Discipline-specific knowledge and capabilities

Communication skills

Digital literacy

Critical thinking

Problem solving

Self-management

Teamwork

Global citizenship

ABSTRACT

Problem solving is one of Deakin University's Graduate Learning Outcomes which states that problem solving is about: 'creating solutions to authentic (real world and ill-defined) problems'. Problem solving skills can also be defined as the journey a student takes when working through details of a certain problem/s in order to reach a solution/s. The following guide provides an overview of how problem-solving skills can be developed in students and assessed.

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WHAT IS PROBLEM SOLVING?

Problem solving skills and outcomes may incorporate a variety of issues that require mathematical, scientific and/or social, cultural solutions. Evidencing problem solving skills can gauge a student's ability to critically think and solve authentic real world problems that are relevant to future working environments. The following information is set out in order to assist Deakin University academics to explore, create and re-imagine teaching and assessing problem solving skills for their students.

WHY IS TEACHING PROBLEM SOLVING IMPORTANT?

Teaching problem solving skills via authentic scenarios sourced from employers and industry are essential in order for students to be exposed to work-based or relevant and complex issues prior to entering a profession. By providing authentic work-related problems for students to solve elicits further potential career development and/or lifelong learning opportunities or, at least, readiness. For example, allowing students the opportunity to become ready for continuing/future employment will require well-developed problem solving techniques. These can include the ability to break down large and complex problems to present potential solutions for positive change. Most pertinent to assuring problem solving skills as a graduate outcome is the introduction of the Collegiate Learning Assessment (CLA) instrument. The CLA instrument is designed to assess higher order thinking. The following quote is from CLA's website:

> The CLA presents realistic problems that require students to analyze complex materials and determine the relevance to the task and credibility. Students' written responses to the tasks are evaluated to assess their abilities to think critically, reason analytically, solve problems and communicate clearly and cogently. Scores are aggregated to the institutional level to provide a signal to the institution about how their students as a whole are performing.
>
> (Retrieved 24 June 2013, **http://www.collegiatelearningassessment.org**)

On the CLA's homepage there are numerous links to additional information about CLA's assessment instruments for problem solving skills. For example, the following webpage: CLA PDF scoring criteria and performance tasks for problem solving is useful for teachers as it provides them with a framework to help implement a 'score criteria and performance task' that is based on marking and critiquing an argument for problem solving. Not only is teaching and assessing problem solving skills essential for evidencing this critical Graduate Learning Outcome, especially in a diverse and changing world, but it is also valuable for academics to understand what constitutes the characteristics of a good problem solver. One reason for this is that when academics are aware of the types of characteristics associated with good problem solving skills then they become confident in understanding what is involved in nurturing and mentoring students effectively throughout their learning journeys as lifelong problem solving learners.

Some examples of the characteristics of a good problem solver are:

- innovative
- creative
- objective
- unbiased
- open minded
- courageous
- risk taker
- reflective
- evaluator
- flexible
- multi-skilled
- versatile
- motivated
- engaged
- embrace
- open to challenge

There are of course many other characteristics that are not listed here, which could also reflect the capacities of a good problem solver. The above list is just an example of the myriad vocabulary associated with effective problem solving. Implementing a similar activity (located or/and in the Cloud) where students (individuals and/or team members) construct their own list that 'they believe' reflects and embodies the characteristics of a good problem solver is a potential interactive 'ice breaker' exercise. This type of introductory exercise into problem solving characteristics can allow students to understand what teachers and employers are looking for when they are assessing and/or recruiting effective problem solvers.

TEACHING PROBLEM SOLVING

Solving problems involves both analytical and creative skills. Fostering skills required for students take control of their learning journey by teaching them problem-solving skills empowers students. It demonstrates that there are choices and there are a range of solutions or options. Effective problem solving skills is about making informed choices in a variety of situations. Not only are problem-solving skills useful in a scholarly context but they can help students understand and develop solutions when coping with many of life's problems or challenges within a varied and problematic environment. Whatever the problem solving situation that may arise for students, they will need to be aware of some fundamental steps in order to solve authentic complex problems in and diverse situations:

Figure 1: An example of common foundational steps in order to problem solve

(Hains-Wesson, R 2013)

The following table is also a framework in order to assist students problem solve effectively The contents in the table can be adapted to aid teachers in implementing a strategy for pre-assessment practices:

Table 1: Possible steps involved when assisting students to problem solve effectively

STEPS	ACTION
Step 1: Planning	Explain and illustrate to students about the importance of 'time' when problem solving. For example, it is essential for students to take time in order to step back and look at the problem. Show students how to: • write down/discuss the problem (individually/groups) and to include all the points of the problem so that students can see the problem more clearly • show students that using creative ways to illustrate/discuss the problem and its points are important. For example the use of mindmaps or an informal discussion group (online/face-to-face) so that they can become familiar with the problem to be solved. Read more: http://www.ehow.com/how_2120954_teach-problem-solving-skills.html#ixzz2OErqZ1jg
Step 2: Pinpoint	It is important for students to understand how to define the problem in their own way. They will also require teachers to show them how to effectively break down the main problem into smaller units or pieces. This process will then help students to time manage/self manage (individuals/groups) regarding the problem that needs to be solved. Illustrating this process by own/student peers or the examples of others is always an effective measure. Read more: http://www.ehow.com/how_2120954_teach-problem-solving-skills.html#ixzz2OEsNzIGC

Step 3: Analyse	Once students have a clearer understanding of each piece of the bigger problem, which is often achieved by using the above steps alongside the use of various examples that illustrate the type of problem solving process required then, it is important for students to take the time to research the 'causes of the problem' individually or in groups. Read more: **http://www.ehow.com/how_2120954_teach-problem-solving-skills.html#ixzz2OEsev9E2**
Step 4: Creativity	A step that is often missed is time for students to begin brainstorming for ideas or solutions to the problem, individually or in groups. It is important that they are encouraged to look at the problem objectively, socially, culturally, theoretically and/or scientifically. This is the section of the problem solving journey where students should explain why some solutions will not work and others might. The journey that led the students to the solution/s can be presented in a variety of ways such as: Mediawikis: • CloudDeakin: https://www.deakin.edu.au/dso/index.php • Conference presentation on wikis: http://dro.deakin.edu.au/view/DU:30005482 • How to implement and use mediawikis: http://www.deakin.edu.au/learning/clouddeakin/clouddeakin-guides/social-tools/mediawiki • admin.phpePortfolios: http://www.deakin.edu.au/teaching-learning/dso/what-is/eportfolio/index.php Other tools that can be use include: spreadsheets, Google docs, images/diagrams, video and/or audio. Read more: http://www.ehow.com/how_2120954_teach-problem-solving-skills.html#ixzz2OEspLNCM
Step 5: Testing	Being able to test the theory that students have come up with is a great opportunity for students to see if the solution will work and/or if it does not then why. It is always imperative to make sure a solution to the problem works before students proceed unless this is part of the assessment due to self-efficacy outcomes. Read more: http://www.ehow.com/how_2120954_teach-problem-solving-skills.html#ixzz2OEszz9ft

The University of South Australia's website located at: http://w3.unisa.edu.au/counsellingservices/balance/problem.asp provides another resource that defines and breaks down the criteria into seven steps.

Equity and diversity

In a changing world, the ability to problem solve effectively is imperative. Additionally, to do this while adapting the knowledge gained to diverse contexts (for instance, taking into account cultural and/or religious contexts) is a highly valuable employability skill. Students who understand the importance of having a willingness to engage in deep personal reflection about inclusivity is fundamental. For instance, the ability to reflect on one's own culture and the aspects of other cultures requires well developed problem solving skills (Hellstén & Prescott 2004). For example, problem solving is often required when students have a curiosity to compare local and international perspectives on discipline matters or collaborate on solutions to problems in teams, which are made up of multi-ethnic and/or multi-religious peers while reflecting on one's own attitudes and beliefs regarding culture and communities in general. Moreover, developing problem solving skills cushioned around intercultural understandings and competence takes time and effort. Thus, care should be taken to interweave appropriate and complex problem solving assessment opportunities throughout the units and/or a course.

However, when teachers are considering planning, developing and implementing problem solving assessment programs that are to incorporate a global view-point and/or equity and/or diversity issues it is important to establish a set of assessment criteria that students have access to and are able to ask questions about prior to the assessment being completed (premium located and/or in the Cloud). The following assessment criteria list illustrates potential problem solving outcomes that centre on a global perspective:

- what was/were the problem solving global perspective analysis undertaken by the student/s?
- what was/were the stances or personal perspectives or reflections on what led to the analysis?
- what was/were the range of resources used in order to draw upon the different cultural perspectives that led towards the solution/s?
- was/were the outcomes superficial and/or at a deep level and how was/is this determined?

Ideally, the most effective way of ensuring that all students feel comfortable and understand how to engage with each individual in the class is to model good inclusive teaching practices (premium located and in the Cloud). This will assist in establishing an appropriate culture for engaging problem solving solutions to manifest (for more details on diversity and equity see the GLO8 resource, and in particular Global citizenship and inclusive teaching practices). Additionally, there are a number of resources in a variety of media to support the implementation of inclusive teaching through Universal design for learning.

ASSESSING PROBLEM SOLVING

It is imperative to teaching how to problem solve effectively and illustrate, by example, the important milestones for students so that they are enabled to progress successfully towards becoming good problem solvers in the classroom and beyond. However, assessing problem solving skills is imperative to ascertain if students have the qualities and capability to problem solve upon graduation. The following web link is to a table that presents problem solving at a course level and has been adapted from the AAC&U VALUE Rubrics http://www.aacu.org/value/rubrics/index_p.cfm?CFID=57925102&CFTOKEN=23955164 and presented on the Assuring Graduate Capabilities website http://boliver.ning.com/page/standards-rubrics-arts-and-education.

Ideally, it is valuable to allow students to contribute to the creation of the assessment rubric used to elicit student 'buy-in' and foster understanding. Alternatively, presenting the rubric that will be used as the marking criteria prior to the assessment to students promotes deep level thinking. It is important to have a discussion to allow for equitable knowledge sharing and understanding to assist students in undertaking the assessment.

An example of a scoring criteria for problem solving is available on CLA's website and can be adapted for the Deakin learning environment. Additionally, there are examples of rubrics on the CLA's website for creative thinking, which is also related to problem solving. The table below illustrates additional areas for assessment practices to help engage students in a problem solving situation.

Table 2: Examples of problem solving assessment practices

TYPE	METHOD
Case studies	A learning platform that can help students relate theory to simulated or real-life practice. This can be presented the learning group as an individual and/or group assessment activity and will require problem solving.
Authentic problems in the classroom (group and individual)	Implementing problem-based learning strategies can assist in assigning projects that require problem solving.
Oral presentations (group and individual)	By introducing debates on contemporary professional issues and dilemmas that demand the construction of arguments and counter-arguments based on different perspectives will also require problem solving skills.
Work-integrated learning (WIL)	The following are examples of WIL that can help stimulate the students' problem solving skills: • assign role-playing (real/virtual) exercises based on typical problems germane to the field of study. • invite external experts and practitioners to discuss their approaches to the solution of particular problems, and relate expert approaches to those of the novice. • use eSimulation programs that develop problem-solving skills.
Work-based Learning	When students are learning through work this can mean that they are in the workplace on internships/placement and/or already work in the professional industry and are in a work-based learning partnership with Deakin. These types of learning experiences allow the opportunity for reflective practice in order for students to actively engage in the process as well as the continual evaluation and development of their problem solving skills in a complex and authentic work environment.

(Deakin University, retrieved 26 June 2013, <http://www.deakin.edu.au/itl/pd/tl-modules/curriculum/grad-attrib/grad-attr-07.php>)

Table 3 provides an example of a rubric that teachers can use for problem solving (either as self and/or peer or faculty assessed). The rubric can also be used as a starting point for students to design their own rubric so that they become a part of the assessment conversation, encouraging intrinsic motivation. As explained earlier, when students are involved in the designing of a rubric then they are more likely to understand what is expected from them. Finally, the rubric can be further developed for self, peer and/or group assessment for problem solving.

Table 3: A rubric for assessing problem solving skills with the number 4 representing the highest score.

TYPE	4	3	2	1
Identify the problem	The team member/s were/was always on task and participated fully in the planning and in the breaking down of the problem to be solved.	The team member/s participated in the planning and breaking down of the problem to be solved and was on.	The team member/s participated in the planning and breaking down of the problem to be solved but wasted.	The team member/s did not participate in the planning and breaking down of the problem to be solved, wasted time, or worked on unrelated problems.
Define the problem	The team member/s defined the problem in an appropriate way and when necessary by helping the group stay on track, encouraging group participation, and having a positive attitude.	The team member/s partly defined the problem in an appropriate way.	The team member/s required a lot of assistance from the group in order to define the problem in a less than appropriate way.	The team member/s did not define the problem and/or in an inappropriate way.
Examines the solution/s	The team member/s always examined the solution/s carefully, considered other solutions.	The team member/s often examined the solution/s carefully and considered sometimes other solutions.	The team member/s rarely examined the solution/s carefully and rarely considered other solutions.	The team member/s never examined the solution/s carefully and never considered other solutions.
Acts on a plan	The team member/s always acted on a plan and was confident when doing so.	The team member/s often acted on a plan and was often confident when doing so.	The team member/s rarely acted on a plan and was rarely confident when doing so.	The team member/s never acted on a plan and never was confident.
Looks at the consequences	The team member/s always looked and considered the consequences.	The team member/s often looked and considered the consequences.	The team member/s rarely looked and considered the consequences.	The team member/s rarely looked and considered the consequences.
Tests the outcomes	The team member/s always tested the outcomes and reflected on the results.	The team member/s often tested the outcomes and reflected on the results.	The team member/s rarely tested the outcomes and reflected on the results.	The team member/s never tested the outcomes and reflected on the results.

Table 4 demonstrates how a student would then complete the proficiency level from the above rubric that describes each group members' participation in the box under the problem solving skill. The higher the number the better the overall result for assessing problem solving skills. Students could include their name in the list.

Table 4: An example of a student grading their peers' problem solving skills

GROUP MEMBER/ STUDENT'S NAME	IDENTIFY THE PROBLEM	DEFINE THE PROBLEM	EXAMINES THE SOLUTION/S	ACTS ON THE PLAN/S	LOOKS AT THE CONSEQUENCES	TESTS THE OUTCOMES	TOTAL
Student A	4	3	3	4	2	1	17
Student B	1	1	3	2	4	1	12

The following table showcases some examples of problem solving tools that teachers can implement in the learning environment to assist students to problem solve effectively as individuals and/or in groups (premium located and/or Cloud).

Table 5: Strategies for problem solving

STRATEGIES FOR PROBLEM SOLVING	EXAMPLES OF TOOLS OF USE
Discussions/unstructured and semi-structured	Smart board/white boards/break out rooms/twitter
Teamwork	Butcher's paper/mindmaps/blogs/media wikis/glogs
Brainstorming sessions	mind maps/diagrams/creativity/free association
Think tanks	Social media/online discussion forums

It is important to note, that no matter how the above information is implemented into the learning environment (premium located and/or Cloud) there is a need to evaluate the time required, work environment, group size, context and scope of the assessment task when teaching and assessing problem solving skills. This will in turn, require teachers to consider in advance how they can best implement teaching and assessment practices in the classroom regarding premium cloud and located learning as well as for students with a disability, international and culturally and socio-economically diverse student cohorts regarding well-developed problem solving outcomes in the learning environment.

An example of an assessment program for a first year undergraduate business student (Economic techniques) for problem solving

Table 6: An assessment example for problem solving

ASSESSMENT TEST	CRITERIA
Mid-term Test	Each student is required to sit a test to be held during the lecture in Week 8. The test will consist of four questions similar to the questions contained in the tutorial exercise sets, covering Topic 1 through Topic 5. The test is worth 30% of the total marks.
Professional skills project	This unit will provide you with the opportunity to develop your problem solving skills in an environment of limited time allowance and competing demands on your attention. An important aspect of your professional development is that you learn to develop your skills independently. Toward this end you are required to read Section 9.1 of the prescribed text (pp. 441–50), and based on this reading, set up and solve Q11 (p. 452). The written solution is to be submitted with your take-home assignment. A tutorial in Week 8 will be dedicated to the problem solving skill employed in this unit. The tutor will present material related the nature of problem solving and how to become a good problem solver. The steps required to structure and solve mathematically structured business problems are identified. This procedure must be followed and the 7 steps are to be documented in completing your Professional skills assignment. That is, students will be assessed both on the correctness of the answer and documentation of the procedure followed. If you do not document the procedure you will lose half of the marks. The project is worth 10% of the total marks. The completed project is to be submitted to the lecturer.
Take-home assignment	The assignment will be posted on the Learning management system. The completed assignment is to be submitted to the lecturer. It should be stapled to, and submitted with your Professional skills project. The assignment is worth 10% of total marks. Assignments will be distributed to students at tutorials after all marking is completed. Please assist distribution by writing your tutor's name and your tutorial time on the cover page of your assignment.
Final Examination	This component represents 50% of total marks. All students must perform satisfactorily in the final exam to pass the unit. The final exam will be held during the examination period.

(Curtin University Business School 2013, retrieved 28 June 2013, <http://business.curtin.edu.au/files/cbsUnitsCourses/Econ_Tech_102.doc>.

The following resource might also be useful as it explains the brainstorming process where problem solving is of a focus: <http://www.businessballs.com/brainstorming.htm>.

CONCLUSION

The development of problem-solving skills is, and should be, constantly challenged in an academic environment. This is important given that Deakin University graduates will be taking up various professional and lifelong learning pathways. Academics have a particular role in fostering these skills. Unpacking the micro skills required to develop problem-solving skills, devising activities as formative tasks, creating rubrics, using these as a basis for deep-level discussion with students are all ways to ensure that students are aware of problem-solving skills and are facilitated in their development of the skill-set required.

FURTHER READINGS & OTHER RESOURCES

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DEVELOPMENT OF THE PROBLEM SOLVING TEACHING RESOURCE

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