Development of Distance Communication and Virtual Teamwork Skills through online-based Teaching

Author:

Erik Bohemia, University of Western Sydney, School of Engineering and Industrial Design, Locked Bag 1797, Penrith South Distribution Centre, NSW 1797, Australia, e.bohemia@uws.edu.au

Abstract — *In 2001, the School of Engineering and Industrial Design undertook an initiative to conduct a pilot of the online delivery of the 'Design Management: Organisational Skills for Designers' subject. This course is one of the core subjects offered by the Industrial Design program to industrial design and engineering students. The course has been developed to address industry needs identified in previous research. One of the key learning outcomes of the course was for students to develop distance communication and virtual teamwork skills, which are becoming increasingly important in new product development.*

This paper describes the on-line component of the subject with a focus on the way this subject incorporated a number of aspects of "good teaching/learning practices" as outlined by Scoufis. The on-line component of the subject was structured to stimulate students independent learning and to develop their critical thinking by arousing their curiosity in the topics by incorporating the seven processes of critical thinking and writing as outlined by James, Scoufis, Farrell and Carmichael. Student evaluation data, both quantitative and qualitative, gathered at the completion of subject has been used to evaluate the effectiveness of the approaches introduced in this subject.

Index Terms — *Communication, Cross-campus course delivery, Design Management, Evaluation, On-line course delivery, Teamwork*

CHANGING MANUFACTURING ENVIRONMENT

Focus on Product Development Time

The importance of reducing the time-to-market cycle is highlighted by various researchers, [1-10]. As global competition is becoming more fierce, organisations need to introduce new products on domestic and international markets at an increasingly faster pace [11-13], resulting in *'Time Base Competition*' [6], which has become a critical measure of business performance [12, 14, 15]. Companies that have fast-cycle product development benefit also from creating a possible technological gap between themselves and their competitors. This gap can provide them with a significant competitive advantage [16]. The advantage of a shorter development time is that the company is 'closer' to the market [17, 18].

Achieving Speed in NPDP

Takeuchi and Nonaka [19] and other authors [e.g. 6, 8, 10, 20-22] identified that the new emphasis on speed and flexibility requires a new and different approach for managing new product development. They point out, that the traditional sequential product development "may conflict with the goals of the maximum speed and flexibility" [19, p. 137]. It is proposed that this type of product development process "is no longer tenable" in fast moving markets [23, p. 5/5].

Takeuchi and Nonaka suggested a holistic concurrent product development approach ('rugby' or 'volleyball') might better be aligned with the today's goals of maximum speed and flexibility [19]. *Concurrent engineering*; also known as simultaneous engineering [24-27]; or parallel design process [28]; and in Japan 'doki-ka', is a relatively new approach [29]. As opposed to a sequential process, it uses overlapping design stages, with less 'gates', and *cross-functional* teams to shorten the development time of a project [5, 25, 30-41].

The major advantage is that a number of critical issues concerned with product development can be looked at and dealt with simultaneously at the early stages of the design development [42]; any immediate and future requirements can be taken into account [38, 43]. With this approach, not only the quality and speed of the design development can be achieved, but also fewer changes are needed to accommodate various functional departments' requirements [44]. It also provides a basis for a design team to define the product and to produce a well-documented design process plan, which has a well-defined target. It is argued that this positively impacts on shortening of the development process, producing competitively superior, and more producible design [45], which can be beneficial to prevent "cost overrun during manufacture" [46, p. 82].

Fostering understanding

Cross-functional teams should increase collaboration from various functions during the design process. According to Oxman, it is important "to establish a knowledge base related to team behaviour in order to prepare designers for interaction in design teams" [47, p. 282]. It is argued that *concurrent engineering* fosters mutual appreciation and understanding between various team members from different disciplines; as it utilises *cross-functional* teams, consisting of key personnel from various functions [36, 38, 39, 48], breaks down the boundaries between various disciplines and fosters communication [49]. Wallace and Jakiela proposed that separation of industrial design and engineering functions "in the design stage can lead to unappealing or difficult-to-manufacture products" [50, p. 66]. *Concurrent engineering* is not an "out of box product", a fixed methodology, or just teamwork; it is a culture, philosophy and the way of thinking [51, 52]. This means that behavioural and mental constructs have to be altered [32]. Thus, organisations have to re-examine "the way products are designed, manufactured, [and] serviced" [52].

Importance of Teamwork

It is well acknowledged that well integrated teams are critically important for successful product development process [48, 53-57]. Maccoby states that team members should have *cross-functional* capabilities in order to appropriately function in teams [58]. These include: understanding of the project/company vision; solid grounding in their discipline so that they can well communicate any developments from their area knowledge; respect for others and their views; a functional empowerment; team skills that include "brainstorming, listening, asking clarifying questions, seeking consensus", and the proper character which is to help others to succeed rather than focussing "on their own interest" [58, pp 57-58]. This would suggest that team members have to be 'team-players' with well-developed team-skills.

Importance of Communication

Pahl, Badke-Schaub and Frankenberger report that "good availability of information" contributes "essentially towards good solution as well as timely and cost effective results", and that a lack of information leads to the opposite effect [56, p. 491]. The Warren Centre for Advanced Engineering found that indeed frequent communication between individual, working groups, and the rest of the organisation is one of "the key elements of a successful [design] environment" [59, p. 5 and pp 54-61]. Tomiyama [37] and Shemas [38] state that communication is essential for successful implementation of *concurrent engineering*. Effective and clear communication is needed to prevent the following [60]:

- delays in passing information to relevant group or person
- misrepresentation of information because information is not clear enough
- loss of information through organisational filtering
- generating unnecessary communication, thus creating informational overload
- disillusionment within the teams and its members (due to unclear project goals and poor motivation)

Elshennawy, Krishnaswamy and Mollaghasemi [36] have also identified that poor communication can lead to "collaboration breaks down", these could be as a result of "communication skills of individuals… [use of] different presentation format, rapid change, use of jargon," too much information, "and cultural mores and norms for individual behaviour" [Curtis, Krasner & Iscoe cited in 61, p. 282], thus resulting "in loss of product functionality, problems in testability, delays in manufacturing, and loss of customers. This finding is also supported by Sonnenwald's [61] study of communication roles and how they support the design process.

Song, Neeley and Yuzhen [62] identified that effective communication fosters integration between departments, and this will in turn lead to successful new product development. Their research identified five "significant" barriers that most often discourage information exchange and integration amongst various functions:

i.) "A lack of trust or respect," that is "personnel perceive lack of credibility in team member from other units."
ii.) "Different ideologies, languages, and even goal orientation lead to miscommunication and general lack of communication and integration."
iii.) "A lack of communication in general," is because of communication structures have not been adequately formalised and this hinders an "effective cross-functional integration."
iv.) A lack of collocation of departments encumbers "information exchange."
v.) "Managerial support" and poor planning, resource and responsibilities allocation that hampers "information exchange and integration" [62, pp 550-551].

In addition, Song, Montoya-Weiss and Schmidt [54, p. 38] identified the following barriers

vi.) Personality differences between functions
vii.) Cultural differences or thought-worlds

viii.) Organisational responsibilities and reward systems

In a classical manufacturing model the progression of communication and interaction flow is mostly one-way traffic (serial). Feedback is also one way and with very little consultation. This type of communication and interaction generally occurs in hierarchical (functional) structures [63] and it can compromise design integrity [64]. As Furbershaw explains: "In the past, industrial designers would do nice renderings of what the product should look like, then they would pass these over to engineering. The engineers might examine it and say it's stupid and couldn't be made that way. They would change it to make it manufacturable, but they wouldn't care about the aesthetics or human factors of the product. Then the engineers would pass it on to manufacturing, which would have its own concerns. There was no product continuity" [48, p. 39].

On the other hand, the flow of communication and interaction between various functional departments in the *concurrent engineering* environment system allows relevant information to be passed on to any functional department within the organisation. According to Maccoby the above communication takes place in *'heterarchy'* team structure. The team structure is the same configuration as the one depicting interaction and communication flow. Maccoby has proposed, that the team members need to "learn the principles of effective dialogue" in ordered to successfully operate in this structure [63].

COURSE IMPLEMENTATION

The University of Western Sydney services a vast area of Greater Western Sydney through its 6 major campuses. During 2000, the University went through a major restructure. As a result of this, it was decided that from year 2002 the Industrial Design degree would be offered on two campuses, Penrith and Campbelltown. These campuses are about one-hours drive apart. To minimise excessive travel by lecturers between campuses, various possibilities were explored, one of these was the on-line delivery of some courses [65]. Therefore, in 2001, the School of Engineering and Industrial Design undertook an initiative to conduct a pilot of the on-line delivery of the Design Management: Organisational Skills for Designers course [65]. Now in its third year, this course is one of the core courses offered by the Industrial Design program to senior students enrolled in these undergraduate degrees: Design & Technology, Industrial Design, and Industrial Design Engineering and also students undertaking Master of Engineering (Industrial Design). The course has been developed to address industry needs identified in previous research [59, 66-70] and key learning outcomes include:

- For students to understand manufacturing paradigms and their impact on the product development process and the design process.
- For students to understand the impact of organisational structures, strategies and processes on the design process.
- To provide students with an understanding of key skills that will enable them to work successfully with various organisational members in the product development process. These skills include teamwork, decision-making and communication, analysis and problem solving.
- The on-line component of this course provides students with the opportunity to develop distance communication and virtual teamwork skills, skills that are becoming increasingly important in new product development.

Three main factors influenced the use of virtual work groups. The first was to provide students with practical exposure to group work related skills, such as virtual teamwork, decision-making, and long distance communication. The second reason was to enhance their learning experience as Wright has pointed-out that "significant learning experience take place as students work together" [71, p. 30]. The last reason was to reduce the amount of work submitted online. Previous training in on-line course delivery by one of the lecturers had highlighted the issue that large amounts of on-line discussion can make the reading task onerous, and act as a disincentive to participation [65]. The group work aimed to expose students, in a practical setting, to the benefits and limitations of on-line group communication and collaboration [65].

The above course's aims have also addressed a number of Engineering Graduate Attributes such as: ability to function effectively as an individual and in multi-disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as an effective team member, social and cultural responsibilities of professional engineer, effective communication (both written and verbal) in addition to the expectation of the need to undertake lifelong learning, and capacity to do so [72, p. 5].

Good Teaching Principles

Results from the student survey administered at the end of the course showed that:

- 93% of students indicated that this subject had helped them to develop virtual team skills
- 78% of students indicated that their writing skills have improved as a result of activities undertaken in this course
- 75% of the students felt that the on-line discussion has encouraged collaboration between their group members
- 53% of students perceived that the on-line activities in this course has helped them in developing a deeper understanding of the subject

These results suggest that most of the students perceive the course is facilitating their learning and especially in the intended areas of development of virtual teamwork and written communication skills. These positive results were made

possible by incorporating into the course structure a number of aspects of "good teaching/learning practices", as outlined by Scoufis [73]. These are:

- Clear expectations – this has been achieved by re-development of the course structures and outlines as well as outlining these clearly in the introductory lecture
- Feedback including peer review – organised independent review which has been conducted by the Educational Development Centre
- Cooperative learning – which has been facilitated by group work and peer review (students)
- Alignment of objectives, method, content and assessment – The assessment tasks are aligned with the course objectives. For example, a structure for the tutorials was developed that encourage reflection, participation and teamwork. This is encouraged by allocating 24 points for students' participation.
- Encourages students to reflect upon their own learning process to facilitate transfer of learning to new context – Structure and assessment of tutorial tasks as well as peer review and academic feedback assist students to reflect on their learning as well as it facilitates transfer of learning, as the above are accessible to all students

Students' independent learning and development of their critical thinking was stimulated by arousing their curiosity in the topics by structuring/organising the units to address the seven processes of critical thinking and writing as outlined by James, Scoufis, Farrell and Carmichael [74]. These are: (i) Question and analysis, (ii) Immersion, (iii) Questioning, (iv) Linking, (v) Views, (vi) Understanding frameworks, and (vii) Positioning. In the Design Management: Organisational Skills for Designers this is accomplished by the following activities and the unit structure:

i.) In this first step of the learning process is for the students to read required texts and accompanied case study prior the lecture. In this step students should be 'questioning and analysing' what they have read.

ii.) During the second step of the learning process students attend a lecture where they are exposed to various views and a debate on the topic, which should lead to an 'immersion' in the topic.

iii.) At this point the students are required to prepare a group seminar presentation paper in which they link theory and practice through analysis of a case study. At this stage students should be 'questioning' the issues presented at the lecture and the readings.

iv.) This stage comprises of production and submission of the 'final' seminar paper. At this stage students should be able to demonstrate 'linking' between what was covered in the lecture/s and readings.

v.) During this activity students who have reviewed the seminar paper would prepare and submit their feedbacks. Thus producing a number of varied 'views' on that week topic (seminar paper). Thus students learning being assessed on ongoing basis [75].

vi.) In the presetting students have to review the feedback provided to them by their colleges and their tutor. The feedback at this stage students is to provide and to encourage the students to develop good 'understanding frameworks'.

vii.) At this stage the presenting student groups prepare and submit their seminar summary papers in which they address any issues raised in the feedback provided to them by their peers and their lecturer. During this activity students should reach the last stage of the critical thinking process, that is 'positioning'.

The above activities not only encompass the seven processes of the critical thinking as outlined by James, Scoufis, Farrell, and Carmichael [74] but they also prepare students for their other assignments (e.g. essay writing and end of the semester exam).

Appropriate feedback plays an important role in students learning and development [75]. Cronin and Sparrow identified the following as main characteristics of effective written feedback: specific and clear comments, comprehensive constructive suggestions, encouragement, prompt return of assignments, justification for grades, respectful presentation and tone [76]. Therefore, students are provided with feedback which encourages students' learning and their participation as is evident from this message which was posted into one off the groups 'coffee room':

- *well i'd like to congratulate to all of us. having been mentioned by Erik on a good response. we should try to keep it up.*

It is important to note that more than two thirds (64%) of students indicated that they have received **more feedback** that they would have normally received in other face-to-face courses.

As stated previously, the incorporation of on-line technologies was to enhance student's learning experience. However, more importantly it has strived to present students with the 'whole' learning experience. Thus, students' learning experience was enhanced through a variety of avenues, these were:

1) Encouraging and motivating students from the very start
   - *Was very approachable. Even before the subject had begun, email communication was very prompt and helpful. The way the subject was structured was extremely effective. On-line component combined with face-to-face tutorial was helpful was very effective in teaching the subject. Overall, excellent.*

2) Well-structured activities and clear learning outcomes
   - *He is assertive, organised, cares about the benefit of our learning and he knows how to encourage students.*
   - *Well structured, approachable, motivational, but firm lecturer. You knew what was expected of you from the beginning and it didn't change.*
   - *The lecturer was very organized so there was no ambiguity once we grasped the system he had set in place.*
   - *He explains what is expected and what skill we were suppose to gain.*
3) Demonstrate passion and knowledge for the profession (leading by example)
   - *Knowledgeable: he has a great knowledge about design and enjoys sharing his knowledge.*
   - *Lecturer was enthusiastic and was well prepared with ample knowledge on topic areas.*
   - *His commitment and organisation of the subject. Full marks! He knew his content of work in depth.*
   - *Enthusiasm – he likes the subject and helps us appreciate it too. Sincerity – he is sincere in wanting us to learn and improve and gives us his time to help us improve.*
   - *Organisation – always prepared, organised. Assignments marked quickly, he is always on time.*
4) Genuine interest in students' learning and well-being
   - *Willing to help students through email, phone, blackboard. Very quick to returning calls, email etc. Good – very good teaching skills and methods. I enjoyed learning from Erik.*
   - *He seemed involved in lectures and showed high interest in what we took away from lectures*
   - *Friendly and a willingness to help when in need.*
5) Make students comfortable to ask questions and have an open discussion.
   - *Comfortable classroom – always willing to answer questions. e.g. Erik was very good as a lecturer, encouraging open communication and providing a large amount of class material. The class reader was great; it placed all the information needed at our finger tips.*
   - *Easy to talk to, and answer questions, on the same level – you feel comfortable talking to him about things that are unclear.*
   - *He also involved us all in discussions each week which gave us a clear understanding of the course.*
   - *Making the lectures student involved with open discussion being used.*
6) Use of humour
   - *Very approachable, humorous and he knows his stuff up to date.*
7) Varying teaching styles and source of instruction
   - *Analysis of each weeks articles in depth. Different media besides the reader etc. Video was good.*
   - *Varies teaching style. Always different and new – kept everyone interested.*
8) Ability to link theory to practice
   - *Ability to divergently discuss topics from many points of view with practical examples relative to topic and issues.*
9) Structure the lectures, tutorials, and other activities to encouraging students' participation
   - *Encouraged us to participate constantly.*
   - *Encouraged participation through weekly activities from reader.*
   - *Very open and willing to communicate or discuss issue it a numerous amount of times.*
10) Open discussions between students are encouraged.
   - *The use of on-line discussion for group participation. Making the lectures student involved with open discussion being used.*
11) Feedback, that motivates is critical, and prompt
   - *Feedback and explanation from lecturer on topics of discussion and assignments.*
   - *Does give useful advice and critise not useless command.*
12) Skills and practice to work in teamwork environment
   - *The teamwork tutorials were a good initiation into working in a team.*

CONCLUSION

The students' feedback indicates that redevelopment Design Management: Organisational Skills for Designers course was well received and the aims of the course have been achieved.

Last year, the School of Engineering and Industrial Design, in view of rationalisation and cost savings, made a decision that from 2005 it will operate only on one campus, Penrith. This decision, to deliver all the courses only on one campus, will remove the physical distance that currently exists amongst the group members used throughout this course. The elimination of this physical distance will negate the need for students and teams to use the on-line communication forums.

This has created an opportunity, whereby the author is seeking to partner with external educational institutions that are interested in research and development of long distance virtual teamwork skills expertise as well as providing an opportunity for their students to be exposed to this type of environment. These institutions are encouraged to contact the author.

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