Higher Cognitive Learning: Critical Thinking & Problem Solving

Dr Roisin Donnelly

The important thing is not to stop questioning - Albert Einstein
All life is problem solving - Popper
Why is it important to encourage higher-cognitive learning?
Emphasis needs to be placed on incorporating the use of higher-order thinking and complex thinking skills, as well as other 21st Century Skills such as collaboration and communication.
21st Century Skills

• Core Subjects and 21st Century Themes
  – Maths, Language Arts, Science, Social Studies
  – Global Awareness and Civic Literacy
  – Economic and Business Literacy
  – Health Literacy

• Learning and Innovation Skills
  – Creativity
  – Critical Thinking and Problem Solving
  – Communication and Collaboration
21st Century Skills

21stCenturySkills.org
'Soft' skills play a central role in preparation for employment in Ireland; The Irish Independent also singled out the National Competitiveness Council's call for skills such as critical thinking, problem solving, communication and self-directed learning in March this year (2010).
The Millennial Generation

“Today’s students are no longer the people our educational system was designed to teach”

– Mark Prensky
Characteristics of Digital Natives

- Active
- Multi-tasking
- Non-linear thinking
- Ubiquity
- Technical Fluency
- Expectations of Feedback
- Individualization
- Risk-taking
- Information sifting
Teaching Students to Think Theoretically & Empirically -do you agree?

• Learning to think theoretically and empirically within a discipline is essential not only to learning its most important content but also to internalizing it as a dimension of lifelong thinking and learning. Students should enter each course, therefore, prepared to internalize theory as well as to analyze and evaluate information.

• Unfortunately, we know all-too-well that students are not so prepared, but look to us to spoon-feed them "important" bits and pieces of stuff to memorize for the exam. Few students know how to isolate, or learn, important theories or important data.
Critical Thinking as an Outcome for Higher Education

• Critical thinking is a vital goal for higher education (e.g. Browne & Freeman, 2000; Costa, 1991; Pithers & Soden, 2000)

• Critical thinking is not a guaranteed outcome of college (e.g., Halpern, 1996; Pascarella & Terenzini, 2005)
1. What is critical thinking?
2. What do you do when you think critically in your discipline?
3. What standards do you use to evaluate someone’s critical thinking?
4. What questions about teaching critical thinking do you hope to have answered today?
The session begins with a general introduction to critical thinking and problem solving and to their significance, not only to the academic but also to the vocational and personal success of students.

It is followed by small group activities which are used to illustrate the application of various dimensions of problem solving and critical thinking strategies to instruction.
We will explore it under 3 areas:

- **Understanding** Critical Thinking
- **Developing** Critical Thinking
- **Assessing** Critical Thinking
Overview

• Critical thinking is an important element in all professional fields and academic disciplines.

• We often say to our students, "Think!" But what do we mean by thinking and how do we encourage it?

• You will be introduced to the various types of critical thinking and demonstrate how to plan for it.
Write a one-sentence definition of CRITICAL THINKING.
Critical Thinking

• Dearth of research that focuses on critical thinking as a distinct skill

  a willingness (a predisposition) and an ability to scrutinize and evaluate thinking – one’s own, as well as others’ – in order to determine truth, accuracy, or worth, and to construct logical arguments to justify claims or assertions - Beyer (1990)
“This boy shows great originality which must be curbed at all costs”

Sir Peter Ustinov
Do you know that...

- **Albert Einstein** was 4 years old before he could speak and 7 before he could read?

- **Beethoven’s** music teacher once told him, “As a composer, you are hopeless?”

- **Winston Churchill** failed his first year in secondary school?

- **Isaac Newton** did poorly in primary school?

- **Thomas Edison’s** teacher told him that he was too stupid to learn anything?
Sometimes thinking creatively means standing out in the crowd.
How? Barriers (students)

- Poor reading skills
- Poor listening skills
- Bias
- Binary reasoning
- Prejudice
- Fear of change
- Selective perception/attention
- Sociocentrism
- Relativism
How? Barriers (teachers)

- Unclear goals
- Misalignment
- Assessment criteria
- Time/Class size
- Content coverage

Teaching without learning is just talking

- Pat Cross
HOW? A developmental approach

Pre-Reflective → Quasi-Reflective → Reflective

Activity: Critical Thinking in the Disciplines

- In pairs, come up with some strategies for that you have used to foster critical thinking in your classroom.

Examples
- Developing the use of sketchbooks as a tool to aid participation, ownership and critical thinking in art & design [the powerful potential of sketchbooks as tools to enable all ages to make life experiences relevant to learning].

Sketchbooks, notebooks or journals as a creative learning tool are a hot topic at the moment and what's exciting is the potential for their use amongst many subject areas and in many contexts; sketchbooks belong to the user, not to the subject.
Activity

Empowering students with thinking skills such as:

• the ability to reason
• to make informed judgements
• to critically evaluate information
• to think creatively
Critical Thinking Theories

• The skills of critical reasoning (such as the ability to assess reasons properly);

• A disposition, in the sense of:
  – A critical attitude (skepticism, the tendency to ask probing questions) and the commitment to give expression to this attitude, or
  – A moral orientation which motivates critical thinking;

• Substantial knowledge of particular content, whether of:
  – Concepts in critical thinking (such as necessary and sufficient conditions), or of
  – A particular discipline, in which one is then capable of critical thought. 

1 Mason, 2007, pp. 343-344.
Critical Thinking Skills

- Ability to recognize and validate problems,
- Original, independent thinking,
- Ability to develop theoretical concepts,
- Knowledge of recent advances within ones field,
- Understanding of relevant research methodologies and techniques,
- Ability to critically analyze and evaluate findings,
- Ability to summarize, document, report, and reflect on progress. ²

Cognitive Thinking Skills

- Interpretation
- Analysis
- Evaluation
- Inference
- Explanation
- Self-regulation

3 Facione, 2009, p. 5.
Complex Thinking Strategies

- Decision Making
- Reasoning
- Investigation
- Experimental Inquiry
- Directed Problem Solving
- Creative Problem Solving
- Reflective Thinking
- Evaluation
Why?

Skills
- Analyzing
- Defining
- Inferring
- Synthesizing
- Listening
- Reasoning
- QUESTIONING

Outcomes
- Evaluating information
- Intellectual curiosity
- Tolerance for ambiguity
- Evaluating our habits of thought
- LIFE-LONG LEARNING
Critical Thinking Dispositions

• Inquisitive
• Systematic
• Judicious
• Analytical
• Truthseeking
• Open-minded
• Confident in reasoning

4 Facione, 2009, p. 10.
Unifying Critical Thinking Theories

• A four part model to unify and teach critical thinking skills and critical thinking dispositions: ⁵
  – Modeling
  – Interactions
  – Opportunities
  – Feedback

Richard Paul’s Critical Thinking Model

INTELLECTUAL STANDARDS
- Clarity
- Accuracy
- Redelance
- Logic
- Breadth
- Suitability
- Precision
- Significance
- Fairness
- Depth
- Concision
- Beauty

ELEMENTS OF THOUGHT
- Purpose
- Point of view
- Data/information
- Inference/conclusions
- Questions
- Assumptions
- Concepts
- Implications

INTELLECTUAL TRAITS/VIRTUES
- Intellectual humility
- Intellectual autonomy
- Intellectual integrity
- Intellectual courage
- Intellectual curiosity
- Fairmindedness
- Confidence in reason
- Intellectual empathy
- Intellectual perseverance
Understanding Critical Thinking

• Effective skills are intended to produce specific and generally pre-determined outcomes within a specific domain
• Significant debate still occurs in academia over what is “Critical Thinking”
• Critical thinking has two components
  – Cognitive thinking skills
  – Critical thinking dispositions
To help students learn how to think critically, teachers must...

- model expert thinking
- talk about thinking: cultivate students’ disposition to think critically
- align goals for student learning with assessment and teaching practices
- use tasks that make critical thinking and dialectical thinking necessary and desirable
- create a classroom in which critical thinking is fostered and rewarded
- focus on the individual with specific formative feedback
- provide frequent opportunities for practice: give on-going opportunities for developing, practicing and refining the skills of thinking
Principles for fostering CT

- Use active methods to achieve learning goals
- Focus on the structure & content of problems to promote transferability
- Focus on the quality of participation
- Setting concrete expectations
- Engage students in challenging activities for a longer period of time
- Vary communication tools according to the demands of the task
- Allow students to engage in metacognition
  - How did you approach the problem?
  - How could you have approached it differently?
  - What would the costs/benefits of an alternative course of action have been?
Fostering critical thinking through teaching strategies

• Empower students with the language, tools and strategies to engage in a wide range of analytical, critical and creative thinking tasks

• Provide instruction and practice in ways of managing, organising and recording thinking

• Engage students (particularly the more gifted learners) in the high order thinking skills

• Assist in the transfer of skills to everyday life and everyday situations as tools for lifelong learning.
Fostering critical thinking through teaching strategies

Achieving such outcomes will require more than the efforts of a few teachers occasionally using one or two thinking strategies as part of their normal classroom practice.

An essential element in developing a thinking culture will be the explicit teaching of thinking skills to all students.

A whole-school approach that provides a scope and sequence for the introduction of thinking skills at specific year levels will have a much greater chance of success.
Creating the Appropriate Conditions for Critical Thinking:
1. Motivation and Relevance

- Tasks should be problem-based  
  (Dewey, 1993; Duffy, 2002)

- Tasks need to be personally relevant  
  (Barab & Duffy, 1998)

- Tasks need to be authentic in their complexity  
  (Brown et al, 1989; Innes, 2004; Resnik, 1987)

- Tasks need to encourage use of different contextual resources  
  (Dewey, 1938; Dewey & Bentley, 1949)
2. Scaffolding

Most learners need scaffolding
(Quintana, Reiser, Davis, Krajcik, Fretz, Duncan, Kyza, Edelson, & Soloway, 2004)

Scaffolding = instructional techniques that would help learners attain goals and use skills that would otherwise be out of their reach (Davis & Miyake, 2004).

Most learners need scaffolding for critical thinking
2. Scaffolding

• Successful scaffolding = identification of **processes** that promote critical thinking

  ![EXTERNALISATION]

• Externalization = manifestation of changes in thought and attitude in the environment

  ![ARTICULATION]

  ![EVALUATIVE FEEDBACK]
3. Articulation

- Articulation = expression of thought in language either verbally or in written form.
  
  - language is critical to organize one’s thinking (Schunk, 1999)
  
  - the act of choosing words to represent our thoughts allows us to consider our ideas more deliberately (Vygotsky, 1987)

- Even in the absence of an audience articulation should promote critical thinking (e.g., journal, self-talk) – implications for unreferenced messages and silence

- The presence of an audience, should further promote critical thinking
3. Articulation

- The presence of an audience, should further promote critical thinking

- writing for an audience helps learners engage in higher levels thinking by pushing them to ‘compact’ internal speech into a form that is understandable to others (Vygotsky, cited in Pugalee, 2004)

- “writers do not simply express thought but transform it in certain complex but describable ways for the needs of a reader “(Flower, 1997; p.20)

Do students who articulate their views more often manifest a higher level of critical thinking?
4. Feedback

• **Expansive activity**
  an increase in the number of ideas available to the individual (exchange of information)
  – enriches opportunities for discovering areas of cognitive conflict
  – does not necessarily have to lead to cognitive conflict
    • Learner has collector’s attitude
    • Learner does not discern conflicting ideas
    • Learner decides to bail out

• **Dialectical activity**
  individuals asking for clarification challenging ideas, presenting counter-ideas
  – ensures opportunities for discovering areas of cognitive conflict
    • Feedback should be dialectical rather than expansive
Developing Critical Thinking

• Transferring critical thinking across multiple domains
  – Include a dispositional or attitudinal component,
  – Provide instruction in and practice with critical thinking skills,
  – Develop structure-training activities designed to facilitate transfer across contexts, and
  – Implement a metacognitive component used to direct and assess critical thinking.  

Developing Critical Thinking

• Use online components
• Combine critical thinking skills and dispositions
  – Structured Assignments
    • Case Studies
    • Experiments
    • Group Projects
• Develop oral and written argumentation skills
  – Seminars
  – Negotiation exercises
  – Research papers
Assessing Critical Thinking

- Assessment is ongoing
  - Formative (improvement)
  - Summative (judgment)
- CATs - Which technique(s) could be used to assess CT in your classroom?
- Multi-level assessments are required
  - Students
    - Grading rubrics
  - Instructors and Courses
    - Student course evaluations
    - Instructor evaluations
  - Programmes and Schools
    - Adhere to mandatory standards where applicable
    - Develop guidelines across programmes
    - Develop entry assessments / Develop exit assessments
CT: Web Sites

• Fostering Intellectual Engagement
• Teaching Through Socratic Questioning and Teaching Students to Ask Essential Questions
• How Can We Best Test and Assess Critical Thinking?
Novice vs. Expert Thinking

**ACTIVITY:** in small groups

- How do you model expert thinking or make it visible to students during your lecture to help novices develop critical thinking skills?

- What opportunities do students have to practice expert thinking (in & out of your class)?
CRITICAL THINKING
STRATEGIES

LET’S TRY THEM OUT!

http://www.criticalthinking.org
Online tool for developing thinking

  The example is from a Science lesson, but you can download the template with instructions on how to create the activity for any subject.
## Six Thinking Hats

*Edward De Bono*

<table>
<thead>
<tr>
<th>Hat</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow Hat</td>
<td>Strengths</td>
</tr>
<tr>
<td>Black Hat</td>
<td>Weaknesses</td>
</tr>
<tr>
<td>Red Hat</td>
<td>Feelings</td>
</tr>
<tr>
<td>White Hat</td>
<td>Information</td>
</tr>
<tr>
<td>Green Hat</td>
<td>– New Ideas</td>
</tr>
<tr>
<td>Blue Hat</td>
<td>– Thinking about Thinking</td>
</tr>
</tbody>
</table>
Summary of Edward de Bono's Six Thinking Hats

AGENDA
DECISION
GLOBAL
OVERVIEW

CRITIC
ANALYST

EMOTIONS
HUNCHES
FEELINGS
INSTINCTS

WHITE
FACTS
DATA
FIGURES

GREEN
CREATIVE
GROWTH
IDEAS

YELLOW
LOGICAL
POSITIVE

BLUE
Six Hats

RED
## A yearly overview

<table>
<thead>
<tr>
<th>Term</th>
<th>Strategy</th>
<th>Student learning outcome</th>
</tr>
</thead>
</table>
| 1    | Six Thinking Hats (one at a time) | **Students can:**  
Explain the thinking for each hat  
Practice orally the appropriate thinking for each hat  
Give example of the hats i.e. yellow hat ideas etc |
| 2    | Hat sequence (evaluation) | ** Students can:**  
Explain the evaluation sequence  
Employ yellow hat and black hat thinking |
| 3    | Hat Sequence (caution)   | **Students can:**  
Explain the caution sequence  
Effectively employ black hat and white hat thinking |
| 4    | Hat Sequence (Design)    | **Students can:**  
Explain the design sequence  
Effectively employ blue, green hat and red hat thinking. |
Brainstorming

Introducing students to the acronym LACE
- ensures the widest possible participation during the brainstorming session.

L = Lots of ideas (piggybacking on ideas ok)
A = All responses recorded (ideas judged later)
C = Criticism in not allowed (Of people or ideas)
E = Encourage ‘way out’ ideas (it might produce a better solution in the end)
Thinkers Keys

T. Ryan first introduced his Thinkers Keys in the 1980s but his keys are still an easy and effective way to introduce different ways of creative thinking to our students.

Are a set of twenty different activities designed to engage and motivate learners in a range of thinking tasks.

Thinker's Keys can be easily included in activities, homework tasks, journal writing activities, extension tasks and as part of a Bloom's and Multiple Intelligence approach to teaching and learning.

We learn more by looking for the answer to a question and not finding it than we do from learning the answer itself.

- L. Alexander
Thinkers Keys

• The Reverse - places words such as cannot, never and would not in sentences e.g. List thing you would never see in Australia.
• The What if - ask any what if question and record thinking in graphic organiser
• The Alphabet - compile a list of words from A - Z which have relevance to a given topic or category
• The BAR - acronym for B=bigger A=add R=remove or replace, can be used for design related activities
• The Construction - a problem solving task that requires the creative use of limited quantities
• The Disadvantages - make a list of disadvantages for a specific object or activity
• Different Uses - use the imagination to make a list of different uses for everyday objects
• The Combination - list the attributes of two unmatched objects then combine their attributes to create a newer or better product
• The Ridiculous - make a ridiculous statement that would be virtually impossible to implement and then attempt to substantiate it.
SCAMPER

Use the letters of the word **SCAMPER** to encourage creative thinking, alternative solutions, and problem solving - can be used within any subject area.

Students may be taught to use it when they are not sure what to do next, whether in a creative writing exercise, a drama activity, or in attempting to solve a problem.

It identifies situations that are generated by asking specific questions about the problem.
SCAMPER

problem – you are over-scheduled in your business

S – **substitute** or switch
   [what can be substituted for one of the tasks you have on your plate?]

C – **combine** with something else
   [Can something be combined or brought together to lessen your responsibilities and find you more time?]

A – **adapt** or alter part of it
   [What adjustment can be made to your schedule to provide more time?]

M – **modify** a part by magnifying or minifying
   [What could happen if you change the situation to match these conditions?]

P – **put** to some other use
   [In what other ways might parts be used? Could your paper in one meeting be expanded to meet the requirements of another]

E – **eliminate** a part of it
   [What could be removed or enhanced? Could you eliminate an extra activity especially one that causes undo stress or takes time?]

R – **rearrange** a part of it
   [What effects would come from changing the sequence]
Blooms Taxonomy

• **Remembering** Get your facts right? Recognise, list, describe, identify, retrieve, name **Can you recall the information?**

• **Understanding** What does it all mean? Interpret, exemplify, summarise, infer, paraphrase **Can you explain ideas or concepts?**

• **Applying** Use it or lose it Implement, carry out, use **Can you use the new knowledge in another situation**

• **Analysing** Breakdown Compare, attribute, organise, deconstruct **Can you differentiate between parts?**

• **Evaluating** Judge and Jury Check, critique, judge, hypothesise **Can you justify a decision or course of action?**
### Questioning Techniques

see handouts on questioning

<table>
<thead>
<tr>
<th></th>
<th><strong>CLOSED</strong></th>
<th><strong>OPEN</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NARROW</strong></td>
<td>One Australian animal that lays eggs is…</td>
<td>Ten animals that are not mammals include…</td>
</tr>
<tr>
<td><strong>WIDE</strong></td>
<td>List 5 ways that a dingo and poodle are similar.</td>
<td>What would happen if all koalas in Australia disappeared? Give many possibilities.</td>
</tr>
</tbody>
</table>

**Activity:** Draw this same matrix and come up with some examples of questions in your own discipline.
Socratic Questioning

What is it?

Socratic Questioning is disciplined questioning that can be used to pursue thought in many directions and for many purposes, including: to explore complex ideas, to get to the truth of things, to open up issues and problems, to uncover assumptions, to analyze concepts, etc.
Socratic Questioning

Conceptual clarification questions

• Get them to think more about what exactly they are asking or thinking about. Prove the concepts behind their argument. Basic 'tell me more' questions that get them to go deeper.

  – Why are you saying that?
  – What exactly does this mean?
  – How does this relate to what we have been talking about?
  – What is the nature of ...?
  – What do we already know about this?
  – Can you give me an example?
  – Are you saying ... or ... ?
  – Can you rephrase that, please?
Socratic Questioning

Probing assumptions

• Probing of assumptions makes them think about the presuppositions and unquestioned beliefs on which they are founding their argument. This is shaking the bedrock and should get them really going!

  – What else could we assume?
  – You seem to be assuming ... ?
  – How did you choose those assumptions?
  – Please explain why/how ... ?
  – How can you verify or disprove that assumption?
  – What would happen if ... ?
  – Do you agree or disagree with ... ?
Socratic Questioning

Probing rationale, reasons and evidence

• When they give a rationale for their arguments, dig into that reasoning rather than assuming it is a given. People often use un-thought-through or weakly understood supports for their arguments.
  – Why is that happening? Why is ... happening?
  – How do you know this? Show me ... ?
  – Can you give me an example of that?
  – What do you think causes ... ?
  – What is the nature of this?
  – Are these reasons good enough?
  – Would it stand up in court? How might it be refuted?
  – How can I be sure of what you are saying?
  – Why? (keep asking it -- you'll never get past a few times)
  – What evidence is there to support what you are saying?
  – On what authority are you basing your argument?
Socratic Questioning

Questioning viewpoints and perspectives

• Most arguments are given from a particular position. So attack the position. Show that there are other, equally valid, viewpoints.
  – Another way of looking at this is ..., does this seem reasonable?
  – What alternative ways of looking at this are there?
  – Why it is ... necessary?
  – Who benefits from this?
  – What is the difference between... and...?
  – Why is it better than ...?
  – What are the strengths and weaknesses of...?
  – How are ... and ... similar?
  – What would ... say about it?
  – What if you compared ... and ...?
  – How could you look another way at this?
Socratic Questioning

Probe implications and consequences

• The argument that they give may have logical implications that can be forecast. Do these make sense? Are they desirable?
  – *Then what would happen?*
  – *What are the consequences of that assumption?*
  – *How could ... be used to ... ?*
  – *What are the implications of ... ?*
  – *How does ... affect ... ?*
  – *How does ... fit with what we learned before?*
  – *Why is ... important?*
  – *What is the best ... ? Why?*
Socratic Questioning

Questions about the question

• And you can also get reflexive about the whole thing, turning the question in on itself. Use their attack against themselves. Bounce the ball back into their court, etc.
  – *What was the point of asking that question?*
  – *Why do you think I asked this question?*
  – *What does that mean?*
“He who asks a question may be a fool for five minutes, but he who never asks a question remains a fool forever.”
Others…

• 3 Story Intellect (see handout)

• PCD – possibilities, consequences, decision

• Critical Thinking and Writing - teaching students to read and understand a text properly is essential to their intellectual survival in a complex world.
<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>consideration of ethical issues in decisions</td>
</tr>
<tr>
<td>5</td>
<td>use of empirical evidence to strengthen theoretical argument</td>
</tr>
<tr>
<td>4</td>
<td>use of theory to make a cohesive argument</td>
</tr>
<tr>
<td>3</td>
<td>analysis of an argument or competing arguments and evaluation with evidence</td>
</tr>
<tr>
<td>2</td>
<td>unsupported assertions, simplistic one-sided arguments</td>
</tr>
<tr>
<td>1</td>
<td>paraphrase, repetition</td>
</tr>
<tr>
<td>0</td>
<td>organizational and off-task</td>
</tr>
</tbody>
</table>
It's not that I'm so smart, it's just that I stay with problems longer.

- Albert Einstein
A Challenge

Write a One Sentence Definition of

PROBLEM SOLVING

Problem solving games
The ability to

...solve problems

...think critically & creatively

...to learn

...plan and organise

...work with others

...use initiative

...take risks

...lead

...think critically & creatively
Why is learning problem solving?

– Authenticity [in everyday life & work, people constantly solve problems]
– Intentionality [problems provide a purpose for learning (intrinsic motivation)]
– Conceptual anchoring [knowledge constructed while solving problems is more integrated, better retained and more transferable]
– Ontology [knowledge that results from solving problems is more meaningful]
Problem solving

Centre for Study of problem solving: http://csps.missouri.edu/

Problem solving

• Jonassen (2007) identified ill structured problems for which no single methods or answers exist, including story problems, rule-using and rule-induction problems, decision-making problems, trouble-shooting problems, policy problems, design problems and dilemmas.

His problem dimensions include:
• **internal factors** that address problem solver’s individual characteristics (prior experience, domain knowledge, reasoning skills, and epistemological beliefs)
• **external factors** that reflect how problems are formed and represented (complexity, structuredness, dynamicity) and situated (cultural expectations).
The brain developed to solve problems related to surviving in an unstable outdoor environment that occur in near constant motion.

– John Medina, *Brain Rules*
If you wanted to create an educational environment that is **directly opposed** to the way the brain is good at doing, you would probably design something like the **modern classroom**.

– John Medina, *Brain Rules*
Incorrect assumptions we have as teachers

• You cannot teach students about problem solving and expect them to solve problems; WHY?
• You must engage and help them to solve a variety of problems

There are no big problems, there are just a lot of little problems.

-Henry Ford
Is it possible to teach problem solving skills?

Too often we give children answers to remember rather than problems to solve.
- Roger Lewin
Life is trying things to see if they work.

http://www.brainstorming.co.uk/quotes/creativequotations.html
ACTIVITY: How Do You Solve Problems?

- What processes do you use?
- Can you explain them to another person?
- Do these processes vary depending upon the problem?
What Skills Do You Use In Problem Solving?

- Making judgements
  - Analytical skills
  - Decision making
- Collecting information
  - Planning
Problem Solving People?

😊 Experts

😊 People who know the area of knowledge thoroughly; Solving problems becomes more natural

😊 People who can think of alternatives even when no clear solutions seems apparent
What types of problems can students learn to solve?

- Design
- Diagnosis-solution
- Dilemmas
- Strategic performance
- Rule induction

The problems that exist in the world today cannot be solved by the level of thinking that created them.

- Albert Einstein
The problem-solving process has been divided into 4 stages (Ferry & Ross-Gordon, 1998)

- Identify problem exists
- Analyse data
- Interpret data
- Review solution
Problem solving

- Cognitive Requirements of Problem-Solving Learning
- Instruction Events for a Problem-Solving Lesson
- Macrostrategies for Problem-Solving Instruction

A specialized skill

Within a domain of knowledge

Yielding new learning

Requires the selection

and combination

of multiple principles

e.g. read music; write computer program; make a medical diagnosis; practice law.
Problem solving

Two Categories of Problems

Well-defined Problems:
• Goals are clear
• A single or a definable range of solutions

Ill-defined Problems:
• Goals are unknown, vague or extremely situation-dependent
• Multiple correct solutions
# Problem solving

<table>
<thead>
<tr>
<th>Problem Type</th>
<th>Solution</th>
<th>Problem Solving Strategies</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well-defined</td>
<td>One correct solution</td>
<td>Multiple ways to get there</td>
<td>Reading in the data (e.g. concrete value)</td>
</tr>
<tr>
<td>Ill-defined</td>
<td>More than one correct solutions</td>
<td>Multiple ways to get there</td>
<td>Reading beyond data (e.g. new hypotheses)</td>
</tr>
</tbody>
</table>

*Everyday work problems are often ill-defined!*
Problem solving: Research

- Problem solving strategies can be identified with little effort.
- Problem solving strategies are highly situated.
- For ill-defined problems different information sources are used, both types of problems allow for multiple strategies.
- Problem solving strategies are related to the solution quality.
- Analyzing problem solving strategies provides suggestions how to improve a tool.
- Problem solving strategies are related to insights, time and errors.
Problem solving

• To solve a problem, three kinds of knowledge must be possessed and applied:
  - principles
  - declarative knowledge
  - cognitive strategies
Problem solving

• Know the first step to solving a problem is to ask the right question;

Students, as they are increasingly posed with problems relating to themselves in the world and with the world, will feel increasingly challenged and obliged to respond to that challenge... Their response to the challenge evokes new challenges, followed by new understandings; and gradually the students come to regard themselves as committed.

  - Freire
Instruction Events for a Problem-Solving Lesson

Introduction
- Deploy Attention
- Establish Instructional Purpose
- Promote Interest and Motivation
- Preview Lesson

Body
- Review Relevant Prior Knowledge
- Process Information
- Focus attention
- Employ Learning Strategies
- Practice
- Process Feedback

Conclusion
- Summary and Review
- Transfer
- Remotivation and Conclusion

Assessment
- Simulations and case problems could be used
- Partial problems might be used
Problem solving

• What kinds of problems can students learn to solve?
• How do we help them to solve them? [they learn to mimic the problem solving process (Eric Mazur, Harvard)]
• But do they really learn to problem solve?
How do problems vary?

Well structured

- static
- Algorithms
- Story problems
- Decision making
- Trouble shooting
- Diagnostic-solution
- Strategic performance
- Policy analysis
- Design problems
- Dilemmas

Ill structured

- complex

simple

- dynamic
How do we help students to learn to solve problems?

Examples on D. Jonassen’s web site

- Decision making problems
- Trouble shooting
- Diagnostic-solution
- Design problems
- Story problems
- Strategic performance
- Policy analysis
- Dilemmas
• ‘Have a go’ attitude
• Making links
• Teamwork
• Accept setbacks as learning experiences
• Take calculated risks
• Independent learner
• Perseveres
• Self-motivated
• Flexible
• Creative and resourceful
Approaches to L&T

- Allow for choice
- Encourage independence
- Give students ownership
- Encourage students to explain their thinking
- Provide meaningful, relevant contexts, including the world of work
- Help students to make connections
Creative Problem Solving

• What is creative problem solving?
• Why don’t we think creatively more often?
• How can we be more creative?
• What is the creative problem solving process?
• What are some other specific creative problem solving tools and techniques?
• Application of learning
Students retain...

- **5%** of what they’ve learned from a lecture
- **10%** of what they’ve learned from reading
- **20%** of what they’ve learned from an audio-visual presentation
- **30%** of what they learn from a demonstration
- **50%** of what they learn when engaged in a discussion
- **75%** of what they learn by doing
- **90%** of what they learn when they teach someone else

Source: NTL Institute for Applied Behavioral Science
Bloom’s Cognitive Taxonomy (1956)

- Knowledge
- Comprehension
- Application
- Analysis
- Synthesis
- Evaluation

- Recall
- Understanding
- Using knowledge in new situations
- Breaking things down
- Creative thinking
- Putting things together

- Judgement
Bloom’s Revised Taxonomy (2001)

Remember “Knowledge”

Understand “Comprehension”

Apply

Evaluate

Analyze

Create “Synthesis”

(Anderson & Krathwohl et al, eds., 2001)
<table>
<thead>
<tr>
<th>Mind-set Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Analyze:</strong> Extract, deduce, investigate, fill in, combine, disassemble,</td>
</tr>
<tr>
<td><strong>Evaluate:</strong> Judge, interpret, justify, assess, weigh, appraise, criticize</td>
</tr>
<tr>
<td><strong>Create:</strong> Develop, invent, extend, hypothesize, compose</td>
</tr>
<tr>
<td><strong>Apply:</strong> Do, use, organize, collect, operate, summarize, practice, solve, try</td>
</tr>
<tr>
<td><strong>Understand:</strong> Restate, reword, describe, illustrate, review, discuss, explain (in your own words)</td>
</tr>
<tr>
<td><strong>Remember:</strong> State, show, list, tally, define, identify, repeat, recall, label, quote</td>
</tr>
</tbody>
</table>
Organizing Bloom’s Taxonomy

• Level 3: High
  – Creating something unique (to the learner)
  – Making judgments, choices, decisions
  – Breaking down concepts into component parts

• Level 2: Intermediate
  – Using information, skills, and concepts in new situations

• Level 1: Low
  – Understanding and interpreting information
  – Acquiring and remembering new information
Supporting Higher-Order Thinking

• It is estimated that 90% of all exam questions asked in the US are of “Low level” - knowledge and comprehension (Wilen, 1992)

• “Low level” doesn’t mean easy:
  Write an essay explaining the decline and fall of the Roman Empire incorporating at least five of the seven causes discussed in class from the writings of Gibbon and Toynbee

• “High level” doesn’t mean hard:
  Which movie did you like more, WALL-E or Cars? Why?
Technology and Complex Thinking

• Intel Thinking Tools
  http://www.intel.com/education/tools

  – **Visual Ranking**: Assign ranking to a list; and then debate differences, reach consensus, and organize ideas
  – **Seeing Reason**: Investigate relationships in complex systems
  – **Showing Evidence**: Construct well-reasoned arguments that are supported by evidence, using a visual framework
Why Projects?

To learn collaboration, work in teams.
To learn critical thinking, take on problems.
To learn oral communication, present.
To learn written communication, write.
To learn technology, use technology.
To develop citizenship, take on civic issues.
To learn about careers, do internships.

To learn content, do all of the above.
Essential Questions

- Are broad, open-ended questions
- Address big ideas and enduring concepts
- Often cross disciplines and help students see how subjects are related

Examples:

- Why is maths important to my life?
- How does conflict produce change?
- What lessons can be learned by running a city?
Unit Questions

– Are open-ended questions that tie directly to a project or unit
– Help students demonstrate the scope of their understanding of a subject

Examples:

• How important is measurement in building a home?
• How are changes in economics a factor in war?
• In the story, Charlotte’s Web, how do the animals’ different abilities help Wilbur survive and succeed?
• How does stress on the environment impact biology?
Content Questions

– Are fact-based, concrete questions
– Have a narrow set of correct answers
– Often relate to definitions, identifications, and general recall of information (example: questions found on a test)

Examples:

• How do you find the values of unknowns in equations?
• What is a fable?
• Who is the main character in *To Kill a Mockingbird*?
• How are volcanoes made?
• Why is it cold in the winter when the sun is shining?
References

References

Critical thinking
- http://www.criticalthinking.org/
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- http://www.psychology.heacademy.ac.uk/webdocs_not_no/f/workshop180902/Suzanne_presentation.htm

Problem solving
- http://www.bioscience.heacademy.ac.uk/resources/problemsolving/index.asp
- http://www.bath.ac.uk/research/pgskills/courses/modules/RP00079.htm
Questions