Teaching Fish When You are a Penguin…

Suzanne Kresta

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http://www.wimp.com/beingpenguins/

Today's Learning Objectives

- Know your own preferred learning styles, and those of your students. Understand how this impacts student learning and course design. *know and affective 1 - respect differences*
- Identify examples of teaching strategies designed to address different learning styles. *understand*
- Validate differences in thinking patterns between expert and novice learners.
- Leave with curiosity about structured problem solving tools...and references to support further explorations.

Step 1

- Complete the Felder and Brent Learning Styles Inventory (available on-line at http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Learning_Styles.html)
- Do not worry too much about getting the "right" answer!
- Tally up your scores in the table at the end (done automatically if you are on-line)
- When you have your score, put it on the podium at the front.
- We won't go to the next page until we have all the scores!

Step 2: Who are we?

• Visual	or	• Verbal
• Sequential	or	• Global
• Active	or	• Reflective
• Sensing	or	• Intuitive

Normalize the Data

- Scale goes from e.g. Visual 7,5,3,1 to 1,3,5,7 Verbal
  - Weight 7 as 4, 5 as 3 and so on for each of the scales
  - Multiply by the number of responses in each bin
  - Add up the sub-total for Visual and the sub-total for Verbal
- Normalize the scores e.g.

$$\text{Visual} = \frac{\text{Visual}}{(\text{Visual} + \text{Verbal})} \times 10$$

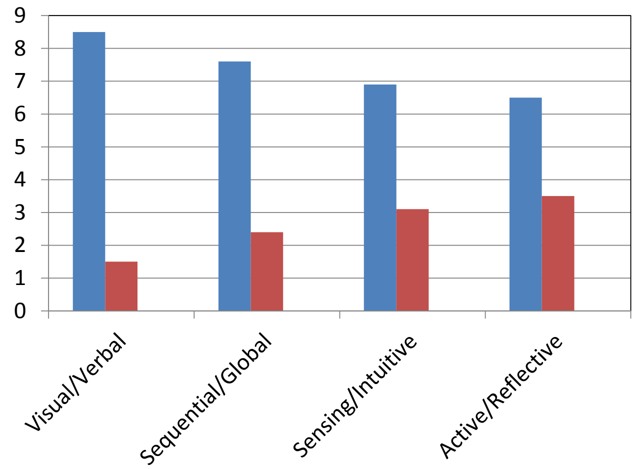
Step 2: Who are we?

- Visual
- Verbal
- Sequential
- Global
- Active
- Reflective
- Sensing
- Intuitive

What does this mean?

See the handout from
http://www4.ncsu.edu/unity/lockers/users/f/felder/public/ILSdir/styles.htm
and Felder's website for more information.

Step 3: Who are our students?



Students are sequential learners.

- Professors prefer global learning (3.5/6.5)
- Sequential learners tend to
  - Gain understanding in linear steps, with each step following logically from the previous one.
  - Follow logical stepwise paths in finding solutions.
- Global learners tend to
  - Need the big picture of a subject before they can master details.
  - They may be able to solve complex problems quickly or put things together in novel ways once they have grasped the big picture.
  - They may also have difficulty explaining how they did it.

Examples open the door between these learning styles!

http://www.youtube.com/watch?v=XZm6y0ALDCc

Identify Teaching Strategies

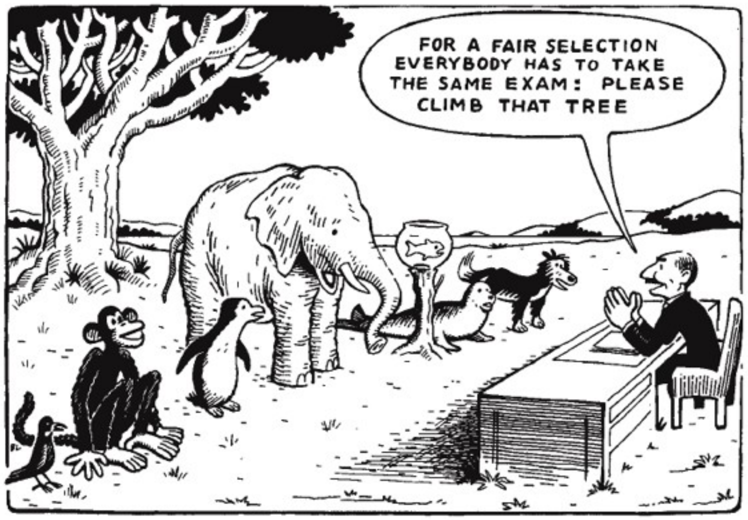
For each of the activities we just did,
identify the learning style or styles that engage:

- Provide learning objectives
- Complete the survey
- Compare data with student results
- Videos of penguins
- Discussion of learning styles

Identify Teaching Strategies

- Provide learning objectives – global and sequential
- Complete the survey - active, sensing
- Compare data with student results – sensing, visual, reflective
- Discussion of learning styles – active, verbal, sensing, reflective, global
- Building up the story one step at a time – sequential
- Videos of penguins – visual, intuitive, *affective 5 - empathy*

What is wrong with this picture?



Some questions

- If our goal is to have students learn, does it make sense to adapt our teaching style to their learning style?
  - *corollary: Would you design a bridge to withstand g on the moon if it is being built on earth?*
- How can we best do this?
  - see the Exploring Examples slides and video http://www.ctl.ualberta.ca/events/tls-catalysts-conversation-series-teaching-exploring-examples-dr-suzanne-kresta
- Is there another interpretation of the data?
  - with thanks to Dr Sigurdson (MecE) and Dr Gauthier (CTL)

Expert vs. Novice: 10 000 hours

Experts

- Have built an extensive, well-organized system of knowledge
- This is their foundation for remembering, reasoning and problem-solving.
- AND organizing and interpreting new information.
- *It allows them to draw on relevant information quickly and flexibly when understanding new situations or solving new problems.*

Novices

- Do not know what ideas are important yet, so they cannot easily organize their growing knowledge.
- Often have a large, unstructured bank of knowledge which they randomly access to retrieve information.
- The relevance of knowledge to a new question or problem is unclear, and even mysterious!

http://duke.edu/arc/faculty_staff/student_learning/experts_vs_novices.php

What do experts do when they learn?

- Pose questions to themselves
- Can separate relevant information from irrelevant information.
- Respond to context
- Recognize meaningful patterns and connections
- Organize knowledge around key principles and concepts.

- Self-regulate their time and efforts including goal setting, time management, self-evaluation, self-motivation.
- Self-motivate
- Remain flexible in thinking, adapting to changing needs.

Bridging the Gap – What Works?

- **Core Concepts and Experiences** – share learning objectives and key outcomes, provide examples organized around the big ideas, show application of the same idea in several contexts
- **Task Analysis** – share the key questions needed to diagnose the problem and structure a solution
- **Pattern Recognition** - learners must be able to see the how ideas are connected (provide concept maps – see CTL workshop)
- **Metacognition** – develop an awareness of their own thinking and behaviors (e.g. administer learning styles, provide CATME team rubric)
- **Self-regulation** – let them know that frustration is normal and they are moving up the cognitive scale every year in the program

Learning Objectives – check progress

- Know your own preferred learning styles, and those of your students. Understand how this impacts student learning and course design. *know and affective 1 - respect differences*
- Identify examples of teaching strategies designed to address different learning styles. *understand*
- Validate differences in thinking patterns between expert and novice learners. *apply*
- Leave with curiosity about structured problem solving tools...and references to support further explorations.

Problem Solving

Experts
- Classify problems based on deep structure
- Structure knowledge and interconnections
- Start with general equations
- Problem solving is a process
- Draw analogies

Novices
- Focus on surface features
- Knowledge is randomly organized
- Start with many specific equations
- Problem solving is a recall task
- Interpret literally

Problem Solving Strategies

Fogler and LeBlanc, Strategies for Creative Problem Solving, 3rd ed. 2013 – TEXTBOOK!
D.R. Woods, An Evidence Based Strategy for Problem Solving,
Journal of Engineering Education, Vol 89, pp 443-460.

1. Engage – self-regulation
2. Define
3. Explore
4. Plan
5. Do it
6. Look Back – Critically Evaluate the Results

See handout for more details. Share this information!

This is now taught explicitly in medicine and business.

Strategic Problem Solving

1. Engage and Motivate
2. Define and Align (with vision and values)
3. Get Clarity (what would be an outstanding result?)
4. Explore and Create Possibilities
5. Refine, Plan the Process and Identify Critical Gates
6. Execute and Iterate
7. Review, Debrief, and Celebrate!

(Kresta, 2011)

Conclusion

- Know your own preferred learning styles, and those of your students. Understand how this impacts student learning and course design.
- Use teaching strategies designed to address different learning styles.
- Structure expectations for students as novice learners.

- Leave with curiosity about structured problem solving tools...and references to support further explorations.

affective 2 – engage and respond

Notice the way active learning worked today – time, structure, focussed objectives!

LEARNING STYLES AND STRATEGIES

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ACTIVE AND REFLECTIVE LEARNERS

- Active learners tend to retain and understand information best by doing something active with it--discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly first.
- "Let's try it out and see how it works" is an active learner's phrase; "Let's think it through first" is the reflective learner's response.
- Active learners tend to like group work more than reflective learners, who prefer working alone.
- Sitting through lectures without getting to do anything physical but take notes is hard for both learning types, but particularly hard for active learners.

Everybody is active sometimes and reflective sometimes. Your preference for one category or the other may be strong, moderate, or mild. A balance of the two is desirable. If you always act before reflecting you can jump into things prematurely and get into trouble, while if you spend too much time reflecting you may never get anything done.

How can active learners help themselves?

If you are an active learner in a class that allows little or no class time for discussion or problem-solving activities, you should try to compensate for these lacks when you study. Study in a group in which the members take turns explaining different topics to each other. Work with others to guess what you will be asked on the next test and figure out how you will answer. You will always retain information better if you find ways to do something with it.

How can reflective learners help themselves?

If you are a reflective learner in a class that allows little or no class time for thinking about new information, you should try to compensate for this lack when you study. Don't simply read or memorize the material; stop periodically to review what you have read and to think of possible questions or applications. You might find it helpful to write short summaries of readings or class notes in your own words. Doing so may take extra time but will enable you to retain the material more effectively.

SENSING AND INTUITIVE LEARNERS

- Sensing learners tend to like learning facts, intuitive learners often prefer discovering possibilities and relationships.
- Sensors often like solving problems by well-established methods and dislike complications and surprises; intuitors like innovation and dislike repetition. Sensors are more likely than intuitors to resent being tested on material that has not been explicitly covered in class.

- Sensors tend to be patient with details and good at memorizing facts and doing hands-on (laboratory) work; intuitors may be better at grasping new concepts and are often more comfortable than sensors with abstractions and mathematical formulations.
- Sensors tend to be more practical and careful than intuitors; intuitors tend to work faster and to be more innovative than sensors.
- Sensors don't like courses that have no apparent connection to the real world; intuitors don't like "plug-and-chug" courses that involve a lot of memorization and routine calculations.

Everybody is sensing sometimes and intuitive sometimes. Your preference for one or the other may be strong, moderate, or mild. To be effective as a learner and problem solver, you need to be able to function both ways. If you overemphasize intuition, you may miss important details or make careless mistakes in calculations or hands-on work; if you overemphasize sensing, you may rely too much on memorization and familiar methods and not concentrate enough on understanding and innovative thinking.

How can sensing learners help themselves?

Sensors remember and understand information best if they can see how it connects to the real world. If you are in a class where most of the material is abstract and theoretical, you may have difficulty. Ask your instructor for specific examples of concepts and procedures, and find out how the concepts apply in practice. If the teacher does not provide enough specifics, try to find some in your course text or other references or by brainstorming with friends or classmates.

How can intuitive learners help themselves?

Many college lecture classes are aimed at intuitors. However, if you are an intuitor and you happen to be in a class that deals primarily with memorization and rote substitution in formulas, you may have trouble with boredom. Ask your instructor for interpretations or theories that link the facts, or try to find the connections yourself. You may also be prone to careless mistakes on test because you are impatient with details and don't like repetition (as in checking your completed solutions). Take time to read the entire question before you start answering and be sure to check your results

VISUAL AND VERBAL LEARNERS

Visual learners remember best what they see--pictures, diagrams, flow charts, time lines, films, and demonstrations. Verbal learners get more out of words--written and spoken explanations. Everyone learns more when information is presented both visually and verbally.

In most college classes very little visual information is presented: students mainly listen to lectures and read material written on chalkboards and in textbooks and handouts. Unfortunately, most people are visual learners, which means that most students do not get nearly as much as they would if more visual presentation were used in class. Good learners are capable of processing information presented either visually or verbally.

How can visual learners help themselves?

If you are a visual learner, try to find diagrams, sketches, schematics, photographs, flow charts, or any other visual representation of course material that is predominantly verbal. Ask your instructor, consult reference books, and see if any videotapes or CD-ROM displays of the course material are available. Prepare a concept map by listing key points, enclosing them in boxes or circles, and drawing lines with arrows between concepts to show connections. Color-code your notes with a highlighter so that everything relating to one topic is the same color.

How can verbal learners help themselves?

Write summaries or outlines of course material in your own words. Working in groups can be particularly effective: you gain understanding of material by hearing classmates' explanations and you learn even more when you do the explaining.

SEQUENTIAL AND GLOBAL LEARNERS

- Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it."
- Sequential learners tend to follow logical stepwise paths in finding solutions; global learners may be able to solve complex problems quickly or put things together in novel ways once they have grasped the big picture, but they may have difficulty explaining how they did it.

Many people who read this description may conclude incorrectly that they are global, since everyone has experienced bewilderment followed by a sudden flash of understanding. What makes you global or not is what happens before the light bulb goes on. Sequential learners may not fully understand the material but they can nevertheless do something with it (like solve the homework problems or pass the test) since the pieces they have absorbed are logically connected. Strongly global learners who lack good sequential thinking abilities, on the other hand, may have serious difficulties until they have the big picture. Even after they have it, they may be fuzzy about the details of the subject, while sequential learners may know a lot about specific aspects of a subject but may have trouble relating them to different aspects of the same subject or to different subjects.

How can sequential learners help themselves?

Most college courses are taught in a sequential manner. However, if you are a sequential learner and you have an instructor who jumps around from topic to topic or skips steps, you may have difficulty following and remembering. Ask the instructor to fill in the skipped steps, or fill them in yourself by consulting references. When you are studying, take the time to outline the lecture material for yourself in logical order. In the long run doing so will save you time. You might also try to strengthen your global thinking skills by relating each new topic you study to things you already know. The more you can do so, the deeper your understanding of the topic is likely to be.

How can global learners help themselves?

If you are a global learner, it can be helpful for you to realize that you need the big picture of a subject before you can master details. If your instructor plunges directly into new topics without bothering to explain how they relate to what you already know, it can cause problems for you. Fortunately, there are steps you can take that may help you get the big picture more rapidly. Before you begin to study the first section of a chapter in a text, skim through the entire chapter to get an overview. Doing so may be time-consuming initially but it may save you from going over and over individual parts later. Instead of spending a short time on every subject every night, you might find it more productive to immerse yourself in individual subjects for large blocks. Try to relate the subject to things you already know, either by asking the instructor to help you see connections or by consulting references. Above all, don't lose faith in yourself; you will eventually understand the new material, and once you do your understanding of how it connects to other topics and disciplines may enable you to apply it in ways that most sequential thinkers would never dream of.

- Click here for more information about the learning styles model and implications of learning styles for instructors and students.

- Click here to return to Richard Felder's home page.

Experts vs Novices: What Students Struggle with Most in STEM Disciplines

"Students know far less when they emerge from courses than most faculty think they do." This was a finding from an NSF funded project on assessing student achievement in undergraduate science, technology, engineering and mathematics (STEM) courses.

Results from this multi-university survey indicate that:

- Faculty are generally not aware of little their students get, and thus tend to test in such a way as to never find out.
- Classroom instruction has remarkably little effect on test scores.
- What faculty teach, despite their best efforts, is not what students learn or how they learn.
- Summative assessment without formative assessment does not give faculty a true indication of student ability.
- Students can master exams successfully *without* successfully mastering disciplinary concepts.
- Student achievement can be increased with effective assessment.
- Assessing student understanding of key concepts takes more than just knowing whether they can produce the right answers to problems.
- No matter how advanced your students are, do not assume they have conceptual knowledge about the most basic concepts.
- Transfer of learning between courses is close to non-existent for many students and yet there are research-based methods to address this issue.
- Formative assessment, integrated with peer teaching in large lecture courses, can dramatically improve learning.
- Active/collaborative/interactive pedagogies are documented to provide greater gains in student learning.
- Rubrics are valuable tools in informing students about expectations for their learning and about the ways in which their learning will be measured.
- Students do not learn if they are expected to 'feedback' only what is in the book (or in their notes).

This Assessment of Student Achievement (ASA) project is one of many initiated by Project Kaleidoscope (www.pkal.org), one of the leading advocates in the United States for building and sustaining strong undergraduate programs in the fields of science, technology, engineering and mathematics (STEM).

These results seem to indicate a troubling disconnect between how students (novice learners in the discipline), learn and understand their course material and how faculty (expert learners in the discipline) traditionally approach and teach this material. Possible reasons for this disconnect become clearer when we look at what differentiates an expert from a novice learner.

What differentiates an 'expert' from a 'novice'?

An expert is someone who has a high degree of proficiency, skill, and knowledge in a particular subject. Experts are able to effectively think about and solve problems. They see patterns in information and are able to identify solutions. Moving from novice to expert involves much more than simply developing a set of generic skills and strategies. Experts develop extensive knowledge that impacts the way they identify problems, organize and interpret data, and formulate solutions. Their approach to reasoning and solving problems is different from that of a novice.

In their report, How People Learn: Brain, Mind, Experience, and School (http://www.nap.edu/html/howpeople1/), Bransford et. al. (1999) identified key principles of experts' knowledge and their potential implications for learning and instruction:

- Experts notice features and meaningful patterns of information that are not noticed by novices.
- Experts have acquired a great deal of content knowledge that is organized in ways that reflect a deep understanding of their subject matter.
- Experts' knowledge cannot be reduced to sets of isolated facts or propositions but, instead, reflects contexts of applicability: that is, the knowledge is "conditionalized" on a set of circumstances.
- Experts are able to flexibly retrieve important aspects of their knowledge with little attentional effort.
- Though experts know their disciplines thoroughly, this does not guarantee that they are able to teach others.
- Experts have varying levels of flexibility in their approach to new situations.

Based on the growing body of research, the following attributes of experts can be identified. Experts:

- Pose useful questions to themselves about the information they are exploring.
- Identify relevant information and ignore irrelevant information.
- Respond to context and select information to address specific needs.
- Recognize meaningful patterns and connections in information
- Organize knowledge around key principles and concepts.
- Self-regulate their time and efforts including goal setting, time management, self-evaluation, self-motivation.
- Self-motivate through varying their methods of study and practice.
- Remain flexible in thinking, adapting to changing needs.

So, how can faculty/experts help students develop the necessary repertoire of knowledge and range of skills and strategies? Consider some of the following key areas:

- **Core Concepts and Experiences** - learners need a foundation of knowledge, background information, examples, resources, and varied experiences related to their topic organized around the big ideas
- **Task Analysis** - learners must develop an understanding of the problem or key questions and be able to prioritize and focus on the key issues
- **Pattern Recognition** - learners must be able to structure information in meaningful ways and see the how ideas are connected
- **Metacognition** - learners must be aware of their thinking and flexible enough to adapt to changing needs
- **Self-regulation** - learners must be able to control their thinking and actions

Content adapted from *virtualinquiry.com (http://virtualinquiry.com/scientist/scientist1a.htm)*

Selected expert-novice differences in problem-solving:

1. *Experts classify problems based on deep structure, while novices classify based on surface features.* Experts/faculty have a cognitive map of their discipline and tend to grasp the 'big picture' easily. Students want to know formulas and equations ("why do I have to know this?") and want to get it *right* rather than understand the *purpose* of the question/problem.

    1. Chi, M.T.H., Feltovich, P., Glaser, R. 1981. Categorization and representation of physics problems by experts and novices. Cognitive Science 5(2):121-152.
    2. Sweller, J. 1988. Cognitive load during problem solving: effects on learning. Cognitive Science 12(2): 257-285.

2. *Expert knowledge is chunked and organized hierarchically (around basic principles), while novice knowledge is more randomly organized (they don't have the expertise to connect new information they learn to something they already know).*

    - Eylon, B and Reif, F. 1984. Effects of knowledge organization on task performance. Cognition and Instruction 1(1): 5-44.
    - Larkin, J.H. 1979. Processing information for effective problem solving. Engineering Education 70(3): 285-288.
    - Reif, F. 1981. Teaching problem solving – a scientific approach. The Physics Teacher 19(5): 310-316.

3. *Experts start with general equations, while novices start with specific equations.* Novices tend to use a "means-to-an-end" approach, in other words, work backwards (the answer defines they way to solve or approach the problem), while experts work forward, checking logic and answers as they go.

    - Simon, D.P. and Simon, H.A. 1978. Individual differences in solving physics problems. In: Seigler, R.S. (ed), Children's Thinking: What Develops? Lawrence Erlbaum Associates, Hillsdale, NJ.

4. *Experts view problem-solving as a process, while novices think it is a recall task.* By the time someone becomes an expert, something that may have been viewed as a "problem" at some point has generally become an "exercise". Experts can make solving problems look easy, which causes novices to mistakenly think that they should be able to understand and solve problems easily too. When this does not translate in practice, novices generally become frustrated and question their ability. This is a problem that can push many students out of STEM disciplines because they feel they "just don't get it and never will".

    - Good., R. 1984. Scientific problem solving by expert systems. Journal of Research in Science Teaching 21(3): 331-340.
    - Whimbey, A. and Lochhead, J. 1980. Problem Solving and Comprehension – A Short Course in Analytical Reasoning. Franklin Institute Press, Philadelphia, PA.

5. *Experts use qualitative representations extensively, while novices have trouble with representations.*

    - Dufresne, R.J., Gerace, W.J., Leonard, W.J. 1997. Solving physics problems with multiple representations. The Physics Teacher 35(5): 270-275.
    - Van Heuvelen, A. 1991. Learning to think like a physicist: a review of research-based strategies. American Journal of Physics 59(10): 891-895.
    - Larkin, J.H. and Simon, A. 1995. Why a diagram is (sometimes) worth 10, 000 words. In Glasgow, J., Narayanan, H. and Chandraskaran, B. (eds). Diagrammatic Reasoning: Cognitive and Computational Perspectives. AAAI Press/MIT Press, Menlo Park, CA.

Content adapted from: *"Making Problem Solving a Priority" presented by Kathleen A. Harper, Department of Physics, Ohio State University at the 32nd Annual Conference of the Professional Organization and Development (POD) Network, October 2007, Pittsburgh, Pennsylvania, U.S.A..*

Problem Solving Strategies

Fogler and LeBlanc, Strategies for Creative Problem Solving, 3rd ed, 2013
D.R. Woods, An Evidence Based Strategy for Problem Solving,
Journal of Engineering Education, Vol 89, pp 443-460.

1. **Engage**
   -focus on solving the problem

2. **Problem Definition**
   -clarify all available information
   -restate the problem: what is known? what is unknown?
   -draw diagrams
   -take notes

3. **Explore Possible Solutions**
   -talk with others: brainstorm
   -collect missing information
   -thought experiments
   -ball park estimates
   -check for errors in logic

4. **Plan a Course of Action**
   -select best approach
   -lay out plan of attack
   -stuck? Take a break!
   -critical path analysis
   -obtain resources

5. **Do it**.

6. **Evaluate the Results**
   -right order of magnitude?
   -viable solution?
   -are all constraints and requirements met?

Kresta/13/11/2013

Characteristics of Expert Problem Solvers

(adapted from ASEE Prism, Oct/96)

Expert problem solvers spend most of their time in the "define" and "explore" stages of the problem. They always evaluate the results. Underlying these actions, they have developed a lot of "mental toughness," (or panic avoidance). Expert problem solvers place a high value on the following approaches:

1. **Accuracy in Reading**
   -focus on the meaning of the problem statement
   -understand <u>every</u> word
   -collect <u>all</u> facts
   -reread the statement several times (at least 3)
   -complete the problem definition before doing any work

2. **Accuracy in Thinking**
   -value accuracy
   -work carefully
   -use words, notation, and procedures consistently
   -check information if unsure
   -work calmly
   -draw conclusions only if warranted

3. **Active Exploration of Possible Solutions**
   -draw sketches
   -think out loud/group think
   -break problem down into parts
   -build from easy solutions to more difficult ones
   -draw on prior knowledge and experience
   -ask questions

4. **Play to Win/Persevere/Believe in Yourself**
   -self confidence
   -self critical - question methods and approaches
   -ground all conclusions thoroughly
   -use a "time out" to regroup for a fresh attack