A model for increasing online engineering student engagement in group project work

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Structured abstract

BACKGROUND
A key industry requirement for a practising engineer is to work and interact effectively with other disciplines, professions and people (Engineers Australia, 2013). Engineering professionals must solve problems, and make decisions as a team. To this end, peer-to-peer and group learning is a critical element within undergraduate engineering studies. Research has demonstrated that small-group learning in science and mathematics based programs promotes academic success, and fosters learning engagement and success levels (Springer, Stanne & Donovan, 1999). However, developing and enhancing critical-thinking skills through collaborative learning is especially challenging within fully online courses and units (Rovai & Downey, 2010). This paper discusses the strategies for supporting online group work within a Level 1 unit in which a key learning outcome is to develop students' ability to successfully contribute to a diverse team.

PURPOSE
In past iterations of the unit, we had noted limited participation and engagement with the small group work, with many groups not persisting in production of the group assignment. Our aim was to introduce strategies which fostered a higher level of engagement and interest in the group work, and a higher level of individual participation in the groups. We considered a number of approaches, including redesigning the module and even adjusting the assessment, but close observation of the group dynamics in earlier units prompted us instead to examine the technical and logistical support we were giving to the group work in the online environment.

DESIGN/METHOD
We developed a four phase model to manage and support each group. This model was based on administering a high level of logistic, pedagogical and technical support for each group early in the project, which was then scaled back as the group began to function more effectively and autonomously. The model focussed on:

- Fostering of group dynamic development
- Initiation of group dialogue within a teacher-managed group asynchronous tool
- Provision of a customised synchronous environment for group interaction
- Scaffolding of team communication and structural development
- Continuing monitoring and adaption of the group interaction

The focus on the synchronous environment was especially important, as evidence for previous units was that the ability to interact synchronously was a major factor in a baling group success.

RESULTS
We found that the implementation of the model had a dramatic impact on the effectiveness of the groups, and on group and individual success in the module. We found a significant percentage increase in the number of groups who submitted their final assignments and in the number of students who passed the module.

CONCLUSIONS
We concluded that while technical, logistic and pedagogical support are instrumental in the success of group work in both online and traditional units, widely expanded support to each individual group is important for fully online students to effectively participate in group projects.

KEYWORDS
Collaborative engineering, online learning, group learning, project based learning

Introduction

The importance of collaborative learning has long been recognised both in the graduate qualities of the University of South Australia (UniSA), which include the ability for a graduate to work both autonomously and collaboratively as a professional, and within the Division of Information Technology, Engineering, and the Environment, which has embedded group work in some form in virtually all undergraduate courses, both technical and professional (UniSA Graduate Qualities, 2013).

Collaborative learning is particularly important in the engineering discipline, because a key industry requirement for a practising engineer is to work and interact effectively with other disciplines, professions and people. Engineers Australia lists effective team membership and team leadership as a Stage 1 competency element for chartered status for professional engineers (Engineers Australia, 2013), and stresses the importance of engineers being able to function as effective members of diverse engineering teams, including those with multi-level, multi-disciplinary and multi-cultural dimensions. Moreover, the 2011 Australian Association of Graduate Employers noted team skills as one of their top four most sought-after qualities for graduate job applicants (Australian Association of Graduate Employers Survey, 2011). It is critical that engineering professionals have the capacity to solve problems and make decisions as a team, and, in the modern engineering workplace, this teamwork is often conducted using online collaboration and communication tools.

Furthermore, research has demonstrated that small-group learning in science and mathematics based programs promotes academic success, and fosters learning engagement and success levels. Springer, Stanne & Donovan (1999) demonstrate that small group learning, if scaffolded and supported effectively, can promote academic achievement and improve retention in science, maths, engineering and technology courses. It can also have a positive impact on the metacognitive aspects of these knowledge domains, by increasing student awareness of their learning processes and their attitudes to learning. The shared learning gives students an opportunity to engage in discussion, take responsibility for their own learning, and thus become critical thinkers (Totten, Sills, Digby, & Russ, 1991).

To this end, peer-to-peer, collaborative and cooperative learning is a critical element within undergraduate engineering studies. Collaboration and project team activities in the curriculum give students a better sense of how engineering teams work, and give them the opportunity to share the responsibility for their learning. Not only do these learning activities promote the development of team work skills for the students, but they also enhance their learning of mathematical and technical skills. Cooperation enables students to maximize learning by working together to accomplish a common goal, and in doing so, give peer support to each other, by discussing ideas, clarifying complex concepts, and effectively 'teaching' each other.

Collaboration in online courses

The development and enhancement of critical-thinking skills through collaborative learning is especially challenging within fully online courses and programs (Rovai & Downey, 2010). Replicating the essence of traditional classroom work in an online environment needs careful planning and consideration to be effective (Bender, 2003; Palloff & Pratt, 2005), especially with regard to enabling communication and interaction. If the learning environment is to provide a socially constructivist environment, so that students are able to develop critical teamwork and communication skills, group work activities need to be thoroughly and carefully planned, structured, and supported (Conrad & Donaldson, 2011). As we have found, there is a crucial difference between simply putting students in groups to learn and letting them 'get on with it', and in structuring and scaffolding the cooperation and communication among students to achieve desired outcomes. Effective online learning design for collaborative work must also consider the constantly evolving world of e-learning

technology, and adapt to the tools with which the students are comfortable. Finally, of course, there are technical issues of accessibility, bandwidth, etc (Moore & Kearsley, 2011).

Through our experiences in delivering a fully online Level 1 engineering course, we have developed a model which has steadily increased the level of participation and success in a major group assessment activity. The Sustainable Engineering Practice (SEP) course has been offered three times as a fully online unit, and is currently due for its fourth delivery.

This course is basically a professional practice course, which introduces students to the engineering profession and how it is practised within a 'sustainable' context. Unit topics include professional engineering roles and working environments, attributes of professional engineers, engineering ethics, and principles of engineering sustainability. The course also aims to develop core professional skills and personal attributes, such as sourcing and using information, critical analysis and reflective practice, effective teamwork, cross-cultural sensitivity, engineering report writing, and effective presentations. The teaching and learning strategies are centered on team and collaborative project work, consultation with cultural and professional advisers, and problem based learning, as students work on real engineering problems in Australian and international contexts.

One of the major assessment activities in this unit is the completion of the Engineers without Borders design challenge, a design program for first-year University students which provides them with the opportunity to learn about design, teamwork, and communication through a real-life, sustainable cross-cultural development project (Engineers Without Borders Challenge, 2013). Students are required to apply the engineering theory they have learnt from the unit resources, lectures and textbook to real life practice. In teams, they define an engineering need, gather and evaluate information to fill the need, and create a design solution, which is submitted in the form of a written report and an oral presentation.

This has proven a popular and engaging learning activity which has been effective in developing the range of skills required for effective team work among students such as participation, constructive communication, negotiation, active listening, reliability and commitment, and a willingness to share information, knowledge and experience. The traditional internal SEP course has also implemented a number of supporting and scaffolding tutorial activities to help them to develop these teamwork skills.

Even in the traditional internal course, helping first year engineering students achieve the learning outcomes for this course presents difficulties and challenges, since cohorts are diverse and many students enter their degree program with a narrow view of engineering and poor communication skills (Kelly, Smith & Ford, 2012). However, the challenges become even more pronounced when presenting courses which develop these skills in off-campus students and, due to the practical difficulties involved, this is an area which is largely neglected in online engineering courses and subjects (McIntosh & Weaver, 2008). The successful incorporation of the EWB Challenge activity into the fully online course has proven to be difficult, and our development of the activity has gone through an extensive evolutionary process. For example, in our first online delivery, we provided a number of online collaborative tools for the students, and extensive supporting resources, but did not actively participate in the actual group formation or interaction. The result was that while a few groups worked together well, most demonstrated limited participation and engagement with this activity, with many groups not persisting in the production of assessment deliverables.

It became evident that we needed to introduce strategies which fostered a higher level of engagement and interest in the group work, and a higher level of individual participation in the groups. The focus on the synchronous environment was especially important, as evidence for previous units was that the ability to interact synchronously was a major factor in group success.

We considered a number of reactive approaches, including redesigning the module and even revising the whole assessment strategy for the online students. However, we took the time

to examine the information which we derived from a number of feedback and evaluation mechanisms, such as student reflective submissions, analytics of the course website and online tools, discussion of the assessment elements with individual students, and close observation of the group dynamics in the few successful groups. This prompted us to refine the technical and logistical support we were giving to the group work in the online environment, rather than the activity itself.

The group work model

We developed a four-phase model to manage and support each group. This model was based on administering a high level of logistic, pedagogical and technical support for each group early in the project, which was then scaled back as the group began to function more effectively and autonomously. The model focussed on:

- Initiation of group dialogue within a teacher-managed group asynchronous tool
- Provision of a customised synchronous environment for group interaction and fostering of group dynamic development
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Group formation and preparatory activities

In our early courses, we had allowed students to select their own teams, via an online tool. However, as this was a first course for many students, they came with little knowledge of their fellow students, although we had several introductory 'Getting connected' activities in place. Furthermore, the implementation of the model meant that the entire group work process needed to be initiated quite early in the course, and there was little time to allow students to get to know each other to the point where they could select meaningful groups. We decided to set the groups ourselves, basing student allocation principally on geographical location, in the hope that students who are situated relatively close to each other will be able to meet in person. Even if this is not feasible, our thinking is that they will at least be in the same time zone for synchronous communication. We now follow this as standard practice, also taking into account any particular student preferences.

In addition, we have set up several preparatory activities, which students are expected to complete prior to the introductory group meeting. They must complete a Belbin Team Role self-assessment activity, which helps their self-awareness of their teamwork potential. They also do some first-hand research on the importance of teamwork in engineering, and complete a team questionnaire about what they expect the team to achieve in the EWB project.

Initial group dialogue

Our initial contact with the groups specifically for their project work is via an asynchronous tool: an online discussion forum. This tool is helpful in providing the students with an effective and efficient method of administrative communication, given their need for flexibility and their geographical remoteness from each other. It allows larger groups to communicate in an orderly way (Preece, 2000).

Our aim is that the forum will be the principle administrative tool for the group, which they can use to organise and manage their communication. It is easily accessible within the course website, it is set up to be private – that is, only group members and teaching staff are able to view it – and students are able to receive email notifications of postings. Moreover, students are familiar with the tool from their introductory activities. At first, it is teacher-driven and teacher-monitored, with an initial posting listing the students in the group, and giving them information and links to the other collaborative tools available to them. Students are able to respond to the post with personal introductions to the group, and with any questions about the assignments. Once the students are progressing in their group work, the teachers are

able to step back and allow the students to drive the directions of the forum posts, although some monitoring is still required.

Introductory synchronous meetings

The most critical tool we provide to the students for their group work is an online synchronous meeting place. We create the meeting place, and then make sure that the students are able to use it effectively.

UniSA has integrated the Adobe Connect Pro platform into the Moodle LMS, and this tool is quite simple for the students to access from the course website. We create a series of virtual classrooms using the Adobe Connect platform. The students are familiar with this platform, as we run regular optional live 'Helpdesk' sessions to answer questions and discuss topics with them in real time throughout the unit, and quite a number of the students attend at least one session. The Adobe Connect tool also provides a number of features which will be valuable to the students' groups, such as the ability to upload and share documents, and an online whiteboard. It has also proven to be reasonably robust with large numbers of participants.

The first synchronous group meeting is, again, teacher-driven. We aim for each group introductory session to last for an hour. These meetings all need to be programmed into the course schedule and attended by teaching staff, so (depending on the size of the class enrolment), this can result in a heavy load for the staff. We have also trialled scheduling two groups together for the introductory work, and then splitting them into separate groups for discussion and planning, and this seems to work reasonably well.

These introductory sessions are timetabled for each group, and groups are also informed of the time of the session via their group forum. This is perhaps the most challenging phase in the model. Given that the online students are usually need maximum flexibility, they often need find it difficult to attend synchronous course activities, and even attendance at the weekly helpdesk sessions is usually comparatively low. Thus, the message that this is a critical session needs to be reinforced heavily for the students, through news announcements, placement in the course schedule, continual reminders, etc. 50% attendance has been our best record to date.

Establishing the group and fostering of group dynamics

In these introductory sessions, we introduce group members and run a short ice-breaking activity. We then spend some time discussing group dynamics, and referring to the Belbin team role which they have determined for themselves. Group are expected to develop a Team Agreement, which establishes the group communication methods, operational guidelines, individual responsibilities, etc, and this must be submitted as part of the unit assessment, so we spend some time helping them with the creation of this agreement (a template is uploaded for them to annotate and fill in). Students also spend time clarifying the requirements of the assessment.

When students are ready, they are then informed of the url of their own group's virtual classroom, and moved there to start work on their EWB Challenge parameters. In this phase, the teacher will stay with them for as long as the students deem it useful.

If possible, we have found that it is useful to set up the various group work virtual classrooms so that they are customised to the project parameters and to the group work tasks. We include a number of standard features for groups:

- Webcam feeds, useful not only for enhancing group dynamics, but for demonstrating some of the task work, such as creation of designs.
- Sets of instructions to facilitate the use of audio and video.
- Downloadable resources on using the virtual classrooms effectively, on drawing diagrams and mathematical calculations in a virtual classroom, and on sharing and uploading documents.

- An annotatable copy of the team agreement template and of a team communication record template.

Ongoing team communication and development

It is important that the initial teacher support in this model is continued throughout the term of the group work project, but also important that after the initial teacher-directed activities, the students have the opportunity to take responsibility for their group communication and productivity themselves. Once the groups have been established, we require them to decide on the frequency and form of their meetings, and to advise us. If the group requests it, a teacher will attend a group meeting to give guidance on the project requirement or to help with group interaction, but the students are encouraged to negotiate solutions amongst themselves, and to reflect on what they have learnt from the group dynamics, interaction and communication. Students are also required to submit finalised versions of their team agreement and their communications records as part of their final project submission.

Collaborative tools

Although the group forum and virtual classroom are the principle collaborative tools which we work with, we also provide other tools for the group, including:

- A group wiki, so that they are able to easily edit online documents. Because a history of each edit is kept, this is particularly useful as evidence of each student's actual contributions.
- A group ePortfolio, so that students are easily able to share media resources and maintain evidence of their group work designs and products for future demonstrations of their abilities.

We did not restrict the students to these tools, and there are a number of groups which also made use of external commercial tools such as Skye, Facebook, etc. However, we encouraged the use of the embedded tools for a number of reasons – technical support, ease of access for both students and teachers, familiarity, and effectiveness for the purpose.

Results and feedback

We have now run this course 3 times, with the model described above being implemented in Study Period 1, 2013. In each delivery, we have aimed to keep the group numbers as even as possible, and the group size depends somewhat on the whole class size.

We noted a significant increase in the number of both successful groups and the number of successful students, as can be seen in Table 1 below:

Table 1: Results of group work in three deliveries of the SEP online course

Course	Delivery	Number of participating students *	Number of groups for the project	Number of successful group project submissions	Number of students who successfully complete the project
Study Period 1 2012	First	23	6 (initial groups of 4 with one group of 3)	1 (16.6%)	6 (one group of four and two students who worked individually due to technical or logistic issues) (26%)
Study Period 3 2012	Second	48	12 (initial groups of 4)	4 (33%)	15 (two groups of four, two groups of three, and one individual student) (31.25%)
Study Period 1	Third	51	11 (initial groups of	9 (81.81%)	33 (one group of five, four groups of four, two

2013			4/5)		groups of three, two groups of two and two individual students (64.7%)

* Note that I have not included those students who did not attempt any of the course activities at all, or who never logged into the website.

These results are highly encouraging, and we plan to continue and develop the model for future courses. Although no formal evaluation of student cohort feedback to the model has been conducted as yet, individual students have been interviewed. Their responses have indicated that they consider the option to meet in real time is crucial to the success of their project work.

Feedback from the students has also been very positive regarding the use of the synchronous meeting tools. The following quotations are representative of student feedback on the various aspects of the model:

> *The virtual classroom is very effective … it's great that we can all chat to each other … if we use the webcams, we can see each other. It's got a great tool with the whiteboard, so while we were discussing what design options we had, we did use that quite a bit and drew up a lot of information.*
>
> *We use the share the screen option quite a bit … so everyone can see what we're looking at at the same time and discuss things together …We can do everything thing here right in the class, so it is great for study.*
>
> *The whiteboard and sharing functions are great to help us collaborate.*
>
> *I like that fact that in our first class, we get told how to use this system, how to work our way around it.*
>
> *If I was doing this on my own I can't imagine doing a third or a quarter or anything similar to what we're doing together as a group, because one of us will make a suggestion, then we'll all put our input in, and by the end that suggestion becomes a fantastic idea.*
>
> *That fact that we're all in different areas in Australia, for us to meet up physically would be almost impossible, but having this online tool makes life a lot easier for us.*

Conclusion

We found that the implementation of the model has had a dramatic impact on the effectiveness of the online group work, and on group and individual success in the module. Creating and implementing group activities has developed or furthered the essential teamwork qualities which are key to professional engineering, as well as achieving technical or subject specific learning outcomes. We have found a significant percentage increase in the number of groups who submit their final assignments and in the number of students who pass the module. Our conclusion is that while technical, logistic and pedagogical support is instrumental in the success of group work in both online and traditional units, widely expanded personal encouragement and support to each individual group is important for fully online students to effectively participate in group projects.

References

Australian Association of Graduate Employers Survey 2011. (2012). Retrieved August 28, 2013, from http://www.aage.com.au/.

Bender, T. (2003). *Discussion-based online teaching to enhance student learning: Theory, practice and assessment.* Virginia: Stylus Publishing.

Conrad, R., & Donaldson, J. A. (2011). *Engaging the online learner: Activities and resources for creative instruction (Updated ed.)*. San Francisco: Jossey-Bass.

Dillenbourg, P. (1999). What do you mean by collaborative learning?. In Dillenbourg, P. (Ed) *Collaborative-learning: Cognitive and Computational Approaches.* (pp.1-19). Oxford: Elsevier

Engineers Australia. (2013). Australian Engineering Competency Standards Stage 1. Retrieved Jun 7, 2013, from http://www.engineersaustralia.org.au/sites/default/files/shado/Education/echartered/competency_standards_june.pdf
Engineers Without Borders Challenge. (2013). Retrieved August 25, 2013, from http://www.ewb.org.au/whatwedo/institute/ewb-challenge
Field, R. M. (2005). Favourable conditions for effective and efficient learning in a blended face-to-face/online method. In *Ascilite 2005: Balance, Fidelity, Mobility: Maintaining the Momentum*, 4-7 December.
Kelly, P., Smith, E. & Ford, J. (2012). *Revisiting a transformative approach to engineering education.* Paper presented at the International Conference on Innovation, Practice and research in Engineering Education 2012, Coventry, UK.
McIntosh, P. C. & Weaver, D. (2008). Fostering collaboration amongst off-campus students. In *Hello! Where are you in the landscape of educational technology?* Paper presented at the Australasian Society for Computers in Learning in Tertiary Education 2008, Melbourne, Australia.
Moore, M. G., & Kearsley, G. (2011). *Distance education: A systems view of online learning* (3rd ed.). Wadsworth: Cengage Learning.
Palloff, R., & Pratt, K. (1999). *Online learning communities revisited*. San Francisco: Jossey-Bass.
Preece, J. (2000). Online Communities: Designing Usability and Supporting Sociability. John Wiley & Sons, Inc: New York.
Rovai, A. P., & Downey, J.R. (2010). Why some distance education programs fail while others in a global environment. *The Internet and Higher Education,* Volume 13, Issue 3, June 2010, 141-147.
Springer, L., Stanne, M. E., & Donovan, S. (1999). Measuring the success of small-group learning in college level SMET teaching: a meta-analysis. *Review of Educational Research* 69, 21–51.
Totten, S., Sills, T., Digby, A. & Russ, P. (1991). *Cooperative learning: A guide to research*. New York: Garland.
UniSA Graduate Qualities. (2013). Retrieved August 25, 2013, from http://w3.unisa.edu.au/gradquals/
Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge: Harvard University Press.

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