Decision Support Tools (DST) for Multi-Disciplinary Applications in Higher Education - Pedagogical Aspects

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1 Introduction

A Decision Support Tool (DST), sometimes referred to as Decision Support Systems (DSS) are a class of information system (including but not limited to computerised systems) that support business and organisational decision-making. DST's are often based on interactive software intended to help decision makers compile useful information from a combination of raw data, documents, personal knowledge and simulation models that help identify and solve problems and make decisions. When purposely integrated into curriculum they can provide invaluable real-world experiences for graduates of a range of disciplines and desirable graduate attributes for their future employers. In many ways DST's are a critical component of Work Integrated Learning (WIL) by providing an authentic learning experience that is consistent with a range of recent reports and investigations that have been conducted within the Australian sector over the past few years. These include:

- BIHECC report on employability skills (Cleary, Flynn et al. 2007);
- Review of Australian Higher Education Discussion Paper (Bradley, Noonan et al. 2008);
- Universities Australia National Internship Scheme (Universities Australia 2008);
- CIRM Report (Scoullar and CIRM Working Group 2008);
- Australian Learning and Teaching Council project, The National Association of Graduate Careers Advisory Services (NAGCAS 2009); and
- Australian Learning and Teaching Council project The WIL (Work Integrated Learning) (Patrick, Peach et al. 2008).

Linking DST's to WIL is important in this position paper and has consistency with the literature and the sector more broadly as shown above. The definition that we take here draws upon the Australian Learning and Teaching Council project The WIL (Work Integrated Learning) report: A national scoping study, where that project team settled on:

> *work integrated learning' (WIL) as an umbrella term for a range of approaches and strategies that integrate theory with the practice of work within a purposefully designed curriculum (Patrick, Peach et al. 2008: 21).*

The introduction of DST's and other technologies, including the Internet and its applications, into university teaching and learning, here called *learning technologies*, have changed the way universities deliver education (Snyder, Marginson et al. 2007). The role that learning technologies play in learning activities today has dramatically increased within higher education (HE), "from tutorial allocations to multimedia lecture presentations, to online resources and communication with students", and the list goes on (Dearn, Fraser et al. 2002: 6). Consequently, in many cases they seem to have also impacted other aspects of university context such as teaching workload, assessment, course design and so forth (Tynan and Smyth 2007; Santiago and Carvalho 2008). Together with this, learning technologies have also affected the way students acquire new knowledge (Laurillard 2006). In today's knowledge society students have increasing access to a whole range of information and a variety of further educational options (Bowden and Marton 2003). Many believe that the successful adoption of learning technologies needs to be supported by appropriate institutional and public policies, together with innovative management and pedagogical strategies (Laurillard 2002; Laurillard 2006). For DST's this is particularly relevant and in fact, research shows that the successful implementation of learning technologies in higher and distance education "occurs when educational and organisational objectives are in harmony" (Snyder, Marginson et al. 2007: 187). Equally important, and the heart of the discussion in this paper, has been the institutional concern with the quality of education offered, how it has impacted on graduate attributes and what relevance it holds for disciplinary applications within various employment sectors where DST's are used .

There are currently a wide range of learning technologies available to assist teaching and learning in HE across different subjects. However, technologies such as production system models, simulation software, decision support tools

(DST) and databases tend to be adopted more frequently by professional and industry sectors for staff training and development. Even though they seem to be less commonly integrated into HE curriculums, applications that provide students with real-world industry experience are being increasingly introduced to some universities' courses, particularly in the past decade (Turban, Aronson et al. 2005). It appears that with the push from various sectors, not least employers, that the integration of DST's within a WIL pedagogy is both valid and essential for preparing work-ready graduates.

This paper begins with a brief review of the body of literature regarding some of the most commonly adopted learning theories and approaches to learning within a HE context. In addition, the paper outlines the current extent of the application of DST across the Australian higher education sector with a particular focus on the agriculture and environment sectors. This paper also explores some of the benefits of DST and its potential to enhance curriculum and consequently, students' graduate outcomes. Together with this, the challenges that may constrain some academics from fully embracing and adopting DST's within their programs are also discussed here. Finally, the paper presents some learning outcomes from a DST based course and the additional skills that students can develop and take into employment.

2 Learning Theories

The ways we learn, acquire, transfer and develop knowledge has challenged and interested philosophers, intellectuals and educators for centuries. In order to make sense of how people learn and the learning process itself, several theories were researched and developed and continue being developed as our understanding of how we learn evolves (Pritchard 2005). Similarly, there might be as many definitions of the learning process as there are theories of learning. Despite the differences amongst the learning theories they do tend to have similarities in their definitions (Driscoll 2000). Driscoll (2000: 3) defines learning as "a persisting change in performance potential that results from experience and interaction with the world". For many, learning is a process of

experiencing and understanding the world around us, which might be influenced by previous experiences, the environment we live in, our values and views (Biggs 2003; Bowden and Marton 2003; Ramsden 2003). Amongst the learning theories developed, behaviourism, cognitivism, and constructivism are the most common ones applied in contemporary educational contexts (Driscoll 2000; Pritchard 2005). They represent three different philosophical frameworks, which have individually evolved and originated from other theories. In this work, however, we are going to focus our discussions mostly on the three main learning theories: behaviourism, cognitivism and constructivism.

2.1 Behaviourism

Behaviourism is the learning theory based on the observations of peoples' responses to a particular stimulus. "Learning is defined simply as the acquisition of new behaviour" (Pritchard 2005: 6) through conditioning. There are two types of possible conditioning; classical conditioning and operant conditioning. The former takes place when a person (or even an animal) is trained to respond and behave in certain ways due to repetition and reinforcement (Driscoll 2000; Pritchard 2005). The later "involves reinforcing a behaviour by rewarding it" (Pritchard 2005: 9). In addition, it could be also applied in the opposite way, to discourage certain behaviours through punishment of some kind; failure to reward when expected can be a punishment (Driscoll 2000; Pritchard 2005). Within this framework, behaviourists are particularly interested in measurable changes in behaviour. Learning theories that have emerged from this model are connectivism, objectivism, applied behaviour analysis, curriculum based measurement and direct instruction.

2.2 Cognitivism

The cognitivism theory of learning was developed in an attempt to fill the gaps and answer the questions that behaviourism was unable to answer; mostly considering aspects of mental process and understanding the learning process (Pritchard 2005). Thus, the cognitive information-processing model of learning is based on how the brain processes, transforms and retains knowledge. For cognitivists our memory system functions as an active organised processor of information when learning occurs. Here, learning involves the cognitive

processing of instructional inputs, and the frequency with which students process inputs, thus influenceing the pace of learning. In addition, this model assumes that learners differ in their preferred learning styles, and the individuals' prior knowledge is a determinant of the effectiveness with which the student processes new information (Leidner and Jarvenpaa 1995; Driscoll 2000). Furthermore, learning is the processing and transfer of new knowledge from sensory memory through to short-term memory into long-term memory (Driscoll 2000). While cognitivism is focused on individual learner's knowledge processing, behaviourism concentrates on the environment in which learning occurs (Pritchard 2005). Theories derived from cognitivism theory are brain research and cognitive load and information processing theory. These theories of learning are very useful as they guide instructional design.

2.3 Constructivism

Different from the above, constructivism rejects that there is an objective reality that can be transmitted by an expert to a learner, and suggests that knowledge is created, or constructed, by each learner individually, based on their experiences and biases. Learners then create their own abstract representation of reality (Driscoll 2000). Constructivism assumes that individuals learn better when they discover things themselves, rather than when they are told, and that "learners are not empty vessels waiting to be filled, but rather active organisms seeking meaning" (Driscoll 2000: 376). Additionally, in constructivism 'learning focuses on discovering conceptual relationships, exploring multiple representations or perspectives on an issue, and/or immersing the learner in the real-world context in which the learning is relevant' (Leidner and Jarvenpaa 1995: 268). In other words, peoples' knowledge and reality evolve as they construct and re-construct knowledge and make sense of the world they live in through their experiences and the experiences of others (Driscoll 2000; Guba and Lincoln 2005) Constructivism is most advantageous in "higher-order learning", where there may be greater understanding achieved when an individual is forced to discover knowledge, rather than being told (Leidner and Jarvenpaa 1995:268). Considered one of the most contemporary learning theories (Fry, Ketteridge et al. 2003), constructivism theory and its variations have been extensively applied

within the higher education context and can be found in the work and research of many (Biggs 2003; Bowden and Marton 2003; Fry, Ketteridge et al. 2003; Ramsden 2003). Variations of constructivism theory include self-directed or active learning, transformational learning, experiential learning, situated cognition, reflective learning, discovery learning, knowledge building and collaborative model of learning, amongst others.

Other learning theories have also been developed for more specific purposes than general learning theories. For example, adult learning theory or andragogy, which investigates and assists the learning of adults, although sceptics have questioned whether adult learning is really different to the learning of others and claim that there is a lack of empirical evidence to support its claims (Fry, Ketteridge et al. 2003). Multimedia learning theory is another novelty and it focuses on the process and methods for the effective use of multimedia in learning (Clark and Mayer 2008).

3 Approaches to Learning

After examining some of the most common learning theories available in the literature, some would even say that the above theories were the foundation of many others after them (Driscoll 2000; Pritchard 2005), we are going to outline some of the approaches to facilitate learning. Once again, the body of knowledge regarding approaches to learning within a higher education context is large and increasing rapidly as our understanding of the learning process evolves. However, the most adopted approaches are summarised and discussed here. Approaches to learning may vary according to learner and/or teacher preferences and characteristics, as well as a response to solve a particular or a series of situations (Biggs 2003; Bowden and Marton 2003; Ramsden 2003).

3.1 Surface Learning

In an educational context, students and/or teachers tend to adopt surface approaches to learning when there is a need to recall facts, words of a specific text or formulas of certain problems (Biggs 2003; Bowden and Marton 2003;

Ramsden 2003). Students "want to be able to answer the questions they are anticipating" (Bowden and Marton 2003: 8). Additionally, for Biggs (2003:14) surface learning might take place when "rote learning selected content instead of understanding it, padding an essay, listing points instead of addressing an argument" and so forth (Biggs 2003: 14). However, memorisation is wrongly related to surface learning because it sometimes can lead to deep learning, some believe (Biggs 2003; Ramsden 2003). It is interesting to notice that while most experts strongly argue that surface learning is inadequate and fails to provide students with opportunities for better and deeper understanding of the object being learned, as well as make the learning discoveries enjoyable and exciting (Biggs 2003; Bowden and Marton 2003; Ramsden 2003), it could be useful and adopted in certain situations (Ramsden 2003).

Above, we described approaches to learning as being a preference of both students and/or teachers. In some cases, it could be an imposition by the teacher when exploring a determinate situation, while also consciously or even unconsciously adopted by the student. Biggs (2003) outlines some factors that might contribute to the adoption of a surface approach to learning. For him, students tend to use surface learning when there is:

> *an intension only to achieve a minimal pass; non-academic priorities exceeding academic ones; insufficient time; too high a workload; misunderstanding requirements, such as thinking that factual recall is adequate; a cynical view of education; high anxiety; and a genuine inability to understand particular content at a deep level (Biggs 2003: 15).*

As for teachers, they normally teach and assess student learning based on parts of a fragmented content rather than to provide deeper understanding of the subject being studied as a whole. In addition, "providing insufficient time to engage the task; emphasising coverage at the expense of depth, and creating undue anxiety or low expectations of success" are also ways that teacher can encourage a surface learning approach (Biggs 2003: 15-16).

Once again, student's and teacher's perspectives and experiences of the surface approach to learning should not be dealt with separately, as one might encourage the other (Biggs 2003).

3.2 Deep Learning

While surface learning is related to students trying to concentrate only on remembering the text, facts, numbers, formulas and so on, deep learning is about trying to understand the meaning and the message behind the content to be learned as a whole. It is believed that when encouraged to experience deep learning, students have more chances to recall previous experiences and link them with future ones (Biggs 2003; Bowden and Marton 2003; Ramsden 2003). Similar to the surface approach to learning, students and teachers play important roles for a successful implementation of deep learning. Students normally approach their learning task with a desire to do well through understanding the meaning behind the subject being learned. In addition, in deep learning students tend to already have some background of the knowledge being addressed, which contributes to further and more solid knowledge building. Consequently, students have "the ability to focus at a high conceptual level, working from first principles, which in turn require a well-structured knowledge base" (Biggs 2003: 16-17). Moreover, students need also to have "a genuine preference, and ability for working conceptually rather than with unrelated detail" (Biggs 2003: 16-17).

As for teachers, they should clarify misunderstandings of learning approaches and assist students to achieve the desired learning outcomes through deep learning. In doing so, teachers teach to build on students' previous knowledge;

> *to explicitly bring out the structure of the topic or subject; to elicit an active response from students; to assess for structure rather than independent facts; to encourage a positive working atmosphere; and emphasizing depth of learning rather than breadth of coverage (Biggs 2003: 17)*.

3.3 Problem Based Learning (PBL)

With a focus on student-centred learning and active learning, problem-based learning (PBL) is seen as one of the constructivists methods of instruction (Driscoll 2000; Tan 2007) and therefore an approach to learning (Pepper 2008). It was first adopted in the areas of health and medicine and its effectiveness and relevance has contributed to its rapid proliferation across several discipline areas within higher education such as business, economics, engineering, agriculture, education and science (Pepper 2008). In addition, the use of PBL in HE courses is favoured by some professional bodies because of its ability to align and enhance university learning strategies, curriculum, assessment and so forth with real life professional situations, thus, providing students with generic employability skills (Driscoll 2000; Savin-Baden 2003; Jarvis 2006; Pepper 2008).

In order to enable effective learning, PBL lecturers are the facilitators of learning rather than simply the transmitters of content. The transition from teaching to facilitating can be very challenging for some academic staff and also students, mostly due to previously established traditional teaching and learning values and understandings of the role of teachers and students (Savin-Baden 2003). Usually, PBL classes have smaller numbers of students (8 to 10 students) than traditional classrooms. Students are encouraged to learn collaboratively, which seems to offer them more opportunities and higher chances to reach a deep understanding, instead of merely surface learning (Jarvis 2006; Pepper 2008). Briefly, the common principles underlying PBL are:

- Problems and scenarios of professional real world situations are chosen by the curriculum designers and presented to students by their instructor "in the same way it would be presented in reality" (Jarvis 2006: 153) ;

- Students then research and search for resources and potential alternatives to solve the problems, and

- With the assistance of their instructor, students assess their learning experiences and "the adequacy of the solutions", as well as "their reasoning, their strategies for resource gathering [and] their group skills" (Driscoll 2000: 393 - 394).

However, there is ongoing debate over whether PBL alone is an appropriate approach to learning. Research and student feedback on PBL reported that PBL students appear to explore more intensively their library resources and interact more often with librarians than traditional students, tend to acquire and improve their researching skills and enjoy their learning experience (Jarvis 2006; Pepper 2008). On the other hand, because students are, most of the time, in control of their learning, sceptics argue that if not applied properly, some important aspects of a discipline might not be fully covered in PBL classes. In addition, in a small classroom, students' learning can be affected negatively if they do not relate well with each other. On the contrary, a close relationship with PBL tutors and instructors might impact on unit and course evaluations or even on student assessment (Jarvis 2006).

4. Web mediated learning and DST integration

Web-mediated learning has become the norm within the higher education sector. No University within Australia, by way of example, is without a Learning Management System. Nor is there a line drawn between what makes a greater learning experience than another when using technology to mediate the experience. Online learning, e-learning, virtual learning, distance education, ubiquitous learning and blended learning are a range of some of the terms that are commonly interchanged as higher education institutions develop and facilitate learning experiences for students who are living in an increasingly wired-world. Students have moved across the divide while their lecturers struggle with previous generations of Web applications (Barnes and Tynan 2007).

Few would dispute that the last decade has seen unprecedented innovation in the area of Web-based learning and teaching in higher education but the

adoption remains well behind the affordances of the technology. Kirkup and Kirkwood have observed that:

> *teaching staff appropriate those technologies which they can incorporate into their teaching activity most easily, that offer affordances for what they already do, rather than those which radically change teaching and learning practices (2005: 188).*

As Barnes and Tynan (2007) also observed that part of the reason for this conservatism is the extent to which teaching modes in higher education are shaped by convention. University teachers have "traditionally progressed from the experience of learning in the classroom to teaching in the classroom" (Jamieson 2004: 22). Few of the current generation of teaching staff have been online learners. With some exceptions, teaching staff and the latest cohort of undergraduates live in different technological worlds.

4.1 Graduate and employer expectations

Web-mediated learning and the integration of software into the workplace have been all pervasive. Increasingly companies require their employees to use sophisticated software to undertake their role and engage in professional development that is delivered at the desktop. Computers, computing, the Internet and the increasing role of ubiquitous learning and ubiquitous computing have meant most workplaces are sophisticated in their development and use of technologies. Industry has an impact on the curriculum and those higher education institutions that fail to respond may well find themselves with irrelevant courses that do not meet the needs of industry. The focus on WIL as noted in these reports only serve to reinforce the requirement for authentic learning experiences:

- BIHECC report on employability skills (Cleary, Flynn et al. 2007);
- Review of Australian Higher Education Discussion Paper (Bradley, Noonan et al. 2008);

- Universities Australia National Internship Scheme (Universities Australia 2008);
- CIRM Report (Scoullar and CIRM Working Group 2008);
- Australian Learning and Teaching Council project, The National Association of Graduate Careers Advisory Services (NAGCAS 2009); and
- Australian Learning and Teaching Council project The WIL (Work Integrated Learning) (Patrick, Peach et al. 2008).

DST's provide an opportunity to provide and create authentic web-mediated learning experiences that are relevant to the workplace and which allow students to participate in problem solving. The failure of learning institutions to include such learning experiences where appropriate may well be to their detriment in course enrollments as students and employers will seek those courses that prepare them for the work environment. However, web mediated learning experiences require careful consideration on a number of levels. One issue of particular concern, and the focus of this paper, is the pedagogical intent. This is not to prioritise pedagogy over other issues such as technological infrastructure, support issues, equity, business models and access nor lack of staff expertise.

5 Decision Support Tools (Systems)(DST - DSS)

5.1 Defining DST's

DST stands for a Decision Support Tool, sometimes referred to as Decision Support Systems (DSS). DST's are a class of information system (including but not limited to computerised systems) that support business and organisational decision-making. DST's are often based on interactive software intended to help decision makers compile useful information from a combination of raw data, documents, personal knowledge and simulation models that help identify and solve problems and make decisions. DST's are often used in the agricultural industry to provide guidance on such things as animal nutrition and production, pasture and crop management, as well as product marketing. They are also increasingly used in environmental management, medicine, health and business.

DST also refers to an academic field of research that involves designing and studying DST's in their context of use (Turban, Aronson et al. 2005). Six more specific DST types include:

- Communication-driven DST,
- Data-driven DST,
- Document-driven DST,
- Knowledge driven DST,
- Model-driven DST, and more recently
- Web-based DST (Marakas 2003; Turban, Aronson et al. 2005).

In addition to the above types of Decision Support Tools there are also two separate categories used to define the systems. One of the categories is *enterprise-wide DST's,* which are systems that are linked into large data warehouses, and offer decision support to managers at all levels of an enterprise. Enterprise-wide systems will typically be basic general use systems that can perform a wide variety of functions. Desktop DST's form the second category. They are typically much smaller applications designed to be run from a desktop PC. While these systems may well be linked into a data warehouse or other large volume of data, they will usually be more limited in scope (Marakas 2003).

As already mentioned, DST's are used to assist decision-makers in comparing, predicting, projecting and analysing situations before making decisions. They can be used in medicine, for instance, to assist medical diagnosis through clinical decision making (Riggio, Sorokin et al. 2009). In business, DST's can predict the sales numbers of a particular period of the year based on statistical measurements of previous annual sales of the same period (Tal 2007). In addition, in environmental management, more specifically forest management, DST's can assist forest managers to address more precisely issues related to transportation, harvest scheduling to sustainability and ecosystem protection (Kaloudis, Lorentzos et al. 2005).

With such a wide range of applications in industry, DST's have been increasingly adopted in the development and training of university students in an attempt to better prepare them for real-world professional tasks. The adoption of DST's in higher education is further discussed next.

5.2 DST's in higher education?

It has been said by many that the adoption of technologies in our daily lives, work and learning has increased as technologies evolve and become cheaper and more accessible (Laurillard 2002; Laurillard 2006). Mostly in education, in this case in higher education specifically, the adoption of technologies, here called learning technologies, has changed the way teaching and learning is approached today. Additionally, higher education itself has shifted from the place where content is taught to a learning place where students and teachers learn together, build competences and capacities in order to successfully engage our ever-changing knowledge society (Bowden and Marton 2003; Ramsden 2003). Today, one of the biggest challenges of higher education is to develop individuals who are able to think critically, competently and at a higher-level (Laurillard 2002; Bowden and Marton 2003).

The above scenario seems to be most appropriate for the implementation of DST's. In fact, research already shows that the introduction of DST's in a wide range of subject areas at university level has the potential to engage students in constructivist and active learning, encourage problem solving and also facilitate the building of knowledge based on prior learning (Scott 2002). As discussed previously, many also argue that DST's can intermediate and pace the application of a PBL approach to learning across different subject areas and curriculum due to the similarities and links DSTs and PBL share (see item 3.3) (Scott 2002; Tal 2007).

Amongst other subject areas, DST's are increasingly applied in agriculture, business and health (Nguyen, Wegener et al. 2006; Tal 2007). In agriculture, DST's have the ability to provide students and teachers with "an almost infinite

range of management choices to explore", which appear to be based on published scientific knowledge (Scott 2002: 21). GrassGro and GrazFeed were two of the pioneering DST's applied in agriculture degrees. However, they were primarily developed for use in the agricultural industry (Scott 2002). As for business courses, students can experience risk-free decision-making, learn how to identify negative trends and allocated business resources with the assistance of DST's. In addition, they can provide students with the skills to develop their own DST's suited specifically to a future employer's activities (Tal 2007).

Tatnall & Burgess (2007) also detail use of DST's in the course *Small Business Internet and Information Systems*. Their work is intended as a "light treatment" of concepts behind decision support systems with the intention of introducing business students to their use. They also outline some of the hurdles that universities may encounter regarding the cost effective implementation of DST's and the overall utility of DST's when used by people with little or no computer experience. Over a number of years Tatnall and Burgess (2007: 1) found that "the proprietary nature and the cost of commercial DSS make their use in teaching less than ideal. Our solution was to produce our own simple systems using Excel, Visual Basic and Visual Basic for Applications, and this has proved to be quite successful".

In health, DST's are known as Clinical Decision Support Systems (CDSSs) and form a significant part of the field of clinical knowledge management technologies. In the training and development of medical students, CDSSs have the potential to simulate real life problems where students are required to find appropriate solutions by exploring the wide range of clinical processes and knowledge available in the systems; from diagnosis and investigation through to treatment and long-term care (Riggio, Sorokin et al. 2009). Currently, there is a whole range of DST related tools and packages available for a variety of areas. Some of these tools are commercially available not only for industry, but can be also applied to education, while others are specially designed for learning with important features that simulate real-world and industrial situations (Marakas 2003; Turban, Aronson et al. 2005).

Another key example funded by JISC under the ELearning Stream is SIMulated Professional Learning Environment [SIMPLE] (Hughes, Gould et al. 2008). SIMPLE began at the Glasgow Graduate School of Law in 2000. Under the JISC banner Ardcalloch: The Transactional Learning Environment (TLE) was expanded and evaluated thoroughly for its simulation application and platform. SIMPLE was implemented across a number of disciplines within the University of Strathclyde and three law schools throughout the UK. The SIMPLE project in general terms aimed:

> *to prove that simulations can effectively enhance learning across a range of disciplines, professions and institutions. It also set out to investigate the drivers and blockers to large-scale implementation of innovative technologies such as simulation within HE and FE (Hughes, Gould et al. 2008: 7).*

The project concluded that:

> *... simulation is a powerful heuristic, capable of enhancing student learning and supporting transformative shifts in education. To implement it, staff need to be committed to changing some of their fundamental practices. They need design support, in order to create effective simulations, and this includes integration of outcomes and methodologies of teaching and learning. They also need practice in designing innovative forms of learning, in building resources for simulation and in rethinking feedback and assessment practices. Management at departmental, faculty and probably institutional level need to give thought to different employment practices within cadres of staff in order to support such forms of learning, resource-building and assessment. In addition simulation practice can facilitate forms of collaborative activity between institutions and disciplines, and internationally (Hughes, Gould et al. 2008: 8).*

The application of DST's in university teaching and learning seems to be very advantageous not only for students, but also for teachers and employers. For teachers, DSTs enable the link between theory and practice. Thus, classes could be more engaging if students can make sense of what they are learning and apply the concepts in real life situations. Also, DST's appear also to increase motivation and students' interest in learning (Scott 2002). Furthermore, they assist teachers to effectively and innovatively teach their units as students can see the relevance of individual units, which are normally taught in isolation, in relation to the big picture (the whole course). This is because some DST's enable the development of "inter-related modules", which can incorporate elements of several units, even from other years (Scott 2002: 21). The advantages of the use of DST's for students seem to be even greater. Firstly, students have the opportunity to engage in highly relevant risk-free real-life simulations of situations in the workplace. This can provide future graduates with experiences and skills to continue engaging in problem-solving and active-learning after they leave university. This will certainly put them in a much better position in relation to others who do not have previous experience with DST's, particularly when searching for jobs (Tal 2007). Secondly, DST's have the potential to explore most of the learning theories and approaches to learning covered in this paper. This shows that DST's are versatile tools and can assist teachers to reach a wide variety of learners across the university. Therefore, one can say that, if adopted appropriately, DST's can also contribute to enhance student learning and performance (Scott 2002; Tal 2007).

Unfortunately, one cannot assume that DST's alone are the solution to all of the issues faced by many universities, teachers and students currently. At an institutional level, DSTs can be very costly. Expenses might include costs with acquisition of software licenses and required hardware, training technicians and academics, and not to mention the costs of maintaining the whole infrastructure and ensuring that it functions effectively (Tal 2007). As for academics, a successful adoption of DSTs will require some academics to have a better and deeper understanding of learning theories and approaches, including PBL. In addition, academics will also need to know how to efficiently integrate DSTs into

the curriculum design. Consequently, the introduction of DSTs into university teaching can be time consuming and increase their workload, considering that most academics have already a very busy professional schedule (Tynan and Smyth 2007; Santiago and Carvalho 2008). Furthermore, the impact of DSTs on students' learning and later on their professional performance still appear unclear and under researched. Sadly, one cannot claim yet that DSTs are being fully and successfully implemented in higher education (Turban, Aronson et al. 2005; Riggio, Sorokin et al. 2009).

5.3 eDST project: audit of applications in use in Australian Higher Education

The Australian Learning and Teaching Council (ALTC) funded research project under the title of '**eDST: Decision Support Tools for Multi-Disciplinary Applications in Higher Education',** was designed to look at issues related to the sharing of DST among Australian tertiary education institutions for use in teaching. The project grew out of the recognition among some Agriculture/Environment academic teachers that the use of these types of software within a single institution was economically unsustainable. The project has implemented a survey of DST users in academia to explore some of the issues raised in this and the accompanying technological position papers prepared for the project. More will be reported about this survey as the project unfolds.

6 Conclusion

Decision Support Tool's based on interactive software help decision makers compile useful information from a combination of raw data, documents, personal knowledge and simulation models that help identify and solve problems and make decisions. As stated in the introduction to this review they can provide invaluable real-world experiences for graduates of a range of disciplines and desirable graduate attributes for their future employers. DSTs are a critical component of Work Integrated Learning (WIL) by providing an authentic learning experience that is consistent with a range of recent reports and investigations that have been conducted within the Australian sector over the past few years. They have the potential to create work ready graduates when

combined within a WIL approach that draws upon the requirements of a range of industries. While there are concerns and issues to investigate DSTs provide a level of relevance within courses that students and employers will find attractive within a world which is increasingly reliant on technology to assist in its decision making processes. Deep learning will occur with the use of DSTs through problem oriented curriculum design that engages the student in constructing ideas facilitated by their teacher. There is no doubt that involving industry will pave the way for more sophisticated developments in DSTs themselves but also in how they are used and develop within the curriculum of graduates.

7 Annotated Bibliography

Barnes, C. and B. Tynan (2007). "The adventures of Miranda in the Brave New World: Learning in a Web 2.0 millennium." Learning Technologies Journal **15**(3): 189-200.

This paper looks at the implications of Web 2.0 technologies for university teaching and learning. The latest wave of social technologies offer the higher education sector the chance to create a new generation of student-centred learning environments, to realise the idea of a University 2.0. The following discussion draws upon a fictional character in order to capture the possible futures of such a brave new world.

Biggs, J. (2003). Teaching for quality learning at university: What the student does. Buckingham, The Society for Research into Higher Education (SRHE) and Open University Press.

This book discusses issues and challenges still relevant for contemporary higher education and academic teaching and learning. It provides useful guidelines for university teachers interested in enhancing their teaching and their students' learning, and for administrator and teaching developers who are involved in teaching-related decisions on an institutional basis.

Bowden, J. and F. Marton (2003). The university of learning: Beyond quality and competence. New York, RoutledgeFalmer.

This book explores in depth many relevant issues of contemporary higher education, including teaching, learning, research, capacity building, assessment, quality assurance and curriculum development. This is an essential reading to all those concerned to see learning developed and improved, including university teachers, researchers, administrators, policy-makers and students alike.

Bradley, D., P. Noonan, et al. (2008). "Review of Australian Higher Education discussion paper." Retrieved 25/07/2008, from http://www.dest.gov.au/NR/rdonlyres/06C65431-8791-4816-ACB9-6F1FF9CA3042/22465/08_222_Review_AusHEd_Internals_100pp_FINAL_WEB.pdf.

The issues outlined in this paper have been informed by the preliminary input we received and we would like to thank those respondents for their contribution. The paper has been structured around nine key challenges and issues for higher education in Australia over the coming decades.

Clark, R. C. and R. E. Mayer (2008). E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning. San Francisco, Pfeiffer.

The overarching theme of this book is that effective use of a new instructional technology must be guided by a research-based theory of how students learn. Fortunately, advances in cognitive psychology provide the starting point for such theories. The book also explores the important avenues of cognitive psychology and its potential to contribute to the understanding of how technology such as multimedia can be used to foster student learning. In this book, the authors provide a research-based review of five principles of multimedia design.

Cleary, M., R. Flynn, et al. (2007). Graduate employability skills: Prepared for the business, industry and higher education Collaboration Council. Canberra, Department of Education, Science and Training (DEST).

This project was initiated by the Business, Industry and Higher Education Collaboration Council (BIHECC) to review: how universities currently develop and integrate employability skills into their programs of study; how universities teach employability skills; how universities currently assess students' employability skills; how graduate employability skills might be assessed and reported upon. The project, undertaken between March and June 2007, has consulted a range of stakeholders including representatives of universities, business and industry to review current activities and to identify best practice for integrating, developing, assessing and reporting on employability skills nationally and internationally. Consultations with these stakeholders have focused on graduates from degree programs across all disciplines of undergraduate higher education.

Dearn, J., K. Fraser, et al. (2002). Investigation into the professional development for university teaching in Australia: A discussion paper. Canberra, Commonwealth of Australia - Department of Education Science and Training**:** 1-72.

This document reports on an investigation into: 1. the current central provision of activities related to professional development for the teaching role of academics in Australian universities; and 2. the attitude of key university stakeholders towards the professionalisation of the teaching role of academics. A survey of 32 universities shows that the provision of both preparation programs and ongoing support for academic staff for their teaching role is uneven and unsystematic. Almost one-quarter of universities do not conduct any initial teaching preparation programs for their staff. Qualitative and quantitative data were collected through interviews and surveys. This report also provides more findings and recommendation on current teaching development in Australia higher education.

Driscoll, M. P. (2000). Psychology of learning for instruction. Boston, Allyn and Bacon.

This book provides a historical evolution of the learning theories, together with a detailed discussion of the work of major learning theorists and their theories such as behaviourism, cognitivism and constructivism. It also includes research findings, suggested reading and reflective questions and activities

Fry, H., S. Ketteridge, et al. (2003). Understanding student learning. A handbook for teaching and learning in higher education: Enhancing academic practice. H. Fry, S. Ketteridge and S. Marshall. London, RoutledgeFalmer.

This book chapter examines the importance of teaching, how teaching assists students' learning and how teaching can foster students' understanding of their own learning. The chapter also explores different models of learning that teachers need to be aware of, which can ultimate impact on how students' learning.

Guba, E. G. and Y. S. Lincoln (2005). Paradigmatic controversies, contradictions, and emerging confluences. The Sage Handbook of Qualitative Research. N. K. Denzin and Y. S. Lincoln. London, Sage Publications**:** 191-215.

This book chapter builds on the authors' previous work and discusses the three methodological approaches and all three present fundamental questions that must be addressed. Can research be conducted between paradigms? Are they equally useful in answering questions of applied research? What constitutes good or ethical research in each? These and other significant questions are examined here.

Hughes, M., H. Gould, et al. (2008). SIMulated Professional Learning Environment (SIMPLE), The Higher Education Academy, JISC and University of Strathclyde**:** 93.

Simulation environments can be agents of substantial change and powerful learning environments across a wide range of HE undergraduate and postgraduate courses. They are potentially disruptive heuristics and staff need supportive environments in which to share good practice and experiment. Students need to be aware of the expectations made of them in these new environments. Collaboration between staff, institutions and students is essential to the growth of simulation activities (p.7).

Jamieson, P. (2004). "The university as workplace: Preparing lecturers to teach in online environment." Quarterly Review of Distance Education **5**(1): 21-27.

This article describes an attempt at Australia's largest university to provide academics with direct experience of learning in a formal online learning environment in order to better prepare them to teach in similar environments.

Jarvis, P. (2006). The theory and practice of teaching. New York, Routledge.

This book is a comprehensive introduction for educators wanting to understand the techniques, contemporary theories and methods of teaching - from facilitating problem-based learning to the role of the lecture. It explores the issues that underpin interpersonal methods of teaching, and offers genuine insights through a broad and multi-disciplinary perspective on these methods. It will help teachers at all levels to understand the techniques that they can call upon at different times and situations, and will help to develop more effective teaching practice. This fully updated second edition contains new material on e-moderating (teaching online) and its implications for teaching theory, issues surrounding disciplinary and teaching and also the ethical dimensions of teaching. The Theory and Practice of Teaching will be of interest to anyone wanting to develop a deep understanding of the key themes and latest developments in teaching, and is an ideal companion volume to The Theory and Practice of Learning.

Kaloudis, S. T., N. A. Lorentzos, et al. (2005). "A decision support system for forest fire management." Operational Research - An International Journal **5**(1): 141-152.

This paper proposes a Decision Support System capable to support policy makers and services to counteract wildfires destruction danger in lowland Pine forests. The system is composed of two major components: (a) A Wildfire Destruction Danger Index and (b) a Forest Management Planning Decision Support System. The open architecture of the system allows incorporation of data coming from external sources e.g. satellite systems, meteorological stations etc. All its subsystems can stand alone so as to satisfy the needs of responsible organisations (peripheral institutions of fire brigade, forest inspection and local authorities).

Kirkup, G. and A. Kirkwood (2005). "Information and communications technologies (ICT) in higher education teaching — a tale of gradualism rather than revolution." Learning Media and Technology **30**(2): 185–199.

This paper draws on a series of large-scale surveys carried out over a 10 year period with distance education tutors at the UK Open University to explore the changing role of ICT in the work of teachers. It investigates how HE teachers in one large distance learning university have, over time, appropriated ICT applications as

teaching tools, and the gradual rather than revolutionary changes that have resulted.

Laurillard, D. (2002). Rethinking university teaching. London and New York, Routledge Falmer.

This book explores the potential of technological media to improve student learning and teaching efficiency, aiming to increase teachers' understanding of what can be done with the new media, and how to do it. Building towards a practical methodology for the design, development and implementation of educational technologies, the book is in three parts. Part one explores students' learning, and what it is that they need from educational technology; Part two looks at individual methods and media; and part three discusses the design methodology, designing learning activites, setting up the learning context, and maintaining quality.

Laurillard, D. (2006). E-learning in higher education. Changing higher education: The development of learning and teaching P. Ashwin. New York, Routledge**:** 71 - 84.

This chapter examines the nature of change in higher education with respect to the introduction and growth of e-learning. While the ostensible aim is to use elearning to improve the quality of the learning experience for students, the drivers of change are numerous, and learning quality ranks poorly in relation to most of them.

Leidner, D. E. and S. L. Jarvenpaa (1995). "The Use of Information Technology to Enhance Management School Education: A Theoretical View." MIS Quarterly **19**(3): 265-291.

This paper reviews different models of learning, surfaces assumptions of electronic teaching technology, and relates those assumptions to the differing models of learning. Our analysis suggests that initial attempts to bring information technology to management education follow a classic story of automating rather than transforming. IT is primarily used to automate the information delivery function in classrooms. In the absence of fundamental changes to the teaching and learning process, such classrooms may do little but speed up ineffective processes and methods of teaching. Our mapping of technologies to learning models identifies sets of technologies in which management schools should invest in order to inform up and down and ultimately transform the educational environment and processes. For researchers interested in the use of information technology to improve learning processes, the paper provides a theoretical foundation for future work.

Marakas, G. M. (2003). Decision support systems in the 21st century. Upper Saddle River, Prentice Hall.

This book provides the concepts and applications of the decision support system (DSS), including type of decisions, type of decision makers, modelling decisions, decisions within organisations, rule based expert systems, and simulation as a DSS application. The book also explores practical issues in DSS such as using integer and linear programming as applications of modelling and solving choices and uncertainties of real world decision problems.

NAGCAS (2009). "The Australian Voice for Career Development in Higher Education.". Retrieved 15/01/2010, from http://www.nagcas.org.au/index.php.

The National Association of Graduate Careers Advisory Services (NAGCAS) is the professional association for staff working in university career services. Whether your work involves careers advice and counselling, careers education and planning,

graduate employment assistance or recruitment this is your association, addressing your interests and meeting your needs.

Nguyen, N., M. Wegener, et al. (2006). DSS in Australian agriculture. International Association of Agricultural Economists Conference, Gold Coast.

This paper was prepared by and presented to the International Association of Agricultural Economists. The paper concerns many of the spheres of interest of the eDST research project, particularly regarding the past viability of DSTs in agriculture and whether there is a future for decision support systems given the generational shift in recent years. Doctors Nguyen, Wegener and Russell are involved with the University of Queensland, Gatton Campus.

Patrick, C.-j., D. Peach, et al. (2008, December 2008). "The WIL [Work Integrated Learning] report: A national scoping study." Australian Learning and Teaching Council (ALTC) Final report. from www.altc.edu.au and www.acen.edu.au.

This report provides an account of the first large-scale scoping study of work integrated learning (WIL) in contemporary Australian higher education. The explicit aim of the project was to identify issues and map a broad and growing picture of WIL across Australia and to identify ways of improving the student learning experience in relation to WIL. The project was undertaken in response to high levels of interest in WIL, which is seen by universities both as a valid pedagogy and as a means to respond to demands by employers for work-ready graduates, and demands by students for employable knowledge and skills. The study identifies a broad range of stakeholders involved in providing or benefiting from WIL experiences, including students, university academic and professional staff, employers, professional associations, and government. The stakeholders consulted reported the need for collaborative and inclusive sector-wide engagement in initiatives that can support and sustain a broad range of WIL experiences, whether those experiences have a long WIL history or are more recent WIL initiatives.

Pepper, C. (2008). "Implementing problem based learning in a science faculty." Issues in Educational Research **18**(1): 60-72.

Problem based learning is a successful teaching and learning strategy used to engage students in deep rather than surface learning and where the learning is student focused rather than teacher focused. The strategy is also successful in aligning university courses with the real-life professional work which students are expected to undertake on graduation. At this university, plans to introduce PBL into a number of units taught in the Science Faculty were initiated in 2006, to improve student engagement and enrich the student learning experience at the first year level. This paper reports on the implementation of PBL into a core first year unit in 2007. Data for the research were gathered through student surveys and semi-structured interviews. While the implementation is perceived as a successful strategy, to achieve both aims there are still challenges, linked to group processes, to overcome.

Pritchard, A. (2005). Ways of learning: Learning theories and learning styles in the classroom. London, David Fulton.

This book provides a brief introduction to the major theories of learning and learning styles in relation to teaching. It covers the areas of behaviourism, multiple intelligence, constructivism and metacoginition, as well as assists readers in how to embed the learning theories explored into teaching.

Ramsden, P. (2003). Learning to teach in higher education. New York, RoutledgeFalmer.

This books combines practical advice with sound theory to provide an introduction to the practice of university teaching. It can be found here information regarding many aspects of teaching and learning such as approaches to learning, the nature of teaching in higher education, design and evaluation.

Riggio, J. M., R. Sorokin, et al. (2009). "Effectiveness of a clinical decision support system in improving compliance with cardiac-care quality measures and supporting resident training." Academic Medicine **84**(12): 1719-1726.

Many of the quality measures for patients with heart failure (HF) or acute myocardial infarction (AMI) require the completion of comprehensive discharge instructions, including instructions about medications to be taken after discharge. To improve compliance in a tertiary care teaching hospital with these evidence-based quality measures, a clinical-decision-support system (CDSS) that uses an electronic checklist was developed. The CDSS prompts clinicians at every training level to consistently create comprehensive discharge instructions addressing quality measures. The authors compared compliance during the 15-month pre-intervention and post-intervention periods. Implementation of a CDSS with computerised electronic prompts improved compliance with selected cardiac-care quality measures. The design of quality-improvement decision-support tools should incorporate educational missions in their message and design.

Santiago, R. and T. Carvalho (2008). "Academics in a new work environment: The impact of new public management on work conditions." Higher Education Quarterly **62**(3): 204 - 223.

This study examines the impact of New Public Management on the working conditions of Portuguese higher education academics. The empirical data are based on official statistics, and the analysis leads to the following conclusions. Changes have been slow, but already reveal a corrosion of traditional employment practices. Employment has become more precarious as professionals are increasingly employed on non-tenured contracts.This tendency is more evident in the polytechnic sector. In short, this means that the growth in skilled employment in higher education in Portugal is based on precarious employment relations.

Savin-Baden, M. (2003). Facilitating problem-based learning: Illuminating perspectives. Philadelphia, SRHE and Open University Press.

This book explores a broad range of issues about facilitation, in particular understanding of facilitation that have emerged from the author's recent research and ways of equipping and supporting staff in different contexts. It also questions how students are assessed. It examines what it might mean to be an effective facilitator and suggests ways of designing problem-based curricula that enhance learning.

Scott, J. (2002). Enhancing student learning using Decision Support Tools across the curriculum. CAL-laborate: A collaborative publication on the use of Information Technology in tertiary teaching and learning for the life sciences. A. Fernandez, T. Walker and S. Sorensen. Sydney, UniServe Science**:** 20-23.

This paper reports on a sophisticated commercially available computer Decision Support Tool, GrassGro, which has been integrated into the curriculum to enhance teaching and learning at the The University of New England (UNE). This computer program permitted the simulation of the climate-soil-pasture-animal-economic

interactions within grazed ecosystems over long time frames in Australia. This innovation was developed under a national CUTSD-funded (Committee for University Teaching and Staff Development) project called the GrassGro Teaching Project (1999-2001).

Scoullar, R. and CIRM Working Group (2008). "Guidelines for good practice in work integrated learning for the integrated resource sciences." Retrieved 28/07/2008, from http://www.cirm.org.au/pdf/CIRM_Improving_employability.pdf.

This study examines the strengths and challenges of establishing successful work placements/internships, and assesses the support for implementing effective models with key stakeholders. This report outlines the study's scope and key findings – including a description of a contemporary model for work placement and internship programs for integrated resource science courses – and makes recommendations for a role for CIRM. A key fi nding of this study is that solutions to the dual problems of graduate employability skills and recruitment can be found through greater involvement of employers and students throughout the education process.

Snyder, I., S. Marginson, et al. (2007). "An alignment of the planets: Mapping the intersections between pedagogy, technology and management in Australian universities." Journal of Higher Education Policy and Management **29**(2): 187 - 202.

The research interrogates the connections between information and communication technologies' (ICTs') use and change processes in Australian higher education. The empirical investigation focuses simultaneously on three domains of practice: the educational, the technological and the organisational, with a particular interest in their overlaps and intersections. The main findings of the study were that the most effective use of ICTs in universities occurs when educational and organisational objectives are in harmony.

Tal, B.-Z. (2007). "Using Business Games in Teaching DSS." Journal of Information Systems Education **18**(1): 113.

In this study a business game is used as a vehicle for implementing decision support systems (DSS). Eighteen companies, consisting of ninety graduating M.B.A. students, participating in a business game were required to develop DSS and to report on the systems developed. Each of the eighteen companies developed a system of their own choosing, without external guidance. Individual questionnaires were later used to evaluate a number of relevant variables: use of systems, contribution of systems, association with systems and user satisfaction. Findings, compared with reported results of previous empirical study, exhibit differentiation in success of DSS between companies. This indicates the potential of using business games as an educational tool for teaching management information systems (MIS) and DSS.

Tan, O.-S. (2007). "Problem-based learning pedagogies : psychological processes and enhancement of intelligence." Educational Research for Policy and Practice **6**(2): 101-114.

This paper addresses the state-of-the-art of PBL along three themes. The first is the psychology of cognition, metacognition, and self-regulation in problem-based pedagogies. The second is the idea of making thinking and mind visible through dialogue and inquiry. The third theme is the use of learning environments beyond the boundaries of the classroom to enhance problem-based thinking. Finally, the implications for educational innovation and practices are discussed.

Tatnall, A. and S. Burgess (2007). "Experiences in building and using decision support systems in postgraduate university courses." Interdisciplinary Journal of Information, Knowledge, and Management **2**.

In this paper we will relate some of our experiences in building and using simple Decision Support Systems (DSS) for use in two postgraduate subjects at Victoria University in Melbourne. These subjects are not about Decision Support Systems, but are Information Systems (IS) subjects that introduce, amongst other things, concepts of decision support and DSS. It has been our experience that the complexity, an inability to examine the logic behind decisions that have been recommended, the proprietary nature and the cost of commercial DSS make their use in teaching less than ideal. Our solution was to produce our own simple systems using Excel, Visual Basic and Visual Basic for Applications, and this has proved to be quite successful. The paper reports on building and using Decision Support Systems in this way.

Turban, E., J. E. Aronson, et al. (2005). Decision support systems and intelligent systems. Upper Saddle River, New Jersey, Pearson/Prentice Hall.

This book explores in detail aspects related to decision making and how advanced systems can support it. In addition, the books highlights the development of decision support systems, mainly enterprise decision support systems and how they can assist collaboration, communication and knowledge management. Finally, the book discusses the fundamentals of intelligent systems, including knowledge acquisition and validation, knowledge representation, inference techniques and intelligent systems development.

Tynan, B. and R. Smyth (2007). Evaluating the work of academic developers: A case study from the University of New England. 30th HERDSA Annual Conference - Enhancing Higher Education, Theory and Scholarship [CD-ROM], Adelaide, Higher Education Research and Development Society of Australasia,.

This paper explores issues about defining of the work of academic developers. It arose from discussions between the authors at the University of New England and colleagues elsewhere who were struggling to find suitable performance measures for their work. The diversity of roles and activities required of academic developers in the various contexts of their work is a critical factor making the job of definition more difficult. Therefore, the intent of the paper is to site the issues in current theory and to propose an instrument to our colleagues, who we encourage to use it and provide us with feedback.

Universities Australia (2008). A national internship scheme: Enhancing the skills and work-readiness of Australian university graduates. Position Paper No. 3/08. Canberra, Universities Australia.

This report reflects widespread consultation with the university sector, business, industry, professions, community groups and other interested bodies. It will be used to promote support for this proposal as a partnership model with government and industry. It also complements the Treasury's priorities for improving the economy through the three Ps: Population; Participation; and Productivity. Each is enhanced by the proposals in this paper, as are further national objectives of social inclusion and international integration.