ELEARNING AND EMAKING IN PRODUCT DESIGN EDUCATION

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ABSTRACT
Creating proactive learners in design education requires inspiring students to think for themselves, to look beyond the classroom and see the opportunities and challenges in the outside world. As blended learning becomes part of design education, a rise in digital technologies allows an innovative thinking approach to eLearning that includes eMaking. This has the potential to have a transformative effect on learning, making it possible to move to a more collaborative form of learning as students and lecturers explore the possibilities of new technologies together, supporting a change in the relationship of students to lecturers, and a change in attitude to the way students see themselves and their own learning.
This paper describes an example of how an open approach to technology in the classroom, supporting eLearning and eMaking, contributes to the personal and professional development of design students and develops the role of the lecturer in response to current thinking in learning and teaching in higher education.

Keywords: 3D printing, eLearning, digital technologies, eMaking, studio

1 INTRODUCTION

The term eLearning no longer refers to content uploaded onto a server for student access outside the lectures, instead eLearning covers a complex range of interactive learning activities that cross over between classroom, lecture and self directed learning to support the overall student experience. The interaction between learning online and offline is becoming seamless in a combined digital and physical learning environment, as laptops and internet enabled phones make computer-based learning mobile, invading the classroom to support on the spot fact-checking and directed research as well as the recording of activity research and inspiration gathering. For Product Design education, eLearning is changing how students learn, what is brought into the classroom, and more importantly, the relationship of the students to their learning and the role of the lecturer. Even beyond that, eLearning in its fullest interpretation of the term - as placing student learning and the organisation of learning within a global environment enabled by digital communication - changes the relationship of the student to the world, projects to the complexities beyond the classroom, the lecturer to peers and the program to collaboration.
Just as eLearning, in its broadest sense, is breaking down the barriers between learning within individual educational institutions and the global community, so too, within design process education, eMaking as part of an eLearning strategy is breaking down barriers that have developed in Product Design education between the digital and the physical. eMaking [1] refers to the linking of digital making in the studio to a broader approach to digitally based learning. It includes all computer numerically controlled forms of making, such as laser cutting and CNC routering as well as 3D printing, and places them within an eLearning strategy that brings together online, on screen and in classroom learning that uses technology to reconnect the design process and operate within the current context of a web of electronic communication devices, networks and applications.

2 SUPPORTING AN ITERATIVE DESIGN PROCESS

At its most basic, digital making tools, such as 3D printing and CNC routering, enable students to produce a physical model of a concept that is dependent on their ability to computer model in three dimensions on screen, as opposed to their ability to manipulate physical materials in a conventional model making workshop. This changes the relationship of the student both to their computer work and to physical model making. For students coming into higher education more familiar with the virtual environment than the practical, 3D printing, at its most fundamental, helps to develop a connection between screen and reality, and rather than add to the disconnect between students and workshop practice, this has been found to provide a bridge between computer modelling and practical making that supports iterative project work [2].

This is significant, as one of the issues for applied design subjects taught in higher education in recent years, including Architecture and Industrial Design, has been the erosion of traditional studio practice [3] through the division of programs into modules to fit with the way other subjects are taught at university and space is organised and booked. Design process has been fragmented into a design studio practice limited to drawing and cardboard modelling, with a separate workshop practice and separate computer modelling courses run as parallel modules. The subjects are then taught in very different spaces and usually treated as separate for assessment until the final year of study when they come together in major project work. In some universities, workshops are becoming less accessible for the exploration of materials, structures and processes, and even for design development, and restricted to a role in final project outcomes in a documentation process, rather than as a developmental tool. This can be particularly the case for the larger first year cohorts, and this distances students from making as part of their process in the most formative part of their study. It is in the first year where design process is introduced and practices inculcated in the student and the culture of the discipline established, to be built on for the rest of the degree. As designing is an iterative process, students need to learn to explore and develop their ideas through research, drawing and studio model making as a whole right from the first year and that includes computer based modelling as a design tool, not as the documentation tool it used to be - computer based modelling needs to be integrated into design process and studio learning as much as the other design development tools [4].

2.1 Organisation of space

The first year 3D design studio at Griffith University has been reorganized to respond to the concept of eMaking as part of a broader eLearning strategy. At its most basic, the approach aimed to reconnect studio, CAD and workshop, with assessments running across modules and the physical space organized into group working pods, called ‘digipods’, that provide workspace for drawing and studio model making in amongst high end computer modelling software and digital fabrication technologies, in particular 3D printers for everyday use.

Figure 1. Organisation of space into ‘digipods’ where students can work iteratively between screen, conventional design studio practice and prototyping

The workspace meets the needs of those designing now so group work and Internet based communication are essential and constant access to resources on the web and online learning content is a practical requirement. Ramsden suggests that, “a focus on collaborative, supportive and purposeful leadership for teaching is associated with a culture of strong teamwork and student-focused approaches” [5]. By creating studio table space and floor space around the idea of a ‘digital pod’ students can work seamlessly between group discussion, drawing, digital recording and documentation of process, sketch modelling, online research, computer modelling, and digital fabrication, in an iterative learning cycle that moves their design thinking forward with more self determination. This new form of digital design studio places the student very much in the centre of their own learning with the facilities to work iteratively both on their own designs and in groups.

3 STUDENT CENTRED LEARNING

3.1 Connecting to learning

At the centre of bringing an eMaking strategy into the Product Design studio, is the lecturer relinquishing control in the classroom to allow the student a greater level of empowerment, as advocated in Weimer's book: Learner-Centred Teaching [6]. This is not solely focussed on the practical aspects of model making in the classroom, or even its role in integrating design process, but rather that new classroom strategies maximise the current worldwide developments to create essentially 'flipped' classrooms through eMaking as part of an open eLearning strategy that changes the relationship between the student and their own learning. It also changes the relationship of the lecturer to the learning experience, with the shared experience of exploring rapidly changing 3D printing developments on the Internet that are new to the lecturers and the students potentially reinvigorating the studios. This could contribute to addressing a sense of disconnection experienced between some students and lecturers that Race identifies as a reason for student attrition in the first year of University [7]. It could also potentially improve lecturer morale as educational research into relinquishing control in the classroom with courses developed formatively through collaboration between lecturers and students has shown that there are benefits for both from the unpredictability of the experience. For the lecturer, abandoning 'flight mode' for phones, iPads, and laptops and instead actively encouraging students to use electronic devices to check references live during a lecture, or allowing time for students to find related references during a discussion, as well as using active web sites over powerpoint slides does require confidence and a willingness to allow preplanning to be derailed by the students themselves, but the result can be a motivated student cohort and stimulating learning environment.

3.1.1 Flipped classrooms in design learning

This strategy is arguably more important for students studying design subjects than for many other subjects, as the very nature of their work on graduation involves directing new practice. Graduate attributes for designers need to include the ability to direct their own learning for the lifelong learning approach that will be necessary for them to keep up with developments in their profession, and to manage their own learning with skills in mapping, researching information, dissemination and the application of new knowledge to design development tasks.

A 'flipped classroom' approach is a form of blended learning, where students research a topic in their own time, then the time within the classrooms for synthesis, rather than lecturer led dissemination [8]. However, unlike conventional flipped classroom learning, where the lecturer provides material on the university server for the student to download and study prior to coming to the classroom, in this scenario the student provides the study material and brings it to the classroom to share with peers and the lecturer – and 3D printing is a particularly useful tool in supporting this change of practice for Product Design education at the moment. This is for two reasons. The first is that 3D printing is creating such an impact across a myriad of applications that information is coming in too fast for a lecturer to keep up, meaning that a student is well positioned to be able to bring new information to the class, which is an empowering experience and the second is because the development of web 2.0 over the last ten years has led to an interactive networking system that is constantly refreshed that the digital natives (referring to those born after the spread of the internet around 1995) are very well versed at operating within.

Design graduates will work on projects that by their very definition are new each time. Creating proactive learners who base their work on researched information and considered opinions is essential for the discipline. Introducing 3D printing into the studio significantly contributes to this (at this time) if the lecturer fosters a broad eLearning approach, encouraging online research, interaction, and discussion. Formerly information around the study of a particular technology was researched and organized by the lecturer and the studio was based on the resources and research directions the lecturer provided. Because of this, the lecturer would be familiar with all the information and resources and have chosen what to include and what to exclude. This meant that student questions could largely be anticipated and prepared for. As the discipline is an applied one, many Product Design lecturers have an industry background in the design of commercial products for mass production, using conventional technologies such as injection moulding, that they can draw on in any classroom situation. They bring to their role the accumulated knowledge of their industry experience, their own learning experiences – predominantly studio based project learning – and accepted conventions for designing for production practices that have been building since the industrial revolution. However, whereas previous technologies added an additional chapter to previous practice, 3D printing is forcing a rewrite of the entire designers manual. Experience in a previous technology does not, in this case, inform practice in this one, and the underlying principles for mass production and business practice do not apply. For most lecturers, their professional development in response to additive manufacturing technologies is happening alongside the students' learning. There are only a few authoritative publications on 3D printing and its broader implications, such as Gibson et al [9], Anderson [10] and Gershenfeld [11], whilst the pace of change in industry and research at this time, taking printing into metals and polymers in applications as diverse as aeronautical and watchmaking, mean that the lecturer has to strive alongside the student to keep up to date. The reality is that the impact of the technologies across the board means that no single lecturer at this time can maintain an expert status in all applications, from medical to architecture and it is therefore more effective for learning on the subject for lecturers to encourage students to extend their learning outside the classroom and report back. This changes in the student/lecturer relationship with the students providing information as much, if not more, than the lecturer. Because of this, the lecturer will often be meeting the topic for the first time during the class, along with the other students – questions cannot be vetted, subjects that might have been steered around are difficult to avoid, conflicting reports will need to be challenged and discussed in class. For this to work, the lecturer has to be willing to change roles from leader to mentor / facilitator. The student is more likely to develop an attitude towards self-education conducive to lifelong learning, considering the lecturer a mentor rather than leader. An additional potential benefit of this approach is the lecturer can be as stimulated by the learning activities as the student, with the relationship between students and the lecturer positively affected by the shared experience that Race encourages lecturers to foster [12].

3.2 Connecting to the global environment

As much as the role of the lecturer moves towards that of a mentor as students bring knowledge into the classroom, so it can be moved further by the lecturer embracing additional Internet based opportunities to provide the Product Design student with feedback form external sources. For example, students working with 3D printing can be encouraged to upload their designs to an online service provider, such as iMaterialise or Shapeways, to test their designs for prototyping independent of the lecturer. The print needs to work within the constraints of the appropriate additive manufacturing technology, the material choice and the design (clearance etc), or the print will be rejected, as shown in Figure where the wall thickness in the seams of the model were insufficient.

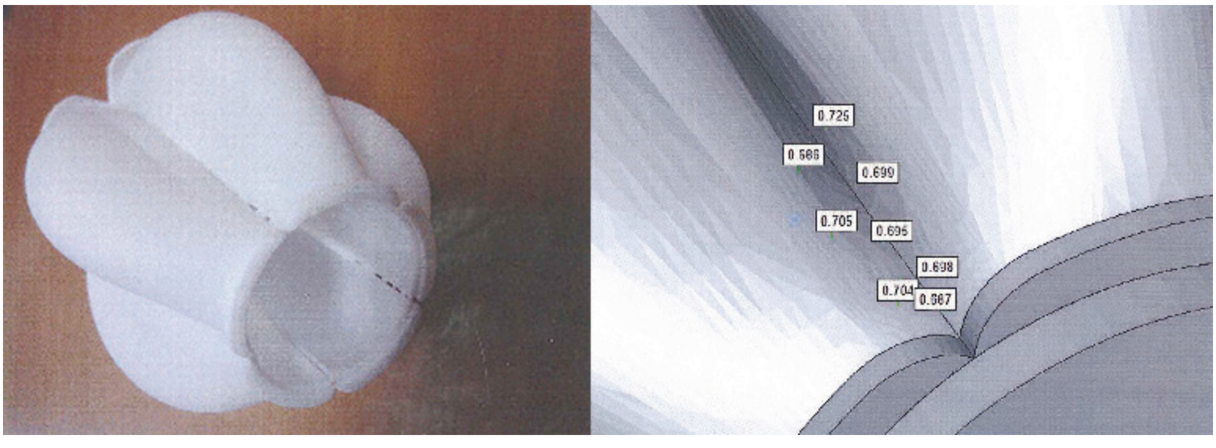

Figure 2. Print failure report from Shapeways showing insufficient wall thickness in the seams

The student can refine the data and resubmit, independent of the lecturer. This significantly changes the relationship of the student to the lecturer and to their own learning as the student learns about the constraints or advantages for their own design before the lecturer. If the part file fails, the student gets that feedback from an external source and works with the lecturer to fix the problem, rather than submitting to the lecturer for assessment.

In addition to external, practical feedback, the study of 3D printing takes student learning outside the studio and into the global digital environment, opening up learning opportunities that contribute to changing the student's perspective. For example, 3D printing provides a new starting point for addressing the current sustainability imperative if it is considered in relation to moving from mass production to mass customization and distributed manufacturing. Hugh Aldersley-Williams, in the RSA 'The New Tin Ear: Manufacturing, Materials and the Rise of the User-Maker', described the industrial revolution as a 'temporary interlude' to be replaced by mass customisation through 3D printing [13], which provides an interesting teaching tool for Product Design as, if it happens, all products will need to be redesigned for the new production methods and, with digital communication and mass customisation, the entire way design is organized and products distributed will have to be rethought, taking into account the interconnectedness of the digital and the physical. Lectures and students will together have to learn new ways of thinking about design, production and distribution, new interactions with users and new skills to meet the increasingly digital online global environment. Bringing 3D printers, and related learning on the context for changing design and production through 3D printing, into the first year design studio as eMaking within an actively eLearning approach, begins the development of students who can work freely between screen and reality, digital communication and production and understand the global contexts of their work and its impact - in its broadest sense - on the world.

3.3 Connecting to issues

The impact of 3D printing as a transformative technology, in that it changes what is possible and how things operate, and if studied as part of an eLearning strategy, it allows the lecturer practical opportunities for project work that bring in a study of contemporary issues. Intellectual property rights in relation to 3D printing is an example, product liability is another. The impact of 3D printing – if Aldersley Williams is right – on urban planning, jobs, transport. There are a myriad of implications that arise from learning strategies that bring the online and offline together through 3D printing, with the potential to 3D print plastic guns and at the same time, replacement kidneys. Bringing this area of study into the classroom allows the lecturer to encourage the student to explore philosophical and ethical issues within project work. For example, in the project shown in figure 3, the student was interested in the use of biomaterials to create a scaffolding for a damaged heart that was 3D printed to allow the patient's own cells to grow around it. The student suggested the potential to then alter the structure of a functioning heart and worked with a pathologist and cardiologist to develop and 3D print a provocation piece for discussion on the ethics of human engineering research.

Figure 3. Heart provocation models by MA student Kaecee Fitzgerald (a) 3D print from the CAD model; and (b) 'Double pump' heart in action showing flow

4 CONCLUSION

Leonardo Da Vinci advocated that in studying science, it was important to develop a 'complete mind', and to realize that 'everything connects to everything else' [14]. Over the last ten years this became much clearer to Product Designers as sustainable design encompassed full lifecycle analysis, but meanwhile a predominantly modularized system of learning was fragmenting the design studio experience and the individual design programs were mainly taught in isolation within academia – even from peer academic institutions. Practicalities prevented the web of communication and interaction that is characteristic of real world design process as a whole being echoed in the learning experience. However, the emergence of Web 2.0 and additive manufacturing is starting to provide an opportunity for design education to be the interconnected experience that it is in the reality of good design as a practice. As the barriers between screen and reality are breaking down in the classroom, so are the barriers between the classroom and the real world, between design institutions globally, and in relation to understanding the complexities of design with respect to society, the environment and economics and the impact of this understanding of educational practice and the student's understanding of themselves as designers.

"When teachers want students to enhance their human interaction capabilities, they have to find ways to help them become more self-aware and other-aware in relation to the subjects being studied" [15]. In design education, the development of proactive, lifelong learners who understand the role of design in the operation of world affairs and the potential impact of their decisions, however small and isolated they may at face value appear, on people and place is paramount because of the cumulative effect of incremental change [16]. By embracing an eLearning strategy in its most ambitious sense, with eMaking embedded, lecturers are able to finally break Product design education out of the silos of university conventions of teaching and put it back into the centre of everything, where it necessarily must be in order to genuinely work within the complexities of a global society and meet needs of people and place for future generations.

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