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New Challenges for a New Century

If we teach today's students as we taught yesterday's, we rob them of tomorrow.
— John Dewey

From today's school desks to the world beyond classroom borders, the global village is undergoing significant changes. Inside the school walls, the range of cultures and ethnicities represented announces that the classroom is reflecting the continuing shift in Australian society to a student population that is more diverse than it has ever been. In the world outside school walls, today's students are flooded with information like no prior generation. Data surrounds them, and spreadsheets, emails, blogs, tweets and texts are everywhere at every moment. Smartphones or headphones are glued to young folks' ears. TV and online ads assault their young consumer brains … and pockets. In this era of information overload, there is no time for young people to learn what will really prepare them for a future that only promises a greater information tsunami.

A range of prominent Australian voices have lately argued that our schools have failed the most recent student generations. Many among these critics recognise that 21st-century skills such as critical thinking and problem-solving are essential for students to live, learn and thrive in the technology-saturated 21st-century work world, and for the production of an Australian workforce able to compete in the new and rapidly changing global economy. For many reasons, this century is not like the one our parents or grandparents knew. It is a new era filled with new challenges, the intensity of which students have not experienced since Gutenberg's press shook the learning world in 1450. What has changed is the tenor of the times.

VOICES OF CONCERN

Over the previous decade, Australian student results in several major international assessments have provoked much consternation in education circles. In particular, concen has focused on the Program for International Student Achievement (PISA) administered by the Organisation for Economic Cooperation and Development (OECD), as well as the Trends in International Mathematics and Science Study and Progress in International Reading Literacy Study (TIMSS & PIRLS). In a recent article, ABC (2012) reported how current PISA, TIMSS & PIRLS results suggest that "Australian school children are well behind a host of other countries when it comes to reading, mathematics and science":

> The Progress in International Reading Literacy Study has revealed that a quarter of Australia's year 4 students failed to meet the minimum standard in reading for their

TABLE 2.1. Applying Feuerstein's cognitive functions (Feuerstein et al. 1980)

The First String	The Second String
Focused Perception	Hypothesising
Control Impulsive Reactions	Internalising
Systematic Searches	Labelling
Problem Discovery and Definition	Testing Strategies
Connecting Facts and Concepts	Spatial Orientation
Seach for Alternatives	Choosing Frame of Reference
Form and Describe Categories	Temporal Orientation
	Planning
	Conservation of Constancies
	Summarising a Concept
	Precise Measurement
	Logical Evidence
	Widen Conceptual Field
	Express a Concept
	Integration of Information Sources
	Express a Virtual Relationship
	Relevant Information Selection
	Avoid Trial and Error Guesses
	Spontaneous Comparisons

Teachers can learn to recognise cognitive functions as *deficient* when they see and hear them blocking students' daily learning attempts. There are seven deficiencies that stand out most consistently in the school day. These present themselves as weak habits of mind and negatively influence student learning success:

- Rampant impulsivity: the student acts without thought or planning.
- Disorganisation: the student's locker, desk and room look as if they were struck by a hurricane.
- Imprecise and inaccurate thought: the student ignores details and fails to double check facts.

In the emerging century's context and driven by international tests, problem-solving is playing an increasingly important role in F–12 education. Two distinct types of problem scenarios are set to overturn old concepts and demand student facility in each. *Tight* or *well-structured* problem-solving, as found in mathematics standards, versus *loose* or *ill-structured* problem-solving, as found in the social sciences and arts, are the focus of PISA's cross-curricular problem-solving thrust, addressed to non-mathematical problems in social studies, English, fine arts and other similar disciplines. Unlike the good old days when mathematics defined problem-solving, problem-solving in these other fields has stolen a space under the spotlight.

THE TIGHTLY STRUCTURED PROBLEM SCENARIO

Tightly structured problem-solving, such as that advocated by Billstein, Libeskind and Lott (2010) and others who work with primary school mathematics, sits at one end of the problem-solving see-saw. Tightly structured problems are those in which the parameters of the problem are clearly defined and delimited, and the methods for resolution can be largely pre-established. Due to the formal structure of mathematics knowledge, tightly structured problem-solving is most applicable to mathematics and mathematical thinking in science or other fields.

The Aims of the new Australian Curriculum: Mathematics establish from the outset the importance of students' ability to "pose and solve problems" with respect to key mathematical concepts (ACARA 2013). Even in the early years, the verb *solve* predominates the other verbs that initiate the Curriculum's content descriptions, as indicated in these statements from Year 2:

- Solve simple addition and subtraction problems using a range of efficient mental and written strategies (ACMNA030)
- Recognise and represent division as grouping into equal sets and solve simple problems using these representations (ACMNA032)
- Solve problems by using number sentences for addition or subtraction (ACMNA036)

When a teacher at this early stage is prepared to place sufficient emphasis on mathematical problem-solving, students should exit not only having learned to apply skills from the curriculum, but having acquired the basics of the more rigorous thinking needed to master the tight problem-solving processes in the secondary years. Eventually, they will be challenged to apply what they know about problem-solving to probability and statistics, with its applications to higher maths in the workplace and in university.

Consider the Year 9 content description that asks students to:

- Apply trigonometry to solve right-angled triangle problems (ACMMG224)

Model how to put the bad news into a problem statement and then ask student teams to replicate your approach before you mediate their trial statements. (Years F–10)

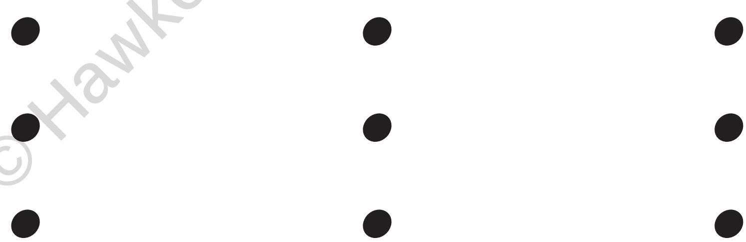
Now, that annoys me. Invite students to share those little things (non-school) that really annoy them. A problem matrix can help stretch thinking, improve ability to define a problem and even eliminate it. Start with a matrix as seen in Table 4.1. Fill in the chart one itch at a time. Complete each entry. Brainstorm solutions to each real problem. Discuss pluses and minuses for eliminating the worst itch. (Years 6–12)

TABLE 4.1. Problem matrix

Itches	**Reasons**	**Bad Results**	**Real Problem**
Whiny brother		Doesn't get way	Lose my temper

The nine dots. Connecting dots without mastering this traditional mental challenge (see Figure 4.1) would be like trying to light a lamp without a bulb. The goal is to link all nine dots using five straight lines or fewer, without lifting the pen or tracing the same line twice. To make this problem-solving brainteaser even more challenging, start with the five-line challenge. Once students have mastered this level, try another variation with five or reduce the usable straight lines to four and then three. End by asking teams to define the problem and compare responses. (For the solutions, google the nine-dot problem and be amazed.) (Years 11–12)

FIGURE 4.1 The nine dots



Measure for measure. After students have completed an open-ended mathematics problem-solving unit, build a list of the tactics and strategies used, note which worked best and construct class posters for later reference on a free site that provides students with adaptable templates to make posters, brochures and other print formats. (Years 6–12)

IN SUMMARY

The focus factor is the most essential of the cognitive functions. It drives students to control their thinking so they can complete increasingly complex thinking tasks. It can direct all of the other cognitive functions so that the thinking being done stays on track. When students think impulsively or episodically, it is difficult for them to maintain the concentration they need to focus their thinking and problem-solving. The more complex the content to which they apply their critical thinking skills, the more they can benefit by intentionally focusing on the task. Teachers can help students with planned interventions that call students to attend to the focus factor on a regular basis throughout the school year.

Connecting the Dots

- List the three ideas from this chapter that are most meaningful to you.
- Explain why you selected each of these ideas.
- How might you transfer these ideas to your work with 21st-century learners?

The secret of concentration is the secret of self-discovery. You reach inside yourself to discover your personal resources, and what it takes to match them to the challenge.

—Arnold Palmer

that systematic thinkers hold an advantage that benefits their gathering and making sense of curricular content, especially if it is organised according to a cross-curricular problem-solving approach. This was true well before the digital age, but it has become especially pressing for students learning to learn in an era of information overload.

The PISA 2012 assessment requires students to solve both mathematical problems and cross-curricular or real-world problems. In the document that outlines the plan for these assessments, distinctions are made between well-defined, tight problems – where "the problem situation is not dynamic," in that "all relevant information is disclosed at the outset and there is a single goal" – and ill-defined, loose problems, "which may be interactive or static in nature" and "often involve multiple goals which are in conflict so that progress towards one may detract from progress towards the other(s). Elaboration and weighing of priorities is required for the problem solver to achieve a balance between the goals" (PISA 2012).

The following activities focus on systematic searches that can help students to define and solve messy problems.

Amazing mazes. The Internet is filled with sites that provide interactive mazes that teachers can transform into age-appropriate opportunities to develop the systematic search function in a problem-solving format. Try *www.clickmazes.com, http://www.logicmazes.com* or *http://mazefrenzy.com*.

Follow the below steps with a sample maze. After students see what is expected, use the variety of mazes to differentiate systematic problem-solving practice.

1. Show the puzzle.
2. Ask students, "What's the problem?" ("To complete the maze.")
3. Brainstorm strategies to solve this problem. ("What do you have to do?")
4. Sequence the procedures from the brainstorm.
5. Brainstorm stuck strategies. ("What do you do when you don't know what to do?")
6. List the ideas for all to see.
7. Have students work on solving the mazes, following the ideas brainstormed.
8. When students have finished a maze, instruct them to answer these prompts: "What I did well to solve this problem in an orderly way was …" and, "I needed help with …"
9. Adjust levels of difficulty for each student's selection of the next maze.
10. Select times to discuss the question, "How are these mazes helping me become a more systematic problem-solver?" (Years 6–10)

In the United States, several alternative schools have served to illustrate the success of productive questioning. Bill Gregory and Vernoy Johnson, two master teachers who served at New Trier High School's Center for Self Directed Learning (1972–1982), are remembered by their English and maths students for what one former pupil (now a university professor who researches addiction among veterans) calls

> their maddening propensity to start the year with ground zero questions: "Well, you signed up for this study. You have me. Now, what do you want to learn?" For the first week, we had to figure that out and come up with the questions. Once we had discovered that the 5Ws make the best questions on which to organise our inquiry, then they would jump to questioning our questions and the material we were asking about. It didn't take us long to show we had done some basic research so we were asking the right questions about the right stuff. When I got to college, I was really ready because I knew how to approach every course with questions. I thought like a researcher, which led to falling in love with research. Today, I expect the same from all of my students, grads and undergrads. I think teaching my students to think, to ask the right questions that guide them to collect the right facts, the right data, about the right stuff is my job. (Bellanca, Paul & Paul 2013)

At Colorado's Denver Green School, too, upper level projects are rife with guiding questions. For instance, Year 6 students who were planning a harvest festival came up with this essential question: "Where does my food come from and why should I care?" For each lesson, they composed specific guiding questions that would provide the needed information: "What are our carbon sources? Where do bananas come from? What makes a healthy commons? What is the ratio between energy and food miles? What is in our lunch?"

When students are explicitly prepared to ask productive questions, especially essential questions that can jumpstart inquiry-strong lessons and projects and be extended with guiding questions, there are several benefits as they create a road map through their ill-defined problem to deeper learning. First, having been empowered to ask their own questions, they are more able to learn the recall information from a course because the memory is based on self-generated need. Second, they have increased their skill with a thinking operation (e.g. *distinguish*). Having mastered the skill, the students are freed to do their own independent inquiries into any coursework assigned. Third, they have learned a basic formula for asking their own questions with similar complex thinking verbs wherever higher-order thinking is called for in the curriculum. Fourth, they are more prepared to use questions that drive the critical and creative thinking processes that advance problem-solving (Mayer & Wittrock 2006). Altogether, these students are no longer dependent on a teacher to feed them each meal; they are ready for their own fishing adventures because they too know how to fish.

As is shown in the research on what happens when students learn to fish, teachers quickly see the increased effectiveness of student thinking, the increased achievements coloured texta. With a different colour, invite students to highlight the precise amounts of each ingredient. Make a side list that puts the ingredients into special groups. Label each group. Repeat these steps each time you do a different recipe. Label the process *analysis* and make a definition for the class, identifying where else students use the skill and what steps are important in making an analysis. With this advance organiser, the class is now ready to transfer the analysis procedures to a book analysis, as called for in the Australian Curriculum: English. (Years F–5)

Who's on first? Select a short story or novel to read or a favourite drama on TV. Pick one character. After the first third of the story, invite student pairs to describe the character on an index card and tell what clues they used. See if their analysis holds up as they finish the story. Identify what obvious and what hidden clues they missed. (Years 6–10)

What's the big idea? Assign students to read a textbook chapter. Ask students what is the main point the author is making and how they know that. Invite each student to keep a weekly journal in a small notebook, responding to the prompt, "This chapter's big idea is … I concluded this because …" They should provide evidence from the text, referenced by page. (Years 6–12)

In conclusion. Give each student pair a copy of an editorial of interest to them. Ask them to summarise what the author said and then write a countering editorial. Share the editorials in groups of four with discussions of inferences made. (Years 6–10)

Who said what? Provide your class with a list of tasks to analyse for bias:

- Read a magazine article, newspaper editorial or non-fiction bestseller.
- View a popular current events show like *60 Minutes* or *A Current Affair*.
- Watch a political debate.
- Watch a Michael Moore movie, such as *Bowling for Columbine*.

Instruct the students to return with a summary of what they read/heard and an analysis of the presenter's bias. "What was the biased statement? What evidence do they have of bias? What inferences does the bias facilitate?" Discuss these questions and determine areas of agreement and disagreement about the inferences made. (Years 11–12)

Watch out! When students are listening to someone argue a point (such as a politician, newscaster, editor, neighbour, car salesperson or real estate developer) there are keywords that indicate when they are drawing an inference. In these cases, they can check to see that the premise is grounded in fact and that the facts justify the conclusion. Or, they can test to see if the conclusion is a biased overstatement hiding false inferences. Share these examples to test:

Glossary

Advance Organiser: A high-effects strategy that is a crucial design element for inquiry projects and lessons. Includes tactics that call up prior knowledge before the start of a lesson or project.

Australian Curriculum: A curriculum document produced by the Australian Curriculum, Assessment and Reporting Agency (ACARA), in consultation with states and territories, stipulating the specific skills and general capabilities that all Australian students should learn as they advance through the school system.

Balanced Assessment: The evaluation of student performance that gives equal weight to the stated process skill (verb or verb form) and the content (direct object) in the curriculum.

Cognitive Engagement: The result of using instructional strategies that actively engage and develop the thinking functions and operations.

Cognitive Function: The Feuerstein term that includes 26 prerequisites of thinking used for thinking and problem-solving across the curriculum.

Collaboration: Two or more persons working together with a common goal usually using a common approach or technology tool (e.g. blog, wiki).

Communication: Interaction between two or more persons to share ideas, feelings, goals and values about their mutual interests and work.

Constructive: The theory of learning which equates learning with the cognitive act of "making sense" of information via three mental phases: gathering information, making sense of information and communicating new ideas.

Content: The facts, ideas, values, specific learning processes and opinions that are the subject matter of any study in any discipline. Reading, writing and arithmetic were the standard school content through the early 19th century. History, art and other subjects blossomed after World War II and laid the stage for 21st-century content which includes financial, technological and other literacies.

Content Descriptions: Statements from the Australian Curriculum, each identified by its own code, that describe the knowledge, understanding and skills teachers are expected to teach and students expected to learn according to their year level and subject.

Creative Thinking: A mode of problem-solving, highlighted in the Australian Curriculum, that entails a series of cognitive sub-skills, such as ideation and evaluation, which are learned, refined and applied to crucial issues in all disciplines. Attributes are fluency, flexibility and divergence and with critical elements lead to solution of a problem.