An overview of the challenges of transnationalising a threshold concepts course

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Abstract*: There are significant challenges in transnationalising a semester mode course to a block mode course. This is complicated further by the nature of the course, in being one that seeks to develop threshold knowledge in the form of a high level conceptual view that is quite unfamiliar to many students. The time compression of a 13 week project based course with supporting lectures, workshops, tutorials to a five day intensive lecturer contact activities and four week post-course project makes it difficult to balance the needs of the many stakeholders involved yet still deliver effective outcomes.*

This paper provides an overview of the challenges and describes the approach used to address these challenges. It identifies the needs of the various stakeholders, from teachers, learners, universities and professional bodies, and discusses how the conflicting needs can be managed and problems mitigated. The final section evaluates the success of the approach and identifies further areas for further improvement.

Background

Systems Engineering 1 is a 3rd year undergraduate course undertaken as part of Bachelor of Engineering degrees at the School of Electrical and Information Engineering at the University of South Australia. The course focuses on applying Systems Engineering concepts to the management of complex projects, as is used particularly in the defence industry. Students undertake a 13 week project in small teams to produce a high level conceptual design of a complex system. They apply systems engineering standards, lifecycles and techniques to achieve a balanced, holistically optimised system that meet the customers needs. Students find this quite challenging as the concept of systems is the opposite to the reductionist approach followed throughout much of their undergraduate program and prior education.

Threshold Concepts and Systems Engineering

Meyer and Land (2003) describe threshold concepts as representing a “transformed way of understanding, interpreting, or viewing something without which the learner cannot progress.” and as a result their view of the subject matter and thinking has changed. In systems engineering this is the idea that complex systems need to be viewed at different levels to aid in their analysis and understanding, but without losing sight of the high level view or emergent properties of the system of interest. Traditionally engineers are very good at working at conceptually low levels, eg designing circuits. At this level the Cartesian or reductionist approach is used i.e. break the problem down in to smaller simpler parts to understand and solve and then combine the parts together. This approach works for simple systems but for a novel, complex or social system this proves to be impractical due to overlooking the high level balanced solution to the product, problem or system.

Take, as an example, a ten year old original piece of equipment on an aircraft with a lifecycle of 30 years needs to be replaced. It is not possible to source a replacement piece of equipment, a new piece of equipment, using newer technology, will be needed to perform the same function. It may not be satisfactory just to provide a newer piece of equipment that performs the same function. The replacement needs to interact with the other sub-systems around it and operate in an unusual environment. The piece of equipment need not only be optimised for cost, but also needs to interact with legacy equipment using legacy physical connections and legacy protocols. It needs to not consume any more power than its predecessor. Using newer technology the piece of equipment possibly weighs less and consumes less space. This may present issues with balance in the aircraft, and so this needs to be taken in to account in replacement. It needs to operate in extreme temperature ranges, in dusty environments and withstand vibration. Once the technical issues are taken in to account, the equipment needs to be tested at component level, assembly level, sub-system level etc.. The device needs to conform to electrical, communication, safety, aircraft, security and other standards. It then becomes difficult to provide a solution that meets all of these needs and is optimised at the system level, rather than optimising at low levels which may result in a sub-optimal system.

Systems engineering provides a documented and logical approach to improve communication between stakeholders, and to analyse and develop solutions to these complex problems. Systems engineers apply systems lifecycles and follow systems standards to provide balanced system solutions. Following this approach provides a process that helps ensure completeness and traceability. This leads to a greater chance of successful project outcomes.

The challenge in teaching systems engineering is bringing about the application of the ideas of systems and systems thinking to the solving of complex problems. Students can be taught to follow the appropriate process and produce the process artefacts but without experiencing the 'eureka' moment their understanding can be superficial and the value of the process artefacts is limited. The approach used to help bring about this 'eureka' moment in this course is to have the students major assessable piece of work as a group project where they follow the process and produce the artefacts. They are provided with the theory and how to apply it, then through self learning and producing a reflective journal they are given the opportunity to arrive at the 'eureka' moment. Once reached they are able understand the purpose of the background theory they have been introduced to and see how it fits in to their project work in the course and future projects at university and in industry.

Assessment Approach

The assessment for the course consists of two major components. A conceptual design described in a system specification and a reflective learning journal. The system specification consists of three sections. The teams produce a draft of each section then submit it for feedback. The three drafts, detailed in Table 1, are then combined to form the major assessment for the course. The role that the system specification performs is to provide a real high level problem that requires the students to work together as a team. It provides a vehicle for students to perform tasks that systems engineers perform using the methods and following the standards and conventions used. It provides them with a way to see the link between the methods used in their work and theory discussed in lectures.

Templates are provided for each draft. These provide guidance on what is required, enabling the student locate the information required, work with the team and promote student centred learning. Each draft is review after submission, with feedback provided through comments on the work but also discussed with each of the teams individually. This provides the teams a chance to directly ask questions but also allows the tutor to ensure that the feedback provided is understood.

The reflective journal serves to enable students to relate to the theory and project work to their own experiences. It also provides insights in to the students understanding of the concepts, and allows high achieving students to obtain better grades than their team mates encouraging higher quality work to be produced.

The course work is assessed qualitatively, based on the education theory propounded by Biggs (1999) in his book Teaching for Quality Learning in University. The criteria used for Systems Engineering 1 is shown in Table 2.

Students who have the 'eureka' moment are able to understand the threshold concept achieve the higher grades, provided they can demonstrate it in their group and individual work.

Table 1 Sections that form the System Specification

Task	Helps the student	Provides
Management Plan	• Start to work as a team • Assign roles and allocate responsibilities to the team members • Define and realise the tasks and sub-tasks that need to be performed to complete the work on time • Manage the risks that they will face by analysing and documenting the risks and mitigation strategies they will apply	A clear, documented and communicable approach of the work to be undertaken in the production of the conceptual design.
Requirements Specification	• Develop a clear vision of the project problem and to communicate this with others in a technical document • Understand why it is difficult to elicit the needs from stakeholders in interdisciplinary environments • Learn how write in a clear technical style	A technical document that is used as the basis for further work.
Functional Analysis And Allocation	• Further analyse the work they have produced in the previous section • Develop a deeper understanding and different technical representation for communicating information	A functional and physical breakdown of the system.

Table 2 Grading Criteria for Systems Engineering 1

Grade	Understanding Demonstrated
High Distinction	The very best work that can be expected: beyond the level of a Distinction. Student reflects on what has been presented and what they have read and demonstrates the ability to generate novel, quality insights using systems principles for the problems assigned. The student is able to conceptualise at a level extending beyond what has been covered in the lectures and tutorials.
Distinction	Distinguished understanding beyond the level of a Credit. Student has mastered a functional understanding of systems engineering derived from the content presented and substantial additional reading. Student demonstrates the ability to integrate the concepts presented and to uncover useful insights using systems thinking.
Credit	Highly satisfactory understanding evident. Student demonstrates a clear understanding of how and when to apply systems engineering and can explain, analyse, and solve systems issues using the concepts presented and some extensions from their reading.
Pass 1	Student goes beyond what is needed for a Pass 2 by being able to apply the content from the lectures and tutorials within the conceptual framework presented. Work demonstrates a solid, procedural level of understanding of systems engineering principles and practice.
Pass 2	Student knows the terminology and can apply a system engineering process from the lectures and tutorials to tackle a complex problem but work is shallow, mechanistic and lacks insight.

To support the assessment items, in addition to the lectures, workshops are run in tutorial classes and lectures, where the size of the class suits the activity. These include team building and requirements elicitation activities to show the importance of teamwork and also the challenges of communicating within the members of the group and between groups. Videos are used to display the operational concept of a system. This helps demonstrate to the student the difficulties in eliciting requirements from customers who do not necessarily know what they need or are not able to articulate it. They also provide an opportunity for the students to see the link between the theory and practice, relate to their own knowledge, and help provide systems ideas in an enjoyable way, helping with their self-motivation through humour.

Challenges in Transnationalisation

The course has been running since 2002 in semester mode. In mid-2007 the course was offered offshore in short course mode. Maintaining the same outcomes in the changed delivery mode presents a number of challenges. This is further complicated by distance and cultural differences. These are summarised in Table 3. In transnationalising the course there are a number of stakeholders who have interest in the outcomes delivered by the course. These are listed in Table 4.

Table 3 Onshore vs Offshore teaching arrangements

	Onshore	**Offshore**
Cohort educational background	Largely professional students, direct from secondary education.	Largely early career technicians employed full time, with Polytechnic Diplomas.
Language	Approx. 60% English as first language.	Approx. 100% English as second language.
Delivery	2 hour lectures and 2 hour formal and informal tutorials delivered over 13 weeks.	5 days of 4 hour intensive lectures and workshop activities, 4 weeks distance mode.
Cohort size	50 - 80 students.	90 – 100 students.
Assessment timeline	1 draft per week x 3 combined to form final group report, Ongoing reflective journal	1 draft per month x 3 combined to form final group report, Ongoing reflective journal.
Student workload	Sequential courses per study period.	4 concurrent courses per study period.

Table 4 Stakeholder's needs for the course

Stakeholder	**Needs**
Students	Build knowledge as part of the degree program, Have a reasonable workload balancing work and study.
Teachers	Develop students with to have a good understanding of the concepts, Help students reach the 'eureka' moment, Have a reasonable workload balancing teaching and other activities, Promote student centred learning.
School	Build skills of the students for future projects including final year, Financial interests.
University	Meet academic standards, Build generic graduate qualities.
Offshore partner	Want satisfied students, Financial interests.

Professional Bodies	Professional Engineering bodies need to accredit the Engineering degree program. This happens 5 yearly. In Engineers Australia's 2005 report the accreditation panel's feedback recognised "The very distinctive Systems Engineering course strand in the E&IE programs as a vehicle for developing broad context problem solving capabilities and other engineering application skills as well as generic capabilities". It is essential to maintain or improve this in offshore delivery.

The most significant challenge in conversion from semester mode to short course offshore delivery is the time, going from 52 hours of face to face contact time over 13 weeks to 20 hours of face to face contact time over one week, followed by four weeks of distance mode assignment work. Clearly the lecture and tutorial material needs to be rebalanced. The focus in the one week of offshore contact time is on providing as many workshop and group activities as possible. To enable this a more condensed version of the basic concepts is lectured, relying more on the students to be motivated to read the detailed notes and texts. Table 5 discusses some of the changes made to the course to make it suitable for offshore and short course delivery.

Table 5 Issues and discussion

Issues	**Mitigation/Discussion**
In-class activities only for whole class	Hands on activities are difficult in a classroom environment with 90+ people, so activities are group based and don't require time critical tutor interaction.
Shortened course duration – impact on students	Offshore students take the courses sequentially rather than concurrently. This places a high workload on the students but they don't have other courses competing for their time. Very short turnaround time to provide high quality feedback to the students.
Reduced face to face contact	Increased focus on application rather than theory in the face to face contact time. Discussion forums used. 'The grapevine' – One group of students was given advice, often this was shared with their peers.
Reduced time for face to face feedback on work	At the end of each day, groups were to submit their work for review and return in the next days class.
Language differences	Higher percentage of English as second language students means that feedback needs to be expressed as clearly as possible – so that the students can do further self-learning or ask further questions if required.
Internationalisation of examples and activities	International examples used, while not all ideas were from their own experience they were introduced with sufficient detail to make them understood.

Academic Integrity

In courses involving academic writing, plagiarism can sometimes be an issue. To address this, the course has been designed to minimise the chances of this occurring. In addition to the usual discussion of academic integrity and plagiarism that occurs at the commencement of the course, each cohort has a different project topic. This is particularly for the project specific requirement and functional sections. The use of drafts and their delivery at regular intervals requires students to maintain their effort throughout the course rather than leaving the major work until close to the due date. The reflective learning journal also provides indirect support to this approach. Students are reminded that the learning journal is about their own, thoughts ideas and experiences, and that the management plan should contain useful information specific to their project, rather than generic information.

Conclusion

While there is still room for improvement, the outcome from the offshore short course deliveries has had students showing a good level of understanding of the core concepts of the course in the five times it has been delivered to date. The high level of communication and feedback required to help students realise the threshold concept 'eureka' moment presents a high workload on the student and staff in the intensive course mode. Technology, through the use of forums and instant messaging present areas to improve the effectiveness of the teacher – student distance communication. This effective communication could improve the workload on the teacher. The high workload to the student is offset by the fact that the offshore cohort is generally more mature and with more job experience. This leads to a good number of students reaching the 'eureka' moment and gaining understanding of the systems engineering threshold concept.

References

Biggs, J. B. (1999). *Teaching for Quality Learning in University*. Open University Press.

Meyer, J. & Land, R. (2003). *Threshold Concepts and Troublesome Knowledge (1): linkages to ways of thinking and practising within the disciplines*. Improving Student Learning – Ten Years On. C.Rust (Ed), OCSLD, Oxford.