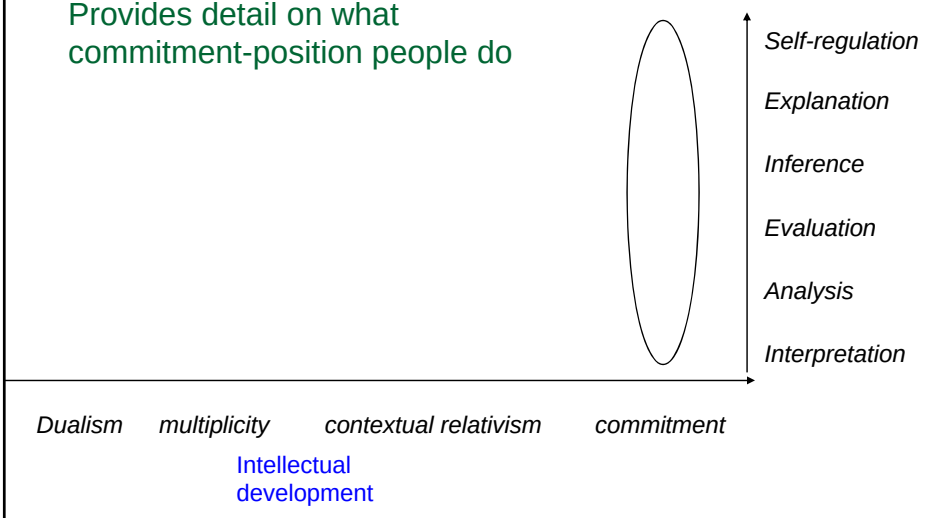
- ⇒ Divide committed-level work into describable steps
- ⇒ Provide learning challenges to students with the goal of developing them intellectually

Critical Thinking Skills: P.A. Facione handout

- Interpretation
  - Comprehend significance of wide variety of information
- Analysis
  - Identify the relationships
- Evaluation
  - Assess credibility of the information and relationships
- Inference
  - Identify and secure elements needed for conclusions
- Explanation
- Self-regulation
  - Self-consciously monitor progress

Critical thinking:

Provides detail on what commitment-position people do



Help our students develop intellectually (I)

- Core idea: epistemic doubt
  - Cause students to worry that their ideas about knowledge/learning needs to develop
- Use questions to target specific critical thinking skills in interactions between students and TAs + Profs
  - "Can you consider this from another point of view?"
  - "What assumptions have led you to that conclusion?"
  - ……
- Respect for where students are and how difficult it is to shift intellectual development level

Write questions you would ask a student to help develop each critical-thinking skill (I)

- Take each of the skills below
  - Write a few questions that you could ask a student (or small group of students) in a teaching/learning interaction, e.g. while they were working on a task
  - Discuss these in your group
- Interpretation
  - Comprehend significance of wide variety of information
- Analysis
  - Identify the relationships
- Evaluation
  - Assess credibility of the information and relationships

Write questions you would ask a student to help develop each critical-thinking skill (II)

- Take each of the skills below
  - Write a few questions that you could ask a student (or small group of students) in a teaching/learning interaction, e.g. while they were working on a task
  - Discuss these in your group

- Inference
  - Identify and secure elements needed for conclusions
- Explanation
- Self-regulation
  - Self-consciously monitor progress

Help our students develop intellectually (II)

- Provide variety of tasks that require students to work at higher development positions
- History: *Investigate different 1st hand accounts of an historical event and assess why they are divergent*
- Engineering: *Perform a risk analysis of the strategic and technical aspects of increasing the production capacity for your company*

- Students need regular exposure to these challenges at all levels of their courses
  - Too vital to be left for senior courses (and too late)

Question

- Write (by yourself) a task that students could do in your course that would require students to work at higher development positions
  - Or choose a freshman course in your major
- Discuss these with your groups

Openness

- Communicate that broad-skills are key goals of course
- Plan tasks that require these skills
- Use *public* grading criteria for these skills
- Example, “modeling projects” in Physics 222

Physics 222, 500 students, groups of 3

Choose some device that you use on a regular basis.

- Calculate how to improve the performance of this system.
- Find some way to quantify the behavior of the system, e.g. derive an expression for the performance as a function of key operating parameters.
- To derive this expression you will need to develop an approximate physics model of the system.
- The challenge in this step is to identify the physics principles (perhaps more than one concept) that dominate how the device works, and to justify which effects can be ignored at the level of approximation that you are making.

Section of Project Rubric

Criteria	Excellent (4 points)	Good (3 points)	Marginal (1 points)	Unacceptable (0 points)
Physics Model	The functioning of the real system, and how it works, is described. From this description, key features of the system are identified, and used to justify a simplified yet tractable model system.	The functioning of the real system, and how it works, is described. From this description, key features of the system are identified, and used to build a simplified yet tractable model system,	The functioning of the real system, and how it works, is described. The model system is also described but it is not clear what the links are between the two systems.	The functioning of the real system, and how it works, is described.

Student reaction to being assessed on critical thinking

- Most probably will be negative
  - "Just tell me what I need to know to pass the exam"
  - "It's only a freshman/sophomore class: I don't need advanced problems/challenges till later…."
  - "Your job is to tell me the facts…"
- Part of this is intellectual development
  - Student may not see importance of rational judgment
- Counterbalancing the negative reaction, surveys at ISU show that students want higher-level intellectual challenges

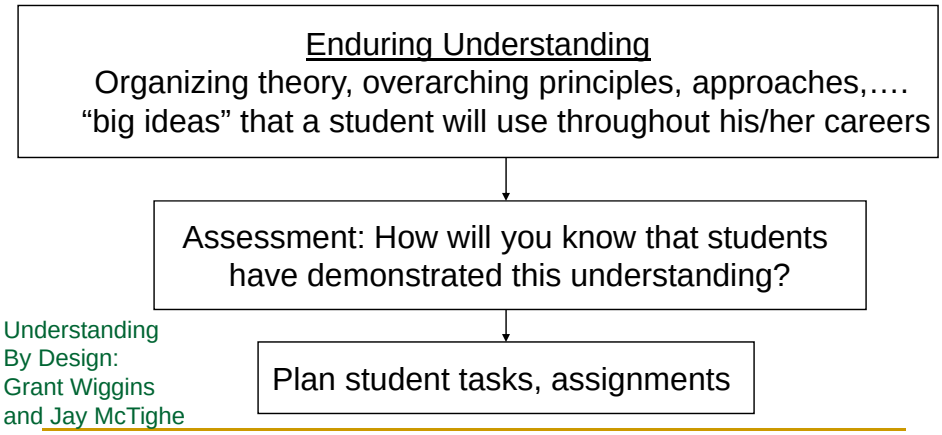
Summary

- Please consider the explicit goal of developing broader skills
- Focus today on intellectual development
  - From dualism: right/wrong answers
  - To commitment: use judgment to rationally choose
- Core idea is to create epistemic doubt
  - Cause students to worry that their beliefs about knowledge/learning needs to develop
- Use questions/interactions to target critical thinking skills
  - "What assumptions have led you to that conclusion?"
- Variety of tasks requiring work at higher development levels
  - Grade on these skills, provide support, feedback.

Backup Slides

Dilemma

- Many open-ended questions you could ask
  - How do you choose?



Understanding By Design: Grant Wiggins and Jay McTighe

Our experience in physics courses

- Modeling-task in physics
  - 500 students, groups of 3
  - Graded by TAs using common rubric
  - Projects submitted twice,
    - 1st is for feedback, 2nd time is for grade
- Some students react enthusiastically to "create" rather than passively receive
- Others bypass goal
  - Project is descriptive (knee-bone is connected to…)
  - Students producing what they are comfortable with ?

Smaller Tasks

- Students don't just start with this large project
- Intermediate tasks of reduced complexity
  - Still ill-defined problems that require analysis, building
- Every two weeks, work on a multi-faceted problem

You are in charge of drinks at a picnic that will start at 3pm.
Place ice inside a cooler at 6am, temperature outside is 10°C.
The day warms up steadily to reach 30°C by 3pm.
Estimate how much ice you will need.

- How does this problem differ from normal?

Definition of critical thinking

Joanne Kurfiss, adapted from "Critical Thinking" 1988

Critical thinking is a rational [judgment about] questions that cannot be answered definitively and for which all the relevant information may not be available.