Simulating Industry:

An Innovative Software Engineering Capstone Design Course

Lynette Johns-Boast and Shayne Flint
College of Engineering and Computer Science
The Australian National University
Canberra, Australia

***Abstract*—Universities are required to produce graduates with good technical knowledge and 'employability skills' such as communication, team work, problem-solving, initiative and enterprise, planning, organizing and self-management. The capstone software development course described in this paper addresses this need. The course design contains three significant innovations: running the course for two cohorts of students in combination; requiring students to be team members in 3rd year and team leaders in their 4th (final) year; and providing assessment and incentives for individuals to pursue quality work in a group-work environment. The course design enables the creation of a simulated industrial context, the benefits of which go well beyond the usual, well-documented benefits of group project work. In order to deliver a successful outcome, students must combine academic theory and practical knowledge whilst overcoming the day-to-day challenges that face project teams. Course design enables the blending of university-based project work and work-integrated learning in an innovative context to better prepare students for participating in, and leading, multi-disciplinary teams on graduation. Outcomes have been compellingly positive for all stakeholders – students, faculty and industry partners.**

Keywords—Software Engineering, Capstone Design Course, Work-Integrated Learning, Group Project, Industry-Based Project, Peer Assessment, Peer Assisted Learning, Internship, Course Design, Curriculum

I. INTRODUCTION

Increasingly employers and society more generally are requiring universities to produce graduates with appropriate 'employability skills' such as communication, team work, problem-solving, initiative and enterprise, planning and organizing, and self-management [1]. To achieve these outcomes, universities and other tertiary institutions frequently use capstone design group project courses to help students develop these important skills.

In the early years of their engineering degree, students learn in a largely theoretical fashion. Although some institutions use approaches such as team work and problem based learning (PBL) from the first year, practice of theoretical learning is frequently limited to artificial assignments or small-scale group projects and problems which fail to demonstrate adequately the true value of important engineering activities. More frequently, however, students work individually without the opportunity to develop the team working skills along with professional skills.

Group project courses require students to work in teams and to undertake medium-sized projects, sometimes for real-world clients from outside the university environment. This enables students to take part in all aspects of the engineering process. Working in teams exposes students to the issues and problems associated with communication and team productivity. Both practice and the literature (for example [2]-[7]) suggests that project courses are highly effective in preparing students to face the real-world, as well as for consolidating learning.

Ensuring satisfactory outcomes for all stakeholders – academics (student learning, confidence in assessment); students (learning, grades, fun) and clients (product, intellectual assets) – can be a difficult task as all three have widely divergent requirements for success. Success for one may not necessarily mean success for another. Additionally, fairly assessing individual student contribution can be an even more difficult and time-consuming task [8].

The group project courses described here are a significant capstone of the software engineering degree at the Australian National University (ANU). Students participate as team members in one project in their 3rd year and as team leaders in another project in their 4th (final) year. For two consecutive semesters, small teams of five or six students, with 4th year team leaders and 3rd year team members, work with industry partners to develop solutions to contemporary, real-world problems. Student teams are closely supported throughout by experienced, industry-based mentors alongside their industry clients and faculty. Academic assessment is achieved principally through the mechanism of three gateway reviews staged through the project.

This design, combined with the assessment scheme, has allowed us to simulate an industrial context. As well as team work skills and experience, students gain practical knowledge of current industry practice which goes well beyond the technical knowledge in their other university subjects. They use software tools, programing languages and project management approaches which are prevalent in industry but not always taught at university. Students learn about the iterative nature of software development and regularly discover that a single approach does not suit all stages of their project – and thus learn through experience the value of adaptability.

Each year, course designers and coordinators work closely with industry partners to offer students a wide selection of

978-1-4673-5261-1/13/$31.00 ©2013 IEEE

projects which range from pure computer science and software engineering research, through developing proof of concept software to the more traditional implementation of e-Commerce and mobile applications. Software developed by students is regularly incorporated into the code base of our industry partners. Student projects win industry awards and the course itself won an Australian Council of Engineering Deans Education Excellence award.

The capstone design course described in this paper has been carefully designed to achieve the overall goal of "*help[ing] students develop leadership skills and become an effective member of a team which makes and implements appropriate engineering decisions related to the development of software systems that deliver measurable value to clients*" [9]. Each year the effectiveness of the course is assessed qualitatively, based on feedback received from students, clients, mentors and faculty.

II. Course Design

At the ANU, Bachelor of Software Engineering (BSEng) students undertake two capstone design courses – one in 3rd year and another in their 4th (final) year while Bachelor of Information Technology (BIT) students undertake a capstone design course in their 3rd (final) year. Students work on real-world problems for real-world industry partners for two consecutive semesters.

The innovation of combining the 3rd and 4th year courses into one, while at the same time working with industry partners, has enabled the creation of a simulated industrial context which provides benefits over and above the usual, well documented benefits obtained from undertaking group project work. Teams consist of five to six students: four or five 3rd year students (both BSEng and BIT) led by one or two 4th year (BSEng) students. Faculty plays the role of senior management in a notional consulting company. Within the simulation, it is assumed that the company (as represented by faculty) successfully tendered for a number of projects for which it has subsequently recruited teams. The role of the company's senior project manager is played by team mentors – who have industry and project experience. Mentors work closely with teams, especially the 4th year team leaders. Teams all work with an industry partner or university client.

Course design incorporates peer assisted learning (PAL) [3] which has been shown to be a powerful method for leveraging learning beyond the direct efforts of the teacher. To be effective, however, it requires situations that motivate the more experienced students to assist the less experienced. Combining 3rd and 4th year students on one team facilitates PAL directly, as the 4th year students have previously completed the course, and have an incentive through their shared project marks to improve their juniors' performance. PAL, lectures and structured reflection homework provide students with opportunities to share the experience of their peers' projects, increase their learning over and above their own design and implementation experiences, and to develop a community of practice [10], [11].

Since assessment is the key to student learning, the best way to change that learning is to change the assessment scheme [12]-[15]. Accordingly, the assessment scheme has been continuously refined to help us better meet the learning outcomes of the course. As the course design has developed, we have moved progressively from focusing assessment efforts on the quality of deliverables to concentrating on process and team work. The key to success in this aspect of the design was the introduction in 2008 of formal peer assessment and in 2009 project reviews in association with a holistic view of the quality of deliverables.

By design, the assessment scheme places responsibility on students to control their projects: to determine scope, schedule and deliverables. In consultation with their project's industry client, students are also responsible for establishing their own systems and software development lifecycle and project management environment. Student teams are closely supported throughout by experienced, industry-based mentors alongside their industry clients and faculty. At three key points through the project, students, industry partners, mentors and academics participate in 'gateway reviews' which examine a team's performance and project progress to provide guidance and assurance that they can progress successfully to the next stage of the project. The gateway review process also provides the principal mechanism for academic assessment.

A significant student and faculty concern related to group work is the existence of non-productive group behavior such as social loafing and free riding [16] where students who do not complete tasks as responsibly as their peers, nonetheless attain the same mark as their more responsible peers [17], [5], [18]. To overcome such problems and to improve learning, course design uses peer assessment of team colleagues to generate differential individual marks from team marks. Mentors and faculty provide feedback and mentoring to individual students and teams to help them learn from their peers' assessment and to improve team performance. Mentors also assist team leaders to use this data to mentor and develop their team members.

Clients treat students as a team of junior consultants, frequently inducting them into their organization. Clients often require that student teams comply with company processes and procedures related to how they run projects within their organization. Reminiscent of industry governance procedures, the gateway reviews involve representatives of all stakeholder groups – clients, faculty, mentors and all members of the team. As well as providing the mechanism for academic assessment the gateway review process provides meaningful feedback and guidance to the team to help them deliver real – tangible – value to clients.

Further detail related to course design can be found in two earlier papers by Johns-Boast & Flint [19], [20].

III. Significance to Engineering Education Practice

Through deliberate and intentional learning opportunities, linked with appropriate and careful assessment, our students obtain the benefits of work-integrated learning [21], [22] without either extending the length of their study or missing out on exposure to valuable content in other courses because these have been sacrificed to provide space in the curriculum for participation in internship programs for credit.

In addition to the usual and well documented benefits from undertaking group project work (for example, [23], [4], [24], [6], [25]), the industrial simulation we have created helps students fuse theory with practice and thus improves students' ability to transfer knowledge from the academic environment to the work-place and vice-versa [21], [22]. The course introduces students to the professional skills required of a competent engineer: leadership, management, communication with both peers and supervisors and teamwork in particular, as well as ethical and other responsibilities.

Unlike internships, sandwich courses and work placements where students work with a single company and frequently a single area of that company for periods of time often no longer than a semester, our students work for eight to nine months each year with different organizations and clients on different projects. Consequently their exposure to different work places, cultures, project types and teams provides them with a much wider experience than a single industrial placement would normally offer. In addition, through the greater autonomy, responsibility and decision making required of students participating in the course, our students are offered greater opportunity to develop leadership capacity than generally happens in traditional work placements and internships.

Project gateway reviews require students to defend their decisions as well as encouraging them to try things and to take risks that would not be possible in traditional internships and work placements. In consultation with their clients, students are responsible for all aspects of the management of their project. They frequently select and use a broad range of tools for project tracking, issue management, continuous integration, code review, configuration management and version control, and adopt approaches widespread in industry which they don't learn at university.

By removing many constraints from the assessment scheme and handing over complete control of their projects to students, and increasing the focus on reflection, self and peer assessment, and critical thinking, we have encouraged the development of autonomous learning [26]. Peer assessment of contribution to the team's work achieves a fair and equitable allocation of marks that adequately reflects both individual knowledge and contribution [27], [17], [5]. More importantly in terms of student learning, however, peer assessment also helps students understand and develop key skills related to team work and performance review as well as enabling 4th year students to develop mentoring skills as they work with team mentors to develop and mentor the 3rd year members of their team.

From anonymous student feedback collected since 2010, it is apparent that students value the challenges and opportunities the course provides; saying for example, that the course provides "*opportunities to learn things that aren't part of a pre-existing and highly structured course - to do something semi-original*" and that they enjoy "*the challenge … to get something designed and built based upon what the client wants, and it gives you a great feeling of satisfaction and pride to know that you built something from scratch*".

Feedback from industry partners is consistently positive. Our partners indicate they see the projects as an "*extremely valuable pedagogical tool*" and "*an innovative educational program that is extremely beneficial for all involved*". Of real benefit from the point of view of student learning is that industry partners assert that "*the tasks that we provide for the students are not artificial or 'make-work' in any way*".

Moreover, our industry partners like that the course "*allows students to engage with industry early*", that they get to "*look over*" the students prior to employing them, and that it provides them with an opportunity "*to give back to the ANU*" as well as providing "*a means for us to corporately contribute to producing more highly skilled and capable engineering graduates. This in turn will be for the betterment of the profession and ultimately for the betterment of society as a whole*".

Faculty have also benefitted from the relationships created with industry: we have recently had a Researcher-in-Business [28] grant which grew from the organization's engagement with the academic through provision of a student project. A side benefit to the School is that by combining 3rd and 4th year classes we achieve a more efficient use of academic time and effort in class contact, project selection and management, at no extra cost in assessment.

A. Demonstrated effectiveness

The assessment scheme is designed to support the principal goal of the course: *to help students develop leadership skills and become an effective member of a team which makes and implements appropriate engineering decisions related to the development of software systems that deliver measurable value to clients* [9]. Feedback gathered since 2010 shows that all stakeholders are pleased with the outcomes delivered by the assessment scheme, especially the project review process and its ability to help students deliver real value to clients and to gain valuable experience.

Anonymous student evaluations show that students generally like the assessment scheme and understand the value of the review process and its rich formative feedback, saying for example that the "*project reviews work well because they force you to process the feedback being given and act on it (at least more than other forms of assessment I've seen). You often don't see the feedback from exams, and I often dismiss the feedback from normal assessments because it's a specific situation. But with the projects, there's a direct link between acting on the feedback and future progress and outcomes*". Students also comment that they "*really like the reviews … [as] they were a great chance to show how our process was working (or not)*". Additionally, the review process develops students' ability to critically assess their own work as it requires them to take "*a step back from the inner workings of the project, [which] gives us an objective view of our project's progress rather than our highly subjective one*".

Students similarly note that they "*like the idea of reflections and peer assessment. It is good way to give feedback and reflect on the working of a team*" as well as liking the unstructured nature of the assessment scheme. While students acknowledge the nature of the work required by the course, they comment that despite sometimes encountering "*a lot of stress caused by the project … it was definitely worth it*".

Feedback from our industry partners indicates that they are impressed both with the operation of the course and the quality of the students. One partner has noted that "*the course has obviously taught them [the students] about the practical components of working in the real world because the project team managers have worked well in liaising between their group and the company sponsoring the project. We asked the team to produce a mobile application ... and the team has delivered, despite many challenges being thrown at them and many unexpected working and technical obstacles appearing along the way*"; another notes that students "*experience of all the complexities ... of real world engineering in a relatively benign and supportive environment*".

The quality of the course is also demonstrated by external measures: a number of student projects have won awards at regional and national levels from the Australian Information Industry Association (AIIA) and the Australian Computer Society (ACS) and in 2012 the course itself received a "Highly Commended" award from the Australian Council of Engineering Deans (ACED) for Engineering Education Excellence.

B. Benefits to industry

Since 2004, 353 students have graduated from the program and 65 external/industry projects with 46 organisations and 26 university projects have been completed. Depending on enrolments, we run up to 13 different projects per year. Over 75% of industry partners have been start-up companies, individuals developing a proof of concept prior to formal start-up, small to medium enterprises (SME) and non-profit organisations. Based on the number of hours it is suggested that each student should spend on their project (10-12 hours per teaching week, i.e. 26 weeks), estimated hours of industry partner involvement and including overheads for mentors and faculty, we estimate that the value of each project is around \$150,000. It can be argued therefore, that through the medium of these student projects the ANU provides \$1 million software development assistance each year, mainly to start-ups and small and medium (SME).

When identifying benefits gained from their participation, industry partners have noted that the student projects "*generally result in the production of 'very nice to have' capability that we would probably not otherwise have been able to introduce ... [and] provide a small but worthwhile addition to the overall operational capability of the software engineering group during the course of the year*" [29]. One regular industry partner obtains a secondary benefit from participation because "*the student projects also provide opportunities for junior software engineers [in the company] ... to participate in the projects as clients and client project managers. This is an educational and career enhancing experience for those engineers"*.

C. User acceptance and take up

Although the course is compulsory for many students, recently there has been increasing enrolment from students for whom it is an elective option. Furthermore, since 2010 over 83% of students who submitted responses, rated the course "Enjoyed and learned a lot" or "Enjoyed and learned something". Students' feedback includes comments that it "*was a really great course. It was practical, enjoyable and interesting (I hope all courses were like this course). The course was organised very well. It's hard to find a thing that should be changed with this course*". Furthermore, depending upon the year in which the data was collected, between 73% and 91% of students who responded said that they would recommend the course to other students.

Students value highly the freedom that the course assessment provides saying, for example, "*I liked organising things for myself and working things out by myself. I liked not having something due every 2 weeks and how there were few well-defined deliverables*". They also appreciate the efforts of the mentors and course faculty who "*spent a lot time and effort in teaching us, also really appreciate for giving us so much valuable feedbacks on our project, coz I really gain a lot in it*". Students who provide feedback generally reflect it is "*all in all, very good course*" and "*is one of my favourite courses I've done at uni*" as well as observing that "*it seems like lecturers have been tinkering with this course for years. But it's good how it is now. Don't change anything*".

Contrary to our experience when we began offering industry-based group project courses in 2002, we now have more projects put forward each year than we have student teams to undertake them. Many of our industry partners are repeat clients; half a dozen of whom have undertaken three or more projects since 2009. They like that "*it is possible to get a good outcome that can be used ... [and that it] lets me stay connected with the latest trends*" as well as stating that they "*intend to continue ... involvement into the foreseeable future*". Industry partners' involvement with the course is "*a very positive one from the point of view of the ... project team and the wider company*". A first time client said "*we had no idea on how the setup worked but the teaching staff were fantastic in making sure we were well prepared in knowing how to earn the right to welcome a project team to the company as well as how best to engage with their students, many of whom the staff work with personally ... It has been so much of a success, we want to come back for more next year. The staff have been supportive and their students superb*".

D. Difficulty and complexity

Increasingly, universities are required to produce graduates with appropriate 'employability skills' such as communication, team work, problem-solving, initiative and enterprise, planning and organisation, and self-management [1]. Frequently this is achieved by requiring students to undertake a 'sandwich course', work placement or internship. Although the benefits of a well-designed work placement course have been well documented, the literature indicates that such courses are rare [20]. We contend that the design of the ANU software engineering group project course both provides the benefits of more traditional work-integrated learning programs while overcoming many of the associated problems, as our course design provides greater control over learning outcomes than is usually possible in more traditional work-integrated learning programs. Additionally, both practice and the literature suggest group projects are also highly effective in preparing students to face the real-world and for consolidating learning [22].

Also well documented in the literature are the difficulties of providing students with both a beneficial and enjoyable group learning and team work experience [5]. To help overcome these, the course introduces students to the concepts of personality and the influence it can have on individual communication and work styles; to the stages of team development and how to move quickly and successfully through those stages to become a self-managing, highly performing team; and to the roles necessary within a team for a team to achieve success. Through the introduction of formal peer assessment the course has helped students learn about and deal with "couch potatoes" and "freeloaders" within teams [5]. These steps have helped make the whole experience a more enjoyable and productive process for students.

Developing an assessment scheme which successfully provides equitable grading of students undertaking a variety of projects, which range from the more straight forward information system implementations to highly complex and conceptually difficult research-based projects has not been an easy task. Making this task even more complex was the combination of the 3rd and 4th year courses into a single course. The combination of the project review process, which focusses on process rather than output, and peer assessment of team contribution has enabled the ANU course to achieve success. Inclusion within the assessment scheme of significant individual and team reflection ensures that students become aware of what they are learning, thus helping them develop an understanding of how this learning is applicable to future projects and in the work-place.

Another difficulty encountered is helping many students move from 'assignment mode' where work is done in short intensive bursts at the last minute to the more continuous effort required of project work. Associated with this is the difficulty of convincing students to share their work with their peers, team mentor and sometimes even their client prior to it being 'perfect' as it would be if they were submitting an assignment for assessment. This problem has been largely overcome by encouraging teams to work closely with their mentors and through the use of team repositories regulated by version control software.

IV. CONTINUOUS MONITORING AND EVALUATION

A variety of different strategies can be used to measure teaching effectiveness [30]. The effectiveness of this course has been measured qualitatively using student ratings (both formal and informal), industry partner feedback, self-evaluation, as part of Engineers Australia (EA) accreditation review of the BSEng, and through external awards won by students and the course itself.

Alongside a formal university-wide course evaluation process, students are encouraged to provide anonymous open-ended feedback at the end of the course using the Moodle learning management system (LMS). In addition to this feedback, students are encouraged to provide constructive criticism and feedback at any point during the course. At the start of each year, students are made aware of the changes that have been made in response to feedback received from the previous year's cohort.

At the end of each course, the course faculty and mentors hold a Post Implementation Review (PIR) and evaluate how well we have met the principal goal of the course: *that we will help students develop leadership skills and become an effective member of a team which makes and implements appropriate engineering decisions related to the development of software systems that deliver measurable value to clients* [9]. This goal has not changed since 2004; and neither have course outcomes: that 4th year students *will demonstrate a high level of professional judgement and application of software engineering best practice, as demonstrated through the identification, development, use and evaluation of appropriate processes and artefacts required to provide real value to the client*; while 3rd year students *will demonstrate technical competence in all aspects of the software development life cycle* [9].

The course is assessed using the concepts of constructive alignment [31] and Tyler's [32] notion that the specification of behavioural change suggests learning activities which lead to increased familiarity with the associated content. This means the PIR focuses on refining the assessment scheme to help the course better meet its learning outcomes. Input to the PIR comes from the anonymous feedback obtained through the LMS, grades, team performance based on mentors' observations, indirect feedback obtained through peer assessment and students' reflective homework, as well as feedback from clients. PIR evaluation has led to both major and minor changes to the assessment scheme. The more significant changes are discussed in the following paragraphs.

Initial course design had students responsible for developing a schedule of deliverables, some of which were mandated, and receiving only formative feedback throughout the year, with summative feedback received at the end of the project. Additionally 3rd and 4th year students had different assessment schemes. All students were required to undertake a three-hour, written examination at the conclusion of the course. The first significant change to the assessment scheme was made in 2006: summative assessment was introduced at regular points through the project, required artefacts were no longer mandated and a common assessment scheme for all students was introduced. While both 3rd and 4th year students were still required to undertake formal examination, 4th year students participated in an oral exam.

Teams had been experiencing difficulty adhering to their own deadlines for production of artefacts and deliverables. Mandating artefacts seemed to lead students to consider them to be something orthogonal to project completion, something that they were required to do for assessment purposes, but not to ensure a greater chance of project success which led to what we called the 'two project syndrome' where some teams produced one set of artefacts for the client and another for course faculty. Separate assessment schemes for 3rd and 4th year students led students to focus attention on what they perceived they were required to do to maximise their marks rather than working as productive team members and ensuring the project provided value to clients. Introduction of an oral exam for 4th year students was in response to academic concern that a final examination, especially a written examination, was not an appropriate assessment method given the goals of the course and the very different projects that students undertook. The oral examination allowed academics to determine more precisely what 4th year students did and didn't understand about conducting a software development project. The positive outcomes from the oral exam led to the introduction of the gateway review process in 2009 in place of examinations for all students.

The two most significant changes which have helped us meet learning outcomes and which we believe set our courses apart are the use of peer assessment – introduced in 2008 – and the project review process – introduced in 2009. Not only has peer assessment helped overcome many of the problems associated with group work [5] faculty have greater confidence in the validity of individual grades. More importantly, however, learning what it means to objectively assess another's contribution is a crucial part in the development of management and leadership skills. Another benefit flowing from the introduction of the project review process is the uncoupling of the academic requirements of the course from the conduct of the project.

The introduction of peer assessment as a method of deriving individual marks for team work has not only improved student enjoyment but appears to have enabled us to improve our ability to differentiate between students. Typically marks for group work cluster closely around a higher mean [33]. While student marks vary from year to year, since the introduction of peer assessment in 2008 the standard deviation from the mean of student marks has increased from 7.74 to 9.94, indicating a wider spread of marks and demonstrating the increased ability of faculty to differentiate between students.

During the most recent BSEng accreditation review carried out by Engineers Australia in 2010, the software engineering group project courses were acknowledged as enabling our students to develop strong professional skills while providing them with an opportunity for rich experiential and cooperative learning. The quality of the projects and the student teams has been externally assessed through participation in competitions run by the Australian Computer Society (ACS) and the Australian Information Industry Association (AIIA) where a number of teams have won awards at both regional and national levels. In 2012 the course itself received a "Highly Commended" award from the Australian Council of Engineering Deans (ACED) for Engineering Education Excellence.

We have not carried out a formal evaluation through survey of graduates and employers in an attempt to ascertain whether the course has made a qualitative difference to the 'employability skills' of students graduating from our programs. One of the significant problems we face with such an evaluation is the small student cohort, averaging 45 students graduating each year, many of whom move, including overseas, to accept employment. Each year, however, we collect input and feedback from our industry partners as part of the PIR conducted at the conclusion of each course. Their feedback, while not specific to the development of 'employability skills', includes statements such as "*the ANU is our primary source of junior software engineers*" and that they "*like employing ANU software engineers*" which could indicate that there is a limited source of graduates or that ANU graduates in particular are sought after, though whether that is because of this course or not we could not tell. Furthermore, the feedback indicates that our industry partners believe the course helps make our students employable as it provides "*students with an experience of all the complexities and difficulties (and rewards!) of real world engineerin*g" and that it helps students gain experience of the "*practical components of working in the real world because the project team managers have worked well in liaising between their group and the company sponsoring the project.*"

V. Conclusion

The innovative course design and assessment scheme described in this paper, result in high quality outcomes for all stakeholders – students, faculty, industry partners and the institution. We believe the ANU course design is unique: it does not appear to have been documented in engineering education elsewhere, nor are we aware of it having been used by other institutions.

The course design – combining two cohorts into one; requiring students to participate first as team members and then as team leaders; working with industry partners on real-world problems; and providing teams with mentors who have significant industrial experience – and the assessment scheme – gateway reviews to assess process and team performance, and peer assessment of contribution to generate differentiated individual marks – has enabled us to create an effective industrial simulation. The simulation provides students with opportunities and benefits that far outweigh the more usual group project capstone design courses. Students combine academic theory and practical knowledge to enable them to over-come the day-to-day challenges faced by multi-disciplinary teams; they use tools and practices prevalent in industry but frequently not taught in university; and they develop professional and team working skills. Moreover, the simulation enables our students to obtain the benefits from participating in work-integrated learning without either extending the length of study or missing out on valuable content because other courses have been sacrificed to provide space for participation in internship programs for academic credit.

VI. References

[1] Australian Government. Department of Education, Science and Technology. 2005. "Employability skills for the future: project final report." Published report.

[2] Dutson, A., R. Todd, S. Magleby and C. Sorensen. January 1997. "A review of literature on teaching engineering design through project oriented capstone courses." *Journal of Engineering Education*, pp. 17-28.

[3] Topping, K., and S. Ehly, Eds. 1998, 2009. *Peer-Assisted Learning*. Lawrence Erlbaum Associates, Inc.

[4] Beasley, R.E. 2003. "Conducting a successful senior capstone course in computing." *Journal of Computing Sciences in Colleges,* vol. 19, no. 1, pp. 122-131.

[5] Oakley, B., R. Felder, R. Brent and I. Elhajj. 2004. "Turning student groups into effective teams." *Journal of Student Centered Learning,* vol. 2, no. 1, pp. 9-34.

[6] Todd, R., and S. Magleby. May 2005. "Elements of a successful capstone course considering the needs of stakeholders." *European Journal of Engineering Education*, vol. 30 (2), pp. 203-214.

[7] Reichlmayr, T. J. 2006. "Collaborating with industry - strategies for an undergraduate software engineering program." *In International Conference on Software Engineering. Proceedings of the 2006 international workshop on Summit on software engineering education*, SSEE06. ACM. New York, NY, USA. pp13-16.

[8] Cooley, W. L. October 2004. "Student assessment in team-based capstone design projects." *In proceedings of the 34th ASEE/IEEE Frontiers in Education Conference,* pp. F1G-5.

[9] ANU Research School of Computer Science, *Course website - Software Engineering Group Projects,* http://cs.anu.edu.au/courses/se_projects/, last modified 11 October 2012.

[10] Brown, S. 2004-05. "Assessment for learning: the changing nature of assessment." *Learning and Teaching in Higher Education*, vol. 1, pp. 81-89.

[11] Falchikov, N. 2005. *Improving Assessment Through Student Involvement*. London and New York.: Routledge Falmer.

[12] Wenger, E. "Communities of practice: a brief introduction." University of Oregon. https://scholarsbank.uoregon.edu/jspui/bitstream/1794/11736/1/A brief introduction to CoP.pdf . Accessed: 7 April 2013.

[13] Wenger, E. June 1998 "Communities of practice: learning as a social system." *Systems Thinker*. vol. 9 (4).

[14] Rust, C. 2002. "The impact of assessment on student learning: how can the research literature practically help to inform the development of departmental assessment strategies and learner-centred assessment practices?" *Active Learning in Higher Education*. vol. 3 (2) pp. 145-158.

[15] Ramsden, P. 2003. *Learning to Teach in Higher Education*. Second ed., Routledge Falmer.

[16] Albanese, R. and D. D. van Fleet. April 1985. "Rational behavior in groups: the free-riding tendency." *The Academcy of Management Review,* vol. 10 (2), pp. 244-255.

[17] Kaufman, D. B., R. M. Felder and H. Fuller. June 1999. "Peer ratings in cooperative learning teams." *In Proceedings of the 1999 Annual ASEE Meeting*. ASEE, Session1430, pp1-11

[18] Ellis, T. J. and W. Hafner. 2007. "Assessing collaborative, project-based learning experiences: drawing from three data sources," in *Frontiers in Education Conference*.

[19] Johns-Boast, L. and S. Flint. December 2009 "Providing students with 'real-world' experience through university group projects." In *Proceedings of the 20th Annual Conference for the Australasian Association for Engineering Education*, AaeE. pp. 299-304.

[20] Johns-Boast, L. F. December 2010. "Group work and individual assessment." In *Proceedings of the 21st Annual Conference for the Australasian Association for Engineering Education*, AaeE. pp. 46-51.

[21] Orrell, J. 2004. "Work-integrated learning programmes: management and educational quality." *The Australian University Quality Forum*.

[22] Abeysekera, I. March 2006. "Issues relating to designing a work-integrated learning program in an undergraduate accounting degree program and its implications for the curriculum." *Asia-Pacific Journal of Cooperative Education*.

[23] Chamillard, A. and K. A. Braun. 2002. "The software engineering capstone: structure and tradeoffs." *ACM SIGCSE Bulletin, Proceedings of the 33rd SIGCSE technical symposium on Computer science education SIGCSE '02*, vol. 34 (1), pp. 227-231.

[24] Clark, N. 2005. "Evaluating student teams developing unique industry projects," *Proceedings of the 7th Australasian conference on Computer education.* vol. 42, pp. 21-30.

[25] Isomoettoenen, V., and T. Kaerkkaeinen. 2008. "The value of a real customer in a capstone project." *In proceedings of the 21st Conference on Software Engineering Education & Training*, pp. 85-92.

[26] Clifford, V. A. 1999. "The development of autonomous learners in a university setting." *Higher Educcation Research and Development,* vol. 18 (1), pp. 115-128.

[27] Brown, R. 1995. "Autorating: getting individual marks from team marks and enhancing teamwork." *In Proceedings of the 1995 Frontiers in Education Conference,* vol. 2, pp. 3c2.15-3c2.18.

[28] Australian Government Department of Industry, Innovation, Science, Research and Tertiary Education, *Researcher in Business,* http://www.enterpriseconnect.gov.au/ecservices/rib/Pages/default.aspx, Accessed 7 April 2013.

[29] Johns-Boast, L.F. and G. Patch. December 2010. "A win-win situation: benefits of industry-based group projects." In *Proceedings of the 21st Annual Conference of the Australasian Association for Engineering Education*. pp355-360.

[30] Berk, R.A. 2005. “Survey of 12 strategies to measure teaching effectiveness.” *International Journal of Teaching and Learning in Higher Education*. vol 17 (1), pp 48-62

[31] Biggs, J. 13-17 April 2003. "Aligning teaching and assessing to course objectives." *Teaching and Learning in Higher Education: New Trends and Innovations.* University of Aveiro.

[32] Tyler, R.W. 1949. *Basic Principles of Curriculum and Instruction*. Paperback 1969 ed., University of Chicago Press.

[33] Kennedy, G.J. 2005. "Peer-assessment in group projects: is it worth it?" In Conferences in Research and Practice in Information Technology, *Proceedings of the Australasian Computing Education Conference 2005*, Newcastle, Australia.