

Establishing a project-based learning environment for first-year engineering students

Dr. Brad Stappenbelt

University of Western Australia

brad.stappenbelt@uwa.edu.au

Abstract. A project-based learning environment was recently established for first-year engineering students at the University of Western Australia. At the focus of this educational approach was a real international development project run within the core undergraduate unit Introduction to Professional Engineering. Students embarking on the professional development component of the engineering degree were traditionally taught about the role of the engineer, social and cultural engineering considerations, the multi-disciplinary nature of large engineering projects and team working and communication skills with minimal involvement in project and group work. The various concepts covered were treated primarily on an abstract theoretical level. Despite the lecturing involvement of a number of prominent practicing engineers, students were generally left with little sense of the relevance or importance of the material to their professional careers. Prior to the introduction of project-based learning, student engagement and their perception of the educational experience in the foundation unit for their professional development were very poor. The adoption of a project-based learning approach for the first-year engineering curriculum is particularly well suited to engineering education since a large proportion of professional engineering work is conducted through projects. Engineering students are also predominantly active learners and are therefore well suited, as a group, to experiential rather than passive and reflective style learning environments. Throughout the establishment and maintenance of the project-based learning environment for the large student group ($n \approx 650$) enrolled in first-year engineering, a number of logistical challenges were encountered. These include the essential requirement to commence with a suitably designed project, the education of the teaching staff in the learning approach, sequencing of the release of information to students through workshops, demonstrations, lectures and tutorial activities, controlling student access to resources and laboratories and the use of self-paced online supplemental material. The project-based learning approach adopted resulted in numerous benefits from both an educational and institutional perspective. Amongst the educational improvements observed were enhanced student engagement and perception of the learning experience, greater depth of learning, student networks and relationship development and improved team-working ability.

1. INTRODUCTION

The sorts of problems and the accompanying learning environments typically employed to educate professional engineers are substantially different from those they will encounter as practicing engineers. Engineering work involves solving complex problems requiring an array of technical and generic skills [14]. Jonassen, Strobel and Lee [12] argue the case that students should be learning to work with complex, ill-defined problems having multiple solution methodologies and often conflicting goals. The problems should require the students to draw upon collaborative solution methodologies, accessing a variety of information sources. Success in the solution of these problems may be based on non-engineering standards and may contain constraints and unanticipated problems that are not technical in nature. Jonassen, Strobel and Lee [12] recommend a curriculum where problem based learning type approaches feature prominently in order to more closely align the learning environment with the conditions under which the professional engineering graduate will function.

Project and problem based learning approaches encourage active learning and development of interdisciplinary knowledge [10], [16]. Increases in independence, individual responsibility and the depth of student learning have been observed with the

introduction of project-based education [1]. Students have been observed to develop stronger communication and team-working abilities and the learning environment promoted the development of inquiry, problem solving, and information management skills [18]. Project based learning also creates awareness of the “Scientific-Technological-Environmental-Social” [10] inter-related aspects of engineering work and a recognition of the need to respond to significant social changes, especially in the context of sustainability, evident in the Australian engineering profession [13].

2. IMPLEMENTATION

The use of project and problem based learning in engineering education is certainly not new (see for example the case studies reported in Bunting, Carre, Kaider, Andrews, Chapple and Mewburn [6], Chartier and Gibson [7] and Tongsakul and Jitgarun [21]). The present implementation of project based learning was conducted through a core first-year engineering unit at the University of Western Australia (UWA). There were significant challenges associated with the large student ($n \approx 650$) and teaching staff numbers.

The unit ‘Introduction to Professional Engineering’ is the foundation of the engineering student’s professional development at UWA. The content of this unit includes examining the multi-disciplinary, legal, ethical, social,

sustainability, communication and environmental aspects of professional engineering activities. The instructional approach employed previously in this unit consisted of leading the students through this material via a series of lectures which were discussed in tutorials and then assessed through weekly essays. Each year a small team project was also undertaken by students in an attempt to teach them about teamwork.

Since 2005, the educational structure of this unit was gradually progressed toward an approach most closely aligned with the pedagogy described by project based learning. Initial strategic educational changes in the unit consisted primarily of a greater focus on the team project. Strong student engagement with this assessment task, in particular the observation that student inquiry regarding the team project was driving much of the educational tutorial interactions, naturally led the redevelopment of the unit along the PBL path. The main project was increasingly employed as the driver for student learning and inquiry.

During the gradual shift toward PBL, online supplemental material was also developed so that students could access this when the team came to the realisation that the information was necessary for successful project completion. A working environment was established where students would function not only in their immediate project teams, but also as part of a larger tutorial group team. This necessitated student development of written and verbal communication skills to allow for effective exchange of information through this business structure. Instead of expecting student to conduct teamwork activities outside the unit contact times, teams would hold meetings and engage in associated activities under the auspices of the tutor (or tutorial team leader).

The use of team work within the project based learning framework appeared to complement rather than obstruct individual inquiry and learning. In particular, students with a tendency to lose motivation benefited greatly from being part of a team. Many teams observed functioned in a manner similar to an action learning set, realising the accompanying educational and personal advantages [17].

From 2008, the Engineers Without Borders (EWB) Design Challenge, an event open to all Australian and New Zealand Universities, was selected as the project around which the project-based educational experience in the unit was based. The EWB Challenge is a design competition open to first-year university students. The competition provided students with the opportunity to learn about design, sustainable development, teamwork and communication whilst contributing towards a real international development project. The EWB Challenge project undertaken in 2008 focused on sustainable development in Cambodian communities of the Kandal province through the innovative application of appropriate technology.

Implementation of this project based learning approach necessitated thorough training of the teaching staff. This was achieved through a series of interactive training sessions which included instruction regarding the design process, teamwork, team management and cultural sensitivity. As part of the training and the tutor briefing sessions throughout semester, a Cambodian expert panel (consisting of all the Cambodian students enrolled at UWA at the time) was made available for tutor and student consultation. These Cambodian students were also involved in a question and answer session to allow our students to gain a greater appreciation of the cultural context of their design work.

A number of workshops were conducted and laboratory space for construction of prototypes was made available to students. An online report writing skills module was also produced in a collaborative effort with UWA Student Services. This material served as a report writing reference for students throughout semester. Report writing assessments, rather than essays, were employed to better align the learning outcomes of the unit with industry demands. A variety of lecturing approaches were also adopted, including interactive team teaching, demonstration lectures and guest lectures with a strong focus on the various EWB Challenge design topics. The unit also made substantial use of discussion boards on WebCT to share information and build teams. The discussion boards allowed students to share reports and other project related insights and to arrange additional team meetings out of tutorials.

All unit lectures, workshops, demonstrations, tutorial activities and assessment tasks undertaken by the students were designed to contribute to the successful completion of the EWB Challenge project. Teamwork and team management skills were an implicit requirement for students to succeed. To assist in the education regarding team roles and team functioning, a behavioural analysis tool, the Belbin team-role inventory [4], was employed to assess student tendencies in team situations and to provide a framework for the discussion of teamwork and team functioning.

Belbin team role theory describes nine primary team roles [4], [9] ranging from leadership to team worker and investigator roles. Henry and Stevens [11] demonstrated that Belbin's roles provide useful information in the formation of teams. In particular, their study focused on the benefits realised by having one strong leader within the team. Manning, Parker and Pogson [15] agree that team role behaviour does appear to be related to individual personality traits, but warn that the team roles are not as constraining as the Belbin theory indicates. Aritzeta, Swailes and Senior [3] concluded that the Belbin team role model and its accompanying inventory have adequate convergent validity. Limited discrimination between some of the team roles (i.e. strong associations between roles) however was observed. Although useful as a team

formation tool, gender differences have been noted in prior studies [2]. A tendency for males to score higher in the leadership roles and females to score higher in the team worker roles has been identified.

Throughout semester, students were also given individual access to the software Turnitin. Turnitin is an online ‘plagiarism detection’ program (although it is more correctly labeled a text-matching program) that attempts to identify the source of student written work. It produces a report, rating the student’s work and assessing the level of originality. Turnitin is traditionally used only after an assignment has been submitted and only as a diagnostic tool for the assignment marker. Instead, in the present implementation, this online system was utilised as a learning tool for students. Rather than using Turnitin to detect plagiarism after assignment submission, students had access to the software, to self-assess their work prior to submission. This allowed them to learn how to properly acknowledge sources and to improve their paraphrasing [19]. Students were able to obtain feedback as often as required before submission of their reports. The tutors were of course also available to assist students that did not understand how to improve their work to reach the writing standards required.

series of workshops were conducted. The first series concerned bamboo construction methods. This was followed by workshops on filtering, alternate energy sources and water supply systems. Students attending these workshops completed a full safety induction and were then permitted access to laboratory space for their projects. Funding for student project construction activities was provided contingent upon approval of a proposal document supplied by the student teams.

Student approach to learning within the unit was measured through the study process questionnaire [5]. The data collected was compared to the results from 2005 when the unit was operating in the traditional lecture-tutorial format with minimal formal teamwork activities.

3. RESULTS AND DISCUSSION

A student perception of teaching (SPOT) survey was conducted in the unit during the penultimate week of second semester (n=436). The SPOT survey responses range from 1 (strongly disagree) to 5 (strongly agree), 3 being the neutral response (see Table 1). The project-based learning changes implemented resulted in very favourable student perceptions of the unit in 2008. The mean response rose from 3.11 to 4.15 since 2005.

Table 1: Unit SPOT survey results; 2008

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable
1	0.5%	1.4%	15.4%	53.7%	29.1%	0.0%
2	0.2%	4.4%	21.3%	42.9%	31.0%	0.2%
3	0.0%	0.7%	9.9%	50.9%	38.5%	0.0%
4	0.7%	5.3%	24.8%	36.0%	27.8%	5.0%
5	0.2%	3.0%	23.9%	43.3%	29.4%	0.2%
6	0.7%	3.7%	18.8%	46.1%	30.3%	0.2%
7	0.7%	1.6%	13.3%	45.2%	38.3%	0.7%
8	0.0%	0.9%	8.0%	47.2%	43.1%	0.7%
9	0.2%	0.2%	6.7%	48.2%	44.3%	0.5%
10	0.0%	0.9%	9.6%	47.7%	41.1%	0.7%
11	0.5%	3.0%	15.1%	31.0%	40.6%	3.7%
12	1.6%	3.4%	18.8%	25.7%	39.7%	4.6%
13	0.7%	3.7%	19.5%	28.4%	39.7%	1.8%

Q1.	The unit has been well organised.
Q2.	The learning objectives have been made clear.
Q3.	I have become aware of non-technical issues that challenge professional engineers.
Q4.	Lecture material has been presented at an appropriate level.
Q5.	Specific ways students could improve their academic performance have been suggested.
Q6.	The amount of work required has been reasonable.
Q7.	This unit is relevant to my future career.
Q8	The tutors were well prepared for classes.
Q9	The tutors have shown enthusiasm for teaching the subject.
Q10	Tutors have shown concern for students.
Q11	Access to the online plagiarism detection tool Turnitin has been useful in report preparation.
Q12	Use of the online plagiarism detection tool Turnitin has improved my ability to avoid plagiarising.
Q13	Instruction given regarding team roles was useful for the team work undertaken.

To encourage the teams to construct prototypes of their designs or develop experiments to prove concepts, four

Student perception of the relevance of the material taught to their future careers went from 3.2 to 4.2 and their awareness of non-technical issues that challenge

professional engineers from 3.61 to 4.27. As one student stated, “I’m glad that I did a project like this at the start of my degree, because I think all my future projects will benefit from the experience. I learned a lot about team work, organisation, time management, and sustainable development because we -needed- them.”

improving the first year experience and the retention rates of first year engineering students.

The student unit reflective feedback (SURF) results for the unit for the past four years are presented in Table 2. The UWA engineering averages are included in

Table 2: Unit SURF survey results; 2005-2008

Unit score (Engineering average)	Q1	Q2	Q3	Q4	Q5	Q6	Response rate
2005	2.3 (2.9)	2.6 (3.0)	2.8 (3.1)	2.7 (2.9)	2.5 (2.9)	2.4 (3.0)	-
2006	2.9 (2.9)	3.1 (3.0)	3.1 (3.1)	3.1 (2.9)	3.0 (2.8)	2.8 (2.9)	95%
2007	2.8 (2.9)	2.9 (3.0)	3.0 (3.1)	2.9 (2.9)	2.9 (2.9)	2.7 (2.9)	85%
2008	3.2 (2.9)	3.3 (3.0)	3.4 (2.9)	3.3 (2.9)	3.3 (2.8)	3.4 (2.9)	72%

- Q1. It was clear what I was expected to learn in this unit
- Q2. The assessment requirements were clearly stated
- Q3. The assessment tasks were closely linked to the unit objectives
- Q4. The unit was well organised
- Q5. The learning resources (handouts, text, web resources, etc) were adequate for my study in the unit
- Q6. Overall, this unit was a good educational experience

Despite there being an increase in the amount of work required and expected with the project based learning approach, student perceptions as to whether the workload was reasonable, improved from 3.32 to 4.02. Perhaps the increased motivation and engagement with the material facilitated this improved perception. Students often commented that they believed the unit was conducted in a fashion more closely resembling the working environment of a professional engineer: “I believe the use of the EWB project as the core of the unit worked very well to provide a ‘real’ insight into the Engineering world. Through many of the units, I don’t believe that the students are exposed to what Engineering really is based on- communication. I have grown up around Engineering (through my dad) and I’ve seen how workplaces in general work, and I feel the unit conveyed this teamwork concept very well.”

The workshops and access to laboratory space often featured positively in written feedback provided by students. As one student stated, “The workshops were a great idea to be able to provide some sort of practical learning, and were vital in merging that link between ideas and reality.” Many students commented that the workshops were one of the best aspects of the unit.

One of the less obvious benefits evident from the feedback obtained was the establishment of social networks between students. Many students commented that the teamwork and lengthy interactive tutorials forged many strong friendships. Students were often unaware of the value of such networks: “I personally thoroughly enjoyed nearly all aspects of this unit as our team worked equally and efficiently, experiencing some success as a result. I know it is irrelevant but from having worked so cohesively and diligently over the semester they have now become some of my good friends.” These social (and upon graduation professional) connections can only be beneficial in

brackets. The scale for the SURF survey spans from 1 (strongly disagree) to 4 (strongly agree). Improvements in student ratings of the unit are significant. Relative to 2007, there was an increase of between 13% and 25% for all survey questions. The greatest improvement and the highest rating were achieved in the summary question regarding the student perception of whether the unit was a good educational experience.

Student perception of the Turnitin software as a learning tool was also very favourable. Student rated the usefulness of the online plagiarism detection tool in report preparation and its influence on their ability to avoid plagiarising at 4.2 and 4.1 respectively. Report originality statistics for three reports completed within the unit concur. These demonstrated significant and consistent improvement throughout semester in student abilities to properly paraphrase and reference material.

Table 3: Overall similarity index for the first draft of three written assignments (n=618)

Assignment	Overall Similarity Index			
	0-24%	25-49%	50-74%	75-100%
1	168	285	120	32
2	431	121	36	16
3	448	135	29	-

The Turnitin overall similarity indices (i.e. percentage of material matching internet sources, publications or student papers) for the first draft of the three written assignments set within the unit are presented in Table 3. In determining these percentages, material contained within quotation marks and reference lists were not included. Text matches of three words or less were also ignored. The Turnitin statistics show a substantial 69% decrease in assignment first-draft mean level of plagiarism from the first to the second written assignment. There were also no cases of plagiarism

detected (i.e. similarity index above 24%) in the final (third) assignment submissions across all students [20].

The Belbin team role preference profiles collected for each student were collated with the results of a teamwork survey. This survey asked students and tutors to rate the teamwork experience on a scale of 1 (poor) to 4 (excellent) along the dimensions of team member attendance, preparedness, communication, workload distribution, motivation, supportiveness and overall performance. This wealth of teamwork related data collected in the present case study is deserving of a dedicated paper. Some preliminary results however, emerging from the analysis indicate that teams that considered their Belbin profiles when forming teams, performed significantly better (academically and with regard to their team interaction) than those that did not.

Table 4: Mean EWB Challenge team report marks; 2008

Team leaders	Mean (%)	SD (%)	n
0	62.63	6.72	28
1	68.05	8.77	44
2 or more	61.28	9.14	38

Table 5: Study process questionnaire results; 2005 and 2008

	Motives and strategies						Approaches			
	SM	SS	DM	DS	AM	AS	Surface	Deep	Achieving	Deep Achieving
2005 (n=229)										
Mean	26.0	24.9	18.5	20.7	21.7	18.2	50.9	39.3	39.9	79.2
SD	5.5	4.7	4.4	4.0	4.1	5.3	7.8	7.0	8.0	12.1
Percentile	90	70	30	40	60	30	90	30	40	40
2008 (n=560)										
Mean	22.7	22.4	23.2	24.4	22.0	20.5	45.0	47.5	42.4	89.9
SD	4.2	3.9	4.7	4.0	4.7	5.1	7.1	7.7	8.3	13.8
Percentile	60	50	70	70	70	40	60	80	50	60

With reference to Table 4, it may be seen that there is academic benefit of having a single leader with a strong preference for this team role in each team. Teams lacking a strong leader performed notably poorer in the final project mark. There did not appear to be a significant distinction between the performance of groups with a shaper or coordinator in the leadership team role. A poor 'overall performance' rating (often indicating a high degree of internal conflict within the group) correlated well with the presence of two or more strong leadership preference roles within a team. It must be noted however, that with teams that consisted of two or more members with strong leadership role preferences the academic outcome varied greatly. An example of this is the winning EWB Challenge team. This team consisted of three strong leaders. These leaders and the other team members however, displayed strong secondary preferences for team worker and implementer roles. In general, it was noted that the

perception of team function improved (as rated by the team and the tutor in the teamwork survey) with more team worker and implementer members (or at least a strong secondary preference for these roles). Interestingly, the inclusion of a female team member had both academic and team function benefits. The student perception of the usefulness of the related team working instruction was very positive (the SPOT survey question rated 4.12).

The study process questionnaire results from 2005 and 2008 showed a clear shift toward a deeper learning approach (Table 5). Students were asked to consider only their approach to learning in the Introduction to Professional Engineering unit. The percentile rankings provided are based on the normalisation data provided by Biggs [5].

As reported previously by Stappenbelt and Barrett-Lennard [19], there were considerable demonstrable benefits of the communication streaming within the unit. A large proportion of the communication stream students are international enrolments. This unit has historically represented a stumbling block for some of these students wishing to complete an engineering degree at UWA. In 2005, the international student group had a progression rate 30% lower than their

Australian counterparts. This figure was decreased to just below 13% in 2006 and then below 10% in 2007. In 2008 the international student pass rate was essentially the same as the Australian student pass rate.

The UWA student teams performed extremely well in the 2008 EWB Challenge competition. Out of approximately 1300 teams consisting of 6668 students across 26 universities, the UWA teams were awarded two of the six finalist spots in the 2008 competition. The UWA teams were awarded first and second place after the presentation of their design solutions at the national conference. The winning team designed an effective low-cost water filter to purify arsenic contaminated ground water while the runner-up produced an environmentally friendly clothes washing system. The water purification team also won the EWB conference poster competition.

The success of the PBL approach has seen improved teacher morale in the faculty and increased support for the development of an integrated learning centre for first year engineering students. Numerous institutional level benefits were also realised in light of the local and national publicity the UWA engineering programme consequently received. This enhanced reputation comes at an opportune time as the struggle continues to attract quality students in light of the recent university degree education targets.

4. CONCLUSION

The adoption of a project-based learning approach for the first year engineering curriculum is particularly well suited to engineering education since a large proportion of professional engineering work is conducted through projects. The type of problem solved by students in this environment is better aligned with real engineering problems as is the development of the requisite solution processes. Engineering students are also predominantly active learners [8] and are therefore well suited, as a group, to experiential rather than passive and reflective style learning environments. In the present project-based learning implementation, it was observed that student motivation and depth of learning were much improved.

The EWB Challenge is one of the few events across Australia that acts as a benchmarking exercise between Universities. The results of the EWB Challenge are therefore great testament to the quality of our students and the effectiveness of the project-based learning approach in developing not only professionally competent but also socially and environmentally conscious graduates.

ACKNOWLEDGEMENTS

I would like to thank my students for their generally wholehearted adoption of the project-based learning approach despite the inevitable teething problems. In particular, I would like to acknowledge the outstanding efforts of our champion teams. I would also like to thank the UWA Student Services staff, Siri Barrett-Lennard and her team, for their work in training the tutors in English language tuition and cultural sensitivity and ensuring the communication focus stream effectively delivered appropriate assistance to the students. Thanks must also go to Dr. Nathan Scott for his contribution to the design component of the unit. The efforts of Wen-Hsi Chua and Chris Rowles for leading their teams to the EWB competition finals and Sabbia Tilli for her continued work as a communication focus stream tutor are also deserving of individual mention.

REFERENCES

1. Ambikairajah, E., S. J. Freney, J. Epps and T. Hesketh (2007). 'Self-directed project based learning : a case study.' Proceedings of the 18th conference of the

- Australasian Association for Engineering Education : 9-13 December 2007, Melbourne, Australia.
2. Anderson, N. and S. Sleap, (2004). 'An evaluation of gender differences on the Belbin Team Role Self-Perception Inventory', *Journal of Occupational and Organisational Psychology*, Vol. 77, pp. 429-437.
3. Aritzeta, A., S. Swailes and B. Senior, (2007). 'Belbin's Team Role Model: Development, Validity and Applications for Team Building', *Journal of Management Studies*, Vol. 44, No.1, pp. 96-118.
4. Belbin Associates, (2009). 'Home to Belbin team roles', Available from: <http://www.belbin.com> [September 2009].
5. Biggs, J., (1987). 'Student approaches to learning and studying', Australian Council for Educational Research, Hawthorne, Victoria.
6. Bunting, A., A. Carre, F. Kaider, J. Andrews, B. Chapple and I. Mewburn (2007). 'Greenhouse gas reduction in industry : a multidisciplinary approach to project-based learning.' Proceedings of the 18th conference of the Australasian Association for Engineering Education : 9-13 December 2007, Melbourne, Australia.
7. Chartier, B. J. and B. A. Gibson (2007). 'Project-based learning : a search and rescue UAV : perceptions of an undergraduate engineering design team : a preliminary study.' Proceedings of the 18th conference of the Australasian Association for Engineering Education : 9-13 December 2007, Melbourne, Australia.
8. Felder, R.M., & Silverman, I.K., (1988), 'Learning and Teaching Styles in Engineering Education,' *Journal of Engineering Education*, Vol. 78, No. 7, 1988, pp. 674-681.
9. Fisher, S. G., T. A. Hunter and W. D. K. Macrosson, (1998). 'The structure of Belbin's team roles', *Journal of Occupational and Organisational Psychology*, Vol. 71, pp. 283-288.
10. Frank, M. and Barzilai, A. (2002). 'Integrating alternative assessment in a project-based learning course for pre-service science and technology teachers', Learning Communities and Assessment Cultures Conference, University of Northumbria, Newcastle, UK.
11. Henry, S. and K. Stevens, (1999). 'Using Belbin's leadership role to improve team effectiveness: An empirical investigation', *Journal of Systems and Software*, Vol. 44, pp.241-250.
12. Jonassen, D., J. Strobel and C. Lee, (2006). 'Everyday Problem Solving in Engineering: Lessons for Engineering Educators', *Journal of Engineering Education*, Vol. 95, No. 2, pp. 139-151.
13. Jorgensen, D. and Howard, P. (2005). 'Assessment for Practice Oriented Education', Third Annual Conference on Practice-Oriented Education, Northern University, Boston.
14. Maier, H. (2008), 'A hybrid just-in-time / project-based learning approach to engineering education',

- Proceedings of the 2008 AaeE Conference, Yeppoon, Australia.
15. Manning T., R. Parker and G. Pogson, (2006). 'A revised model of team roles and some research findings', *Industrial and commercial training*, Vol. 38, No. 6, pp. 287-296.
 16. McAlpine, I., C. Reidsema and B. Allen 2006. 'Educational design and online support for an innovative project-based course in engineering design.' Who: 497-507.
 17. McGill, I. & L. Beaty, 2002, 'Action Learning: a guide for professional, management & educational development', 2nd ed., Kogan Page Ltd., London.
 18. Molyneux, T., S. Setunge, R. Gravina and M. Xie (2007). 'An evaluation of the learning of structural engineering concepts during the first two years of a project-based engineering degree.' *European Journal of Engineering Education* 32(1): 1-8.
 19. Stappenbelt, B. & Barrett-Lennard, S. (2008). 'Teaching smarter to improve the English communication proficiency of international engineering students – collaborations between content and language specialists at UWA', *Australasian Journal of Engineering Education*, Vol.14, No. 2, pp. 115-124.
 20. Stappenbelt, B. & Rowles, C. (2009), 'The effectiveness of plagiarism detection software as a learning tool in academic writing education', 4th Asia Pacific Conference on Educational Integrity, Wollongong, Australia.
 21. Tongsakul, A. and K. Jitgarun (2006). 'Empowering students' learning achievement through project-based learning as perceived by electrical instructors and students.' Engagement and empowerment: new opportunities for growth in higher education', EDU-COM 2006 conference proceedings, 22nd - 24th November 2006: 509-518.