2009-10-01

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Ciaran O'Leary
Technological University Dublin, ciaran.oleary@tudublin.ie

Damian Gordon
Technological University Dublin, Damian.Gordon@tudublin.ie

Recommended Citation

O'Leary, C., & Gordon, D. (2009). Universal design, education and technology. *9th. IT & T Conference*, Technological University Dublin, Dublin, Ireland, 22nd-23rd. October. doi:10.21427/awa6-wy33

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Ciarán O'Leary and Damian Gordon

Dublin Institute of Technology, School of Computing, Kevin St., Dublin 8, Ireland
ciaran.oleary@comp.dit.ie, damian.gordon@comp.dit.ie

Abstract

Universal Design is an approach to design which insists upon the consideration of users with diverse levels of ability. Rather than representing a specialist approach to design, it is recognised that Universal Design results in a better design for all. Furthermore, by isolating design for disability as an independent topic in education, or ignoring it altogether, educators create an exclusionist perception of the role and place of individuals with disability in modern society. Modern education programmes which teach design skills are enhanced in quality by mainstreaming Universal Design as a core topic, permeating all that surrounds it. This paper describes an approach to support and implement this, based on our experience of incorporating Universal Design into a set of three postgraduate programmes in Computing.

Keywords: Universal Design, Education, Computer Science

1 Introduction

Universal design is a philosophy which guides designers to consider all users when designing any product or service, and to provide all users with identical use whenever possible, or at the very least equal use. The philosophy is made concrete through the *Seven Principles of Universal Design*, compiled by researchers at North Carolina State University [1]. Though initially linked closely to the fields of architecture, the built environment, ergonomics and product design, the philosophy of *Universal Design* has now gained relevance across a much broader set of domains, in many cases supplementing an already rich understanding of *accessibility*, *user-centred design* and *interface design*, but in other cases it has been responsible for developing *ab initio* an interest in diversity and universality in design.

Universal Design and its various cousins and ancestors in accessibility and interface design have often been considered specialist topics, of interest only to those who will develop careers in areas such as *assistive technology* and *special needs*. As such, mainstream higher education programmes in technology and elsewhere have mostly been delivered without any consideration for *Universal Design*, sometimes offering modules as options or electives, but rarely incorporating *Universal Design* as a core topic in the programme, either as a standalone module, or as a component of several modules.

The effect of this approach has been a perception among designers that design for individuals with disability is a specialist skill independent of design for the remainder of the population. This is, in fact, contrary to the spirit of *Universal Design*, which demands that designers consider the full extent of user ability. Importantly, *Universal Design* leads to good design, with several notable examples demonstrating that those designers who consider the limits of human ability produce designs which are substantially more usable for all its users [2, 3]. Consider for example, the incorporation of an elevator into a building. Such a facility may have been incorporated only due to an accessibility guideline, or legal imperative, to assist wheelchair users. However, such a facility is clearly of great use to a large

number of non-wheelchair users. Parents with buggies, delivery personnel or people with luggage are all examples of people for whom the design is improved through the incorporation of the elevator.

The same applies for products and services outside the built environment. Websites are perhaps one of the best examples of an area which has seen considerable effort and attention directed towards accessibility and *Universal Design* [4]. While *accessibility* implies that the resulting product should be able to offer a service to individuals with a disability, *Universal Design* goes further than this, by insisting that wherever possible, the same product offers the same service to all people, and by insisting that this creates a better product for all users. Websites with a text-only version, for example, may be accessible, but hardly *Universally Designed*. Cases are reported, for example, where the alternative, or accessible version of an online shopping website did not present users with special offers [5]. In contrast, some *Universally Designed* websites present a highly configurable interface to the user who is not penalised in any way for changing the colour scheme, resizing or using an assistive technology such as a screen reader to interact with the website [6].

In the past academic year, a module entitled *Universal Design* was delivered to students on a set of three MSc programmes in the School of Computing, at the Dublin Institute of Technology. The three MSc programmes contributed to a student cohort which was diverse in background and career specialisation, as well as the typical diversity expected of all programmes. The module was core to the students undertaking the MSc Assistive Technology (AT), but was available as an elective module to students on the MSc Knowledge Management (KM) and MSc Information Technology (IT). Students on the MSc AT already have a rich background in related and relevant topics such as *ergonomics*, *accessible web design* and *special needs education* and their intended career progression is towards accessibility consultation. As such, Universal Design represents a core competency for this area. Graduates of the MSc KM operate as knowledge analysts and architects in knowledge-rich organisations across the private and public sectors. Universal Design would not typically be considered a core competency in these roles, but we recognise that a key function of analysts and architects is design, which can be significantly enhanced by the principles and philosophy of *Universal Design*. Equally, graduates of the MSc IT, while qualified to work as software engineers and Information Technology managers, would benefit significantly from a deep understanding of *Universal Design*, its application to software, and its support for the successful marketing and sale of software products.

This paper consists of an experiential report on the delivery of the module described above. It incorporates reflections on the module itself, and well as the positioning of the module within the respective programmes. This discussion includes reflections on the process by which the instructional material was designed and delivered to the students, according to the principles of Universal Design. The core contribution of this work is a clear and supported set of guidelines for the inclusion of the topic of *Universal Design* in higher level education programmes. These guidelines will support the future development of our own programmes, as well as contributing to the growing body of literature addressing *Universal Design* in education, and education of *Universal Design*.

Section 2 details the seven principles of *Universal Design*, and addresses their applicability to their domain of origin and other domains of interest. Section 3 outlines the relationships which exist between *Universal Design* and more established related topics such as *accessibility*, *usability*, *user-centred design* and *assistive technology*. This serves to highlight the means through which *Universal Design* could be seamlessly integrated with existing programmes, as a temporary measure awaiting a fuller redesign. Section 4 describes the delivery of the module, identifying the learning outcomes, the learning and teaching methods, the assessment methods and the content of the module. This serves as an initial template for equivalent and related modules. Section 5 provides the guidelines as discussed above, to support the mainstreaming of *Universal Design* through programmes for technologists. The remaining sections summarise and conclude.

2 Universal Design

Assistive technology is the term used to describe those specialised technologies which assist individuals with disabilities. A walking stick, for example, is an assistive technology, as is screen reading software. In truth, all inventions represent some new form of technology, and such inventions would swiftly disappear were they not assistive to someone. Email software, for example, assists users in communicating, cars assist people in travelling, music players assist people in relaxing (or not) and so on. A problem with some technologies, indeed many technologies, is that while they were designed to assist users, the reliance that is placed upon them by society has resulted in an exclusion of other users. Stairs represent an excellent invention for multi-story buildings (to continue the elevator example from earlier), but they clearly serve to exclude all but those who can easily use them. The World-Wide-Web is an incredible technology which initially served to disseminate information, but now allows many diverse uses, and indeed often represents the only means of interaction with certain organisations. Mobile phones, televisions, video recorders, kitchen appliances, music players, and the personal computer all represent technologies which assist their users in performing some operation and fulfilling some activity. Unlike conventional assistive technologies which are aimed specifically at users with a disability, these technologies are often designed for users without any significant disability, and can therefore only assist those users.

Universal Design addresses this specific problem. Technology, when being designed to assist users, must be designed such that it can assist all users, in so far as possible. This represents a design challenge, but often one that is easily met at the early stages of design. A multi-story building designed with an elevator costs only marginally more than a building without an elevator, when considered at the early stages of design. A multi-story building designed without an elevator that subsequently needs to be modified to incorporate an elevator may cost marginally less initially, but will cost substantially more in the long term. The same applies across the board, leading to the position that Universal Design is a process, or at least an aspect of a process, rather than an activity that can be applied at the end of a design.

A software engineer who completes a product and delivers it to a customer who is then asked to *make it accessible* because a new hire in the company has a disability faces a significant problem. Accessibility by users with disabilities is not simply a matter of modifying an interface, it is something which affects the entire design. In order to make a software product accessible, for example, it may be necessary to provide word suggestions as data is being entered. This, in turn, can affect how data is being handled as it is entered, stored and persisted to a database. Word suggestions, as well as making the software product more accessible, will make the product more usable for all users, and more appealing to a wider market of potential customers. *Consider all users, present and potential,* is a useful mantra for *Universal Design*, which promises a better design for all users.

The world of technology is moving on from adapted interfaces being considered sufficient for inclusion. Ostroff [7] argues convincingly that the 1954 ruling of the United States Supreme Court on the case of Brown -v- The Board of Education outlawed the argument of *separate but equal*. While this judgment was made in respect of the institutional apartheid of many of the southern states at the time, the lesson is clear for other problems and in other countries. Clearly, Universal Design is motivated by the need to *do the right thing*, but as in all such cases, where a reliance is placed on altruism and self regulated ethics, this is both patronising and unsustainable. As such, many jurisdictions have legislated for Universal Design, often not by name, but in spirit. Laws punishing those who discriminate have proliferated in the past decades, but often discrimination was considered only in terms of housing or employment. In the United States, the 1968 Architectural Barriers Act required that all federal buildings be accessible to all. This was supplemented by the Rehabilitation Act of 1973, the Americans with Disabilities Act of 1990 and the Telecommunications Act of 1996, as well as others such that now it is a legal requirement for buildings, places of employment and information technology to be accessible, if in receipt of public funding. Ireland's most important act in this area was the 2005 Disability Act [8], which, for the first time globally, included in legislation a definition of *Universal Design*, established an advisory *Centre for Excellence in Universal Design* as

part of the *National Disability Authority*, and required that in so far as is possible, courses of education in *Universal Design* be made available to practitioners for whom it is relevant.

While the legislative imperatives are strong, two of the strongest motivations for Universal Design are self-motivated and non-altruistic. Such motivations are always the most sustainable. Firstly, the economic benefits of Universal Design are due to both improved public perception of a product and an expanded target market. Secondly, Universal Design represents a design challenge which drives new technology. Natural language processing, speech recognition, image processing, text messaging, interface design and wireless communication are all areas of technology where developments were motivated, at least in part, by the needs of users with disability. Currently, the Google Image Labeller [9], derived from the extraordinary ideas of Luis van Ahn, owes much to van Ahn's recognition of the barriers faced by visually impaired and blind web users when presented with an image. Coupled with the opportunity image labelling afforded Google to provide a better image search engine, the new technology represents the biggest leap forward, probably ever, in the labelling of enormous databases of images. Notable historical precedents for this are the invention of both the telephone and the typewriter (by Alexander Graham Bell and Rasmus Malling-Hansen respectively).

Those who take Universal Design seriously recognise the diversity of the potential user base, identify potential barriers, and anticipate the future profile of users. Given how our global population is rapidly ageing, to the degree that by 2040 it is expected that there will be more human beings alive over the age of 65 than under the age of 5 [10], it is becoming more and more important that designers of all products, environments and technologies consider how their inventions and creations will be used by individuals with declining motor, visual, hearing and cognitive abilities. As Suzman observes, "Global ageing is changing the social and economic nature of the planet" [10].

Universal Design, therefore, is sustainable design.

3 Principles and Guidelines

In brief, the *Seven Principles of Universal Design*, as presented in 1997 by researchers at North Carolina State University, are as follows:

1. *Equitable Use*: The design is useful and marketable to people with diverse abilities.
2. *Flexibility in Use*: The design accommodates a wide range of individual preferences and abilities.
3. *Simple and Intuitive Use*: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
4. *Perceptible Information*: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
5. *Tolerance for Error*: The design minimises hazards and the adverse consequences of accidental or unintended actions.
6. *Low Physical Effort*: The design can be used efficiently and comfortably and with a minimum of fatigue.
7. *Size and Space for Approach and Use*: Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

The first of these principles states quite clearly the overriding philosophy of Universal Design, with the next four principles presenting general, domain independent means of arriving at a Universally Designed product or service. The final two principles are clearly most relevant for the built environment and the design for physical products, and may find less relevance in domains such as software design. Most examples in that domain are reasonably contrived and could probably be better captured with other principles, though some examples do demonstrate the importance of low physical effort in interacting with software interfaces. Any web user who has needed to tab through links because they cannot use the mouse peripheral, or any user who has needed to use a mouth stick to type

and scroll through screens of content, will certainly appreciate the relevance of designing software for low physical effort.

In addition to these principles, Gregg Vanderheiden's *Basic Guidelines and Strategies for Access to Electronic Products and Documents* [11] present a set of useful means of designing software to be usable by all. For example, the first principle requires that all information be perceivable by users:

- Without vision
- With low vision and no hearing
- With little or no tactile sensitivity
- Without hearing
- With impaired hearing
- Without reading (due to low vision, learning disability, illiteracy, cognition or other)
- Without colour perception
- Without causing seizure
- From different heights

In addition to the motivation of providing access to individuals with disability, adherence to this principle facilitates access for individuals who cannot look at something due to a distraction (such as driving – perhaps not to be encouraged, but there is little harm, one supposes in one using a screen reader to read a well designed news article while driving), or cannot hear something due to noise in a public area, or simply due to being in a public area and not wishing to make noise (train commuters will relate to this).

Vanderheiden's other principles set out and justify means and motivations for increasing accessibility, and making interfaces accessible to all. The relationship between his principles and the Web Content Accessibility Guidelines version 2.0 [12] which followed, is clear to observe, as both are based less on a strict set of clear rules and measurements akin to those used by architects when deciding on doorway widths, and more on an understanding of the user and the means through which they interact with products.

User centred, or human centred, design has been a popular approach to design in software and elsewhere for some time. The term, however, leaves itself open to interpretation, with designers often considering that user testing at the end of the process has made their design user centred, or that user interviews at the beginning of the process did likewise. In reality, many of the Agile Software Methods [13] which are rapidly growing in popularity are the most powerful in terms of their involvement of the user. By stipulating that users be present during design, and often part of the design team, the Agile methods provide designers with rapid feedback on the quality of their design and implementation, and allow for swift modification of designs and much more impressive meeting of deadlines with operational, functioning products. Consider the contrast between this approach and the much maligned usability consultant. Usability and good design became key buzzwords in the 1990s due primarily to two gurus of the usability art. Jakob Nielsen frequently compiled *Top 10 Mistakes* lists based on his own experience of interacting with websites and other software. His word often became gospel with producers and purchasers of software, who would pay for usability tests on software before, or indeed after, release. Donald Norman shot to fame with his book *The Psychology of Everyday Things*, later renamed to *The Design of Everyday Things* (the change in title was due to a self confessed recognition of Norman not considering the user / reader who may be intimidated by the slightly more pompous sounding *Psychology* instead of the easily appreciated *Design*), which established, described and justified his guidelines for the design of everything from kettles to nuclear power plants. Nielsen and Norman teamed up to form their own consultancy, with much of their work now hidden behind the subscription form on their website. Regardless, the opposition in the software and product design fields to the work of Nielsen and Norman is due to a reluctance to accept that, say, a hyperlink must always be blue. Opponents argue that there is more to design than ease of function, often designs are required to create a mood or react to an attitude. Music websites that need to create a

feeling of *cool* are good examples. Contrast, for example, the clickable images of attractive popstars on music.com to the functional ugliness of Nielsen's own site (useit.com). Norman recognised the validity of the opposition and followed his influential early work with *Emotional Design*, a book which sandwiched his earlier *behavioural* rules, between layers he labelled *visceral* or *reactive*, and *reflective*. At the visceral layer, the designer needs to consider how the user will react to the product – first impressions etc. At the reflective layer, priority is given to how the product makes the person feel about themselves, considering life goals etc. The marketing of branded products appeals exclusively to this level.

The importance of the argument over usability is the recognition that quantitative measures of usability are less effective than the qualitative measures. The *hard and fastness* of certain rules, while understandable and easily implemented and communicated, does not contribute as much to assessment of usability as observation of users, leading to general principles, perhaps supported by examples or patterns, but not enforced through *never* and *don't* rules. In this respect, Universal Design shares much with user-centred design, usability and similar efforts. The key distinction between Universal Design and user-centred design is its characterisation of the user. While it would be desirable to involve users across the entire spectrum of ability, along various dimensions in the design project, often this is not possible. Designers then, must be instructed in some way to consider the effect of their design on the mobility impaired, the hearing impaired, the visually impaired and the cognitively impaired. In the absence of a practical ability to perform this real time interaction, the designer should be able to develop an empathy with the user, by observing occasionally, or perhaps through recorded media, how various users interact with their product, or similar products.

An excellent example of this is web accessibility. Most web developers are competent in technologies such as HTML, CSS and JavaScript, and use these to develop rich, interactive websites. Many of these developers are considerate enough to validate that their website is correctly rendered in different user agents before deployment. Often when the site is being developed the designer will have consulted the Web Content Accessibility Guidelines and implemented the rules relating to images, rich media, tables etc. Often they will not. The rules are sometimes restrictive on the art of the developer, preventing them from utilising, say, JavaScript, in the way they wanted. However, by observing blind, dyslexic, or arthritic web users interacting with their site, or another site, they can quickly develop an empathy with that user, and can then engage with the new design challenge. Often, this will result in a clearer organisation of the website, the redrafting of textual content into more paragraphs, using less idiomatic language, and appropriate markup for emphasis and exclamation, more appropriate colours, advanced configurability, employment of innovative technology such as AJAX for delegating jobs such as *hint generation* to the server and so on. Clearly, these changes make a much improved site for all users. The same would be true for anything which must be designed for another person to interact with, from an essay to an operating system. By designing with an empathy for the limits of human ability, the design is improved for all users. This is the promise of Universal Design.

Cooper [14] explains with conviction how software should be *considerate* or *polite*. Recognising that all technology is assistive technology, or at least ought to be, Cooper encourages software designers to personify their software by designing them to fulfil the role of an intelligent and considerate assistant. Considerate software, then, should:

1. Take an interest
2. Be deferential
3. Be forthcoming
4. Use common sense
5. Anticipate needs
6. Be conscientious
7. Not burden with other problems
8. Keep informed
9. Be perceptive
10. Be self confident

11. Not ask lots of questions
12. Fail gracefully
13. Know when to bend the rules
14. Take responsibility

Each of these represent a challenge for the designer. Once again, the designer will develop their own understanding of how to achieve considerate software by observing users, and will address each of these challenges in novel ways. Qualitative principles such as these represent a path to Universal Design, but this path must be populated with users who can motivate the reasons and means for these.

Cooper [14] proposed the use of *personas*, user models derived from research of the user population, to develop the empathy between designers and users. A persona is a type of user who captures many of the problems encountered by real users. By assigning the user a name and involving them in discussions over design features and interaction methods, the design team should be able to create a design closer to the needs of that user. Some suggestions regarding the incorporation of *personas* into software design processes have been made for established methods such as the Rational Unified Process [15]. Ongoing research within our group is examining the incorporation of personas into the agile methods.

Universal Design is a process. The process requires those involved in the process to understand the limits, behaviour, fears and personalities of the end users. By designing for extremes, the result is a better design for all.

4 Module Delivery Case Study

As part of our various programmes on *Computer Science*, *Computing*, *Information Technology* and *Information Systems*, students would historically have been taught the values and methods of user-centred design as a branch of *Software Engineering*. *Universal Design* was a topic in the content of modules in *Human Computer Interaction* at stage 3 of our four year degree programme. For the first time, a standalone module on Universal Design was offered to students on the three MSc programmes in our school in the past academic year. For many of the students taking the module, this represented their first exposure to the topic, and often the terminology, of Universal Design. Others taking the module were specialist practitioners in the field of *Assistive Technology* and *disability*, and as such started the module with a greater understanding of, at least, the requirement for *Universal Design*.

While we accept that much of the case study described here amounts to the presentation of anecdotal evidence, such is the case with much of educational research. We endeavour to demonstrate our approach such that this can inform others, and recognise that what we present is a starting point. We firmly believe that the act of design is one that requires communication for evolution of ideas and methods.

The module was delivered with three hour classes over thirteen weeks. The journey through the module began with development of a general understanding of *Universal Design*, through the *Seven Principles of Universal Design*, several case studies and examples. The economic and legislative motivations for Universal Design were treated in detail, with students required to perform investigation on the relevant topics and report back to their classmates. Case studies on web accessibility and interaction design were followed by an examination of the role and potential of tools such as *personas* for arriving at *Universal Design*. This led to a treatment of *Universal Design* as a process, with students required to examine, criticise and invent process models appropriate for given domains.

The module was assessed partially through examination, with the remainder of the assessment marks awarded for the design assignment. Students were required to identify a domain, investigate it thoroughly to establish how limited products and services within that domain were with respect to the principles and philosophy of *Universal Design*. Students were then required to present and evaluate

two designs. One, a retrofit, was required to show how the identified problems could be fixed. The second, an *ab initio* design, imposed no restriction on the student, allowing them start from the beginning to produce a *Universal Design* to meet the same goal of the deficient design. Topics such as costs, legislative requirements and economic and moral benefits were also covered by students.

Students began their assignment at the start of the semester, and presented their final designs and reports to the class at the end of the semester. Weekly, students gave informal reports to the class, allowing them learn from each other and contribute to each other's ongoing work, as well as the collective knowledge within the class. Ultimately, students produced some excellent designs for products such as *automated teller machines*, *motor cars*, *light switches*, *websites*, *shopping trolleys* and *travel time tables*. Importantly, some of the work produced had an immediate impact on the professional environment in which the students worked.

The students on the module all had a background in computing, and as such had spent considerable time in their academic and professional histories producing and realising designs. While some had a familiarity with certain rules and principles, they associated these mainly with the *Human Computer Interaction* speciality, rather than recognising it as a foundation of good design.

A cursory review of the literature on *Universal Design* will reveal that, surprisingly, one of the fields which has produced most publications on *Universal Design* is education and instructional design. Many authors have written about how they modified their teaching and learning methods to accommodate students with disability [16], as well as other classes of student such as international students and student parents. While some authors reference the *Seven Principles of Universal Design*, most reference only the philosophy of *Universal Design*, captured by the first principle – *equitable use* [17]. Some of the methods which are presented in the literature include offering the taught material in many forms e.g. online, in class; and lack of reliance on images and visual material – though recognising that visual material can help many learners, students for whom visual material is less useful should be provided with a meaningful and useful alternative. Others wrote of how simply speaking more slowly to accommodate sign language interpreters or international students improved learning across the entire cohort. Recognising the value of blending the message and medium, effort was made to deliver the module on Universal Design through adherence to the principles of Universal Design. This included the use of an accessible website, the publication of notes using accessible PDF documents, redundant description of images, and careful design of assessment to cater for diverse learning styles.

5 Mainstreaming

Universal Design is for all designers, regardless of what they are designing. As educators, we design programmes, modules, classes, examinations, assignments and lectures. As technology educators, we teach students to design software, applications, and solutions. By subscribing to the philosophy that Universal Design is good design, and that it is arrived at through the development of an empathy by the designer for the user at the limits of various human abilities, as well as the development of the means to address design problems (such as how to develop software, how to program mobile devices, how to network two computers etc.), we suggest that rather than being a specialist topic, Universal Design needs to be mainstreamed through all stages of the education of designers, and importantly that it be embodied in both the message and the medium. In this case, the message is the value of the Universal Design approach to design, and the medium is our approach to education.

What follows below is an example of how we view Universal Design being mainstreamed throughout the higher education of technology students.

5.1 Early, Often and Everywhere

It is important that Universal Design as a philosophy, and design for the extremes of human ability as a motivation, be introduced to students early in their study. Rather than rely on specialist training of graduates, or at the latter stages of their education, students should be asked to consider how their designs and decisions will affect the users of their applications. Introducing the concept of a user to students from the very beginning will direct the students to consider their work from the perspective of those directly involved in interfacing with their design. This ought to be a core concern across design related modules such as *Software Engineering*, *Software Development* and *Web Design*, but also should be used as a motivation for modules on *Algorithm Design*, *Problem Solving* and so on. In these modules, students are asked to address specific problems, such as searching, sorting and representing. By making real these problems through use of user-centred examples, the student continuously develops their empathy with users, and further understands the motivation for the problems they are trying to address.

Consider for example, the following question in a first year examination paper for *Algorithms and Data Structures*:

> Show how the *quicksort* algorithm sorts the following numbers:
>
> `45 30 12 19 35 11 10 19 1`

This question could be reframed in the following way, which continues to assesses precisely the same skill and assess the same knowledge, but reinforces the centrality of the user in computing and uses Universal Design as a motivator for good design.

> Tom's in-car navigation system automatically calculates possible routes home for him, depending on his current location. Today, it has determined nine different routes, which Tom would like to be read out by the system, ordered by distance. Show how the *quicksort* algorithm could organise the following distances, from highest to lowest.
>
> `45 30 12 19 35 11 10 19 1`

This example presents Tom, a circumstantially disabled user who cannot use his eyes to scan nine distances to find the least, but must instead rely on speech generation software to read the nine distances. Because of the time involved in reading, it is clearly preferable that these be ordered, so that Tom can quickly learn about the shortest routes, without needing to remember which distance is the shortest so far.

Clearly, the same question can be asked using a permanently disabled user as an example:

> Mary's grandchildren bought her a personal computer for her 80th birthday, and have shown her how to visit online stores to make purchases. To compare prices on different websites, Mary uses software which records prices when clicked, and then displays prices in order on the top of the screen. Show how this software would use the *quicksort* algorithm to order the following prices, from lowest to highest:
>
> `45 30 12 19 35 11 10 19 1`

The key point here is that all technology design and development, from the front end all the way backwards, should be motivated by the user need. Students who understand Universal Design from an early stage will have a better understanding of why certain problems must be solved, and also may be motivated to solve some problems, such as those identified above, which will result in new applications which are better for all.

5.2 User Empathy

Design is a process involving requirements gathering, initial design, detailed design, implementation, testing and deployment. Depending on the type of design process, the various stages of design may be completed and signed off, or revisited in continuing iterations. Most modern design processes involve the user in more than one of these stages, with the requirement that the user be observed interacting with the current design, either through an artificial means such as paper-prototyping, or through a prototype realised in software and/or hardware.

Universal Design requires that a wide set of users be considered and as such, the designer should have an empathy with users with diverse levels of ability. Use cases and user stories for designs should cater for these different abilities. By introducing students to different users, either in person, or through media such as video recordings, and then assessing students based on how identified personas could use a particular design, the students are forced to develop their understanding of why the user must be central to the design process, and how this leads to better design.

For example, students at a particular stage of the programme could be presented with descriptions of a set of personas at the start of the academic year. Each of these personas could inform the various modules at that stage, such that the student both refers to, and is assessed with reference to each of those personas.

Rather than simply designing a website that the student finds attractive, the student should be guided to design a website that John, a blind web user can interact effectively with. Rather than providing advanced features for their hotel booking system toy application in the Software Development class, the student incorporates features that assist Betty, who interacts with her computer using a mouth stick.

Personas are recognised as a useful means of supporting Universal Design in the professional environment. Equally, they should be used to teach effective design in the academic and training environment.

5.3 Message and Medium

Efforts to improve access to education for all students, to promote lifelong learning and to include students with disabilities have resulted in a diverse cohort in the modern classroom. Rather than simply catering for certain types of student through expensive supplementary supports such as note takers, sign language interpreters and additional tutors, educators should be seen to place diverse users at the centre of their own design process. This includes the design of the classroom environment, the design of instructional material such as lecture notes, the design of support material such as web sites and the design of assessment through assignments and examinations. There exists a substantial body of knowledge in this area which should inform the approach that all educators take to designing and delivering their own material, recognising that the class which is made more accessible to the deaf, blind or mobility impaired student has benefits for all students. For example, models of learning styles [18] suggest that all students have a specific set of learning preferences, some prefer graphical information, some prefer textual information, some oral information, some kinesthetic information, etc. therefore universally designed teaching materials will address this range of preferences.

This also has the effect of reinforcing the relationship between Universal Design and good design for students in the class, and serves to further enhance the empathy of both staff and students for users with diverse abilities.

5.4 When, Why and How

The philosophy of Universal Design is best captured by the first principle of Universal Design – equitable use. In order to produce better students with better design skills, these students must understand when to consider diverse sets of users, why to consider diverse sets of users and how to

consider diverse sets of users. The three guidelines explored above represent our recommended approach for mainstreaming this approach and philosophy in education programmes centred on design – particularly technology related programmes. This does not suggest that focussed modules on user-centred design, Universal Design and interaction design should not be included in programmes, but rather that if they are included they should not represent the only exposure the student has to the principles and philosophy of Universal Design. We suggest that Universal Design should be the core around which all programmes are designed, and we've presented three means through which this core can permeate all that surrounds it.

6 Summary and Conclusions

Universal Design is not a specialised skill, nor is it a speciality topic. It is a process which leads to good design, sustainable design and inclusive design. Separating it from the core process of design results in an implied and mistaken understanding by the student of the place in society of individuals with disability, and results in designs which are limited in their application in a society where users with permanent or circumstantial disability represent both a large and growing part of the user base and a substantial market. Twenty-first century graduates must understand the motivation and means for Universal Design, and through this understanding they will produce better designs, better technology, better ideas and a better society.

Acknowledgements

The authors wish to acknowledge the support of the Centre for Excellence in Universal Design at the National Disability Authority in Dublin, Ireland.

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