Learning Goals:
What
Why
How

Carl Wieman Science Education Initiative
at the University of British Columbia

CWSEI

Jared Taylor, STLF Life Sciences
Beth Simon, STLF Computer Science
Steve Wolfman, Instructor Computer Science

By the end of this session you will be able to…

- LG1: Give examples of both a "high-level" – course learning goal and a "lower-level" topic learning goal.

- LG2: Be able to list at least two characteristics of well-designed learning goals.

- LG3: Describe to a colleague how students at UBC who had lecture-level LGs found it helped them "know what they needed to know" for a course.

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Agenda

- What, Why, (What)

- Evidence:
  - A study of the usefulness of learning goals for students

  - Anecdotal evidence of the value for instructors
    - E.g. your colleagues' thoughts and reflections

- How
  - Guidelines and a role play

- Give it a try!

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Before we get started…

- Get a piece of paper

- Think of a class you teach
  - think of the most important concept/skills/issue in that course

- Write down a learning goal you have regarding that concept
  - It should be a complete English sentence.

- Folder your paper in half or turn it face down

What's in a name?

- Learning goals (for us) are
  - Set of statements that describe how a student should be different at the end of a course
  - Reflect the key abilities, attitudes, and items of mastery that a student should (strive to) attain

What's not a learning goal (to us)?

- Chapter Headings:
  - DNA Replication, Minerals, Organelles, etc.

- List of concepts:
  - Newton's First Law, Loops, Second Law of Thermodynamics, First Derivative

- Something that a student can't figure out if they have done/can do
  - Understand looping in Java
  - Develop problem solving skills
  - Know about gene regulation
  - Understand landslides

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What are learning goals?

- Let's wait
  - Why we want them might influence what we put in them...

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Why Make Learning Goals

- ## Audience 1: Instructors
  - ### For yourself
    - Reflect on problematic course
    - Change in scope/book/requirements
    - Create new class, organize
  - ### For your colleagues
    - Share same "mission" for common course
    - Make sure students have common experience
      - To prepare them for next course in sequence/discipline
    - Support pre- post- requisite planning
  - ### Departmentally: define what students in your program know

Why Make Learning Goals

- Audience 2: Students
  - Help them clearly identify what they should be mastering for exam/course
  - Help them identify key aspects of lecture
  - Give them a "checklist" to see if they are "on track" in the course
  - Exploit (or avoid) the question of "is this going to be on the exam"

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What are learning goals

- They complete the sentence:
  - By the end of this course you will be able to…

- They are measurable:
  - That is a student who has NOT YET mastered that goal can determine that they have, in fact, not yet mastered it
    - Corollary: Vague terms like "understand" are not helpful (since the level of understanding/mastery is not specified)

Example of employing these two principles

Original

- Know about gene regulation.

New and Improved

- Predict of the effect of removing an operator that is normally found in front of a gene

- Compare and contrast the differences between negative and positive feedback in gene regulation.

What are learning goals

- They might be high level – and reflective of a change a student should get from a course:

    - Learn what you and your community can do to prepare for natural disasters.

    - Identify and evaluate trade-offs in design and implementation decisions for systems of an intermediate size.

- They might be detailed – and reflective of a change a student should get from a lecture

    - Be able to diagnose the type of strain by the way a material deforms.

    - Compare and contrast the use of inheritance and delegation in software design.

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Why make LGs "our way"?

- Two studies
  - How students responded to the use of lecture-level learning goals presented daily.
    - They found them VERY VALUABLE
  - How a group of 9 instructors at UBC felt about a process by which they created
    - Detailed topic-level LGs
    - "Higher-level" Course LGs
    - Found it easier to make exams, revise/create lectures, talk to colleagues about curriculum

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What Value Are Learning Goals to Students?*

- Three courses (2 CS, 1 Bio)

- Instructors independently developed LGs
  - Reflective of unit or topic (57-75 LGs)

- Incorporated them in lectures
  - Presented at beginning of each lecture or topic (at least 1-2 times a week)

- Variation in use:
  - One instructor promised all exam questions would come from LGs

*Draft of article submitted to Journal of College Science Teaching available from http://cwsei.ubc.ca

Methodology

- ## Students
  - End of term survey asked to complete this sentence 5 times
  - "For me, in this course, the use of learning goals was_____"

- ## Analysis
  - Grounded-theory based analysis
    - Two coders read through all answers from one course, develop categories of answers, discuss, refine
    - Code and count each response into one category
    - Apply to other 2 courses

- ## Faculty Interviews
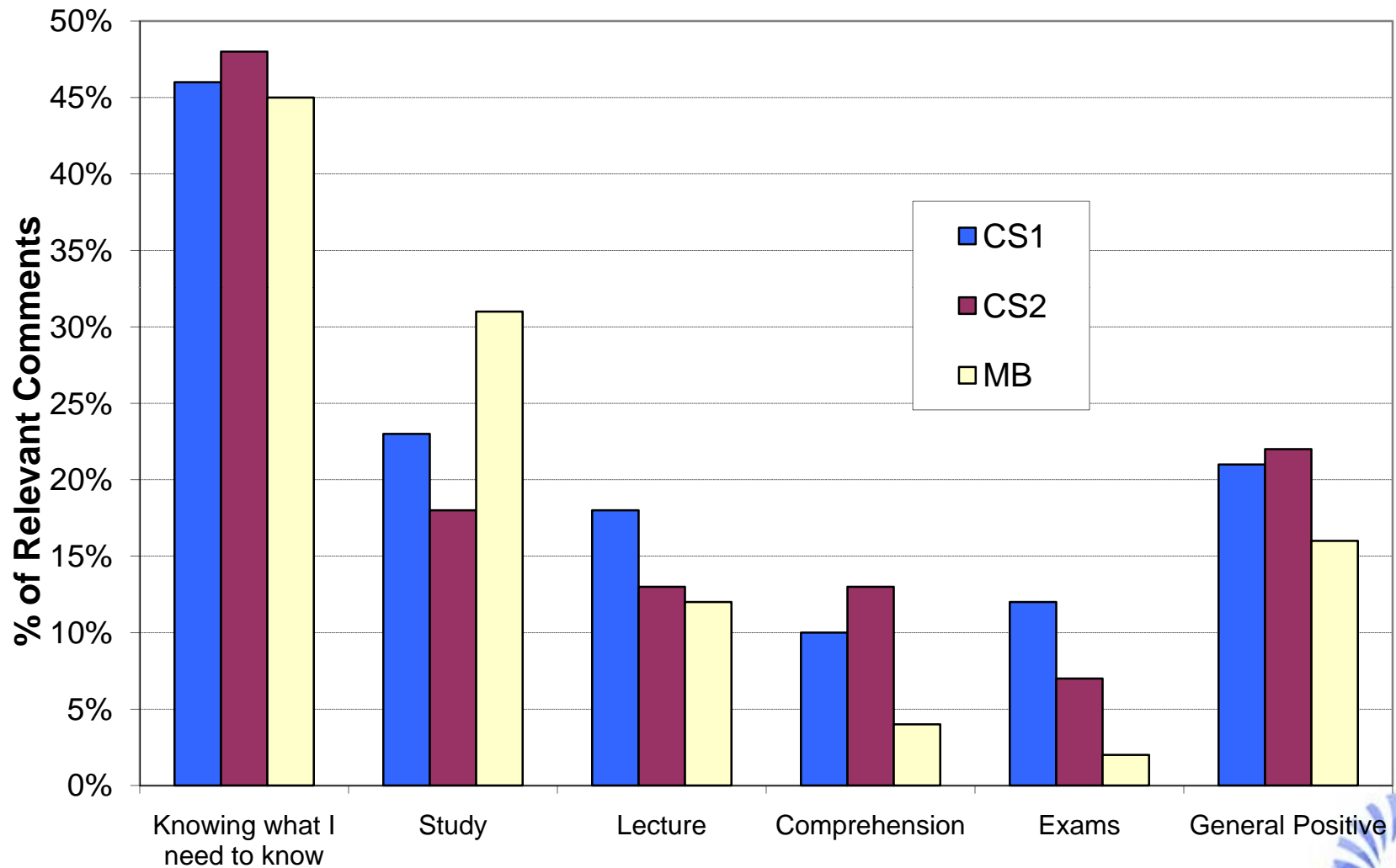
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Findings: View them positively

Percent Positive and Negative Comments

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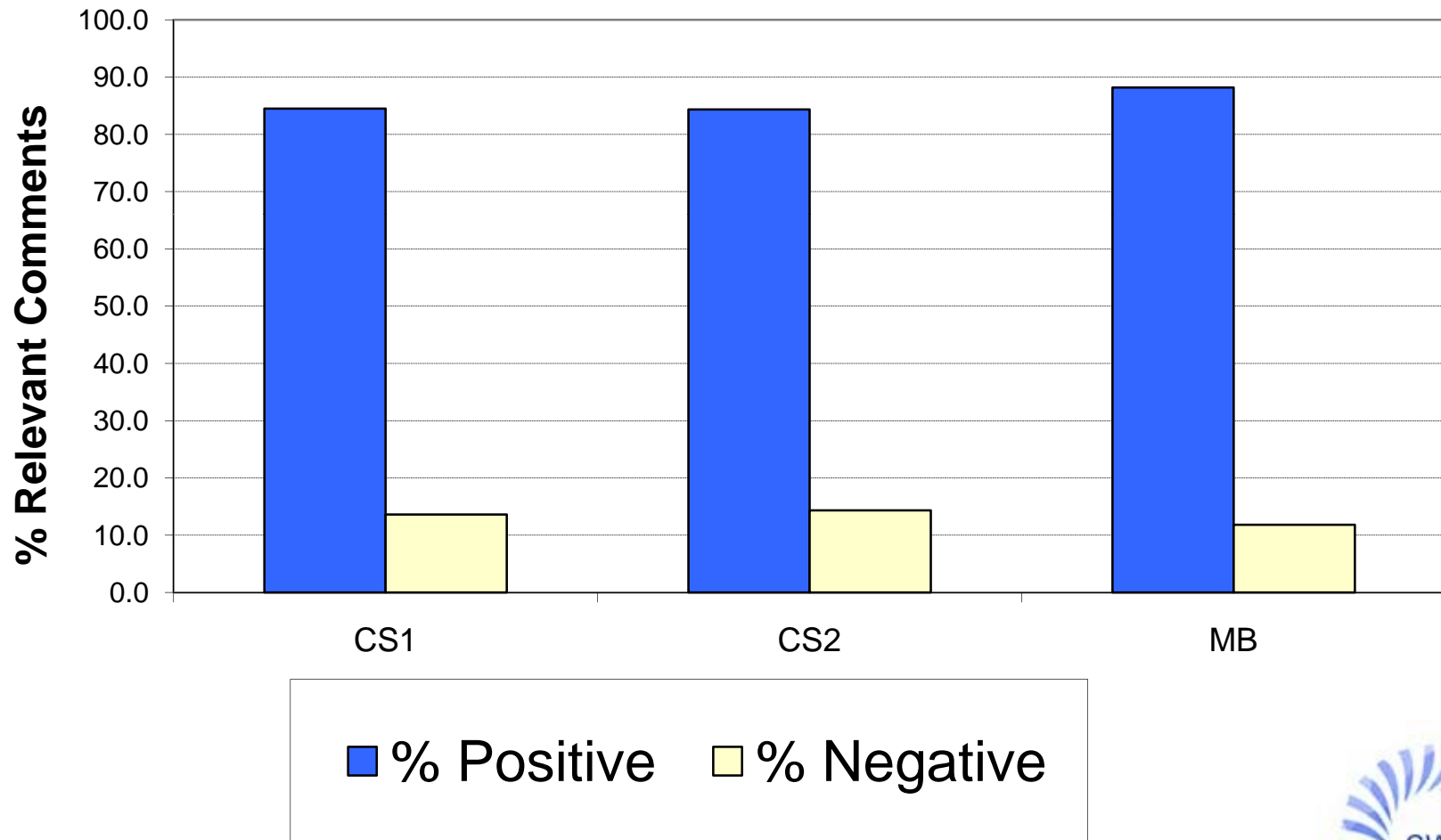
Findings: What students value them for
Percent of Comments by Category

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Findings: What to Remember

- Learning Goals presented regularly as part of lecture

  - Help students "know what they need to know" in a course.

Category	Student response
Focus	"helpful because it tells me what I need to focus on"
Track	"good for keeping me on track"
Guide	"useful because it guides me through the progression of the class throughout the term"
Study, Prepare, Review	"improves my study habits"

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OK: But is it worth the effort?

- 9 Instructors in Comp Sci spent about 10-20 hours (in teams of 2-3) developing topic and course level LGs.
  - For each of the 5 1st and 2nd year required courses

- At the end, they reflected:
  - Exam design is much easier
  - New emphasis in class/homework/exams on "something we always thought was important"
  - Validation of sections of course that "never seemed to fit well"
  - Different than prior experiences with LGs which seemed "vague" and "not helpful"
  - Enables/eases refining of lectures
  - Come to consensus with colleagues on key pervading issues
  - Incredibly valuable to share ideas about, discuss, and debate what we're teaching

How did they actually DO THIS?

- Role-Play
  - This is just one possible way, others have used other methods/techniques

- Structure: 2 instructors and 1 STLF moderator/note-taker

- Process overview:
  - Review final exam questions and answers:
    - If a student got this right, then they can…
  - "Walk through" lecture materials, content
  - Overview all topic-level goals, create course-level
    - Make grid placing TL under CL

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The Exam Question

- If the colour of a pixel is a shade of gray, what constraints must the three colour intensities satisfy?

Take Home Points From Demo

- ## This is not a solo endeavor

  - Colleagues are critical, moderator helpful

- ## Identify if questions can be correctly answered without desired knowledge

- ## Discuss core concepts and goals

  - Work into specific expectations

- ## Move from understand to better verbs

About that Piece of Paper…

- Turn it back over

- Can you see how to re-write it so that
  - It completes "By the end of the course a student can…"
  - Is something that a student can read and know that they "don't know this yet"

- Take a minute and write a second version…

Final Notes

- ## Some say
  - Providing LGs for students is not a good idea – they should be able to figure those out for themselves!

- ## Our experience:
  - Faculty often don't concur on "core aspects" or motivations or ordering for concepts in a course.
  - We need to remember that if experts vary, it's reasonable that novices NEED structure to effectively engage a new discipline.

Learning Conference 2008:
Bringing Learning Goals to Fruition.

Carl Wieman Science Education Initiative
at the University of British Columbia

Introductions

Francis Jones
EOS

Brett Gilley
EOS

Erin Lane
EOS

Jared Taylor
Life Sci.

Beth Simon,
UC San Diago

Steve Wolfman
Computer Sci.

The Carl Wieman Science Education Initiative (CWSEI)
http://www.cwsei.ubc.ca/

Departments of Earth and Ocean Sciences
Earth and Ocean Sciences   Science Education Initiative
 http://www.eos.ubc.ca/research/cwsei/

Workshop Learning Goals:

After this <u>workshop</u> you should be able to …

1. Give arguments for using explicit learning goals;

2. Convert a *topics list* into *learning goals* that reflect what <u>students</u> should be able to do;

3. Write learning goals targeting three *learning domains*;

4. Use Bloom's taxonomy to help write effectively *assessments* that link to learning goals*;*

How many already use learning goals?

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Workshop plan of action

1. Introduction: characteristics of useful learning goals.

2. Topics list versus goals.

3. Targeting learning domains.

4. Bloom's taxonomy and assessments that inform both students and instructors.

Today's work will contribute to new, online, resources.

Practice and collaborate in working groups

⇒ No substitute for discussion with peers & iteration.
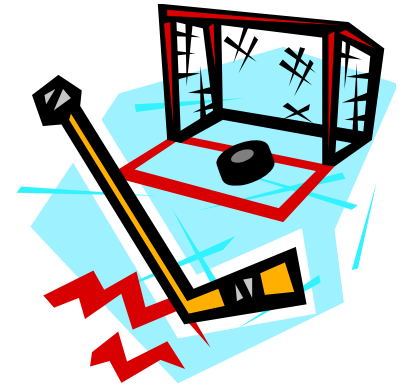
⇒ General & small group discussion, and revisions.

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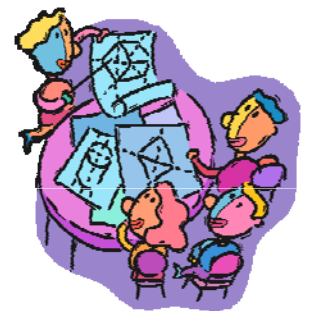
Activity 1: Brainstorming

- Characteristics of learning goals that will be useful to
  - students
  - Instructors
- List on flipchart paper

- To be used later, then added to legacy

Types of learning goals

Wide range of possible goals:
- memorizing terminology
- complex problem solving skills
- transferring ideas to new contexts
- thinking like a professional / scientist
- many others …..

- Goals are never perfect but always valuable.

- Discussion with colleagues and revision are beneficial. (as per Beth and Steve.)

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Context for learning goals:

Institution (UBC) Faculty (Science)

Department / Degree programs / Professions

Course level

Module (topic) level

Lesson / assignment level

Goals at any level should emphasize students

- **Students** must do their *own* learning;
  We can not do the learning for them.

- Goals that will help students learn must focus on **what students do**, not instructors or content.

- Think:
  - *"How will students demonstrate achievement?"*
  - *"What should students remember 2-5 years on?"*

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Are all your goals visible?

- Students miss important information if they are NOT explicitly looking for it.

- *Hidden* goals do not help students learn.

- As experts, we often forget what we did not know.

EOS-SEI
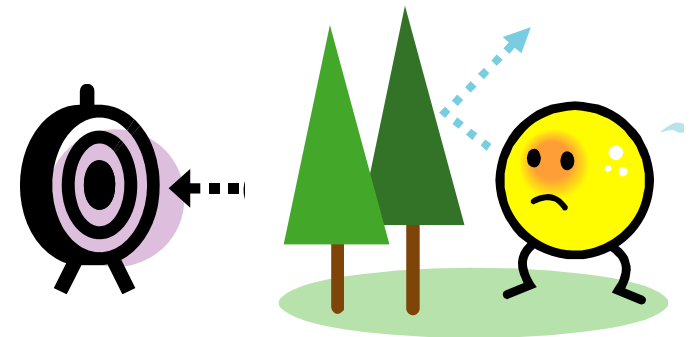
Developing learning goals

- Exams → goals   *(as per Comp. Sci.)*
  - Start with old exam questions
  - Investigate content details
  - Generate learning goals;   Iterate ….

- Topics → goals   *(what we'll practice here)*
  - Start with old topic lists
  - Generate learning goal equivalents
  - Consider assessments   (followed by active learning)
  - Iterate ….

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Topics list to learning goals
Example: introductory mineralogy

<u>Context</u> is important for steering goals

- 2nd year students, mostly pursuing a geology degree

- Pre-requisite for many subsequent courses
    - Well defined requirements for learning

- Background
    - Minimal experience in geology
    - 1st year chemistry

Topics list to learning goals
Example: introductory mineralogy

Topics list	Learning goals:
• Introduction to common rock forming minerals	After this course, students will ... • **use** observations about minerals and rocks to **infer** geological processes and economic potential.
• Mineralological processes	
• Rocks & minerals indicating economic potential.	• **Describe** the processes that produce kimberlites.

Activity 2:

Draft learning goals for your own course.

- Topics → goals:
  - Write down one topic in a class you may teach
  - Develop one or two learning goals on your own

- Share / discuss with your table; Refer to characteristics.

- Questions? Comments?

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Refining goals,   3 learning domains
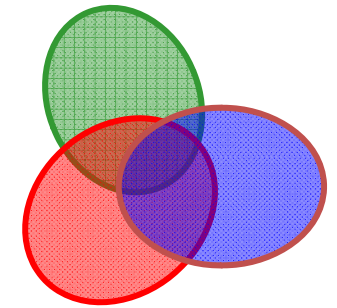
Cognitive: "Knowing about stuff"
- Describe, explain, predict aspects of the discipline.
- Reasoning, Problem Solving, Evaluating, Critiquing…

SKILLS: "Doing stuff"
- Lab skills, instruments, tools, computer programming, …
- Library, research, writing, presenting, …

ATTITUDES: Appreciate, Enjoy, Value
- e.g. Stimulate enthusiasm for Earth Sciences.
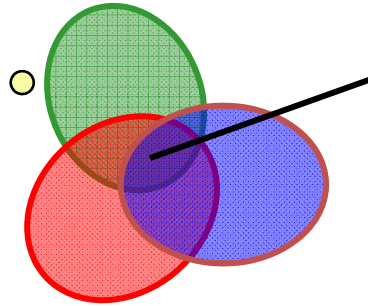
   About the nature of learning and doing
- e.g. Believe that learning and doing physics is more about
   reasoning and making sense, not memorizing.

N.B. There are many "models" for learning domains.

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Example:

COGNITIVE

SKILLS

ATTITUDES

One Lecture-scale Learning Goal could touch upon 3 course-level goals

Goals for a 1st yr physics course include all 3 aspects of learning:

Course-level learning goals

Recognize that the behavior of the world around you is not magical and mysterious, but rather can be understood and predicted using certain fundamental principles.

Use knowledge about properties and motion of electric charges to predict and explain various aspects of electricity.

Lecture-level learning goals

Be able to design a fluorescent light bulb.

Explain and justify the requirements on specifications of various basic electronic components.

Activity 3: Learning domains

CONCEPTS
SKILLS
ATTITUDES

- Consider these …

    1. *Intro. Biology*:
       Contrast the features that distinguish viruses, bacterial cells, and eukaryotic cells from each other.

    2. *Gen. Chemistry*:
       Students will recognize and explain how chemistry concepts apply to everyday phenomena.

- Which types of learning are targeted?
- Do you prefer either one of these?   Why?

EOS-SEI
45mins

Activity 4:   Learning domains

CONCEPTS
SKILLS
ATTITUDES

1. In groups, categorize your earlier goals.

2. Consider refining one or more of them.

Thoughts?   Questions?

Assessments

- Clarity … and "verbs that don't work".
- Good assessment will need clear learning goals.
- Framework for connecting assessments to goals.

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Blooms Taxonomy of Learning

1. <u>Factual Knowledge</u>: remember and recall factual information

2. <u>Comprehension</u>: demonstrate understanding of ideas, concepts

3. <u>Application</u>: apply comprehension to unfamiliar situations

4. <u>Analysis</u>: break down concepts into parts

5. <u>Synthesis</u>: transform, combine ideas to create something new

6. <u>Evaluation</u>: think critically about and defend a position

See the handouts page 3.

EOS-SEI

Blooms Taxonomy of Learning

1. <u>Factual Knowledge</u>: remember and recall factual information
   Define, List, State, Label, Name, Describe

2. <u>Comprehension</u>: demonstrate understanding of ideas, concepts
   Describe, Explain, Summarize, Interpret, Illustrate

3. <u>Application</u>: apply comprehension to unfamiliar situations
   Apply, Demonstrate, Use, Compute, Solve, Predict, Construct, Modify

4. <u>Analysis</u>: break down concepts into parts
   Compare, Contrast, Categorize, Distinguish, Identify, Infer

5. <u>Synthesis</u>: transform, combine ideas to create something new
   Develop, Create, Propose, Formulate, Design, Invent

6. <u>Evaluation</u>: think critically about and defend a position
   Judge, Appraise, Recommend, Justify, Defend, Criticize, Evaluate

These levels expect deeper conceptual understanding

EOS-SEI

Practice thinking about Bloom's taxonomy

Learning goals: **What Bloom's level are these?**   (from mineralogy)

1. Propose a diamond exploration plan based upon mineralogical evidence found in rocks of a given area.

2. Compare the chemistry of binary solid solutions which have miscibility gaps to complete solid solutions.

3. Use binary and ternary diagrams to plot mineral compositions.

Are any levels "better" than others?

EOS-SEI
60mins

Testing achievement of learning goals
ie assessing progress.

Why:
- Formative assessment = closing the feedback loop.
  Work / test / quiz/ etc. informs instructor & student
  about knowledge gaps.
- Discover what students think *now* (before exam), and react !

When:
- Pre-test / Post-test
- Active learning = formative feedback
- Evaluations of home- class- lab- group-work.
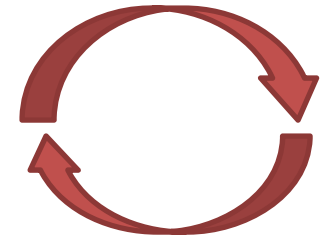
How: Today's focus is how to ask **questions** which effectively
assess specific learning goals.

Handout page5: Formative Assessment Questions

Example from a 1st year geoscience lab

Course level goal: Make interpretations and draw conclusions about Earth systems using observations and analyses.

Topic goal: Approximate the location of an earthquake using seismograph data provided, and consider possible errors.

Questions:

1. Given three seismograms and their locations, estimate the location of the earthquake's epicentre.

   Low level, (cognitive & skill)

2. What is a reasonable way to "pick" the epicentre location IF your distance circles do not intersect exactly?

   Moderate level; (cognitive → implications)

1. If you only had two seismometers, could you determine the location of the epicentre? Explain.

   Higher level; (cognitive "what if …")

EOS-SEI
120mins

Activity 4: Back to your goals

- Pick one of the goals from your last group activity.
- Write two questions to test learning of that goal.
  - One at Bloom's level 1 – 3
  - One at Bloom's level 4 – 6

Guidelines - keep in mind:

- student perspective; - learning domains;
- clarity of purpose;   - what will students do?

Avoid rote memorization.   Try:

- *"Troubleshooting"* (what could cause a given change?)
- *"Redesign …"*
- *"Compare and contrast …"* scenarios

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Implementing assessments (questions)
Not just exams …

- **In class is important – why?**
  - Active learning
  - Rapid feedback for students AND instructors

- **Who has experience with**
  - in-class active assessments?
  - Tutored labs / recitations?
  - Team / group work?

Just in Time Teaching and **Peer Instruction**
(Eric Mazur, Harvard)
http://www.youtube.com/watch?v=lBYrKPoVFwg&NR=1

EOS-SEI

Implementing assessments (questions)

What are some options?   (Any can be solo / pairs / group work.)

- Clickers
- Coloured cards to raise (multiple choice questions)
- 1 minute papers
- Team work with "instant" deliverables to enable compare & discuss
- Pre-test quizzes (solo and/or groups)
- Pre-test + Post-test.   Fosters curiosity.   Enables engagement.

- Many options.   Faculty teaching support are there to help with ideas.

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Recap 1 -

Values of explicit learning goals:

- *Students:* Define what they should be learning, and why.

- *Instructor:* to better define, guide, & check your teaching.

- *Both:* Essential for <u>measuring</u> what students are learning;
  i.e. goals help build assessments which provide feedback
  to students and instructor.

- Enhances transfer of the course to new instructors.

Your characteristics:
We will compile and post as a resource.

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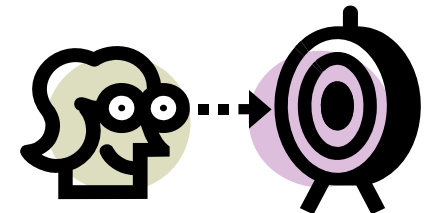
Recap 2 -

Building linked course level and topic level goals

- Student (NOT teacher) point of view.

- Aspects of learning (concepts, skills, attitudes).

- Bloom's taxonomy can be a useful as a framework.

- What will students DO to demonstrate achievement?
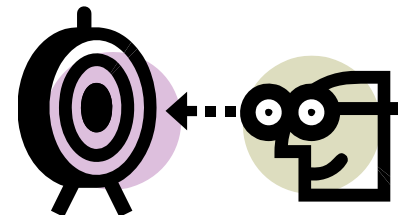
Recap 3 -

Assessment is the key;

- Closes the learning feedback loop.

- Aim to target all levels of learning appropriately

- Clarity is crucial but non-trivial

- Implementation:
  - In class, labs, home, online,
  - Frequent and immediate feedback.

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Questions ....

Homework ☺

- Refine the learning goals for your course.

- A wide range of resources are available from many reputable institutions.

Follow-up

EOS-SEI   http://www.eos.ubc.ca/research/cwsei/

CWSEI   http://www.cwsei.ubc.ca/

TAG   http://www.tag.ubc.ca/

Workshop evaluations   (Handout – last page).
Were these learning goals useful?   Achieved?

1. Give arguments for using explicit learning goals;

2. Convert a *topics list* into *learning goals* that reflect what <u>students</u> should be able to do;

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EOS-SEI
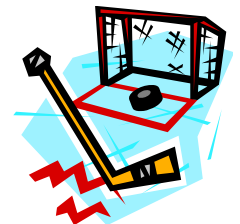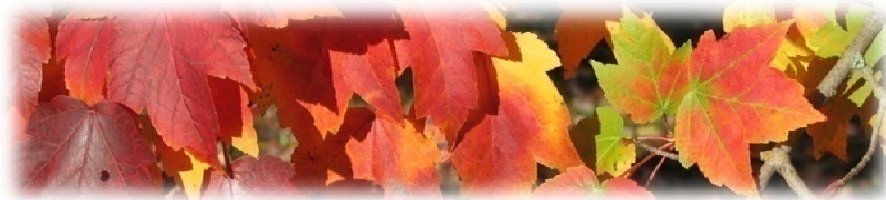
Topic-level learning goals (2-3 per class period)

<u>Check-list for creating topic-level learning goals</u>

1. Is goal expressed in terms of what the student will achieve? Does it identify what students will be able to do after the topic is covered?

2. Is the Bloom's level of the goal aligned with your expectations for students' learning … Is this what students will be able to do if they "understand" the topic at the level you want?
   - If you expect reasoning for "why", does it convey that?
   - Could you expect a higher level goal?

3. Is it well-defined? Is it clear how you would test achievement?

4. Do chosen verbs have a clear meaning?

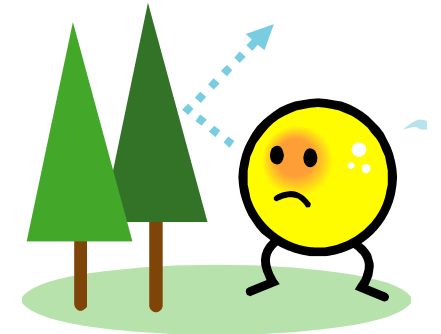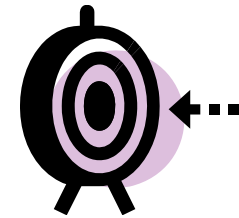5. Is terminology familiar/common? If not, is the terminology a goal?

   Not every goal can achieve the following, but it is better if you can:

6. Is it relevant and useful to students? (e.g. connected to their everyday life, or does it represent a useful application of the ideas).
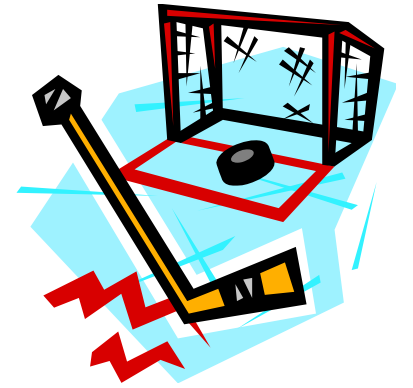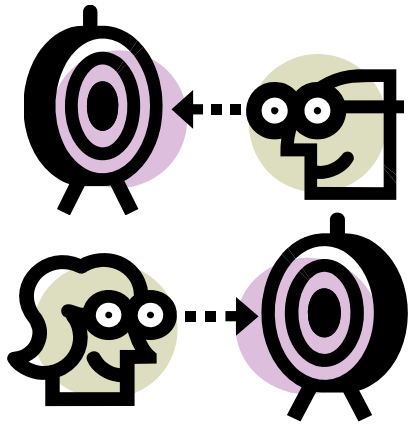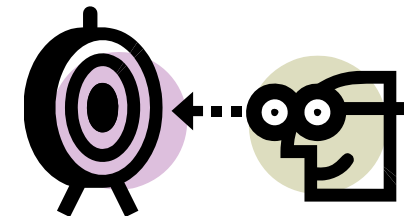
Student-centric

Recap: *Some* aspects of <u>course-level</u> goals

- Minimal   jargon (unlike topic level goals).

- Should be informed by …
  - Pre- and post-requisites
  - Department goals and resources
  - Discipline context & constraints (professions etc)

- Articulate …
  - Attitudes / beliefs you hope students will gain.
 - Concept areas and skill sets students should acquire

Recap: *Some* benefits of <u>course-level</u> goals

- Structure the course & guide methods of instruction.

- Study guide – help students manage time & effort.

- Helps instructors assess levels of prior learning.

- Enhances transfer *between* instructors.
     (Instructors retain flexibility at the topic level)
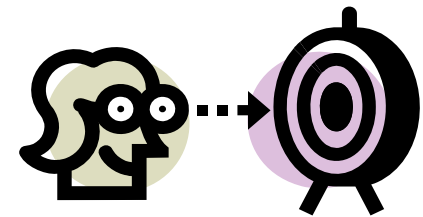
ONLY IF DESIRED …

Find earthquake's location using seismograms from 3 stations.
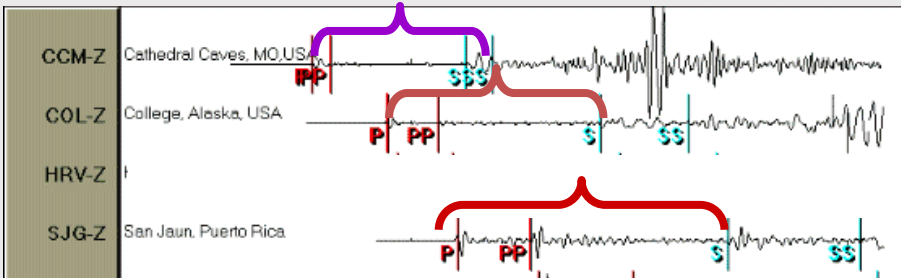
Procedure:

A. "Convert" P-S time to distance

B. Draw circle at distance.

C. Do it at 3 or more places.

Intersection is the epicentre.

EOS-SEI