Griffith Graduate Attributes
Problem Solving Skills Toolkit

(D) Socially Responsible and Engaged in their Communities

1. Ethical awareness (professional and personal) and academic integrity

2. Capacity to apply disciplinary knowledge to solving real life problems in relevant communities

3. Understanding of social and civic responsibilities, human rights and sustainability

4. Understanding the value of further learning and professional development
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Problem Solving Skills Toolkit 2nd Edition

Authorial Attribution:
http://www.griffith.edu.au/gihe/resources-support/graduate-attributes

NOTE: The URLs listed in this toolkit were current at the time of retrieval. However, please note these may change with time as websites update.
Purpose of this toolkit

The Toolkits developed by members of the Griffith Graduate Project are intended primarily for academic staff. They offer an overview of some of the main issues related to developing students’ graduate skills during their degree studies.

They draw heavily on existing literature and current practice in universities around the world and include numerous references and links to useful web resources.

They are not comprehensive ‘guides’ or ‘how to’ booklets. Rather, they incorporate the perspectives of academic staff, students, graduates and employers on the graduate skills adopted by Griffith University in its Griffith Graduate Statement.


This Toolkit, Problem Solving Skills, focuses on how students can develop approaches and strategies that will enable them to frame, set and solve problems in a variety of learning contexts, inside and outside the university.

This toolkit, together with others in the series (as shown in the following table) can be accessed via the Griffith Institute for Higher Education webpage, the URL of which is listed on the following page.

<table>
<thead>
<tr>
<th>GRADUATE ATTRIBUTES</th>
<th>DESCRIPTOR</th>
<th>TOOLKIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Knowledgeable and Skilled in their Disciplines</td>
<td>Comprehensive knowledge and skills relating to their disciplines</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>An interdisciplinary perspective</td>
<td>Interdisciplinary Skills</td>
</tr>
<tr>
<td></td>
<td>Capacity to find, evaluate and use information</td>
<td>Information Literacy</td>
</tr>
<tr>
<td></td>
<td>Ability to apply discipline/professional skills and knowledge in the workplace</td>
<td>Professional Skills</td>
</tr>
<tr>
<td>(2) Effective Communicators and Team Members</td>
<td>Capacity to communicate effectively with others orally</td>
<td>Oral Communication</td>
</tr>
<tr>
<td></td>
<td>Capacity to communicate effectively with others in writing</td>
<td>Written Communication</td>
</tr>
<tr>
<td></td>
<td>Capacity to communicate effectively with others using ICTs, multimedia, visual, musical and other forms appropriate to their disciplines</td>
<td>ICT and Other Discipline-Related Communication Skills</td>
</tr>
<tr>
<td></td>
<td>Capacity to interact and collaborate with others effectively, including in teams, in the workplace, and in culturally or linguistically diverse contexts.</td>
<td>Teamwork Skills</td>
</tr>
<tr>
<td>GRADUATE ATTRIBUTES</td>
<td>DESCRIPTOR</td>
<td>TOOLKIT</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>(3) Innovative and Creative, with Critical Judgement</td>
<td>Ability to use knowledge and skills to devise solutions to unfamiliar problems</td>
<td>Creativity and Innovation*</td>
</tr>
<tr>
<td></td>
<td>Ability to analyse and critically evaluate arguments and evidence appropriate to their disciplines (e.g. collect analyse and interpret data and information, generate and test hypotheses, synthesise and organise information)</td>
<td>Critical Evaluation</td>
</tr>
<tr>
<td></td>
<td>Knowledge of research methodologies in their disciplines and capacity to interpret findings</td>
<td>Research Skills</td>
</tr>
<tr>
<td></td>
<td>Ability to generate ideas/products/art works/methods/approaches/perspectives as appropriate to the discipline.</td>
<td>Creativity and Innovation*</td>
</tr>
<tr>
<td>(4) Socially Responsible and Engaged in their Communities</td>
<td>Ethical awareness (professional and personal) and academic integrity</td>
<td>Ethical Behaviour and Social Responsibility*</td>
</tr>
<tr>
<td></td>
<td>Capacity to apply disciplinary knowledge to solving real life problems in relevant communities</td>
<td>Problem Solving</td>
</tr>
<tr>
<td></td>
<td>Understanding of social and civic responsibilities, human rights and sustainability</td>
<td>Ethical Behaviour and Social Responsibility*</td>
</tr>
<tr>
<td></td>
<td>Understanding the value of further learning and professional development</td>
<td>Further Learning</td>
</tr>
<tr>
<td>(5) Competent in Culturally Diverse and International Environments</td>
<td>Awareness of and respect for the values and knowledges of Australian Aboriginal and Torres Strait Islander First Peoples</td>
<td>To be developed</td>
</tr>
<tr>
<td></td>
<td>Respect, awareness, knowledge and skills to interact effectively in culturally or linguistically diverse contexts</td>
<td>Global and International Perspective and Awareness*</td>
</tr>
<tr>
<td></td>
<td>A global and international perspective on their disciplines.</td>
<td>Global and International Perspective and Awareness*</td>
</tr>
</tbody>
</table>

NB: * Toolkit covers two sub-attributes. ** Toolkit development in progress
Why your students need problem solving skills

The need for problem solving skills

Good problem solving skills empower students in their educational, professional, and personal lives. Nationally and internationally, there is growing recognition that if education is to produce skilled thinkers and innovators in a fast-changing global economy, then problem solving skills are more important than ever. The ability to solve problems in a range of learning contexts is essential for the development of knowledge, understanding and performance. Requiring students to engage with complex, authentic problem solving encourages them to use content knowledge in innovative and creative ways and promotes deep understanding.

In a recent report, employers in small, medium and large enterprises identified the following aspects of problem solving as crucial to success in their organisations:

- developing creative, innovative solutions;
- developing practical solutions;
- showing independence and initiative in identifying problems and solving them;
- solving problems in teams;
- applying a range of strategies to problem solving;
- using mathematics including budgeting and financial management to solve problems;
- applying problem solving strategies across a range of areas;
- testing assumptions taking data and circumstances into account; and
- resolving customer concerns in relation to complex project issues.


Definition

Solving problems effectively requires students to identify, define and solve problems using logic, as well as lateral and creative thinking. In the process, students arrive at a deep understanding of the topic area and construct new knowledge and understanding on which they are able to make decisions.

There is an important distinction between solving ‘exercises’ and solving ‘problems.’ The former usually have predetermined solutions, with “a well-defined route to the solution and students must simply follow the formula” (Woods, 1985, p. 20). The latter, however, are often fuzzy, open-ended, unstructured and ‘one-offs,’ with no predictable outcomes:
“While these exercises make an important first step in helping students bridge the gap between theory and application, they do not provide the depth and complexity necessary to master problem solving skills... Students who train mostly in exercise solving tend to develop a serious handicap. They rely heavily on solutions they have seen before, rather than working from first principles. Thus a problem with brand new context presents a formidable challenge to them.”

What employers, graduates and students say about problem solving skills

Employers’ comments

“We look for a whole range of skills in our graduates. Basically, people who are able to problem solve are important to us. We look for evidence of this in their work experience, their technical performance as well as their academic results.”
(Employer of Griffith Accounting Graduates, 2001)

“Problem solving is a quality that really stood out with the Griffith graduate we have at the moment. If he comes across a barrier he seeks advice, but doesn’t require constant supervision or feedback. He has the initiative to go out and solve problems on his own, which is great.”
(Employer of Griffith Microelectronic Engineering Graduate, 2003)

“We look for a whole range of skills in graduates we select. Academic results are important but they’re not the only thing and not necessarily the first thing we look at. We are interested in people who can think about a diverse range of problems and bring a large amount of information down to important points. So people who are able to problem solve are important to us. We look for evidence of this in their work experience, and technically, as well as their academic results.”
(Employer of Griffith Science Graduates, 2001)

“As an employer, the most important thing I look for in graduates is good problem solving skills. Within the university situation there is a lot of opportunity for problem solving, through exams and assignments but those situations can be fairly contrived. So there also needs to be opportunity for problem solving that is more open and authentic, where the solution is not necessarily clear.”
(Employer of Griffith Microelectronic Engineering Graduates, 2002)
Graduates’ comments

“I’ve learnt to make decisions about which pieces of information to retain and how to use that information to formulate a good response to a problem, both at university and in my part-time work.”
(Griffith Graduate, 2002)

“I find myself using information from one context in another, but changing the way I use it. I do that a lot now, which is good because it has improved my problem solving abilities.”
(Griffith Graduate, 2003)

Students’ comments

“I think that my study of literature has helped me become a better problem-solver. For example, sympathetic imagination is a procedure we use to examine situations from different points-of-view, such as the different perspectives each character in a novel might have. It has helped me to develop the ability to examine problems from many perspectives.”
(Griffith Student, 2004)

“Through my study of ethics, I have learned to identify core problems arising from the issues being considered, examine the reasons why the problems exist and then seek ways of responding to, dealing with or solving the problems.”
(Griffith Student, 2004)
Teaching tips – How to develop your students’ problem solving skills

Why teach students problem solving skills?
Students need to be able to transfer the ability to solve problems in one context into new and different contexts and situations. Certain aspects of problem solving are transferable, even if the particular problem to be solved is discipline- or context-specific. Toohey lists these transferable aspects as:

“being able to analyse problems, to generate a range of possible solutions, to evaluate the alternatives systematically before choosing and implementing the best.”

Preparing students for problem solving
Below are some aspects of problem solving to draw to students’ attention, especially in group tasks:

- avoid focussing on solutions prematurely before the problem has been thoroughly identified, defined and discussed;
- avoid a ‘quick fix’ approach that seeks to eliminate the problem as quickly as possible – it is better to tolerate uncertainty, ambiguity and doubt;
- maintain an open mind and be willing to consider new ideas;
- be aware of individual biases when evaluating the facts of a case; and
- when working in a group, don’t misinterpret disagreement for dislike – view different opinions as a positive consequence of the group’s diversity.

Designing problems for students to solve
Students develop problem solving skills through tasks which:

- have visible real-world value and use;
- are achievable;
- challenge them to display their grasp and use of skills that are important in their domain;
- help them become aware of the range of other generic skills they are using during the problem solving process (e.g., teamwork, communication, analytical skills etc.); and
- are drawn from authentic activities that will help them learn to manage complexity and diversity. Novice problem-solvers will need help and support in this process.
Defined problems have a clear structure, a clearly specified start and goal, and a set of steps by which to move through the problem. An example of a defined problem is an algebraic one, which has one unknown and only one right answer. Through the use of algorithms (step-by-step procedures), the problem can be solved correctly, or at least to the satisfaction of the discipline community. By contrast, real-world problems are usually not clearly defined and have vague specifications, uncertain goals and no set method of proceeding. Problem solving involves error and uncertainty and even if your students are eventually successful, it is likely they will feel uncomfortable, or at risk, as they come to terms with the problem solving processes they will encounter in the workplace.

Adapted from:

Whatever form the problem takes and whatever approach is used to help students develop their problem solving skills, it is important to recognise and make students aware of the difference between solving exercises and solving problems. For example:

<table>
<thead>
<tr>
<th>Exercise solving</th>
<th>Problem solving</th>
</tr>
</thead>
<tbody>
<tr>
<td>A process used to obtain the one and only right answer for the data given.</td>
<td>A process used to obtain a best answer to an unknown, subject to some constraints.</td>
</tr>
<tr>
<td>The situation is well defined. There is an explicit problem statement with all the necessary information (known and unknown).</td>
<td>The situation is ill-defined. There may be some ambiguity in the information provided. Students must define the problem themselves. Assumptions may need to be made about what is known and what needs to be found.</td>
</tr>
<tr>
<td>The student has encountered similar exercises in books, in class or in homework.</td>
<td>The context of the problem is brand new (ie. the student has not encountered this situation before).</td>
</tr>
<tr>
<td>Exercises often prescribe assumptions to be made, principles to be used and sometimes they even give hints.</td>
<td>There is no explicit statement in the problem that tells the student what knowledge/technique/skill to use in order to solve the problem.</td>
</tr>
<tr>
<td>There is usually one approach that gives the right answer.</td>
<td>There may be more than one valid approach.</td>
</tr>
<tr>
<td>The usual method is to recall familiar solutions from previously solved exercises.</td>
<td>The algorithm for solving the problem is unclear.</td>
</tr>
<tr>
<td>Exercises involve one subject and in many cases only one topic from this subject</td>
<td>Integration of knowledge from a variety of subjects may be necessary to address all aspects of the problem.</td>
</tr>
<tr>
<td>Communication skills are not essential.</td>
<td>Requires oral and/or written communication skills to convey the essence of the problem and present the results.</td>
</tr>
</tbody>
</table>

Structuring a problem solving task

Problem solving is an iterative, or cyclical process. The various steps in the process outlined below need to be carried out and revisited from time to time.

<table>
<thead>
<tr>
<th>Stages in the problem solving process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify the problem</td>
<td>Either present a defined problem or ask students to identify their own.</td>
</tr>
</tbody>
</table>
| Define the problem                   | Ask students to represent the problem in their own words, defining the key words, terms and concepts. Students should ask themselves questions such as:  
  • What do I know already about this problem or question?  
  • What do I need to know to effectively address this problem or question?  
  • What resources can I access to determine a proposed solution or hypothesis?  
In this stage, a very focused problem statement is needed, though that statement will go through a series of changes as new information is accessed and processed. |
| Collect, evaluate and organise information about the problem | Determine what information will be relevant, useful and absolutely essential for solving the problem; retrieve information from print, web and other sources; classify and categorise relevant information. |
| Create or select a strategy to resolve the problem | Ask students to collect examples of similar problems and the strategies used to solve them. |
| Allocate resources to solve the problem | Encourage students to develop timelines, action plans, progress reports and role allocations to ensure the problem is satisfactorily resolved. |
| Monitor the problem solving process | Ask students to submit regular progress reports or updates to ensure deadlines are met; require submission of reflective documents on process issues as part of their assessment. |
| Evaluate the final solution | Ask students to evaluate their final solution to the problem from multiple perspectives (e.g., an accountant; a manager; a researcher; an end-user; an advertising agent) to test its validity in a range of contexts. |

Useful resources

Teaching Problem Solving

  http://depts.washington.edu/cidrweb/TAHandbook/ProblemSolving.html
Different approaches to the problem solving process

Problem-based learning

“Problem-Based Learning (PBL) is a system of teaching and learning where, without prior preparation, small groups of students consider an unfamiliar situation, problem or task. By exploring the nature of this unfamiliar situation, the students share prior knowledge and experience. As they progress, they pose questions which they need to explore in order to progress with the task.

After a period of individual study and other supportive educational experiences, they discuss what they have learned and how this relates to the original situation. Curriculum construct and assessments are designed and implemented, in order to support this form of self-directed learning. Teachers adopt the roles of facilitators and managers of the students’ learning.”


Problem-based learning (PBL) had its origins in medical practice in North America in the 1960s, but is receiving increasing application in a number of other curriculum areas. In some universities, the entire curriculum has moved to problem-based learning, and many medical schools rely on it instead of the traditional curriculum. In a problem-based learning curriculum, “the problems are the curriculum” (Biggs, 1999, p. 207). PBL draws on real-world problems, not hypothetical case studies with neat, convergent outcomes. It is in the process of struggling with actual problems that students “acquire knowledge, content-related skills, self-management skills, attitudes, know-how: in a word, professional wisdom” (Biggs, 1999, p. 207). Students in a course or program grounded in problem-based learning will learn what they need to know in order to function and behave as a practicing professional:

“An essential component of problem-based learning is that content is introduced in the context of complex, real-world problems. In other words, the problem comes first (Boud, 1985; Boud and Feletti, 1991; Woods, 1985). This contrasts with prevalent teaching strategies where the concepts, presented in a lecture format, precede ‘end-of-the-chapter’ problems. In problem-based learning, students working in small groups must identify what they know, and more importantly, what they don’t know and must learn to solve a problem. These are prerequisites for understanding the problem and making decisions required by the problem. The nature of the problem precludes simple answers. Students must go beyond their textbooks to pursue knowledge in other resources in between their group meetings. The primary role of the instructor is to facilitate group process and learning, not to provide easy answers.”

Benefits of problem-based learning

Biggs (1999) summarises the benefits of problem-based learning to students in the following way:

“The motivational context is pressing. In a typical medical programme, students in their first week of the first year are faced with the responsibility of a real patient with, say, a broken leg. The felt need to learn is strong.

Learners become active very quickly. They are assigned to small problem solving groups and begin interacting with teachers, peers and clients (who present the problem).

Learners build up a knowledge base of relevant material; they learn where to go to check it and to seek out more. They are variously guided towards resource materials, including films, videos, the library and the lecture room. Knowledge is elaborated and consolidated. Students meet a tutor and discuss the case in relation to the knowledge they have obtained.

The knowledge is applied: the case is treated.

The case is reviewed, and learners develop self-management and self-monitoring skills which they review throughout the programme.”


Useful resources

Some relevant material including sample problems in the fields of Biology, Chemistry, Biochemistry, Criminal Justice and Physics can be found at:


Devil’s advocacy

The Devil’s Advocacy strategy can be used with pairs or groups of students to develop not only problem solving skills, but also critical thinking and group skills. It relies on structured, managed conflict rather than group harmony to help groups solve problems, while at the same time avoiding damage to interpersonal relations. This strategy is often used by managers and strategic planners in industry, so students need to know about it. Subjecting recommendations and assumptions to intense critique develops the better ones and ensures that the team’s plan will ultimately be able to survive the same sorts of critiques from outsiders.

In this approach, a solid, well-supported argument is made for a set of recommendations or solution in response to a problem. This is then subjected to interrogation and critical evaluation by another person or sub-group. Only the best plans or solutions will survive unscathed. This is how you can implement it:

- Divide the class into two groups, one of which will serve as Devil’s Advocate;
- The other group should develop a plan to solve the problem, making sure to write down all key assumptions and facts that support them;
- This group then submits the recommendations and a list of the assumptions that underlie them to the Devil’s Advocate group;
- The Devil’s Advocate group then interrogates and evaluates the plan, trying to uncover everything that is wrong with the recommendations and inaccurate with the assumptions;
- The first group then revisits their solution and adjusts their recommendations based on these criticisms.

Useful resources


de Bono’s ‘six hats’

Meetings or group sessions frequently get bogged down in arguments when people take firm positions and defend them to the death. The ‘six hats’ strategy is a co-operative, rather than an adversarial tool. In a team or meeting context, it can be easy for someone not to see the positives of an idea or initiative they don’t support, but the ‘six hats’ technique challenges participants to see all sides of a problem. de Bono describes the ‘six hats’ as a ‘game’, but despite its simplicity, his method is very powerful and is used extensively in industry and the professions. This is how it works.

Each of the six hats has a different colour, with each hat representing a perspective, or way of thinking. Ask each student in the group to ‘put on’ different hats in a sequence to encourage them to adopt different perspectives. It is important that the hats do not categorise or label people. Rather than limiting people, the aim of this strategy is to get the thinker/problem solver to use all six hats and broaden their horizons.
<table>
<thead>
<tr>
<th>Hat colour</th>
<th>Explanation</th>
<th>Characteristic statements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>White</strong></td>
<td>White is neutral. While wearing the white hat, ignore arguments and proposals. Instead, examine the facts, figures and information. Identify what information is needed and how it might be acquired.</td>
<td>What information do we have here? What information is missing? What information would we like to have? How are we going to get the information?</td>
</tr>
<tr>
<td><strong>Red</strong></td>
<td>Red is for feelings, hunches and intuition. It permits people to put forward their feelings without the need for apology, explanation or justification. Intuition may be a composite judgement based on years of experience, and it can be valuable, even if the reasons behind it cannot be spelled out.</td>
<td>My gut feeling is that it won’t work. I don’t like the way this is being done. My intuition tells me that this process won’t be sustainable.</td>
</tr>
<tr>
<td><strong>Black</strong></td>
<td>The black hat is the logical negative. It is the hat of caution and critical judgement. It is the most used hat, and perhaps the most valuable hat; however, it is very easy to overuse the black hat and stifle creative ideas with early negativity.</td>
<td>The policies will prevent us from doing that. We do not have the resources to do this project. The team doesn’t have the necessary project management experience.</td>
</tr>
<tr>
<td><strong>Yellow</strong></td>
<td>The yellow hat is for optimism and the logical positive view of things. It looks for feasibility and how something can be done. It looks for benefits, but they must be logically based.</td>
<td>That might work if we rearranged the timeline. It’s possible the team could take this further in a second project. We have the resources to make this work.</td>
</tr>
<tr>
<td><strong>Green</strong></td>
<td>The green hat is for creative thinking, new ideas and additional alternatives. This is where lateral thinking and other creative techniques are engaged.</td>
<td>We need some new ideas here. Are there any other alternatives? Could we do this in a different way? Could there be another explanation?</td>
</tr>
<tr>
<td><strong>Blue</strong></td>
<td>The blue hat is the thinking overview, or process control hat. It is generally used by the chairperson of the meeting, as it sets the agenda for thinking, suggests the next step, and asks for summaries, conclusions and decisions.</td>
<td>We have spent far too much time looking for someone to blame. Could we have a summary of your views? I think we should take a look at the priorities.</td>
</tr>
</tbody>
</table>

Table based on:
Questions to help students monitor their problem solving processes

The following prompt questions are useful to help students monitor their own processes while solving problems. Designed for use specifically with novice design students, they nevertheless are relevant to students in a number of disciplines.

<table>
<thead>
<tr>
<th>Questions to prompt generative thinking</th>
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</thead>
<tbody>
<tr>
<td><strong>Procedure</strong></td>
</tr>
<tr>
<td>Retrieval</td>
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<tr>
<td>Search</td>
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<tr>
<td>Association</td>
</tr>
<tr>
<td>Contrast</td>
</tr>
<tr>
<td>Synthesis</td>
</tr>
<tr>
<td>Transformation</td>
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<tr>
<td>Analogy</td>
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<tr>
<td>Categorical reduction</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Questions to prompt explorative thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge application</strong></td>
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<tr>
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</tr>
<tr>
<td>Experimentation</td>
</tr>
<tr>
<td>Context shifting</td>
</tr>
<tr>
<td>Attribute finding</td>
</tr>
<tr>
<td>Acknowledging limitations</td>
</tr>
</tbody>
</table>
### Questions to prompt evaluative thinking

<table>
<thead>
<tr>
<th><strong>Analysis</strong></th>
<th>What are the strengths and weaknesses of this solution?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assessment</strong></td>
<td>Am I ready to make some definite decisions about whether this idea is a good one?</td>
</tr>
<tr>
<td><strong>Verification</strong></td>
<td>What's good about the things I've decided to keep in so far?</td>
</tr>
<tr>
<td><strong>Trialing</strong></td>
<td>If I ‘test drive’ this, does it work?</td>
</tr>
<tr>
<td><strong>Criteria fulfillment</strong></td>
<td>Does this solution do (or look like it will eventually do) everything it is supposed to?</td>
</tr>
<tr>
<td><strong>Elimination</strong></td>
<td>Does this idea, or some part of it, need to be taken out because it is just not useful for this particular project?</td>
</tr>
<tr>
<td><strong>Selection</strong></td>
<td>Some ideas or parts of them may have to go, but what is definitely staying?</td>
</tr>
<tr>
<td><strong>Comparison</strong></td>
<td>Why is this outcome better or worse than another one?</td>
</tr>
<tr>
<td><strong>Review</strong></td>
<td>Would doing a ‘stock take’ of where I am now be helpful?</td>
</tr>
</tbody>
</table>

### Questions to prompt strategic thinking

<table>
<thead>
<tr>
<th><strong>Goal setting</strong></th>
<th>When I’m finished, what do I want this outcome to achieve?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Switching</strong></td>
<td>If what I’m doing at the moment isn’t working or if I’m stuck, or if I simply want some fresh ideas – what else can I do?</td>
</tr>
<tr>
<td><strong>Cognitive awareness</strong></td>
<td>What questions should I ask myself at the moment to help me decide whether or not I’m generally happy with the way things are going?</td>
</tr>
<tr>
<td><strong>Goal monitoring</strong></td>
<td>Is what I’m doing at the moment going to help me achieve the aim of the project?</td>
</tr>
<tr>
<td><strong>Strategy formulation</strong></td>
<td>Is what I’m doing at the moment taking me in the general direction of where I think I want to go, even if I’m not sure about where that is exactly?</td>
</tr>
</tbody>
</table>

Assessing students’ problem solving skills

**Options for assessing problem solving**

It is likely that the traditional methods of assessing students' work (e.g., examination; research essay; project or laboratory report; oral presentation) will need to be supplemented with other methods more closely aligned with real-world problem solving.

**Why not:**

Design assessment items based on:

- problem scenarios;
- group work;
- work-based problems;
- a committee of enquiry report;
- a research bid to a realistic brief;
- a case analysis; or
- a conference paper (or notes for a conference paper plus annotated bibliography).


Other methods for assessing problem solving skills include:

- modified essay question;
- simulated client interviews;
- Objective Structured Clinical Assessment (OSCA);
- social history report; and
- research poster.

Assessment Tools

The Project Approach

Embed tasks within a project, or simulated project, which itself is constructed in accordance with the individual steps of the problem solving process, including:

1. defining the goal;
2. analysing the situation;
3. planning the solution;
4. executing the plan; and
5. evaluating the result.

The situation should involve tasks, which might occur in a similar situation in real life and should contain:

1. a description of the problem situation;
2. the participant’s role in the situation;
3. the participant’s task; and
4. a listing of the steps in the work.

PC Networks

Assess problem solving competencies in collaborative problem solving tasks where individual students contribute to a group task in an internet discussion environment. This allows you to monitor individual student responses.

Co-operative Planning

Provide each student within a small group (three students) with separate introductory information for a project, with each student being responsible for different goals. Each student works out a solution for his or her part of the problem. A common solution then has to be arrived at in a group discussion. (Klieme, quoted in J. Reeff.)


Problem Solving Rubric

The scale (illustrated in the table on the following page) evaluates the process employed in response to a problem solving task. It takes into consideration the level of student knowledge and understanding with respect to the given problem solving task; the selection and implementation of appropriate procedures and/or strategies; and the accuracy of the solution obtained.
**Level 0**

Response is characterised by the following:

- It is blank.
- The student response only repeats information in the problem task;
- An incorrect solution/response is given and no other information is shown;
- The solution/response and supportive information is totally irrelevant to the problem task.

**Level 1**

Response is characterised by the following:

An incomplete and/or incorrect response/solution is provided evidencing an attempt to solve the problem. In addition, one or more of the following are apparent:

- The student did consider a constraint or variable of the problem situation;
- The student understands some concepts relevant to the problem task; and/or
- The student selected a totally inappropriate procedure/strategy.

**Level 2**

Response is characterised by one of the following:

The student selects appropriate procedures/strategies to solve this problem; however, the response/solution is not correct because one or more of the following are:

- There is evidence that the student has several misconceptions or has failed to consider several relevant concepts needed to solve the problem correctly;
- The student fails to consider several constraints of the problem situation;
- The student has also considered several irrelevant variables or failed to consider several relevant variables;
- The student did not carry the procedures/strategies far enough to reach a solution; and/or
- The response/solution is generally correct; however, there is no information showing how the student arrived at this response/solution.

**Level 3**

Response is characterised by one of the following:

The student selects appropriate procedures to solve this problem; however, the response/solution is not entirely correct because one of the following is apparent:

- There is evidence the student has a misconception or has failed to consider a relevant concept needed to solve the problem correctly;
- The student fails to consider a constraint of the problem situation;
- The student has considered an irrelevant variable or failed to consider a relevant variable; and/or
- The response/solution is generally correct; however, from the information provided it is not completely clear how the student arrived at this solution.

**Level 4**

Response is characterised by one of the following:

- The student selects and implements relevant concepts and procedures/strategies needed to solve this problem.
- The student considers all constraints of the problem situation.
- The solution and all relevant work is correct; or, there is a mistake due to some minor computational or copying error.

Adapted from:
http://www.cse.ucla.edu/CRESST/pages/rubrics.htm - holistic
## Strategies for assessing problem solving skills

### Approach: Problem recognition tasks

**Examples of common problems are presented to students and they are expected to identify the basic type of problem represented by each example.**

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students often view problems as separate or distinct situations that share few common features.</td>
<td>This assessment technique is most appropriate in quantitative and technical courses but may also be used to evaluate global problem solving skills in the humanities and social sciences. Specific steps involved in developing a problem-recognition task instrument include:</td>
</tr>
<tr>
<td>Recognition of problem types is the first step to solving the problem. Increasing the students’ understanding of the type of problem involved should increase the speed and accuracy with which subsequent problems are solved.</td>
<td>• Selecting examples that represent different (but related) problem types that are difficult for students to differentiate. Each individual example should represent only one type of problem type;</td>
</tr>
<tr>
<td>Lecturers benefit by learning if students are correctly identifying types of problems. If students are incorrectly classifying the types of problems, corrective measures need to be taken. The material to be presented in any course can be presented more efficiently and effectively when students quickly recognise the type of problem involved.</td>
<td>• Determining if the students will be asked to match the examples to a list of problem types or to name the problem type without the aid of such a list;</td>
</tr>
<tr>
<td>Allow students more time to complete the problem-recognition tasks.</td>
<td>• Testing your examples using colleagues, graduate students, or advanced undergraduate students. Information gained from testing can include if the examples, amount of time needed to complete the task, and the level of difficulty for students are appropriate.</td>
</tr>
</tbody>
</table>

### Approach: What's the Principle?

This assessment technique logically follows problem recognition tasks. Once a type of problem is correctly identified, students must identify which of the principles must be applied to solve the problem.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>One goal of What's the Principle? is to assist students in understanding which general types of problems can be solved with the individual principles involved in the class. This technique can also be used to help students understand why problems may be encountered when basic principles are not used.</td>
<td>This technique can readily be applied in any course where students are expected to learn rules or principles. What's the Principle? tasks may be applied in the humanities and social sciences as well as traditional science and technology subjects. The steps are:</td>
</tr>
<tr>
<td></td>
<td>• Identify the basic principles that the students are expected to learn;</td>
</tr>
<tr>
<td></td>
<td>• Create examples that demonstrate the application of each of these principles;</td>
</tr>
<tr>
<td></td>
<td>• Develop a What's the Principle? assessment tool that asks students to match a list of examples with a list of principles or asks students to identify the principle(s) appropriate to the example without the aid of a list.</td>
</tr>
<tr>
<td></td>
<td>Administering comparable What's the Principle? instruments over the course of an academic semester permits the evaluation of the enhancement of student learning in problem recognition and in the selection of principles appropriate for solving various problems.</td>
</tr>
</tbody>
</table>
Approach: Documented problem solutions. This technique asks students to keep track of the steps involved in solving particular types of problems.

One goal of What's the Principle? is to assist students in understanding which general types of problems can be solved with the individual principles involved in the class. This technique can also be used to help students understand why problems may be encountered when basic principles are not used.

This technique can readily be applied in any course where students are expected to learn rules or principles. What's the Principle? tasks may be applied in the humanities and social sciences as well as traditional science and technology subjects. The steps are:

- Identify the basic principles that the students are expected to learn;
- Create examples that demonstrate the application of each of these principles;
- Develop a What's the Principle? assessment tool that asks students to match a list of examples with a list of principles or asks students to identify the principle(s) appropriate to the example without the aid of a list.

Administering comparable What's the Principle? instruments over the course of an academic semester permits the evaluation of the enhancement of student learning in problem recognition and in the selection of principles appropriate for solving various problems.

Table based on:
http://www.ndsu.nodak.edu/ndsu/marmcdon/assessment/assessment_techniques/problem_solving_skills.htm

Useful resources

Principles of effective problem solving

Students’ problem solving skills

- develop incrementally though a series of stages, e.g.:
  - identifying the problem;
  - defining the problem;
  - collecting, evaluating and organising information about the problem;
  - creating or selecting a strategy to resolve the problem;
  - allocating resources to solve the problem;
  - monitoring the problem solving process; and
  - evaluating the final solution.

- can be monitored by asking them to challenge and reflect on processes and progress;
- can be developed through real-world problems to which there are no correct answers;
- can be extended by asking them to view the problem from a range of perspectives; and
- can be focused by using different problem solving strategies, such as: case studies, Devil’s Advocacy or de Bono’s ‘six hats.’

Designing problems for students to solve

Students develop problem solving skills through tasks which:

- have visible real-world value and use;
- are achievable;
- challenge them to display their grasp and use of skills that are important in their domain;
- help them become aware of the range of other generic skills they are using during the problem solving process (e.g., teamwork, communication, analytical skills etc.); and
- are drawn from authentic activities to help them manage complexity and diversity.
Students should be aware of the risks

Students should be made aware of the risks involved in:

- focussing on solutions prematurely before the problem has been thoroughly identified, defined and discussed;
- adopting a ‘quick fix’ approach that seeks to eliminate the problem as quickly as possible – it is better to tolerate uncertainty, ambiguity and doubt;
- not adopting an open mind and being willing to consider new ideas;
- not taking into account individual biases when evaluating the facts of a case; and
- misinterpreting others’ disagreement for dislike – different opinions are a positive consequence of the group’s diversity.

When assessing problem solving skills

Look for evidence that the student has:

- interpreted the problem;
- considered a range of alternative solutions;
- thought creatively and laterally about the problem;
- tested and tried possible solutions;
- evaluated the worth of the solutions; and
- decided on the ‘best’ solution in light of the criteria.
Where to go for help

Contact:

- The Griffith Institute for Higher Education.
- Information Services, Learning and Teaching.

Learning Services

Problem solving is an area where the University has recognised that support is crucial. Learning Services has teams of learning advisers here to work with you. They can:

- advise you on teaching, learning and assessment strategies; and
- team teach with you in your lectures and tutorials.

There are also services to which you can refer your students so that they can independently develop their Problem solving skills. These include:

- individual or small group consultations with a learning adviser;
- workshops;
- self-help resources.

For more information on these services, visit the Information Services, Learning and Teaching website.

Additional resources

Print resources


- Woods, D.R. (1994). *Problem-based learning: How to gain the most from PBL*. Hamilton: Donald R. Woods, Publisher.

Web resources


Appendix A- Student handouts

Please note: Appendix A contains reproduced information from within this toolkit that may be useful to your students. For ease of reference and printing, this collection of ready to use resources associated with various aspects of facilitating, teaching and assessing problem solving has been collated in this appendix as follows:

1. Principles of effective problem solving

2. What employers, graduates and students say about problem solving skills

3. Solving problems

4. The ‘six hats’ strategy for problem solving

5. Questions for monitoring problem solving processes
Principles of effective problem solving

Problem solving skills

- develop incrementally through a series of stages, e.g.:
  - identifying the problem;
  - defining the problem;
  - collecting, evaluating and organising information about the problem;
  - creating or selecting a strategy to resolve the problem;
  - allocating resources to solve the problem;
  - monitoring the problem solving process; and
  - evaluating the final solution.
- can be monitored by asking them to challenge and reflect on processes and progress;
- can be developed through real-world problems to which there are no correct answers;
- can be extended by asking them to view the problem from a range of perspectives; and
- can be focused by using different problem solving strategies such as: case studies, Devil’s Advocacy or de Bono’s ‘six hats.’

Problem solving skills are developed through tasks

Problem solving-skills are developed through tasks which:

- have visible real-world value and use;
- are achievable;
- challenge them to display their grasp and use of skills that are important in their domain;
- help them become aware of the range of other generic skills they are using during the problem solving process (e.g., teamwork, communication, analytical skills etc.); and
- are drawn from authentic activities to help them manage complexity and diversity.

Be aware of the risks

You need to be aware of the risks involved in:

- focussing on solutions prematurely before the problem has been thoroughly identified, defined and discussed;
- adopting a ‘quick fix’ approach that seeks to eliminate the problem as quickly as possible – it is better to tolerate uncertainty, ambiguity and doubt;
- not adopting an open mind and being willing to consider new ideas;
• not taking into account individual biases when evaluating the facts of a case;
• misinterpreting others' disagreement for dislike – different opinions are a positive consequence of the group’s diversity.

When assessing problem solving skills
Your lecturer or tutor will be looking for evidence that you have:
• interpreted the problem;
• considered a range of alternative solutions;
• thought creatively and laterally about the problem;
• tested and tried possible solutions;
• evaluated the worth of the solutions; and
• decided on the ‘best’ solution in light of the criteria.
What employers, graduates and students say about problem solving skills

Employers’ comments

“We look for a whole range of skills in our graduates. Basically, people who are able to problem solve are important to us. We look for evidence of this in their work experience, their technical performance as well as their academic results.”
(Employer of Griffith Accounting Graduates, 2001)

“Problem solving is a quality that really stood out with the Griffith graduate we have at the moment. If he comes across a barrier he seeks advice, but doesn’t require constant supervision or feedback. He has the initiative to go out and solve problems on his own, which is great.”
(Employer of Griffith Microelectronic Engineering Graduate, 2003)

“We look for a whole range of skills in graduates we select. Academic results are important but they’re not the only thing and not necessarily the first thing we look at. We are interested in people who can think about a diverse range of problems and bring a large amount of information down to important points. So people who are able to problem solve are important to us. We look for evidence of this in their work experience, and technically, as well as their academic results.”
(Employer of Griffith Science Graduates, 2001)

“As an employer, the most important thing I look for in graduates is good problem solving skills. Within the university situation there is a lot of opportunity for problem solving, through exams and assignments but those situations can be fairly contrived. So there also needs to be opportunity for problem solving that is more open and authentic, where the solution is not necessarily clear.”
(Employer of Griffith Microelectronic Engineering Graduates, 2002)
Graduates’ comments
“*I’ve learnt to make decisions about which pieces of information to retain and how to use that information to formulate a good response to a problem, both at university and in my part-time work.*”
(Griffith Graduate, 2002)

“I find myself using information from one context in another, but changing the way I use it. I do that a lot now, which is good because it has improved my problem solving abilities.”
(Griffith Graduate, 2003)

Students’ comments
“I think that my study of literature has helped me become a better problem-solver. For example, sympathetic imagination is a procedure we use to examine situations from different points-of-view, such as the different perspectives each character in a novel might have. It has helped me to develop the ability to examine problems from many perspectives.”
(Griffith Student, 2004)

“Through my study of ethics, I have learned to identify core problems arising from the issues being considered, examine the reasons why the problems exist and then seek ways of responding to, dealing with or solving the problems.”
(Griffith Student, 2004)
Solving problems

- Avoid focusing on solutions prematurely before the problem has been thoroughly identified, defined and discussed;
- Avoid a ‘quick fix’ approach that seeks to eliminate the problem as quickly as possible – it is better to tolerate uncertainty, ambiguity and doubt;
- Maintain an open mind and be willing to consider new ideas;
- Be aware of individual biases when evaluating the facts of a case;
- When working in a group, don’t misinterpret disagreement for dislike – view different opinions as a positive consequence of the group’s diversity.

<table>
<thead>
<tr>
<th>Stages in the problem solving process</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify the problem</td>
<td>Either present a defined problem or ask students to identify their own.</td>
</tr>
<tr>
<td>Define the problem</td>
<td>Represent the problem in your own words defining the key words, terms and concepts. Ask yourselves questions such as:</td>
</tr>
<tr>
<td></td>
<td>• What do I know already about this problem or question?</td>
</tr>
<tr>
<td></td>
<td>• What do I need to know to effectively address this problem or question?</td>
</tr>
<tr>
<td></td>
<td>• What resources can I access to determine a proposed solution or hypothesis?</td>
</tr>
<tr>
<td></td>
<td>In this stage, a very focused problem statement is needed, though that statement will go through a series of changes as new information is accessed and processed.</td>
</tr>
<tr>
<td>Collect, evaluate and organise</td>
<td>Determine what information will be relevant, useful and absolutely essential for solving the problem; retrieve information from print, web and other sources; classify and categorise relevant information.</td>
</tr>
<tr>
<td>information about the problem</td>
<td></td>
</tr>
<tr>
<td>Create or select a strategy to</td>
<td>Collect examples of similar problems and the strategies used to solve them.</td>
</tr>
<tr>
<td>resolve the problem</td>
<td></td>
</tr>
<tr>
<td>Allocate resources to solve the</td>
<td>Develop timelines, action plans, progress reports and role allocations to ensure the problem is satisfactorily resolved.</td>
</tr>
<tr>
<td>problem</td>
<td></td>
</tr>
<tr>
<td>Monitor the problem solving process</td>
<td>Submit regular progress reports or updates to ensure deadlines are met and reflective documents on process issues as part of the assessment.</td>
</tr>
<tr>
<td>Evaluate the final solution</td>
<td>Evaluate your final solution to the problem from multiple perspectives (e.g., an accountant; a manager; a researcher; an end-user; an advertising agent) to test its validity in a range of contexts.</td>
</tr>
</tbody>
</table>
The ‘six hats’ strategy for problem solving

de Bono’s method

de Bono describes the ‘six hats’ as a ‘game’, but despite its simplicity, his method is very powerful and is used extensively in industry and the professions. This is how it works. Each of the six hats has a different colour, with each hat representing a perspective, or way of thinking. The members of the group ‘put on’ different hats in a sequence to encourage them to adopt different perspectives.

<table>
<thead>
<tr>
<th>de Bono’s Six Hats</th>
<th>Hat colour</th>
<th>Explanation</th>
<th>Characteristic statements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>White</strong></td>
<td>White</td>
<td>White is neutral. While wearing the white hat, ignore arguments and proposals. Instead, examine the facts, figures and information. Identify what information is needed and how it might be acquired.</td>
<td>What information do we have here? What information is missing? What information would we like to have? How are we going to get the information?</td>
</tr>
<tr>
<td><strong>Red</strong></td>
<td>Red</td>
<td>Red is for feelings, hunches and intuition. It permits people to put forward their feelings without the need for apology, explanation or justification. Intuition may be a composite judgement based on years of experience, and it can be valuable, even if the reasons behind it cannot be spelled out.</td>
<td>My gut feeling is that it won’t work. I don’t like the way this is being done. My intuition tells me that this process won’t be sustainable.</td>
</tr>
<tr>
<td><strong>Black</strong></td>
<td>Black</td>
<td>The black hat is the logical negative. It is the hat of caution and critical judgement. It is the most used hat, and perhaps the most valuable hat; however, it is very easy to overuse the black hat and stifle creative ideas with early negativity.</td>
<td>The policies will prevent us from doing that. We do not have the resources to do this project. The team doesn’t have the necessary project management experience.</td>
</tr>
<tr>
<td><strong>Yellow</strong></td>
<td>Yellow</td>
<td>The yellow hat is for optimism and the logical positive view of things. It looks for feasibility and how something can be done. It looks for benefits, but they must be logically based.</td>
<td>That might work if we rearranged the timeline. It’s possible the team could take this further in a second project. We have the resources to make this work.</td>
</tr>
<tr>
<td><strong>Green</strong></td>
<td>Green</td>
<td>The green hat is for creative thinking, new ideas and additional alternatives. This is where lateral thinking and other creative techniques are engaged.</td>
<td>We need some new ideas here. Are there any other alternatives? Could we do this in a different way? Could there be another explanation?</td>
</tr>
<tr>
<td><strong>Blue</strong></td>
<td>Blue</td>
<td>The blue hat is the thinking overview, or process control hat. It is generally used by the chairperson of the meeting, as it sets the agenda for thinking, suggests the next step, and asks for summaries, conclusions and decisions.</td>
<td>We have spent far too much time looking for someone to blame. Could we have a summary of your views? I think we should take a look at the priorities.</td>
</tr>
</tbody>
</table>

Questions for monitoring problem solving processes

Although these questions were designed for use by design students, they nevertheless are relevant in a number of different contexts or disciplines.

<table>
<thead>
<tr>
<th>Questions to prompt generative thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure</td>
</tr>
<tr>
<td>Retrieval</td>
</tr>
<tr>
<td>Search</td>
</tr>
<tr>
<td>Association</td>
</tr>
<tr>
<td>Contrast</td>
</tr>
<tr>
<td>Synthesis</td>
</tr>
<tr>
<td>Transformation</td>
</tr>
<tr>
<td>Analogy</td>
</tr>
<tr>
<td>Categorical reduction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questions to prompt explorative thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge application</td>
</tr>
<tr>
<td>Experimentation</td>
</tr>
<tr>
<td>Context shifting</td>
</tr>
<tr>
<td>Attribute finding</td>
</tr>
<tr>
<td>Acknowledging limitations</td>
</tr>
</tbody>
</table>
### Questions to prompt evaluative thinking

<table>
<thead>
<tr>
<th>Analysis</th>
<th>What are the strengths and weaknesses of this solution?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment</td>
<td>Am I ready to make some definite decisions about whether this idea is a good one?</td>
</tr>
<tr>
<td>Verification</td>
<td>What’s good about the things I’ve decided to keep in so far?</td>
</tr>
<tr>
<td>Trialing</td>
<td>If I ’test drive’ this, does it work?</td>
</tr>
<tr>
<td>Criteria fulfillment</td>
<td>Does this solution do (or look like it will eventually do) everything it is supposed to?</td>
</tr>
<tr>
<td>Elimination</td>
<td>Does this idea, or some part of it, need to be taken out because it is just not useful for this particular project?</td>
</tr>
<tr>
<td>Selection</td>
<td>Some ideas or parts of them may have to go, but what is definitely staying?</td>
</tr>
<tr>
<td>Comparison</td>
<td>Why is this outcome better or worse than another one?</td>
</tr>
<tr>
<td>Review</td>
<td>Would doing a ‘stock take’ of where I am now be helpful?</td>
</tr>
</tbody>
</table>

### Questions to prompt strategic thinking

<table>
<thead>
<tr>
<th>Goal setting</th>
<th>When I’m finished, what do I want this outcome to achieve?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching</td>
<td>If what I’m doing at the moment isn’t working or if I’m stuck, or if I simply want some fresh ideas – what else can I do?</td>
</tr>
<tr>
<td>Cognitive awareness</td>
<td>What questions should I ask myself at the moment to help me decide whether or not I’m generally happy with the way things are going?</td>
</tr>
<tr>
<td>Goal monitoring</td>
<td>Is what I’m doing at the moment going to help me achieve the aim of the project?</td>
</tr>
<tr>
<td>Strategy formulation</td>
<td>Is what I’m doing at the moment taking me in the general direction of where I think I want to go, even if I’m not sure about where that is exactly?</td>
</tr>
</tbody>
</table>