First Year Agricultural Science Student Perspectives in Graduate Attribute Development through Problem-Based Learning

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Abstract

Academic staff are required to include graduate attributes like problem-solving in student learning to meet university proclamations. In response to student evaluations that a traditional lecture-based first year agriculture science course was not effective in motivating students, a new course introduced problem-based learning (PBL) primarily to motivate and engage students. This PBL approach aimed to develop discipline knowledge and graduate attributes in a seamless manner to promote deep learning and problem-solving skills. Instead of giving the students a questionnaire with options for students to indicate what graduate attribute they had learned, a structured learning journal was used to question students about their learning without specifically asking about any graduate attributes. Analysis of the learning journals revealed that significant numbers of students perceived that they had learned or practiced a range of graduate attributes, including teamwork, research, personal attributes, writing abilities, time management, problem solving, leadership, and multidisciplinary skills. The students had learned and practiced these graduate attributes while engaging in authentic problem-solving activities as groups in online and face-to-face environments. These student perceptions exceeded the teachers' expectations and revealed that problem-based learning in teams can be used for learning discipline knowledge and developing graduate attributes.

Introduction

Graduate attributes are the generic qualities developed by students while at university and they have been defined as: "the qualities, skills and understandings a university community agrees its students would desirably develop during their time at the institution and, consequently, shape the contribution they are able to make to their profession and as a citizen." (Bowden, Hart, King, Trigwell, & Watts, 2000). This definition indicates the general nature of graduate attributes and that they may be specific to particular university communities which are usually formed around disciplines. Different universities describe their graduate attributes in various ways and they can be difficult to teach and measure because of the range of conceptions expressed by institutions and individuals (Barrie, 2004; 2006). There is also uncertainty as to the attainment of claimed generic attributes of graduates (Barrie, 2005). Despite this general vagueness about the meaning, teaching and acquisition of

graduate attributes, the interim Australian Universities Quality Agency (AUQA) expressed the desirability for monitoring and grading of graduate attributes in higher education (AUQA, 2009).

The interim AUQA has been replaced by the new Tertiary Education Quality and Standards Agency (TEQSA) which audits the Higher Education Standards Framework (HESF) against which Australian universities are now evaluated (HESF 2015). Recently, Learning and Teaching Academic Standard (LTAS) Statements including the national LTAS Science (Jones, Yates and Kelder 2011) and the LTAS Agricultural Science (Botwright Acuña, Kelder, Lane, Hannan, & Jones, 2013; Botwright Acuña, Able, Kelder, Bobbi, Guisard, Bellotti, McDonald, Doyle, Wormell, & Meinke, 2014a) projects have been published and have contributed to the national regulation being developed by the Higher Education Standards Panel (HESP) which sets the HESF. This includes the Agricultural Science Threshold Learning Outcome (TLOs) statements representing the minimum levels of achievement expected of a bachelor level Agricultural Science graduate (Botwright Acuña et al. 2013; 2014a). The Faculty of Agriculture and Environment at the University of Sydney is considering combining generic attributes (The University of Sydney 2016) together with Agricultural Science TLOs in teaching and curriculum development. Many of the key agricultural science TLOs such as inquiry and problem solving, communication and personal and professional responsibility are consistent to the generic attributes approach although the TLOs are standards-based compared with generic attributes which are more aspirational.

To clarify understanding of graduate attributes amongst the academic community, Bennett, Dunne and Carré (1999) and Barrie (2006) have derived models or patterns from studies of academic conceptions. The former authors identified four groups of comprehensive generic attributes (42 individual items) that apply to any discipline: the management of self, others, information and task, and related them to disciplinary content, disciplinary skills, workplace awareness and workplace experience. Their analysis of academic practices gave six patterns of course provision in relation to generic skills, the discipline and the workplace. For example, Pattern 2 is concerned with discipline knowledge and the acquisition of specific generic skills, and Pattern 6 includes an emphasis on 'real-world' experiences in the workplace. From an analysis of interviews with academics, Barrie (2006) concluded that there were four broad graduate attribute conceptions amongst academics that increase in complexity from students having a basic set of abilities to which discipline knowledge is added (level 1) to level 4 where scholarly learning can transform disciplinary knowledge and the individual. These authors illustrate that there is a broad range of academic conceptions and course practices in relation to the development of graduate attributes. Furthermore, the categories given for course provision and academic conceptions allow an appraisal of academic intent in declared course objectives and outcomes.

There are relatively few publications concerned with the student perceptions of graduate attributes and how they believe the attributes have been acquired. Tapper (2004) interviewed agriculture students who perceived that they developed critical thinking in the context of literature reviews but generally did not relate the ability to other circumstances. Oliver, Herrington and McLoughlin (2000) used a survey and interview technique to ascertain from first year students how well they perceived that they had practiced and developed the graduate attributes given by Bennett, Dunne and Carré (1999) in a problem-based online learning environment. The students felt that they had practiced and developed most of the 40 attributes tested. Bath, Smith, Stein, and Swann, (2004) reported on cyclical surveys of students and their teachers regarding perceptions on the development of graduate attributes within a discipline (music) with the intent of maintaining alignment in the curriculum

between what the teachers espoused and what the students perceived that they had learned. These papers illustrate that the graduate attributes can be developed within the learning context rather than being taught separately and that the students may be aware of them and what they are learning. This current paper reports on the student perceptive in developing graduate attributes within the discipline context.

An approach to determine which graduate attributes are relevant in a particular discipline is to ask employers of graduates. A common list of graduate attributes given by employers include: academic achievement in a suitable discipline, literacy, numeracy, comprehension of business processes, and a range of skills including: basic computer skills, interpersonal skills, time management, written business communication, oral communication, team working, and problem solving (AC Nielsen Research Services 2000). There was good agreement between these common skills sought by employers and the qualities that students thought were necessary to be a successful employee in the wine industry (Savocchia, Thompson, Greer, Meunier, Gray, Clark, & Adlong, 2009). In contrast to the expectations of academics, these students also observed that good communication skills included a broad range of interpersonal skills such as listening, conflict management and workplace negotiations.

Singh, Ekanem, Tegegne, Muhammad, and Comer, (2004) surveyed employers (51 firms) for a wide range (40 in total) of skills, knowledge and attributes desired of recent agriculture graduates and found that the top six requirements were: self-motivation; the ability to write clear reports; having strong presentation skills and use of graphics; the ability to speak clearly and concisely; the ability to express technical concepts clearly and in a non-technical manner; and teamwork abilities. The results showed that employers placed a higher value on skills and personal attributes than knowledge and experience.

The development of graduate attributes usually occurs throughout a degree program during various activities that focus on particular attributes such as described by Chapman (2004) for the University of New England (UNE). Examples from this study at UNE include the development of a range of attributes in agriculture in addition to discipline knowledge: communication skills; global perspective; information literacy; lifelong learning; problem solving; social responsibility and teamwork. The generic attributes of the University of Sydney (The University of Sydney, 2016) (where this study was carried out), has identified three overarching graduate attributes: Scholarship, Lifelong Learning and Global Citizenship, and within these is a combination of five overlapping clusters of skills and abilities: research and inquiry, information literacy, personal and intellectual autonomy, ethical, social and professional understanding, and communication. These will be compared to the actual graduate attributes that the students perceived that they had acquired or practiced in this particular study.

Problem-based learning (PBL) has often been advocated as supporting the development of a wide range of graduate attributes as well as discipline learning (Oliver 2000; Oliver & McLoughlin, 2000; Major & Palmer, 2001; Edwards 2005). These authors note that PBL promotes the learning of theory and content as well as generic skills such as problem solving, critical thinking, teamwork, and communication skills. There is a need for integration of learning in a discipline context so that students are more likely to attain the aspirational graduate attributes and their perception of the activity would support that learning. This paper is concerned with the use of problem-based learning to teach discipline material as well as develop graduate attributes and examines the outcomes mainly from the perspective of

students. The student perspective and conceptions of their learning were derived from analysis of their learning journals, and these were compared with the original teacher intent.

Method

Course aims and intended outcomes
The previous course, 'Agricultural Science 1B' was teacher-centred and based on traditional lecturing methods. Student unit of study evaluations indicated that students lacked motivation and learning was not always effective. The unit was fragmented with distinct components (for example, crop physiology, soil science, crop management) that the students did not relate to agricultural practice. A new course in 2008, 'Climate and the Environment' introduced PBL primarily to motivate and engage students to promote deep learning. The course designer and instructor (Daniel Tan) had the twin aims of the students learning discipline material concerned with farming problems in the rural environment and developing contextual student generic skills. The original intention was for the first year students to develop skills in problem identification and teamwork, conduct research using online scientific databases, provide plausible solutions to a complex problem, and write a scientific report with the correct referencing style. These aims correspond to Pattern 2 of Bennett, Dunne and Carré (1999) which is concerned with the development of discipline knowledge and specific generic skills in context. The conceptual approach taken by the teacher also corresponds with Barrie's (2006) Level 4 "enabling conception" where the development of the graduate attributes is seen as interwoven with the disciplinary learning. The generic graduate skills are intended to be transferable to other units of study, the workplace and life generally. Ethics approval for data collection was obtained from the University of Sydney Human Research Ethics Committee (HREC) before the start of the project.

Course structure and learning activities
The 12-week course in 2008 'Climate and the Environment' was a core first year unit for four degrees: Bachelor of Science in Agriculture; Bachelor of Animal and Veterinary Bioscience, Bachelor of Horticultural Science and Bachelor of Land and Water Science. The 113 students in the cohort were allocated to mixed groups (small online groups and larger face-to-face tutorial groups) therefore providing the opportunity for cross-disciplinary and cross-group interchange. The unit allowed the students to discover how climate influences the biophysical and biotic environment and how this affects rural production, native and domestic animals, crops and pastures, native vegetation and pest populations; it also highlighted the importance of physics in solving problems in relation to climate and rural production.

The components of the course and their assessment proportion were: formal examination (50%); laboratory work (15%); workshops (10%); problem-based learning (PBL) project (20%); and reflective journal (5%). The PBL project was intended as the main means of developing and practicing the generic attributes. The PBL project (beginning in week 5 with weekly activities) was concerned with kangaroo and sheep farming and was highly topical with regular media reports during the time the students were engaged with the learning activities (see Table 1). For the PBL project the student activities included the preparation of a consultancy report by conducting research (for example, internet and ISI Web of Science database) on various aspects of the problem and contributing to the online discussion forum and face-to-face class discussions. A submitted draft consultancy report from each student received feedback from course tutors prior to a final submission at the end of the semester. The PBL activities were conducted as group activities (in teams of 8-10 students per group) and the consultancy reports were submitted as individual assessments. The reflective learning

journal, which was explicitly linked to the PBL task, was also submitted near the end of the course. Students were also given feedback on their reflective learning journal.

Table 1. Problem-based learning activities and assessment points.

Tasks	Assessment Point
1. Read initial scenario, http://www.kangaroo-industry.asn.au/media/Bulletin_24401.html, think about the problem and share finding using the online Discussion Board on Blackboard about it.	Week 5 – Post 1
2. Conduct research (on internet and ISI Web of Science) on the climate, topography, soils, native vegetation and fauna of the Mundi Mundi Plains area and contribute to discussion on Blackboard and in class.	Week 6 – Post 2
3. Conduct research (on internet and ISI Web of Science, Econlit) on production (e.g. carrying capacity), financial (e.g. gross margins and cost/returns) and marketing (price and markets) aspects for sheep and kangaroo. Contribute to discussion on Blackboard and in class.	Week 7 – Post 3
4. Conduct research (on internet and ISI Web of Science) on the response to climate change policy (e.g. carbon emissions trading) and animal welfare ethical issues with sheep and kangaroo farming. Contribute to discussion on Blackboard and in class.	Week 8 – Post 4
5. Submit printed draft consultancy report for marking. This draft report to be submitted by each student as an individual assessment with a 2000-word limit and referenced according to the Harvard System. The report requires each student to define a unique problem identified from the scenario and justify why the student has identified this as the problem. The student has to recommend management strategies to address this problem.	Week 9 – Submit draft report
6. Submit Reflective Journal	Week 10 – Submit Reflective Journal
7. Receive feedback from demonstrators on draft report on Week 11	
8. Submit final report incorporating comments from demonstrators together with draft report.	Week 12 – Submit final report on Blackboard Dropbox

Assessment of discipline and generic attribute learning
The discipline assessment criteria on the final individual report were within the context of the problem based learning and required a description and discussion of the various components (physical, environmental, biological, economic, production, and ethics) as well as the definition and justification of the problem and management recommendations to address the problem. Marks were distributed between the components and problem issues.

An analysis of the learning journals allowed the assessment of generic attribute learning from the perspective of the students. The learning journals were structured with the following 10 questions.

1. How do you feel about working with your team?
2. Are your team discussions useful to your team's progress in this exercise? Why or why not?
3. Were there some comments made by your team members that made you think differently? What were they, and how did they make you modify your thinking?
4. What motivates you to learn through this exercise?
5. How have you changed as a learner through this exercise? Give examples.
6. Have you learned anything about "how you learn"?
7. What obstacles did you face in completing this exercise, and how did you overcome them?
8. What are some of the strengths you have demonstrated in this exercise?
9. Are you satisfied with what and how you learned through this exercise?
10. Do you think your learning through this exercise helps you in your field of study?

Comments made by students regarding graduate attributes were unsolicited as none of the learning journal questions specifically asked about them. This approach to identifying student perceptions of learned or practiced graduate attributes is markedly different to students completing a questionnaire that lists the graduate attributes and allowing the students to select from given choices, such as administered by Oliver et al. (2000). Moreover, the graduate attributes were not the governing criteria used to analyse the text of the learning journals. The text responses to the questions were qualitatively analysed manually by a three-stage approach. The first stage involved reading of the responses to enable categories of responses to be created (categories such as: multiple perspectives, research, social responsibility). As practiced in a variety of qualitative research methods, a thematic analysis was undertaken so that the categories could be created from the text responses themselves rather than imposing a set of pre-ordained categories. The second stage was to find typical expressions (quotes) from the respondents that would illustrate and confirm the categories. The third stage was to identify graduate attributes of any kind as expressed by the students within the original categories identified, and these are reported here with quotes as examples. This approach allowed the student perception of graduate attributes learned or practiced to be identified independently from the teaching intent.

Results
The results presented here are entirely from the perspective of the students as given in their learning journals. The teacher's intent is noted above, and the outcomes are a product of the authentic PBL challenge and circumstances that allowed student autonomy within the group-learning environment.

Student perceptions of graduate attributes learned and practiced
The graduate attributes that the students revealed in their journals (104 in total) were:
- Teamwork skills
- Research skills
- Writing abilities
- Personal attributes
- Personal development

- Time management
- Problem solving
- Leadership
- Multidisciplinary skills

The development of *teamwork skills* and learning through different perspectives of team members (for example, noted by 33% of respondents to question 2) is the most commonly mentioned of the graduate attributes, for example:

> "By working in a team I feel that I had gained a broad view of the issue at hand, by being presented with information and suggestions from different people with different perspectives, ideas and knowledge…Together Everyone Achieves More."

> "…working in groups allows for an easier way of gathering opinions and being able to understand various aspects of one idea… I probably wouldn't have been able to think up some of the ideas that other people thought of and it really helped to expand my thought process and apply concepts to real-world circumstances."

> "I feel that working in a team is an essential part in life and that it is a skill that needs to be learnt… I also felt that I learnt a lot more than I would have on my own due to the contributions of the other team members…. It gave me a chance to learn to accept people's ideas even if I didn't totally agree as everyone has a different opinion."

Not all students like teamwork and some do not have positive expectations, yet a good experience can change that opinion, for example:

> "The greatest obstacle in completing this exercise was getting over the stigma that group work is unhelpful and time wasting… In the end, it was my own team members that helped me leap over this obstacle with significant ease. I feel very fortunate to be placed in such a good group."

Students commented that the quality of learning and the development of other skills were improved as a result of teamwork, for example:

> "It allowed for a greater understanding of the presented problem and through teamwork I have managed to write a much better report than I would have if I had been working on my own."

> "Working with a team was great it really assisted me with my assignment because it gave me other perspectives, opinions and ideas about the topic… and also made me research things more thoroughly."

> "At some times in life we have to work in teams and the team discussion board will and has helped me and others to practice these skills. I think that teamwork develops the qualities of helping others, being patient and open minded to other opinions. These qualities are key attributes that employers search for when interviewing potential employees."

> "The contribution of various ideas from team members was also of great assistance in gaining a broader outlook on the issue…As I mentioned I usually prefer to tackle assignments individually. Yet this co-operative approach was an enriching new learning experience."

> "I thoroughly enjoyed the team work involved in this exercise and the discussions it created. I found these discussions to be a very positive and constructive way to improve my research skills."

Research skills were practiced constantly and mentioned by almost every student (96% of students used the word 'research' at least once) in a variety of contexts, and particularly in the recognition of developing arguments supported by research, for example:

> "Also, specific research undertaken by different people could be referred to and then further researched to gain a full understanding of different areas involved."

> "All the members that contributed to the discussion had valid points of view which were mostly backed up by journal articles."

> "Collaborating ideas and research with one another allowed me to get a deeper understanding of the topics in order to discuss them in my paper...I feel that I contributed very significant research to our discussions."

> "It was hard at times, as some comments on the discussion [board] contradicted others and this required extensive research over many sources in order to be sure you had the correct information."

> "If you don't agree with something someone wrote, you find that you would like to back up your opinion and argument with some level of fact, so that also stimulates extra research."

> "It is also motivating in the sense that if you have an idea, have it backed up by research and are sure about its relevance, you are able to defend it against another idea held by someone else in your team."

> ""Also, I find that, 'one thing leads on to another' and as I started researching, more ideas came to me and this propelled me to research more, to find articles that back up what the first article said, and so on."

Writing ability was perceived as an important attribute (e.g., mentioned by 27% of people in response to question 8), particularly in a professional context, for example:

> "I also think that it is important to learn how to write sophisticated consultancy reports as it is likely that we will have to write lots of them when we enter the workforce."

> "My writing skills on the discussion board are one of my strengths. I am able to express myself through writing and lay down evidential fact with some ideas of further research areas."

> "By constructing discussions I was able to strengthen my writing skills and write a coherent report dense with information and minimal wording."

> "I have become more successful in writing and expressing my beliefs while being able to support these beliefs with objective evidence."

> "The writing style and structure of my report illustrates the thought process of my research and is very persuasive of the problem I presented and my suggested strategies for improvement."

Through the group work, several students expressed the development of a range of *personal attributes* including better listening, collaboration and communication skills, for example:

> "By working with a team, one of the major changes I have made as a learner is being able to open myself up to new and differing opinions rather than simply focusing on my first reaction to the issue."

> "My tacit knowledge has broadened giving me vital skills in communication and working with other people."

> "My collaboration skills have improved as I have become more likely to take people's ideas and opinions into consideration."

> "I have learnt to work as a team… I have also become more able to listen to other people's opinions and respect them, whether I agree or I disagree with them."

> "The one thing that this exercise really helped me overcome is listening to other people's ideas. I always had trouble listening, but this has in a way forced me to overcome that problem and changed my learning."

> "I changed from being just a listener to being both a talker and a listener. This change has helped me learn through this exercise as I was not as timid as I usually am and was able to voice my opinion and receive feedback."

In addition to personal attributes, the students also included wider aspects of *personal development*, such as being more open-minded, the ability to change personal beliefs and attitudes, and acknowledging different points of view that may also be evidence-based, for example:

> "This was seen with my initial view of being against kangaroo farming with no actual knowledge of the problem just my personal feelings. Then after collecting all the evidence and becoming informed on the problem I was able to understand that kangaroo farming is a viable and feasible option to solve the problem."

> "I learnt to consider all team members' viewpoints and although some did not correspond to what I believed in, I could see that these were just as important to include in my report."

> "Before beginning this PBL I was a very close minded learner and I valued my own opinion more than that of others….I think I am now more open to the opinions of others as I have seen that they can actually broaden your own understanding."

> "This exercise has made me capable of taking other people's view points into consideration and researching their issues further in order to see if it is useful for me."

> "I am now a lot more open minded about issues and try to observe things from different points of view. This enables relationships between different areas to form and increases the understanding of the area of interest."

> "As a learner I have also changed in my attitude towards working in peer-groups, for example it has taught me that interaction with other people could help the learning process."

The management of self is one of the key groups of generic attributes given by Bennett, Dunne and Carré (1999) and that includes effective management of limited time available. The problems of time and time management were often mentioned by the students (for example, 21% of respondents to question 7) and some students gave strategies for managing their time in their individual circumstances, for example:

> "As mentioned earlier, another obstacle I faced common to all assignments I complete was that of ineffective time management skills. This was overcome by writing each section of the report as the topic of discussion for each week was undertaken by my group."

> "The main obstacle that I faced when completing this task was the one of time management… To overcome this problem I worked out a plan that I could follow and set aside particular times in which I would complete the work."

> "My greatest obstacle to the whole exercise was time management…I had to create a timetable for myself, giving myself goals and deadlines …Creating this timetable … allowed me to put the same amount of effort into each task, and work to the best of my ability on each so that nothing fell behind or became a last minute rush job."

A part of problem solving with an authentic complex problem is the identification of the problem that is to be solved (Boud & Feletti, 1997; Savery & Duffy, 2001) and several students made the observation that this was not an easy task in relation to sheep and kangaroo farming, for example:

"The main obstacle I had to face was identifying the problem within the issue and solving only that problem."

"In this particular exercise I found it difficult to define the problem that was at hand. There were so many angles that this report could have taken and it was difficult to determine which was the most important one to me."

"Largely the obstacles faced in this exercise were the initial vagueness surrounding the problem definition and sourcing of the information. These were both overcome through group work…"

However, many students (for example, 29% in response to question 10) mentioned that they had developed or practiced valuable problem solving skills and several noted that this required the combination of a range of skills, including teamwork, research, communication, and a multi-disciplinary approach, for example:

"This exercise demonstrated to me that working as a team is an extremely efficient way of managing and solving a problem."

"Exercises such as this demonstrate the need for teamwork in identifying and solving problems I may face in my field of study. They also demonstrate that initial problems are not always as they first appear, further research and study may need to be undertaken to find the real problem."

"The learning I undertook in this exercise definitely will help me in my future field of study, as it expanded on my research, communication, problem solving and consultancy report writing skills."

"I feel that it gives students an idea of the problems they will face in the future as well as give confidence in deciphering problems in the context of science, agriculture as well as contemporary Australia."

"Geographical and geological, legal, technical, economic and business issues were identified and addressed, which [were] researched and integrated into the solution to the problem."

"…and all the different aspects (such as; climate, weather topography, soils, climate change, economy, market) that need to be researched and understood before you are able to go into pin pointing the problem and addressing it with management strategies."

While teamwork was widely acknowledged as a skill practiced during the problem solving abilities, a few (6% of responses to question 8) students indicated exercising *leadership* skills. This seems a realistic self-appraisal since by definition relatively few people would actually be leaders. Example quotes are as follows.

"Some of the strengths I demonstrated in this exercise I think include the way I was able to provide a good sounding board for the ideas of my group members in our group discussions and help them develop their own ideas better."

"Brainstorm and leadership. As an university student, everyone has certain capability to solve the problem by independent research, learning from media and find the answer, but sharing the idea and leading the team to success is quite different from learning"

"Another strength I was able to demonstrate was being able to demonstrate my communication skills and discuss my ideas with fellow students, providing my opinions and helping them to understand the issue more clearly as well."

Some students (20% of responses to question 10, for example) observed that they were practicing and developing interdisciplinary approaches, or utilising the perspective from many disciplines to problem solving, for example:

"This research task incorporated many different ideas that span across my course of study, including animal management, environmental factors and precautions such as greenhouse effect and land degradation from natural and unnatural factors and their implications on the future for farmers and Australia's landscape."

"This assignment covered a broad range of issues to do with the sustainable management of our fragile environment and limited natural resources. This included considering past and present land uses, the biodiversity of ecosystems as well as taking into account social, political and economic issues alike."

"Geographical and geological, legal, technical, economic and business issues were identified and addressed, which was researched and integrated into the solution to the problem."

"I've learnt to consider many holistic approaches to an issue in an animal industry by considering the factors such as conservation, community impacts (in this case the rural communities), welfare of the animal, economics, environmental sustainability, wildlife management, related diseases and the animals natural biology (especially the reproduction cycle)."

"I touched upon medicine, geology, economics and marketing. All of these subjects I have studied to a limited degree but have not until this point had the opportunity to draw it all together."

Discussion and conclusions

From an analysis of structured learning journals that did not question students specifically about graduate attributes, it was clear that first year students perceived that they learned or practiced a range of graduate attributes (including teamwork, research, personal attributes (including personal development), writing abilities, time management, problem solving, leadership, and multidisciplinary skills) while engaging in authentic problem-solving activities as groups in online and face-to-face environments. These are in broad agreement with the University of Sydney clusters of generic attributes (The University of Sydney 2016). Assessment of the individual student reports (separate from the learning journals) showed that students had achieved the main skills of being able to define a problem and make recommendations to address the problem. The assessment (consultancy reports and reflective learning journal) demonstrated a bimodal curve with the majority of students who engaged in the PBL process having a deep understanding and receiving excellent grades, and the minority who did not engage with the process having failed. This was similar to another PBL study in first year undergraduate sports therapy in the UK (Wright, Duncan, & Savin-Baden, 2015).

During the problem-solving group work, students felt that they had improved their personal abilities, such as collaboration, overcoming shyness, listening and communication skills. Development of these personal attributes was facilitated by the contextual disciplinary problem-solving environment and not by the presence of a teacher. Contextualising the content is critical in the PBL process so that the students gain specific application knowledge about the concepts in their discipline as well general conceptual knowledge (Hung 2015). In addition, students also commented on their personal development such as being more open-minded and changing personal beliefs. These personal qualities contribute to the behaviour of professionals in the discipline.

Many students observed that problem solving is a skill that requires effective use of other skills such as teamwork, research and communication. That students linked problem solving with the social context reflects a realistic approach because as practicing scientists we

frequently use our peers to assist with problem clarification and solution strategies. It can be a problem in teaching to encourage students to see the connection between disciplines and to relate their current learning with past or even present studies of different topics. However during this problem-based learning project many students made these connections for themselves during their teamwork and research activities.

The student responses in their learning journal demonstrated that the students had more than exceeded the basic expectations of problem identification, problem solving, teamwork, research and report writing. The students perceived that they had developed collaborative teamwork skills and advanced research skills similar to another study with first year Agricultural Economics students (Koppi, Nolan, & Field, 2010). Agricultural industry representatives considered highly developed problem solving and communication skills that can generate innovation in agriculture of greater importance than vocational knowledge (Botwright Acuña, Kelder, Able, Guisard, Bellotti, McDonald, Doyle, Wormell, & Meinke, 2014b). These findings were a pleasant surprise and have incited a re-thinking of the general approach to teaching. Analysis of the learning journals has demonstrated that first year agricultural science students are more than capable of critically reflecting on their own learning.

Acknowledgement

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