Managing Increasing Complexity in Undergraduate Digital Media Design Education: The impact and benefits of multidisciplinary collaboration

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Abstract
Increasing complexity is one of the most pertinent issues when discussing the role and future of design, designers and their education. The evolving nature of digital media technology has resulted in a profession in a state of flux with increasingly complex communication and design problems. The ability to collaborate and interact with other disciplines has recently been strongly articulated as an imperative skill for the future designer. How the education of such a designer is facilitated in practice is less well defined. The implementation of authentic problem-solving processes that introduce design students to workplace realities is often missing in design education. In order to manage the increasing complexities of design problems and technology a learning and teaching approach that facilitates the interaction of multiple disciplines was implemented and trialed over a period of two years in an undergraduate digital media design programme. This approach, known as the POOL model framework, is based on a 'pool' of resources and people to be applied as needed when responding to complex design problems. This paper focuses on the extent to which complex interactive design projects can be managed through multidisciplinary collaboration. Feedback from students and educators is presented and which reveals that the framework does provide an opportunity for students to resolve complex design and technological problems and contribute to project outcomes that could not be achieved when working individually.

Key words
multidisciplinary collaboration, digital media design education, POOL Model framework, alternative learning and teaching approach

Introduction

Increasing complexity is one of the most pertinent issues regarding the role and future of design, designers and their education. Our lives have become more complex; interconnectedness has facilitated the building of a global society, greater awareness of systems and their dynamics in a rapidly changing world (Sanders, 2003; Davis, 2011; Malouf, 2011). According to Barnes-Powell (2008:378), the 'two momentum trends of this century are growing complexity and increasing rates of change'. Advancements in digital technology can be directly linked to these developments (Malouf, 2011). The design industry has undergone significant change since the introduction of the computer and the emergence of interactive digital media. The widespread growth of the Internet has created a wealth of new areas in which designers are engaged and has also transformed their work, creative processes and role. Early on, it was argued by commentators such as Nelson (1995), McCoy (1998) and Viemeister (2001) that a new breed of designer was required to manage these new and technologically complex media forms. Indeed, Heller (2001:ix) noted that 'a new designer is needed to orchestrate and construct the future'.

Designers now need to be able to navigate within a shifting economic, social, cultural and technological landscape; design and communication problems have become increasingly complex. They are often part of larger systems, with design solutions required to be effective on more than just a component level, but for 'a group of interacting, interrelated, and interdependent components that form a complex and unified whole' (Pegasus Communications, 2012). Problem-solving today often includes a multitude of other disciplines (e.g. Cullen, 1998; McCoy, 1998; Kerlow, 2001; Kelly, 2005; Whyte and Bessant, 2007; Dubberly, 2011; Hunt, 2011) and 'boundaries between design disciplines are more fluid' (Icograda, 2011:8), thus resulting in the growth of interdisciplinary knowledge. This situation is challenging for designers because in this 'complex, changing professional environment…design involves more skills and knowledge than one designer can hope to provide' (Friedman, 2000:21). Indeed, the profession of a digital media designer has altered considerably in just a few years and a contemporary designer should 'focus on the distinctive areas where their skills will make a contribution and allow other specialists to take primary responsibility for others' (Whyte and Bessant, 2007:15). In fact, according to Whyte and Bessant (2007:15) it is '[t]his collaborative approach to design [that] will be particularly relevant in some areas as the design of multi-technology products is simply too complex for an individual to comprehend'.

While work processes in the design profession have changed from a solitary approach to working as part of collaborative and multidisciplinary teams, in design education such methods are rare, particularly at undergraduate level. Design educators seem at times oblivious to the context today's designers are operating in and what design graduates need to be prepared for (60Sox, 2009; Bennett, 2009; Design Victoria, 2009;

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Rothstein, 2002; Canniffe, 2011; ISIS, 2011). While collaboration and interaction with other disciplines is increasingly articulated as a key skill for a designer (e.g. Heller and Talarico, 2011; Hunt, 2011), the means of educating such a designer is less well defined. VanPatter (2010) argues that '[a]s early as 2002 many of the need for change signals were there [yet] many design education institutions ignored them for as long as possible'.

In fact, professional design bodies and design practitioners are increasingly alarmed by the gap between what is taught in design education programmes and what is practiced. Davis (2011:73) argues that '[c]omplexity is an essential characteristic of our present context and it has serious implications for what and how we teach'. Reports continue to emerge suggesting that digital media design graduates are not sufficiently prepared to enter the world of work (Ball, 2003; Design Council and Creative & Cultural Skills, 2007; Whyte and Bessant, 2007; 60Sox, 2010; ISIS, 2011). If digital media design graduates are not sufficiently prepared to tackle today's complexities, what can be expected of them in the future?

The increasing complexity of digital technology and the digital media designer

Buchanan (1992:19), in his paper 'Wicked Problems in Design Thinking', raised the fact that technology was regarded by people 'as things and machines, observing with concern that the machines of our culture often appear out of human control, threatening to trap and enslave rather than liberate'. While digital technology and its rapid development are still often regarded as confronting, the notion of technology being abstracted or 'out of human control' has been challenged. Digital technology has become so intertwined with the post-industrial world that it is seen as an enabler–to communicate, to access knowledge, to deliver entertainment and to an enhanced lifestyle. The profession of the digital media designer is inextricably linked to technological progress, using it to create these enabling services, products and applications. However, the evolving nature of digital media technology has created a digital media design profession in a state of flux (Kerlow, 2001; Davis, 2005a). Mobile devices, for example, turned into 'a channel for delivering communication, services and media' (McMillan, 2009:28), which is a new paradigm with its own set of rules and a design language still to be fully developed (McMillan, 2009). New opportunities are currently emerging for the digital media designer, with immersive systems being developed, promising users 'the same sensations from simulated environments that they would have from physical ones' (Colucci, 2011:66).

Digital paradigms and potential new areas for designers to engage in have been largely driven by an interdependent relationship between design and information technology (IT). The sophistication of the IT components driving many digital media projects requires specialised expertise beyond the capacity of any one individual (Cooper, 2001; Kacmarek, 2001; Womack, 2005). Websites 'have evolved from simple "brochureware" to sophisticated "megasystems", and this logical progression has led to the challenge to successfully develop complex Websites' (Waltuch, 2001:154). This increased complexity is illustrated in Figure 1.

As Figure 1 shows, not only is website production now increasingly complex, but the area of digital media design now contains several areas of expertise, each a discipline in its own right. The cast of contributors extends beyond digital media and/or graphic design to include a diverse range of expertise such as information architecture, software engineering, research and theory, business strategy and content production—as well as digital photography, illustration, 3D model making, musical composition, performance and other allied creative disciplines (Nelson, 2001). Specialists from other areas such as 'communications theory…, including semiotics, but also cognitive and perceptual psychology and strategies from the social sciences and cultural anthropology' (McCoy, 1998) are also often involved in the development of interactive digital media design solutions.

Kacmarek (2001) described this shift of collaboration from a vertical to a more horizontal approach. Indeed, the increasing complexity of many digital media projects now demands collaboration between digital media designers and information technology experts. Dubberly (2011:80) describes this changed relationship:

> A designer's relation to a printer is very different than a designer's relation to a programmer. In both cases, a designer may develop a specification, but both the specifications and proceeding steps are very different. Printing is all about reproduction and requires little invention from the printer; programming has almost nothing to do with reproduction and requires a lot of invention by the programmer. Consulting your printer during design is a good idea; consulting your programmer during design is a necessity.

Commentators today reiterate the collaborative and flexible nature of the digital media design process. For example, Friedman (2012:143) states that designers work in 'transdisciplinary teams whose nature and constituency

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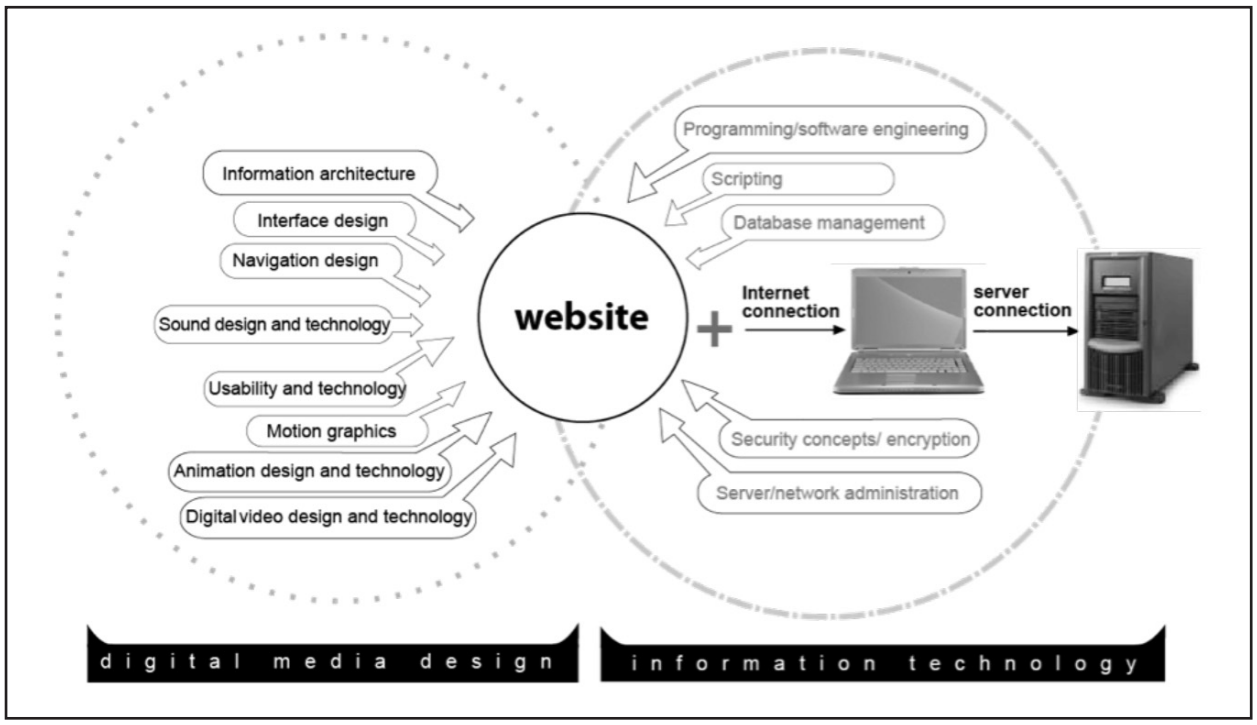

Figure 1. Specialised design and IT knowledge domains involved in creating a website with e-commerce functionality.

changes according to the project at hand'. This is, complex design scenarios today cannot be resolved by one person or discipline alone.

Is education capable of managing increasing complexities in digital media design?

Change typically occurs faster in industry than in education (Marshall and Austin, 2004; Davis, 2005b), 'making it difficult for education to keep pace with the world of work' (Marshall and Austin 2004:102). This scenario, according to DiPaola, Dorosh and Brandt (2004), leads to 'shortfalls and inadequacies in the education students receive. The skills they need to effectively work in professional practice are not necessarily the ones that are emphasized'. Heller (2005:128) echoes this view, stating that undergraduate students 'are not entirely prepared (or confident) to function in a world of integrated practice and advanced technology'. Scholz (2005) argues that design education requires a flexible curriculum. Latham (2002:829) agrees and argues for 'design programmes that are flexible and adaptable'. Longhauser (2005:125) states that it is the 'responsibility of design education to take a leadership role and develop a narrative that remains relevant regardless of evolving fashion and technological advances'.

For design students, learning in an ever-changing digital media environment can be demanding, because of the extensive use of hard- and software in digital media design and the time it takes to acquire technical skills (Heller, 2005). Information technology (scripting and programming) is a component of most interactive digital media design projects. While Reed and Davies (2006:183) explained that authoring software such as Dreamweaver and GoLive allowed 'designers to move directly from a mocked-up design to a finished and coded layout with only a rudimentary understanding of the underlying code' when creating websites, the reality is that the 'rapid deployment and development of dynamic online content…has brought coding back into the design classroom'. This was recently reiterated by Amiri (2011:201), who explains that the 'code-less approach to developing interactivity is no longer sufficient to meet the sophistication that people and the industry have come to expect from interactive digital artefacts'.

Consequently, design students would initially have to learn and master a variety of software, video and sound compression technologies, as well as programming and scripting, before engaging in the creative idea-finding process. They will arguably be overwhelmed by the technical and technological skills required of them before they are able to start designing (Maeda, 2002; Amiri, 2011). Although Maeda (2002) and Amiri (2011) argue that design schools should enable students to learn both

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design and programming skills, others (e.g. Weiman, 2001; Zee, 2001) believe that developing a basic understanding is sufficient. In fact Young (2001:66) sees the advantage of design students working 'much more closely with the programming team members … [in that it] allows designers to communicate more intelligently and to have much closer collaborations'.

Flexible and responsive digital media design education

As part of developing the principles for an alternative learning and teaching framework, an extensive review of literature and research into the practice of design education and the nature of the digital media design industry was conducted and which has been reported previously (Fleischmann, 2010). These foregrounding investigations were conducted so as to create a framework intended to enhance the employability of digital media design students. In order to provide authentic processes in problem-solving and/or product development in design education, the framework is based on the interaction of multiple disciplines, in order to enable students to solve complex problems collaboratively. At its core, and to facilitate a flexible curriculum design, the learning and teaching approach is based on a 'pool' idea, defined as a group of resources or people to be used when needed.

Thus, the POOL Model framework consists of a teaching and a learning pool containing specialists from diverse but connected disciplines. In the teaching pool, educators work collaboratively to define a problem or project for students in multidisciplinary teams. Stakeholders external to the university are also part of the teaching pool, including industry professionals, community clients, advisors, experts or sponsors. In the learning pool, students from different disciplines form teams to solve a defined problem or produce a project collaboratively. The composition of the team will depend upon the presented problem/project. While working in these collaborative multidisciplinary teams, a student will gain insights into, and develop an understanding of, other disciplines. Additional time will be used to concentrate upon discipline-specific skill development while experiencing a more holistic and efficient approach to solving complex problems or completing projects. Figure 2 provides an illustration of the POOL Model framework in action.

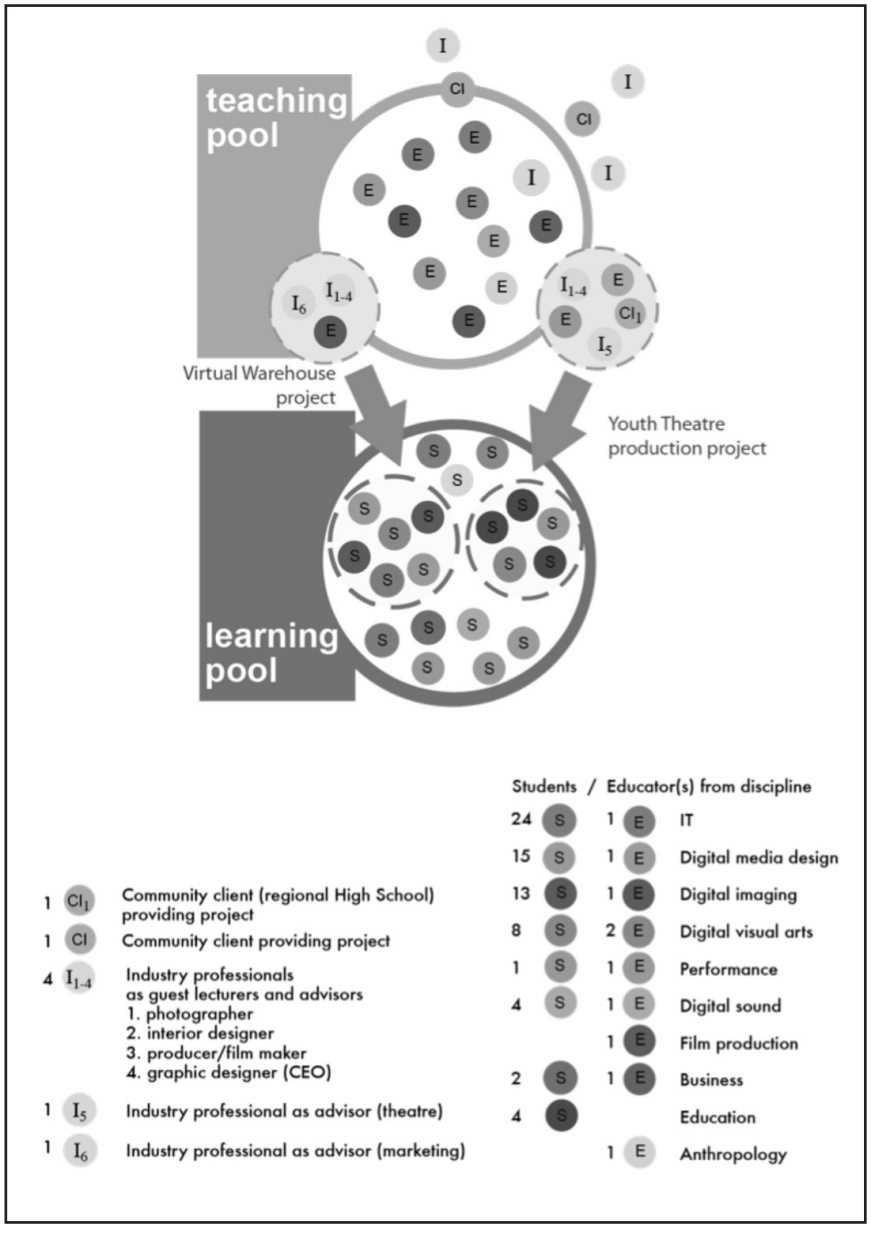

Figure 2. POOL Model framework (subject trial CXC Trial B).

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Implementing the POOL Model framework in an academic environment

The POOL Model framework was implemented at a medium sized regional Australian University within a three-year undergraduate degree programme titled Bachelor of New Media Arts. As well as majoring in digital media design, students choose a minor or another major (double major) in digital imaging, digital visual arts, digital sound or

Subject trial/ Study level	**Feedback mechanism** at the end of project (week 13)	**No. of student feedback participants**	**Response rate (%)**
Trial A/Trial B		**Trial A/Trial B**	**Trial A/Trial B**
Web 1 2nd year digital media design	**Online questionnaire**	20/32	59/63
	Focus group interviews	**11 teams; 42 students** (disciplines: digital media design, IT)/ **20 teams, 95 students** (disciplines: digital media design, IT, multimedia journalism, business)	74/92
Educator	**Interview**	1/1	N/A
Web 2 3rd year digital media design	**Online questionnaire**	28/18	90/90
	Focus group interviews	**8 teams; 48 students** (disciplines: digital media design, IT)/ **9 teams, 48 students** (disciplines: digital media design, IT)	94/96
Educator(s)	**Interview**	1/2	N/A
Industry professionals	**Interviews**	0/1	N/A
CXC 3rd year digital media design*	**Online questionnaire**	29/22	97/79
	Focus group interviews	**13 teams, 44 students** (digital media design, IT, digital imaging, digital visual arts, performance, digital sound)/ **11 teams, 45 students** (digital media design, IT, digital imaging, digital visual arts, performance, digital sound, business, education)	92/90
Educator(s)	**Interviews**	8/8	N/A
Industry professionals	**Interviews**	6/6	N/A
* includes students majoring in digital media design and students with a double major in digital media design.			

Table 1. Data gathering methods applied to explore perspectives of students, educators and external stakeholders.

Question	Answer	Web 1 A	Web 1 B	Web 2 A	Web 2 B	CXC A	CXC B	Total no of responses	Total %
Do you think your project has benefited from working with students of other disciplines?	Yes	95% (19)	88% (28)	86% (24)	94% (17)	100% (28)	100% (22)	138	93.2
	No	5.0% (1)	12% (4)	14% (4)	6% (1)	0% (0)	0% (0)	10	6.8
No of participants, n=		20	32	28	18	28	22	148	100

Table 2. Digital media design students' reflections on the benefits of the multidisciplinary approach on project outcomes.

performance. Whether students choose a second major or a minor, they develop basic skills and an understanding of another creative arts discipline.

The following three subjects from the digital media design major were selected for application of the POOL Model framework: Web Authoring 1–an introductory web design subject (Web 1), Web Authoring 2–an advanced interactive media design subject (Web 2) and Creative Exchange Project–the production of a major creative project or large scale published work (CXC). These three subjects were identified as suitable to trial the POOL Model framework because of the nature of the projects that students would work with, and in particular, the opportunity to develop more advanced and realized outcomes. Each subject involved three hours of contact time per academic week (totalling 39 hours over the semester). Weekly contact time typically comprised a one-hour lecture and a two-hour practical session in a computer lab, with the latter focused on ideas generation and collaborative problem solving. Students are expected to study independently for an additional seven hours per subject per week.

Methods applied to explore the impact of the POOL Model framework

This research study was framed by a pragmatic approach (Punch, 2009) and methods that best helped to answer the following research question (Johnson and Christensen, 2008; Punch, 2009; Teddlie and Tashakkori, 2009): to what extent can the complexities of today's interactive digital media design projects be managed through multidisciplinary collaboration in undergraduate digital media design education? With pragmatism rejecting the incompatibility of mixing qualitative and quantitative research methods, a parallel mixed design (a single-phase design in which researchers implement the quantitative and qualitative methods at the same time or with slight overlaps) was applied. This would provide insider and outsider viewpoints (Johnson and Christensen, 2008); 'offer depth of qualitative understanding with reach of quantitative techniques' (Fielding, 2012:124); use triangulation for different data sources (students, educators, industry professionals) and 'allow expression of different facets of knowledge or experience' (Bazeley, 2004:4) adding depth and/or breadth to the study; and use triangulation for data obtained through different methods (questionnaires and interviews), providing corroborating evidence for the conclusions drawn, i.e. validation technique (Bazeley, 2004; Johnson and Christensen, 2008; Teddlie and Tashakkori, 2009).

The study was conducted over a two-year period across three subjects taught in two iterations (Trial A and Trial B), with minor changes made in Trial B reflecting feedback from the initial trial. Overall, an identical approach to data analysis was applied across the trials. Quantitative data were analysed using statistic functions provided by an online survey tool (SurveyMonkey). Qualitative data were coded using the research analysis software NVivo. In some instances qualitative data was quantified.

Participants in the trials who provided feedback included 149 undergraduate digital media design students and 173 undergraduate students from four other creative arts disciplines and from eight non-creative arts disciplines. A total of 25 educators from nine disciplines and 13 creative industry professionals and external industry/community clients were involved. Table 1 outlines details of participants, the feedback mechanism used, the number of participants and the response from each subject trial.

As shown in Table 1, with the exception of CXC in Trial A, focus group interviews yielded higher response rates than questionnaires. Nevertheless, three of the six questionnaires yielded a response rate of 90 per cent or higher. The response rate of educators was positive; 21 of the 25 educators involved (84 per cent) participated in the interviews.

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Student reflections on the impact and benefits of the POOL Model framework

Table 2 presents digital media design students' reflections on the extent to which they felt the projects benefited from a multidisciplinary collaborative approach.

The findings are positive, with over 90 per cent of students acknowledging the benefits of working with other disciplines. To further evidence this finding, qualitative explanations in questionnaires were coded as themes and quantified in terms of the number of times they were referenced by students. The main identified themes, presented in descending order, were:

- having other disciplines on the team is beneficial in order to achieve the project outcome (65);
- project could not have been completed without the other discipline(s) (25);
- created a better and bigger project (25);
- continued to focus on own discipline within multidisciplinary team (23);
- gained insights into other disciplines (18);
- learned to work with others and understand multidisciplinary teamwork process (14);
- having an authentic experience (7).

It is encouraging that not only do students refer to the project outcome as being more developed and improved, but they also support the multidisciplinary process. To further explore this, Table 3 presents the additional findings obtained within focus group interviews.

The findings presented in Table 3 provide further evidence in support of the intended outcome of the framework. What is notable is that the students—regardless of their discipline—were able to identify how the multidisciplinarity of teams facilitated an enhanced project outcome, in that group members could:

- draw on the expertise of others;
- benefit from a complementary skill set or range of skills;
- and create a better, professional, functional and more complete project of higher quality than one produced as an individual or in a single discipline team.

Educator and industry/community reflections on the impact and benefits of the POOL Model framework

Table 4 presents the key themes that emerged in regard to the project outcomes from the coding of interviews with educators (21) and six external clients from the community and industry.

Key benefits Questionnaires (No of references)	Key benefits Focus group interviews extending/confirming view	No of references in focus group interviews		Example of typical comment by digital media design students
		DM Design	Other disciplines	
Having other disciplines on the team is beneficial in order to achieve project outcome (65)	Draw on expertise of others	31	22	It is good because sometimes I can't do something by myself, like the coding, because I'm a designer. But … some of the other group members can actually do code…. You can create more. (Web 1 B)
	Benefit from complementary skill sets or range of skills	23	46	In our particular group we have someone from Journalism, IT and Arts so that gave us a very broad range of skills and knowledge for this particular project. … journalism content creation was quite natural for her, the IT quite natural for him … and we had design, so we had a very big knowledge base. It was very easy to get people to do the things they liked doing in order to come together and complete the project. (Web 1 A)
	Achieve more	21	4	You can definitely achieve more because you have more people with more skills who can do stuff that you can't do. (Web 1 B)
	Benefit from sharing and bouncing ideas around with other disciplines	19	9	It is nice because you can germinate an idea and pass it around and watch it grow. Certainly when you have a good group you can go in unexpectedly good directions. (CXC A)
	Total	94	81	
Project could not have been completed without the other discipline (25)	Other discipline was needed to complete the project	43	24	If Joe, Marlene and I were trying to work out PHP, MySQL data-basing, etc., we wouldn't have a finished project. Without the IT guys we would have something that might look nice but actually won't do anything. (Web 2 A)
	Total	43	24	
Create a bigger and better project (25)	Project is better	20	10	There are people from different disciplines, who have different skills, who can be brought together to make a better project or final outcome. (Web 1 A)
	Project has higher quality	13	6	The project is of higher quality because each person does something they are good at. So it is a high quality project because each part is made by someone who is quite talented. (Web 2 A)
	Project is professional, functional and more complete	12	7	… because everyone has their thing … they are really good at. The project you are undertaking is going to be so much more sophisticated and professional than if you were just a single discipline team. (Web 1 B)
	Project is bigger/more complex	15	10	I basically inputted all my ideas of the promotional stuff, a booklet that goes with it, that kind of thing. It was just going to be a film with a jacket, but I extended that part. I also created an animation, logo design,… It just sort of extended it a little. Just by adding one discipline, it was better. (CXC A)
	Total	60	33	
115	Total no of references	197	138	

Table 3. Coded themes from student focus group interviews that evidence the opportunity to contribute to a product or outcome that could not be achieved when working as an individual or in a single discipline team.

Key benefits	Stated as an outcome in the interviews (no of educators if more than one)			Exemplar comment in support of the intended benefit and outcome
		Trial A	Trial B	
Projects are more developed than could be achieved by a single person/ discipline	Web 1	4	4	The scope and quality of the project was big. They have done things that they would not have done on their own. (Educator, Trial A) Projects had functional, database-driven content … which was connected to the front-end [design interface] in all the websites, …so it was far more than one student or a team of only IT students could have achieved. (Educator, Trial B)
	Web 2	4	4 (2)	Students did integrate XML with Action Script…they did figure out how to use PHP and connect to MySQL. In any other subject that I know of they wouldn't have … worked with all those tools and at the same time had to figure out what the website was going to look like to an end user. (Educator, Trial A) Design students didn't feel limited by their knowledge of the back-end stuff. …the knowledge from those disciplines was shared in such a way that the solutions were possible and of higher quality. (Educator, Trial B)
	CXC	4 (8)	4 (8)	[T]he game project was a good example of people working together on their strengths and contributing from their discipline to create something that was not possible without the investment of time from those people with those particular skills. (Educator, Trial A) You would never see a project produced like this without having those different disciplines working together…You are talking about two music videos, a fully designed, produced, CD-recorded album, … One person simply cannot do that, not at the level of quality that those students produced. (Educator, Trial B)
No of educators, n=	21			
Project outcomes matched client expectations	Web 1	4	4	I was very impressed with many of the projects… (Community Client, Trial A) They were all gorgeous websites. You've got very professional students. (Community Client, Trial B)
	Web 2	X	X	N/A (no client involved)
	CXC	4 (2)	4 (2)	I think we got everything that we would've wanted out of the project. (Creative Industry Client 1, Trial A) I am absolutely delighted with the way it has all turned out..... I can't be more pleased. (Community Client 2, Trial B)
No of clients, n=	6			
Projects could have been more realised or developed	Web 1	4	4	Some projects seem unfinished..... I don't know if they underestimated how much work it was, or they just didn't work well together as a group. It's kind of odd because they say positive things about working together but the final result shows that they didn't work together as well as they could have…(Educator, Trial A) Looking at it I still feel like they could have done more… (Educator, Trial B)
	Web 2	4	4	… had there been more reciprocity I think a lot of the absence of appropriate interaction would have been resolved. (Educator, Trial A) There were a few projects that were flatter and not taking full advantage of the technology. (Educator, Trial B)
	CXC	4	4	I don't think any of the projects were runaway; this is absolute magic stuff. They all had problems within them, some managed more elegantly than others. (Educator, Trial A) If you look at the masses of really imaginative stuff that children's book authors produce..... there are some fantastic models that students could have used. …but they just put a block of justified text and there was no design. …. It's not engaging. (Educator, Trial B)
No of educators, n=	6			

Table 4. Reflections from educators and external clients on project outcomes.

Projects were more developed in subsequent trial	Web 1	-	4	My overall feeling is that we have more exceptional projects. I think our efforts in explaining how design, IT and journalism work together and how it is visible on a website paid off. (Educator, Trial B)
	Web 2	-	4	For the majority of projects the ideas were more interesting than last year. I think the concepts were thought through in a much more interesting way. (Educator, Trial B)
	CXC	-	X	N/A (not specifically identified)
No of educators, n=	2			

Table 4. Reflections from educators and external clients on project outcomes (continued).

It is evident from Table 4 that all educators (21) felt that projects displayed characteristics of being produced in a multidisciplinary team. It can also be seen that educators reflected on the quality of final projects. For example, educators in Web 1 and Web 2 stated that more could have been achieved. Similarly, one educator in CXC, while acknowledging that there was a range of quality in project outcomes, felt that all projects had problems. Nevertheless, the majority of educators in both trials of CXC (14) were very satisfied with the project outcomes. Indeed, one educator in Trial A argued that 'some of it is industry standard, some of it is really innovative, some of it you would happily send anywhere in the world as an example of the type of project that students do' (CXC A).

The largely positive views on project outcomes were supported by external clients from industry/community, all of whom stated that they were very satisfied with the projects and how students had responded to the project requirements. At the same time, the external client in Web 1 A implicitly agrees that there was a range in the quality of final outcomes, stating, 'I was very impressed with many of the projects'. Ultimately, diverse project outcomes are arguably typical when students work on open-ended problems. Indeed, a variety of factors can influence the achievement of project outcomes, e.g., skill and motivation levels of students, teamwork functionality, external client tastes. Finally, it is noteworthy that the changes made to Trial B were regarded as successful by the educators involved, revealing the benefit of ongoing adjustments and enhancements to the framework.

Factors inhibiting the success of projects

A small number of students argued that the multidisciplinarity of teams did not enable the achievement of a more advanced or developed project outcome (n=10, seven per cent). Equally, some educators noted that certain projects were not as well developed as they could have been. In the following sections, both stakeholder groups' perspectives are considered regarding the factors that may have prevented teams from developing projects to their full potential.

Inhibiting factors: student reflections

Table 5 summarises the digital media design students' (n=10, seven per cent) feedback from questionnaires on factors inhibiting the full development of their projects.

Although the number of comments is too small to draw generalisations from, they do illustrate important realities of multidisciplinary teamwork, in that individuals who fail to contribute and lack of communication can be

Key challenges Questionnaires	No of references	Example of typical comment by digital media design students
Different work ethic and lack of communication	7	On paper I do believe that working in a multidisciplinary team is great for design and IT students. But the students I was with in the team lacked motivation… (Web 2 B)
Students of other disciplines were unreliable or not confident in their subject area	6	Theoretically, multidisciplinary assignments work and I strongly recommend this. However, this time I think there was very little benefit... Most of the action scripting was done by the design team and the IT team had very little to do with helping the site function (due to lack of knowledge and will to learn) ... (Web 2 A)
Total no of references	13	

Table 5. Digital media design students' reflections on challenges inhibiting the achievement of a fully developed project outcome.

detrimental to the process. Furthermore, the comments highlight the fact that expectations of some team members may not be completely met and may cause projects to be underdeveloped. However, it is positive that some of these students, while acknowledging challenges within their own experience, still argued in favour of the process and the framework that underpins it.

Inhibiting factors: educator reflections

Although the educators were generally satisfied with the project outcomes, some expressed the view that certain projects needed greater development. Key identified challenges were:

- some students did not pull their weight;
- some groups had team issues, and hence performance issues; and
- some students had a low skill level, and therefore were not able to perform as requested.

These are clearly typical issues involved in any teamwork process, which can be to a certain extent managed through assessment strategies. In terms of the POOL Model framework, students are assessed on their specific disciplinary contribution (assessed by an educator from the discipline) and on their team contribution and performance (e.g. teamwork skills, communication skills and organization skills), the latter evaluated by their peers. The final project mark for each student is also scaled, in order to reflect his or her individual contribution and attitude towards the team. However, although these assessment strategies can minimise team dysfunctionalities–in making assessment fairer as each individual student takes responsibility for their learning and behavior within the team–it nevertheless cannot prevent the fact that students have varying skill levels, diverse creative talent, as well as different level of motivation.

Three educators provided a realistic view of the realities of working with students, exemplified in the following comment:

> Sometimes we are treating students as if they are the experts…but they are not… So being able to say, 'Yes, I can implement that,' and comfortably doing it is probably difficult if they haven't done it before. (Educator, Web 1 B).

The above comment demonstrates a situation which is particular to undergraduate design education, when multidisciplinary collaboration approaches are implemented while students are still acquiring knowledge and skills. In contrast to a capstone and final semester subject where students are asked to integrate the knowledge and skills they have gained during their course of study (as in CXC), in the case of Web 1 and Web 2, students both acquire new knowledge and skills and apply them simultaneously to a team project. Hence, careful planning is required in order to 1) manage the delivery of discipline-specific content, 2) prepare students for the collaborative process and 3) ensure that students develop discipline-specific skills while part of the multidisciplinary team (for a detailed description see Fleischmann, 2013).

Conclusion

The feedback from both students and educators demonstrated that the POOL Model framework enabled digital media design students to contribute to a product or outcome that could not be achieved by an individual or a single discipline team. This suggests that students were able to manage complexities inherent to interactive digital media design projects by utilising a multidisciplinary collaboration approach. Indeed, both digital media design students and those from other disciplines were very positive about this part of the process. Educators, while positive about the potential of the framework, did identify a range in the quality of outcomes and also a varying level of engagement across the teams. Ultimately, the POOL Model framework enables multidisciplinary collaboration to facilitate the production of complex concepts and projects; nevertheless, there is no guarantee that the quality of projects will match educators' expectations, nor those of any external client involved. However, this is a situation inherent in any open-ended project work in design education, and regardless of whether students work as individuals or in teams. At the same time, it was evident that facilitating processes where students can draw on the expertise of others and hence benefit from a complementary skill set or range of skills is an effective way to approach the increasing complexity of technology and communication problems in digital media design.

Overall, the POOL Model framework was developed to respond to the increasing complexities of technology, design and communication problems and to manage them effectively. Facilitating design students' engagement in authentic problem-solving processes and environments that reflect industry practice is one way to help achieve this, as was the premise of the POOL Model framework trials. It certainly became clear during these trials, that if design educators are committed to taking steps to move away from traditional ways of teaching design, then graduates have the potential to be able to design, create and innovate as part of multidisciplinary collaborative teams in contemporary as well as future work environments.

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