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Embedding Universal Design at the Core of a Computing Degree Programme: Key Challenges Faced and Lessons Learned

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Embedding Universal Design at the core of a Computing Degree programme: key challenges faced and lessons learned.¹

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1. Abstract

Over the past three years, DkIT has embarked on a program to embed Universal Design as a core learning outcome within its Level 8 Computing Degrees. The key instrument in this initiative has been the development of a new *Universal Design Project* module, which all students must take in third year (Semester 5). Furthermore, Universal Design principles have been thematically embedded into existing UX and interaction design modules as well as within the final year Team Project modules (Craddock et al. 2015).

This paper considers both the background to and rationale for this important initiative. Although graduate software developers appreciate the importance of user (or customer) centred design, Universal Design takes this even further. In particular, two key challenges in the design of ICT products and services are addressed: firstly, being more usable “*accessed, understood and used to the greatest extent possible*” (UD 2015a) and secondly deployment across the widest range of users “*by any persons of any age or size or having any particular physical, sensory, mental health or intellectual ability or disability*” (UD 2015a). Enhancing usability in this wider context has helped to drive design innovation. Dealing with greater user diversity, particularly by addressing the needs of “non-standard” users, can also provide novel capabilities and additional benefits to all potential users.

This paper also considers how a structured approach to Universal Design (in particular the four key stages: Discover, Define, Develop and Deliver) can be mapped effectively onto modern software development best practice, in particular iterative prototyping using agile development, whilst also providing a unifying theme and an effective means of balancing technological capability, “*we developed it because we now can*”, against more realistic user benefits, “*we developed it because somebody really needs it*”. Finally this paper considers some of the lessons learned and challenges faced working with non-standard user groups, especially where the goal of their well-being enhancement is set and also, how the impact of the ICT product or service developed might be assessed or measured (Finn et al. 2014).

2. Background and Rationale

Over the past twenty years, the Department of Computing and Mathematics in DkIT has endeavoured to keep its programmes as up to date and relevant as possible from a technological, commercial and an increasingly diverse user perspective. Since the mid-1990s, HCI has been at the core of the B.Sc. in Commercial Computing. User-centred design techniques were emphasised and applied in order to bring a more balanced approach to IT design and development. By the year 2000, the emphasis had moved towards emerging Internet Technologies, in particular, content and media rich client websites and interactive applications deployed across a range of GUI platforms and web browsers. The focus of design shifted somewhat away from user requirements towards the technical challenges of deploying commercial applications on a range of differing windowing technologies. However, from around 2004, as mobile computing became increasingly mainstream presenting significant human factors and usability issues, this necessitated the introduction of specialist modules in order to better train and equip developers to address these increasingly challenging demands. Such human aspects of design were also given more comprehensive consideration within the M.Sc. in Computing programme.

¹ User Experience (UX); Information Communications Technology (ICT); Human Computer Interaction (HCI); Information Technology (IT); Graphic User Interface (GUI); Artificial Intelligence (AI); National Disability Authority (NDA); Centre of Excellence in Universal Design (CEUD); User Interface (UI); Seasonal Adjustment Disorder (SAD); Multiple Sclerosis (MS); Non-Verbal Communication (NVC); Virtual Reality (VR);

After the reorganisation of programmes within the newly created School of Informatics and Creative Arts, beginning in 2004, the B.Sc. in Computing in Games Development was introduced. Given the range of both technical and creative specialisms required in order to develop fully functional 3D computer games (e.g. game engine and physics, 3D graphics and 3D animation, sound, AI) team projects were introduced allowing students to both specialise within and cooperate across different team roles. Challenging human factors issues relating to multi-modal interaction, immersive 3D, virtual and augmented reality and simulation were becoming more commonplace. Alongside these, usability now extended to achieving and ensuring “playability” and “flow”. Furthermore, demand for “serious games” that could support challenging real-world applications such as early childhood learning, tourism and even well-being enhancement within care and therapy settings began to increase.

As part of the most recent review and revamp of these programmes in 2014 and following approaches from and collaboration with the NDA’s CEUD, a new *Universal Design Project* module was proposed and developed to replace the existing Group Project module which will be deployed into the third year (semester five) in the common core of all computing degree programmes from September 2016 onwards. Furthermore, Universal Design principles were thematically embedded into existing UX and interaction design modules in Human Factors in Design, Usability Design and HCI as well as within the existing final year Team Project. This particular module will provide both the follow-on from the new Universal Design Project module and act as the cap stone to the various specialised streams. More detailed information on this can be accessed within the various module descriptors available online (Modules 2015).

3. Key challenges Faced in Relation to Universal Design.

It’s one thing to have Universal Design embedded within a curriculum, at least “on paper”, as part of various course modules. It is another thing entirely to make the application of Universal Design real, to undergraduate computing students in particular, as part of their own learning experience in general and project practice in particular. Considering Universal Design principles as just another set of design guidelines or perhaps as a model of best practice within a broader, often quite theoretical presentation or wider discussion on topics such as usability or human factors doesn’t really present too much of a challenge. Generally, students are comfortable with taking specific principles, such as Universal Design principles and applying them to say a relatively small, continuous assessment project within a particular module. For example, a student might look at the UI design for a programmable heating control unit in a domestic central heating system as part of their human factors module. In one such specific case, the particular student project was even short listed for the 2014 UDGC finals! However, the challenge increases considerably where Universal Design becomes central to the design theme or thrust of students final year project work, especially where the full scope of Universal Design is considered, embracing not just principles of design, but also the approach to and process of design, across the widest range of users.

Building on an existing applied research cooperation between DkIT and its partner Satakunta University of Applied Sciences (SAMK), based in Pori, Finland, which considered the development and deployment of relatively simple 2D serious games as a mean of rehabilitation for people with memory impairment (Merilampi et al 2014), the Well-being Enhancing Technology (WET) research group involved proposed that as part of the B.Sc. in Computing in Games Development final year Team Project, fully functional 3D games prototypes would be designed and developed with Universal Design and well-being enhancement as the main design theme. Beginning in 2013, three game prototypes were developed by final year student teams over a period of two semesters. Figure 1 provides a brief visual summary of the major stages of this project and a more detailed discussion and write up of these games is available (Finn et al. 2014).



Figure 1 Exploring Interactive Gameplay for Well-being Enhancement (Finn 2014)

The three games developed were:

- **“Evoke”** is a third-person sandbox adventure aimed at people affected by mood related conditions such as SAD. Evoke was presented at the NDA Universal Design Grand Challenge final in May 2014.
- **“Nyx”** is an open world puzzle adventure for people suffering from physical impairment such as MS. Nyx was overall winner of the Microsoft Imagine Cup 2013: Global Citizen Competition as well as winner of the 2014 Honeycomb Creative Awards Best Project. The team were also invited to participate in the European Finals of the Intel Business Challenge Europe in Vilnius, Lithuania, in September 2014.
- **“Babel”** is an on-line / LAN co-operative exploration platformer game which explores the use of NVC and gestures to support gameplay particularly for people who suffer from social anxiety.

Following on from this project development cycle, in September 2014 the same theme of Universal Design and well-being enhancement was continued with both DkIT and SAMK providing support and expert input for incoming student teams. One team in particular, Red Ember Games, successfully developed and tested their game, “Haven” (Figure 2) in close cooperation with external experts in cognitive behavioural therapy, child psychology, child development and early learning. Haven was presented at the NDA Universal Design Grand Challenge final in May 2015 and also showcased at the Irish game Based Learning conference in June 2015 where it won the award for best student project (IGBL 2015).



Figure 2 – Haven is a configurable simulation game designed to engage children from ages 8+ in scenarios devised to elicit an emotional response.

Developing and in particular evaluating such advanced 3D game prototypes was not without its challenges. The academic team within DkIT's Computing & Maths department were very experienced in the management of the development of complex, interactive 3D games by student teams. However, applying this experience and expertise to such serious games, which attempted to fully embrace both Universal Design and well-being enhancement took this task to another level. In particular, there were two key challenges, both coming directly from the definition of Universal Design offered by the NDA CEUD:

- Firstly, being more usable, "*accessed, understood and used to the greatest extent possible*" (UD 2015a). The combination of "use" i.e. playability with both "access" i.e. ergonomic design and "understood" i.e. cognitive design meant that the fullest spectrum of interaction design issues needed to be carefully considered in each and every case. What's more, playability, accessibility and comprehensibility were inter-related and inter-dependent.
- Secondly, deployment across the widest range of users, "*by any persons of any age or size or having any particular physical, sensory, mental health or intellectual ability or disability*" (UD 2015a). Never before had a team attempted to both consider and (where possible) accommodate such a wide diversity of potential user profiles. Added to this was the fact that such immersive 3D games are normally played by a narrower range of more able users.

In order to meet these challenges, the project supervision panel needed to draw on expert assistance and advice from across a range of disciplines including nursing, physiotherapy, psychology, cognitive behavioural therapy, social care and product design / electronic engineering. There were also a number of ethical issues relating to the particular special needs of people in care and also the fact that some of the games addressed behavioural needs and issues in young children and teenagers. Several of the external experts involved acted as "user proxies" in order to allow for evaluation and user test simulation outside of more formal research trial deployment. There was also the challenge imposed by the high degree of design innovation necessary in attempting to support the inclusion of a combination of new and emerging interaction technologies and devices, often in quite novel configurations. Despite all these difficulties, it was very encouraging to see how the student teams willingly embraced and worked with Universal Design.

4. Embedding Universal Design within an Agile Software Development Process

Usability experts such as Jeffrey Rubin (Rubin and Chisnell 2008) generally tend to highlight at least the following three key aspects of good design practice, in order to ensure the delivery of a usable product or service: early focus on users and on tasks, evaluate and measure usage, iterative design and testing. As noted in the previous section however, delivering a usable product or service does not necessarily imply optimal usability but hopefully it will mean at least adequate usability, nor does it imply universal usability but it should at least accommodate more than just the “ideal” user (persona, group or particular market niche). Agile software development is a modern process model and approach to software development that not only allows for efficient, flexible and effective management of the complexities of software design and development, it is also highly accommodating of user requirements gathering, verification and prioritisation.

Figure 3 provides a visual overview of a typical agile development process. There are three stages that are of particular importance. In the first stage, required features or “stories” are elicited from stakeholders, customers / users (or expert proxies) who own them. Using formal sprint meetings the development team analyse, estimate and priorities these stories into a list of what they can commit to delivering for a given development sprint. In the second stage, the development team work together under the guidance of their scrum master to manage the completion of the sprint and each of the associated stories. The sprint burndown chart is the key instrument in helping keep things on track. In the final stage, the finished sprint is “delivered” as a set of demonstrable functions and features that can be reviewed by the customer / users (or their proxy) or, more typically the product owner, who in our case usually one or more of the academic supervision panel. Depending on how long each sprint is set up for (typically one to two weeks for a semester based academic project), in the third stage, a full “product” development release is produced at the end of about three to four sprints (i.e. the “finished work” in figure 3). Both the sprint reviews and especially sprint retrospective (at the end of a product iteration release) help drive customer / user feedback into the next major development iteration (and its subsequent sprints).

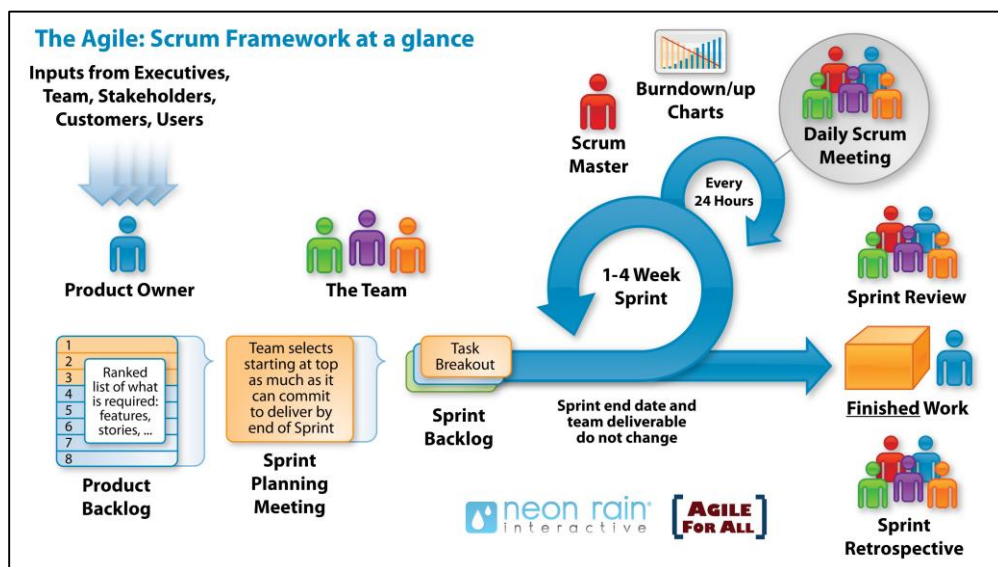


Figure 3 – The Agile: Scrum Framework at a Glance (Agile 2015)

Universal Design provides for a four stage, structured approach to the development of products (and services) based on the Design Council of the UK’s Double Diamond Design process model (UD 2015b). This model outlines four clear stages: Discover, Define, Develop and Deliver. Two points are worth highlighting here. Firstly, the setup of an agile process model maps very well onto the requirements of the Double Diamond model in relation to the first stage, mapping almost identically to “Discover” activities and the third stage mapping to the “Deliver” stage.

In our experience there isn’t necessarily such a clear mapping of the second stage of the agile process (sprint execution) and the Universal Design process stages of “Define” and “Develop”, even though there is some overlap in terms of what is being considered e.g. “Define” being driven by considering usage scenarios and user profiles and “Develop” being focused mainly on user interactions. In agile development, the second stage is very sharply focused on producing working or at least demonstrable functionality.

However, this mismatch can be got around where each development iteration (with its associated sprints) is mapped onto a larger process framework where, for example, three consecutive development iterations are mapped to incremental prototype releases and evaluations such as Proof of Concept, followed by product Alpha release followed by (a final) product Beta release. Once this is done then the important emphasis placed by each of the Double Diamond mid stages (i.e. Define and Develop) can be adequately accommodated and properly addressed.

It is important to point out that this embedding of Universal Design as a process model and not just as a set of design principles is itself a work in progress. It has taken the last two years of the Team Project process to attempt to establish this “hybrid” process model. It is hoped that through the deployment of the dedicated Universal Design Project module (in third year, prior to the fourth year Team Project) priority can be given to the Double Diamond model, i.e. it will become the development driver. In other words, groups will work in a fully Universal Design mode and use a simpler approach to agile development to manage each of the four Double Diamond model stages. Furthermore, it has been very easy to re-interpret the roles identified in the agile process, for example, “Stakeholder” and “Product Owner” and map these to actual external experts supporting the project, particularly those providing expert user proxy support. This approach is also quite accommodating of multi-disciplinary teams.

Finally, considering Universal Design, particularly along with well being enhancement has provided a unifying theme for customers, users, stakeholders (external experts) and the development teams. This has really helped focus teams around requirements gathering and prioritisation in particular. Understandably, teams will tend to both interpret and prioritise stated requirements more from a technological bias or capability, “*we developed it because we now can*”, whereas they should show at least equal (if not greater) consideration for more realistic, tangible and demanded user benefits, “*we developed it because somebody really needs it*”. A breakthrough in terms of innovation, effective game play and fun can come when teams manage to get these two equally important demands to harmonise or overlap. In short, when “*somebody really needs*” what we technologically “*now can do*” (for example augment a complex game controller input device with a hands free, simpler gesture based device) then there is potential for real breakthrough!

5. Impact and Future Developments

Comprehensively embedding Universal Design at the core of the two Computing degree programmes discussed is an on-going process which from start to finish will have taken four years to complete. It was spawned from an already well-established commitment to instilling a deeper appreciation in undergraduates of the importance of user-centred design, enhanced usability and increased effectiveness. Indeed, the core component of this process is the delivery of the Universal Design Project, which will not actually roll out until September 2016. Given the reality of the three-year lead-time between inception, development and actual delivery at the teaching coalface, the full impact has yet to be fully assessed.

However, the more immediate inclusion of Universal Design within exiting modules and in particular the adoption of Universal Design as both a design theme and as a development process driver has already made a significant and very positive impact. In particular, enhancing usability in this wider context has helped to drive design innovation. For example, the inclusion and adoption of advanced interaction technologies such as the Leap Motion Controller (LEAP 2015) combined with the integration of advanced VR visualisation technologies such the Oculus Rift (Oculus 2015) could be considered as highly innovate for undergraduate projects in particular. But what is perhaps most significant and indeed satisfying is to realise that the inclusion of both of these technologies has been undertaken in order to explicitly support non-standard users and to address significant accessibility and cognitive limitations. Added to this is the fact that these enhancements have had demonstrable benefit for other user groups and have also allowed for novel interaction and game play capabilities.

But the effect of Universal Design, particularly in relation to a clearly stated design goal of demonstrably enhancing some specific aspect of a users well-being, be it physical, such as improved motor skills, cognitive such as improved problem solving capability or even emotional, such as through mood enhancement or increased social interaction and engagement, or indeed a combination of all of these has provided a significant driver towards delivering better and more beneficial applications. In short, it’s been as much about improving peoples lives as it has been about producing better software!

Such altruistic benefits are noteworthy but when these can be demonstrated alongside enhanced business and entrepreneurial potential than the full impact of Universal Design can be highlighted. Three of the projects achieved significant success in both national and international competitions. Indeed all three were not just, “best in class” but also “first of their kind” in more than one event entered. In particular, Nyx is the first Team Project to successfully transition from competition winners to business start-up. Three members of the student team who produced this well-being enhancing game have gone on to set up their own games development company, Mega Future Games (Mega 2015). Their game has gone from strength to strength and is now at an advanced user trial stage with the goal of being certified and approved as a therapeutic device for MS sufferers.

Beyond these more immediate and clearly measurable effects there are other long-term, more subtle effects that have yet to be fully determined. There is of course the impact on users, from a long-term perspective. One key issue here is that given the nature of under-graduate projects in particular, maintaining the development momentum for each successful project sufficiently to allow for longitudinal trials to be conducted has proved difficult. Much of this relates also to the availability (or lack) of adequate resources and research infrastructure in order to more fully assess the impact.

But even where such follow-up is either difficult to simply not feasible there are other positive effects that provide sufficient justification for the effort and resources already put in. In particular, the very nature of the additional challenges presented have actually provided for increased levels of cross-disciplinary cooperation and collaboration. Student, staff and external stakeholders have all benefited and will hopefully continue to benefit from the kind of innovation and design breakthrough already experienced. Necessity is indeed the mother of invention and Universal Design, where fully embraced, certainly delivers in terms of innovation, creativity and new thinking. Added to this there is also the effect of increased design empathy and the commitment to providing workable solutions to significant social issues as well as being able to make real and positive impact on people’s lives. It is my firm belief that the full impact of such an initiative will take perhaps several more years to fully assess.

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