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Managing Multidisciplinary Student Design Teams

Martin Masek
Edith Cowan University

Joo Jung
Edith Cowan University

Barnard Clarkson
Edith Cowan University

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Martin Masek
School of Computer and Security Science
Edith Cowan University
Australia
m.masek@ecu.edu.au

Barnard Clarkson
School of Communications and Arts
Edith Cowan University
Australia
b.clarkson@ecu.edu.au

Joo Ho (Jo) Jung
School of Communications and Arts
Edith Cowan University
Australia
j.jung@ecu.edu.au

Abstract: The management of multidisciplinary student teams is a challenge. In this paper we describe our experience in running a shared assessment across several units. Four multidisciplinary teams were formed, and success was mixed, with one team splitting into two along discipline lines and all experiencing communication issues. The main management challenges that arose were based around difficulty in communication and the understanding of the other discipline's requirements. We outline the process we used to construct the shared assessment, and provide some insight in how the student groups dealt with issues that arose.

Introduction

Many real-world systems rely on the work of people from a variety of disciplines. For example, an automobile requires input from experts in various fields in order to make it mechanically sound, reliable, safe, aesthetically pleasing, useable, marketable, and so on. Each field of expertise typically has its own language and ways of working and thus participating in an multidisciplinary project poses a challenge in communication and understanding. In response, various educators have attempted to introduce multidisciplinary projects to their curriculum in order to prepare students for real-world projects. In fact, in some disciplines, such as Engineering, multidisciplinary team skills are required by some accreditation bodies such as ABET (ABET Engineering Accreditation Commission 2010).

Furthermore there are sound educational reasons for grouping students too. Working in multidisciplinary teams has been shown to improve student's interpersonal skills and personal performance, (Ivins 1997; Goff 2006). Such students also develop a deeper understanding of the other disciplines, changing their perceptions from initial stereotypes towards gaining a more accurate understanding of where a discipline can contribute (Burnell 2002; Goff 2006; Ivins 1997; Schaffer 2010)

The effective management of multidisciplinary student teams presents some challenges, both for the students managing their team, and for academic staff from the various disciplines. In this paper we present our experiences in management of a multidisciplinary semester project spread over two faculties and three design disciplines – interface design, software design, and 3D design.

Background of the Study

In the second half of 2010, the authors, each teaching in a different discipline, set a shared project for the students in their units. The project required students to design and develop a means to communicate through a tangible user interface the availability of computers in laboratories to people entering the building. Four teams were formed, with each team made up of interface designers, software engineers, and a 3D designer. Each discipline came from a specific unit in which their contribution formed an assessable part. A summary of the units and the expected contribution of their members is shown in (Table 1).

Discipline	Class	Expected contribution
Software Engineering (4-5 students per group, with a leader)	Postgraduate class, mostly taken by students in the Master of Computer Science degree.	Design and implementation of the project's software components, and interfacing the software to sensors and actuators.
Interface Design (5-6 students per group, with a leader)	Undergraduate, 2nd year level unit for students completing the Bachelor of Creative Industries.	Design of the user interface and the Human Computer Interaction aspects of the system.
3D Design (1-2 students per group)	Undergraduate, 3rd year level unit for students completing the Bachelor of Creative Industries.	Build a 3D model of the environment for prototyping.

Table 1: Roles, levels and expectations of team members.

The project built upon previous work where multiple units from a single school (School of Communication and Arts) worked together on a collaborative project. In that instance, the theme of the project was the same, communicating lab availability information. However, the output was limited to a screen-based medium, with solutions typically presenting lab usage in a graphical format. Software Engineering students from the School of Computer and Security Science were added for the current iteration of the project in order to expand the scope and build a more interactive product.

Managing the Students

Course Structure

The course structure involved running three separate classes (as indicated in Table 1), each with different learning outcomes and lecturers, in addition to students coming together to work on their project. This approach involves some challenges. Lovejoy et al. (2002) reported that such a structure is not optimal as the different classes will tend to focus on different outcomes, and the sub groups have trouble integrating. This is a finding that we confirm in our results discussion. Lovejoy reported success in terms of student outcomes in a structure where students from multiple disciplines undertook a single combined class coordinated by staff from multiple disciplines. A similar model has been reported by Jaccheri and Sindre (2007), in their Experts in Teams unit, taken by a majority of students from all faculties. There, students are assigned to multidisciplinary groups and choose a project theme. Each theme, known as a 'village', is supervised by one academic staff member. These models were not suitable in our situation as they involve running a specific multidisciplinary project class to run as a capstone unit. Such units assume that students from the disciplines have enough experience to contribute their skills. In our situation, students were still learning the skills of software, interface, and 3D design and thus needed separate instruction in each. Instead, we hoped to make the students from different units into cohesive project groups by providing a project that they would be motivated to work on. Besides, there are arguments that conflicting requirements and group integration issues should be present in order to simulate an industry environment (Brunell et al. 2002).

The Management Process

The staff approached the running of the project in three stages, a planning phase prior to the start of semester, the execution stage where students were completing the project, and a reflective analysis phase at the end of the project. In the planning phase**,** the structure of the project as well as the resources and constraints presented to the students were decided. For this, the staff met weekly in the months leading up to the start of semester. In this phase the parameters outlined in (Table 2) were determined.

Parameter	**Description**
Physical location	A stairwell leading up to the labs was set as the installation location.
Data source	A web service was operating from the previous semester, this provided the number of computers that were in use in each lab.
Hardware solution	The USB Bit Whacker (UBW) (Schmalz N.D.) was selected as an interface to the outside world. Requiring minimal electronics experience, sensors and actuators can be hooked up to this board and operated through software.
Cost constraint	AU$100.00
Time constraint	Installation complete by the last week of semester
Motivation	Common meetings, and a competition, with one group voted to install their project.

Table 2: Project parameters determined by staff in the planning phase.

Engineering Motivation

The project featured several aspects to motivate the students. Factors that contribute to student motivation include, among others, the relevance of a topic along with the ability for students to be actively involved (Sass, 1989). As the product produced would actually be used, the project was deemed to be very relevant to students who, from past experience, value real-life projects. A real industry project features conflicting goals, differences in skills, and lack of communication between disciplines (Burnell et al. 2002). Though we did not specifically engineer these qualities into the project (just as they are not intended to arise in industry), they arose anyway.

Furthermore, the multidisciplinary nature of the project taught students important skills that most of their assessments do not. In feedback from students, discussed in the Discussion section, many indicated that the multidisciplinary factor did contribute to their enjoyment. As the students had free reign in designing their product (besides meeting the requirements), there was also a lot of scope for them to be actively involved in driving the project, serving to motivate them further.

To add additional motivation, a competition element was used in that the winning group (as voted by the staff) would have an opportunity to install their project in a public space (a stairwell leading to the labs), and be provided with the budget to do so. Groups who did not win were still required to complete the project as a working prototype. In order to enhance the competition element, all students attended a common class four times during the semester where they presented their progress on the project. This was also done to counteract cultural barriers between the disciplines given that each discipline would normally be attending their class at a different day and time to the others.

Handover to the Students

Once the semester started, the project entered the execution stage. The students were assigned into groups and took over the project. Each class was seen by their respective lecturer each week. Though formal instruction occurred in these classes on the respective subject, project-wise, the staff member took on the form of facilitator, leaving the students to lead the learning process and pose their own questions. As observed by Jaccheri (2007), this requires a deeper level of engagement than standard instruction in order for staff members to understand the project. Interaction between staff occurred when problems were encountered and updates were announced (e.g. meetings). For example, the initial $100 budget proved restrictive and was increased. We now discuss the strategies employed by the student groups in managing their projects.

Management Strategies Used by Students

All four teams used a similar organisational structure, each group having five to six interface designers, four to five software designers, and one 3D designer (except one group that had two 3D designers). No leadership or communication structure was enforced, but the interface designer sub-group was encouraged to lead the project. The software designers on the team were also coordinated by their own lead. Each group attempted to organise a full group meeting on a weekly basis, whilst the interface and software design subgroups also met separately on a weekly basis in class.

The integration of multiple disciplines into a unified project team is a crucial factor for success. Kim and McNair (2009) reported that teams that maintain regular contacts and interactions experience less conflict and achieve better results. This is also reflected in our results, with the winning team having the highest level of engagement between their software design and interface design students. In software design post-mortem reports, the team members from that group also identified this as a reason for their success.

Managing Problems between Disciplines

Although the teams worked on a shared project, the different units had their own outcomes and deliverables. This became a source of conflict and frustration. For the first major deliverable the interface designers were required to produce visual prototypes and the software designers a working proof-of-concept. Although due dates for these were synchronised, the interface designers of some groups did not communicate the design to the software designers in time for it to be implemented. This caused some stress for software design students, who had a looming deadline without a clear understanding of what to implement. The software design students were advised to follow industry practice, to make assumptions and document them. For two groups, this involved designing a complete system as they had no input from the interface designers.

The lateness of interface designers in providing their design for comments in turn caused problems with the feasibility of the designs. The goal was to produce a design that could be implemented given the constraints of the chosen hardware platform (eg. the USB Bit Whacker board has a limited number of inputs and outputs) and the time to assemble and install the product. Although the software design students were made aware of hardware limitations, and alternatives for easier implementation, they often did not communicate these effectively to the interface designers. As a result, the designs produced were complex in terms of hardware – requiring extra circuitry to allow more sensors and actuators. This in turn led to higher cost and a blow-out in the time requirement to complete the project. This in turn frustrated the interface designers who were not aware of the extra work involved.

Burnell et al (2002) experienced similar problems with deliverables from one discipline being provided too late for another discipline. Their problem was also compounded because their discipline sub-groups were at different universities and deliverables were passed between disciplines through the teaching staff. To alleviate this they recommend direct communication between students using email and online chat rooms. Though the direct communication model was followed in our case, problems still occurred. This highlights that while physical delays in communication can impact the project, there is also a gap in the understanding of the requirements for the different disciplines, a finding also noted by Burnell.

Unfortunately, one group experienced a complete split between the interface and software designers. The software design students from the group initially approached the teaching staff for advice as the interface designers were not responsive to their input and they could not arrange a common meeting time. The students were encouraged to resolve their problems, with no direct interference from teaching staff. The communication issues however were not resolved and the software design students decided to "go it alone". In the end the interface designers of the group produced their own visual prototype, whilst the software designers designed and produced their own different working prototype. Although these prototypes featured some interesting and novel ideas, the absence of input by the full spectrum of disciplines meant they were incomplete. The software designers missed key useability issues whilst the interface designers lacked a clear idea of how to implement their design. As Goff et al. (2006), found, whilst a group's perceptions of team quality, such as working well together, leadership, and confidence tend to be similar for both multidisciplinary and single discipline groups, multidisciplinary teams produce higher quality designs.

Discussion

The students experienced mixed success with their management strategies. In order for us to evaluate the experience as part of the staff reflective management stage, several sources of data were used. All students participating in the project were invited to complete an anonymous on-line survey. This instrument included a general question about the student's level of participation, and asked them to list three things they liked and three they did not like about the project. Ten responses were received, but six of these were from members of the winning group, highlighting their engagement with the project.

Regarding selection of group leader, there were two interesting comments. From the winning group: "I volunteered to be the interface design team group manager because my high standards and previous management experience made me the best choice...". This contrasted with another group leader who wrote: "I was told that it had been decided that I was group leader, and so I felt I had to try, even though the unit was not what I wanted". The experience and motivation of the group leader might partly explain the difference between groups.

The inclusion of multiple disciplines in the project was listed both as a factor that made the project worthwhile, and also in the category of things the students didn't like about the project. Nine out of the ten responses to the item asking for aspects that made the project worthwhile featured something relating to the multidisciplinary nature of the project. Students appreciated "practice working in a multi-discipline team" and seeing "…different people's ideas about coming up with a solution".

In talking about negative aspects of the project, the students were more descriptive. One respondent indicated that as only one group would be selected for installation it was difficult to plan the project. Four respondents indicated issues related to working with another discipline. The separate scheduling of different discipline units was highlighted as one barrier to planning meetings, thus increasing the time taken to coordinate the multiple weekly meetings that resulted. Two respondents indicated that it was unclear what the requirements of the other units were: "thus the clash of ideas would occur quite often".

On the one hand, these issues appear to be shortcomings of the unit, but on the other they provide great experience in managing the situation. In fact, Burnell et al (2002) state that these kinds of issues should be experienced by the students in order to simulate an authentic industry experience.

Nevertheless, one possible solution to alleviating communication issues is the introduction of tools that let multiple disciplines express ideas free of their own specific jargon. In a unit on tangible interface design, taken by a mixture of engineering, art, and social science students, Shaer et al (2009) used a visual modelling language – TUIML. The language was used to describe tangible user interfaces using technology independent diagrams. Introducing such a language would add some overhead to the course but may be worth the benefit.

In addition to data obtained from the survey, one of the deliverables for the Software Design class included a post-mortem report. In this report the students were instructed to write about things that went right and things that went wrong. Fifteen of these reports were submitted most written individually, but one group elected to write a single one for their project.

Though the software design post-mortem was completed only by people undertaking that unit, the responses mirrored those seen in the anonymous survey. The winning group all listed 'working together' and 'communicating with the interface design students' under the 'things that went right' heading, whereas the team that split along those discipline lines all decried their lack of communication with interface designers in the 'things that went wrong' section.

From their positive comments, the project also allowed teams to bond: "we even stayed at university till 3am … this game [sic] us opportunities to know each of the group members more and become good friends … this in a way helped to finish off the project successfully". Another team reported going camping during the mid-semester break and enjoying "late night dinners" which "helped improve team relations and team morale".

We plan to make several improvements to counteract the shortcomings experienced in this iteration of running a multidisciplinary student project. More work needs to be done to make students of different disciplines aware of each other and their capabilities. This can be achieved by providing an introduction to the discipline during class time, and it would be useful to run some combined classes at the start of semester where students get an overview of the requirements of each unit. These combined classes would also be useful in introducing the students to each other, so that they would be in a better position to choose their groups.

Unit timetabling is another issue that can be addressed. Running units separately, but on the same day would, from student feedback, make it easier for students to find a common meeting time. This would in turn lessen the number of single-discipline and thus improve the team cohesion.

Lastly, a true remedy to communications issues may only lie in experience. Schaffer et al. (2010) showed that experience in multidisciplinary teams increases the student's confidence allowing them to better gauge team member's skills and engage in discussions. Hopefully from their experience, our students will find subsequent multidisciplinary projects easier to manage.

Conclusion

Overall, students enjoyed the experience in working with multidisciplinary teams and could see the benefit of the experience despite the problems they encountered. Due to accreditation requirements, multidisciplinary work is bound to play a larger role in future curriculum development, and instructors need to be prepared. From our results, the key seems to be in designing the project structure to allow easy communication between students of different disciplines. This includes adjusting class schedules so that all group members can be on campus at the same time. Traditional 'team bonding' activities – such as meals and going camping were also indicated by students as helpful, though such things are typically up to the students own initiative and hard to introduce formally into a unit. Lastly, a mutual understanding of the disciplines involved in a project is also a requirement for success. The team with the best communication strategy won the day, whilst the team that split along discipline lines produced two solutions, neither of which could fully meet the requirements.

References

ABET Engineering Accreditation Commission, (2010). Criteria for Accrediting Engineering Programs, Accreditation Board for Engineering and Technology (ABET), retrieved from http://www.abet.org/Linked%20Documents-UPDATE/Program%20Docs/abet-eac-criteria-2011-2012.pdf.

Burnell, L.J., Priest, J.W., & Durrett, J.R. (2002). Teaching distributed multidisciplinary software development, *IEEE Software*, September/October 2002, pp86-93.

Goff, R.M., Terpenny, J.P., Vernon, M.R., & Green, W.R. (2006). Evolution of student perception in a human centered interdisciplinary design project, *Proceedings of the 36th ASEE/IEEE Frontiers in Education Conference*, San Diego, California.

Ivins, J.R. (1997). Interdisciplinary project work: Practice makes perfect?, *IEEE Transactions of Education*, 40(3), pp179-183.

Jaccheri, L., & Sindre, G. (2007). Software engineering students meet interdisciplinary project work and art, *Proceedings of the 11th International Conference on Information Visualization*. Zurich, Switzerland.

Kim, K., & McNair, L.D., (2009). Work in progress – flexible learning environments to improve interdisciplinary creativity and team interactions, *Proceedings of the 39th ASEE/IEEE Frontiers in Education Conference*, San Antonio, Texas, 2pp.

Lovejoy, W.S., & Srinivasan, V. (2002). Perspective: Ten years of experience teaching a multi-disciplinary product development course, *The Journal of Product Innovation Management*, (19), pp32-45.

Sass, E.J. (1989),Motivation in the college classroom:What students tell us, *Teaching of Psychology*, 16(2), pp86-88.

Schaffer, S.P., Chen, X., & Oakes, W.C. (2010). Work in progress – measuring cross-disciplinary team learning in undergraduate project teams, *Proceedings of the 40th ASEE/IEEE Frontiers in Education Conference*, Washington, DC. 3pp.

Schmalz, B. (N.D.). UBW32 (32 bit PIC32 based USB Bit Whacker), retrieved from http://www.schmalzhaus.com/UBW32/

Shaer, O., Horn, M.S., & Jacob, R.J.K. (2009). Tangible user interface laboratory: Teaching tangible interaction design in practice, *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*, 23, pp251-261.