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Understanding the graphical challenges faced by vision-impaired students in Australian universities

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ABSTRACT

Information graphics such as plots, maps, plans, charts, tables and diagrams form an integral part of the student learning experience in many disciplines. However, for a vision impaired student accessing such graphical materials can be problematic. This research seeks to understand the current state of accessible graphics provision in Australian higher education. We conducted an online survey of 71 vision-impaired university students and semi-structured interviews with 44 key stakeholders (students, academics, disability liaison officers and accessible graphics providers). We found that difficulty in accessing graphical materials was a barrier to many vision-impaired students and that there were systemic problems with current processes for accessible graphics provision. Recommendations are made on ways to address these concerns in order to provide a more equitable higher education experience.

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Equity; inclusive education; STEM education; student experience

1. Introduction

The number of disabled students attending Australian universities has greatly increased over the last 25 years, rising from 1.94% of students (11,656 enrolments) in 1996 to 5.15% (50,079 enrolments) in 2013 (Department of Education & Training, 2012). This is in accord with global trends and is the result of legislation prohibiting discrimination against disabled students and improved educational opportunities in primary and secondary schools, as well as changing community attitudes. In 2010, there were 4305 effective full-time students enrolled in higher education (HE) who were vision impaired (Department of Education & Training, 2012). Here, we investigate how well Australian universities are supporting the needs of students with vision impairment (by which we mean both blind and low-vision students but excluding students with other forms of print disability such as dyslexia).

One of the long-standing difficulties facing vision-impaired students has been access to educational materials, such as textbooks and classroom materials. The situation has markedly improved in recent years, as materials are increasingly available in electronic format, enabling vision-impaired students to access textual content with adaptive technologies, such as screen or braille readers. This is in contrast to graphical materials, which vision-impaired students find much harder to access (Armstrong & Murray, 2007).

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This is problematic because graphics such as plots, maps, plans, charts, tables and diagrams form an increasingly integral part of the student learning experience in many disciplines.

This paper investigates the degree to which access to educational graphics is a barrier to vision-impaired students studying at Australian universities and the reasons for this. We conducted an online survey of 71 such students, as well as conducting semi-structured interviews with 13 vision-impaired students, 10 academics with recent experience of teaching a vision-impaired student, 12 university disability liaison officers (DLOs) who provide support for vision-impaired students and nine transcription staff responsible for preparing accessible graphics from materials provided by the DLOs. It is one of the largest studies of its kind.

The responses gave clear indication that access to graphics is a significant issue, with most students skipping graphical materials, virtually all agreeing that they could benefit from improved access to graphics in their study materials, half experiencing difficulty in group activities, and half stating that it had affected their study choices. In particular, we found that vision-impaired students were less likely to enrol in STEM disciplines but more likely to enrol in the arts and humanities. The reasons we identified for this lack of access were communication difficulties, unclear responsibilities, lack of awareness and expertise, as well as inadequate resources.

2. Context

There were an estimated 357,000 vision-impaired Australians in 2013, with the number predicted to rise to 564,000 by 2030 (Vision Australia, 2013). Before embarking in tertiary education, the vast majority of vision-impaired students in Australia attend mainstream primary and secondary schools. Support is provided through occasional visits by specialist vision support teachers, part-time aides in the classroom, production of accessible formats by the state or territory education department, and funding for adaptive equipment.

Legislation and guidelines that exist in Australia that relate to the provision of education and learning materials for vision-impaired students include:

- The Disability Discrimination Act (DDA) (1992) – designed to eliminate, as far as possible, discrimination on the ground of disability in education and other realms of life
- The Disability Standards for Education (2005) – designed to clarify the rights of students with disability to access and participate in education and training, and give guidance on how education providers can meet their obligations under the DDA
- Guidelines from the Australian Vice Chancellors' Committee (AVCC) – these include its 1996 guidelines on how to best accommodate disabled students, updated in 2006 (AVVC, 2006) and specific guidelines for students with print disability (AVCC, 2004).

While the expectations are clear, adherence to these standards is not regulated.

Most Australian universities employ specialised DLOs to provide services and support for students who have registered with the university as having a disability. DLOs support a wide range of disabilities. In the case of vision-impaired students, services include provision of teaching and examination materials in accessible formats, access to adaptive equipment and special arrangements for examinations. Some universities, but not all,

provide equipment loans and training. Government funding reimburses around 50–60% of costs for disabled local students (Department of Education and Training, 2015) but universities are required to cover costs for disabled international students (McLean, Heagney, & Gardner, 2003).

Three main methods are used to provide access to graphics for vision-impaired students: enlargement, description and tactile graphics. Enlargement is the most readily available method, though only appropriate for students with sufficient usable vision. However, it can be difficult to navigate and obtain an overview of the graphic when viewed at a large magnification, and viewing enlarged images can lead to fatigue and headaches.

Written or verbal description is the next most common method. Descriptions may be prepared in advance by an experienced transcriber or at the time of need by a tutor, aide, fellow student or family member. The utility of the resulting description can vary greatly. Furthermore, it is difficult to build an accurate mental model of the graphic's spatial layout from a description and descriptions necessarily summarise and partially interpret the original graphic with consequent loss of information.

Accessibility guidelines recommend the use of tactile graphics for presenting graphics in which spatial relationships are important, such as maps, plans and technical drawings (Round Table on Information Access for People with Print Disabilities Inc, 2005). Tactile graphics are raised line drawings usually created with specialist equipment. The main drawbacks are that they can be expensive and time consuming to produce, require specialist transcribers for their production and the student must have sufficient tactile reading skills.

A number of other technologies for providing accessible graphics have been developed in the last decade, although none are yet in widespread use. These include sonification (e.g., Brown & Brewster, 2003); haptic feedback (e.g., Darrah, 2013); integrated eBook delivery on touch screen (Goncu & Marriott, 2015) and 3D-printed tactile models (e.g., Grice, Christian, Nota, & Greenfield, 2015; Kolitsky, 2014).

3. Prior research

A substantial body of work has been conducted exploring the experiences of disabled students in HE in recent years, revealing a range of barriers to equity and access to education. For example, Brandt (2011) was clear that 'the disabled students who participated in this study did not have the same study opportunities as non-disabled students and barriers relating to educational accessibility keep disabled students from acquiring expertise' (p. 116).

In their pioneering study of 22 disabled students and two senior tutors in the UK, Borland and James (1999) concluded that students with disabilities spend more time accessing information than their peers and proposed three main barriers to inclusive education: (1) physical access barriers, such as infrastructures and spaces; (2) curricular access barriers, such as methodology and content and (3) attitudinal barriers, which are the most difficult to eradicate. More recent work has supported and elaborated on their conclusions.

Attitudinal barriers, which include a lack of training, understanding or experience dealing with disabilities (Díez, López, & Molina, 2015; Hadjikakou & Hartas, 2008; Lewin-Jones & Hodgson, 2004; Moswela & Mukhopadhyay, 2011), are consistently reported. This results in highly variable academic understanding and support for students

(Holloway, 2001; Vickerman & Blundell, 2010). In Australia, the Department of Education's review found that there is a low awareness of their Disability Standards for Education among teaching staff and a lack of engagement by academic staff has been observed in HE (Department of Education and Training, 2015).

These barriers impact on access to content, with lecturers rarely complying with requests from students for materials in advance (Fuller, Healey, Bradley, & Hall, 2004; Holloway, 2001) and being disinclined to change their teaching style and adapt to the needs of disabled students (Borland & James, 1999; Díez et al., 2015; Moswela & Mukhopadhyay, 2011). A recent review of the Disability Support Program by the Department of Education and Training (2015) found that 11% of the 1900 disabled students surveyed in Australia were concerned about difficulties in accessing course materials. Compounding all of these problems, Brandt (2011) and Holloway (2001) raised concern that there is a lack of feedback systems related to the particular needs of disabled students.

Studies of the barriers and enablers specifically facing vision-impaired HE students are less frequent but reveal similar issues. Overseas, Bishop and Rhind (2011) interviewed nine vision-impaired students at a single HE institution in the UK; Lewin-Jones and Hodgson (2004) detailed the experience of a single severely vision-impaired HE student studying a foreign language (German) in the UK; Frank, McLinden, and Douglas (2014) interviewed three recent or current vision-impaired students studying physiotherapy at an HE institution in the UK and Reed and Curtis (2012) surveyed 70 vision-impaired HE students studying and 55 HE staff members providing disability support in Canada. More locally, Doepel (2014) conducted interviews with 22 professional blind citizens from Australia and New Zealand and the Australian Human Rights and Equal Opportunities Commission (HREOC) conducted a forum to examine access to tertiary education materials for vision-impaired students in 2002. Hollier, McGrath, Scott, Varley, and Woodford (2013) consulted with 49 professionals regarding the issues in vision education.

It is striking that the lack of timely access to study materials was found in all of these studies. Creation and provision of accessible materials was found to be a major issue for vision education services (Hollier et al., 2013), delays in the provision of course materials are common (Bishop & Rhind, 2011; Department of Education and Training, 2015; Frank et al., 2014; Reed & Curtis, 2012) and the ad hoc approach to provision of accessible materials for HE students was said to be failing (HREOC, 2002). Again, awareness and attitudes were found to be problematic, with reports that some academic staff are unable or unwilling to adapt their teaching to make it accessible (Bishop & Rhind, 2011; Frank et al., 2014; Reed & Curtis, 2012). These findings are of particular concern given Doepel's (2014) conclusion that braille skills and access to learning materials are the most important elements in education to enable the professional success for blind adults.

Communication is an additional issue in the provision of accessible materials for vision-impaired students. Studies have highlighted that communication between students and staff was potentially hindered by the student's fear of disclosing their disability (Bishop & Rhind, 2011; Frank et al., 2014), that communication and understanding between universities and accessible formats producers can be poor (HREOC, 2002) and vision-impaired students may experience difficulty working in a group (Lewin-Jones & Hodgson, 2004; Reed & Curtis, 2012). Further barriers for vision-impaired students in HE include extra time and effort required by students to achieve the same learning outcomes as their sighted peers (Armstrong & Murray, 2007; Frank et al., 2014); lack of

training or access to adaptive technologies (Reed & Curtis, 2012) and difficulties navigating around the university (Bishop & Rhind, 2011; Frank et al., 2014).

We are not aware of any prior studies focusing primarily on access to graphics by vision-impaired students. However, graphics have repeatedly been recognised as an area of particular difficulty. For example, Hollier and colleagues (2013) reported that accessible graphs and diagrams are the most commonly identified resource need in vision education for primary and secondary students in Australia. Armstrong and Murray (2007) highlighted the fact that diagrams, images and visual cues, which are largely inaccessible to blind and vision-impaired students, are heavily used in technical subjects to convey complex concepts, and Lewin-Jones and Hodgson (2004) explicitly noted difficulties accessing graphical and video materials. This is clearly an issue that requires better understanding and intervention.

4. Methodology

In order to investigate whether vision-impaired students studying at Australian universities experienced difficulty accessing graphical materials, two data collection approaches were used: a national online survey of vision-impaired students and in-depth interviews with key stakeholders.

4.1. National online survey of students

4.1.1. Data collection

In order to gain an understanding across the whole Australian sector, a nationwide survey of vision-impaired students was conducted. There were 32 questions, mainly multiple choice, concluding with three open-ended questions. Respondents were asked whether they had encountered problems with accessing graphical materials, what kind of graphics were commonly encountered, what, if any, impact access had on their studies, adequacy of university support and processes, and what technologies they had used or would like to use. The survey was carefully designed and tested for accessibility.

Students were recruited by email through two main channels. A request was circulated on the AUST-ED email list of Australian Tertiary Education Network on Disability (ATEND), asking DLOs to circulate the call for participants to students at their university. A further request was sent directly to potential participants through blindness and accessibility-related Australian listservs and social media groups.

4.1.2. Participants

Responses were analysed from 71 participants, of whom 60 completed the whole survey and 11 provided partial completion. Responses from an additional seven participants were disqualified because the participant did not give consent, they did not have a vision or print disability or they completed their university studies more than five years ago.

Participants had recently studied at one of 26 different universities. Thirty-four per cent of respondents were blind, with the remainder having low vision or a print disability. Forty-nine per cent had experienced deterioration in their vision in the last five years. Ten per cent were international students. Seventy per cent identified their most recent level of study as undergraduates, 22% as postgraduate by coursework and 8% as

postgraduate by research. There was a relatively even spread of ages: 18–24 (39%), 25–39 (26%), 40–54 (30%) and 54+ (9%) years.

4.2. Semi-structured interviews

4.2.1. Data collection

Semi-structured interviews were conducted with the key stakeholders in the creation, delivery and use of accessible graphics: vision-impaired students, academics, DLOs and accessible format transcribers. The interviews were designed to investigate the issues raised in the online survey in more depth and to gain a better understanding of university processes for providing accessible graphics.

The semi-structured interviews were conducted from November 2014 to April 2015 by one of the researchers. Interviews were carried out in person at the participant's place of work or study or via telephone. The interviews ranged from 17 to 84 minutes in duration. The interviewer asked up to 29 set questions relating to the participant's experience with access to print for vision-impaired students at university. The question topics related to the participant's background, university materials, provisions for vision-impaired students and evaluation. Most interviews were audio-recorded. All answers were recorded in writing, in verbatim for key responses.

4.2.2. Participants

Interviews were conducted with a total of 44 participants in Australia, including 13 current or recent university students with a print disability, 12 university Disability Services staff, 10 academics with experience teaching a vision-impaired student and nine staff involved in the production of accessible formats.

Students were recruited through Disability Services at Monash University ($n = 7$), Deakin University ($n = 4$), La Trobe University ($n = 1$) and the University of Adelaide ($n = 1$). Four (31%) of the students were blind, one had a vision-based learning disability and the remaining eight had low vision. We expect that, due to self-selection, the sample may have been biased towards students for whom access to graphics is a more salient issue, either due to their level of vision impairment or subjects studied.

Disability Support staff were recruited through the AUST-ED email list of the ATEND. Participants worked at a range of universities throughout Australia: Charles Sturt, Deakin, Griffith, La Trobe ($n = 3$), Edith Cowan, Flinders, Monash ($n = 2$), RMIT and the University of Adelaide. As with the students, due to self-selection, the sample may have been biased towards staff with greater experience with high-needs vision-impaired students and/or knowledge of vision impairment.

University teaching staff were referred by DLO staff at Monash and Deakin Universities. While the participation rate was well over 50% of the academics who were approached, all interviewees were from Monash University and nine of the 10 interviewees had taught the same student.

Accessible formats production staff were recruited from the Vision Australia accessible formats production teams in Victoria ($n = 6$) and NSW ($n = 3$). Their roles included customer service, transcription, proofreading and management. The staff shared an average of 18 years of experience in accessible formats provision. The participation rate was well over 50%, giving a reasonably representative sample from within the organisation.

4.2.3. Analysis

In order to analyse the interview data, a number of preliminary themes were developed independently by two of the researchers. Data were then analysed using these themes for all participant groups. On completion of the first phase, the themes were compared to determine the commonly identified themes, as well as gaps in each analysis. While the themes were slightly different in name, the same six core ideas emerged: Awareness and Attitudes, Timeliness, Expertise, Communication, Resources, and Responsibilities and Independence.

5. Results and discussion

5.1. The use of graphics in HE learning materials

Survey respondents were asked what type of graphics they had encountered in their university materials. While charts & graphs (79%) and tables (78%) were most common, a wide variety of other kinds of graphics were used: photographs (64%), videos or animations (64%), process flow diagrams (49%), concept maps (49%), timelines (48%), cartoons (44%), tree diagrams (35%), maps (30%) and Venn diagrams (29%). Less common were technical drawings (18%), network or circuit diagrams (14%) and architectural plans or floor plans (6%).

Survey respondents reported using a wide range of methods to access graphics. Unsurprisingly, image magnification (84%) was the most common approach for students with low vision or a print disability, while the most common approach for blind students was a written description (74%) or verbal description of the graphic provided by university staff (74%) or a friend, fellow student or family (53%). Blind students also made use of tactile graphics (26%) and three-dimensional models (21%).

Many of the respondents indicated that they may have benefitted from methods of presenting accessible graphics which were not provided to them. In particular, most blind students (76%) had used tactile graphics outside university but only 26% were provided with this format at university.

5.2. University support processes and practices

All universities reported a similar process by which vision-impaired students register with Disability Services and meet with a staff member to discuss their needs. Where required, the DLO arranges accessible formats in consultation with the relevant academic staff. Ideally, the print materials should be submitted for adaptation at least four weeks in advance; however, both academics and support staff reported that this is often not possible.

The level and type of support provided to students varies widely between universities. At best, a staff member specialising in vision impairment may be able to provide advice and facilitate training tailored to each student's individual needs. At worst, a single staff member may be required to assist up to 800 different students, incorporating a wide variety of disabilities.

The services most commonly used by the survey respondents were provision of materials in accessible formats (83%) and special arrangements for examinations (81%). Other services included provision of support workers or extra time with tutors (45%)

and adaptive technology advice (42%), rooms (36%), loans (17%) and training (11%). Students who were blind more frequently used these services. All respondents confirmed that they were aware of the services available from their university.

5.3. Impact on students

Access to graphics was found to be a significant issue for HE students with vision impairment. Most of the survey respondents indicated that they had often (41%) or sometimes (43%) 'skipped over graphical material and potentially missed important information because it was inaccessible'. Virtually all respondents indicated that they could often (41%) or sometimes (53%) 'benefit from improved access to graphics in my study materials'. When asked an open-ended question about the main barriers to access to graphics at university, half (53%) of the survey respondents stated that materials were simply not provided in an accessible format or the format provided was not adequate.

While less than half (41%) of the survey respondents indicated that they had needed to produce their own graphics for study purposes, the rate was much higher (92%) in interviews given prompting. Of the 12 interviewed students expected to produce their own graphics, less than half (42%) were able to do so independently. Both survey and interview participants shared stories of relying on help from others, negotiating a different task or deliberately avoiding production of their own graphics, sometimes as a matter of principle.

Half of the survey respondents had often (15%) or sometimes (36%) 'experienced difficulty in collaborating with other students due to lack of access to graphics'. This was a greater issue for blind students, with two-thirds experiencing difficulty often (17%) or sometimes (50%). One low-vision respondent with recent vision loss wrote:

> Group work is just really horrible, stressful and publicly humiliating with a vision impairment.

Lack of access to graphical materials significantly impacted study and career choices of vision-impaired students. Half of the survey respondents said that they had definitely (30%) or somewhat (20%) 'avoided a potential study area or career due to concerns about access to graphics in that field'. This was a greater issue for blind respondents, of whom 44% indicated that they had definitely avoided an area or career. Students made statements such as:

> 'I avoided anything with a lot of reading or graphics' or
> 'I tried to stay away from sciences because of the amount of graphics.'

Other students discontinued or withdrew from subjects that involved a lot of graphics. For example, one student 'may have taken psychology further if it had been easier to access the statistics'.

While many DLOs struggled to think of times when students had avoided study areas, both DLOs and academics voiced opinions that it is easier for students to reconsider study areas involving a lot of graphics. One DLO openly admitted that they had guided students to avoid subjects where there were concerns with graphics accessibility, while another praised a student's decision to change courses after struggling with access to technical materials.

Further evidence for the impact of vision impairment on study choice is found in the survey respondents' fields of study. Compared with ABS data for the general population

(Australian Government Department of Education and Training, 2014), a high proportion (43%) of the respondents were studying the largely text-based field of Society & Culture, compared with the typical proportion of 24%. This difference was statistically significant (χ^2 (1, 494,984) = 13.84, $P < .001$). Vision-impaired students were underrepresented in almost all other areas, including the STEM disciplines (Natural & Physical Sciences including Mathematics, Information Technology and Engineering), where the 11% participation rate was significantly lower than the 24% rate for the general population (χ^2 (1, 494,984) = 4.13, $P < .05$).

5.4. Issues/barriers/difficulties

When asked about barriers, Australian HE students with vision impairment raised similar issues to those identified in previous international studies.

5.4.1. Awareness and attitudes

Eighteen per cent of survey respondents mentioned lack of awareness by university staff. One wrote:

> Lecturers need to understand diversity and learn about disabilities.

Most academics interviewed were largely unaware of accessibility issues until discovering that they had a vision-impaired student in their class. Even after teaching a vision-impaired student, many remained unaware of suitable strategies and teaching practices. There was little recognition that improvements in accessibility of graphical material, such as improved clarity of diagrams or textual descriptions, could actually benefit all students, not just those with vision impairment. Instead, there was a general sense that it is not appropriate to adapt materials or teaching approach for only one student. While some academics made a conscious effort to be more inclusive, some acknowledged that they would forget, particularly when delivering a lecture.

5.4.2. Timeliness

Thirteen per cent of survey respondents raised timeliness in provision of accessible formats. In a separate question, 56% of respondents that used accessible formats reported that they did not 'receive accessible study materials on time' often (17%) or sometimes (39%). Academics confirmed that much of their material is produced just in time, citing restructuring of course materials as a reason along with high demands on academics and the importance of keeping materials fresh and current. Typically, DLOs try to get material early but are resigned that it is often not possible.

Braille and tactile graphics require longer to produce and are often avoided for this reason due to the belief that 'it would take so long that the student would be disadvantaged by the time they received all the materials they need', as stated by a DLO. Similarly, an academic reported that their student did not get access to some material because the 6–8 weeks for conversion was 'impossible'.

5.4.3. Expertise

Identifying the best approach for each situation and learner can present a considerable challenge because a wide variety of very different formats and software solutions are

available; however their viability depends on the graphic, available resources and skills of the student. All stakeholder groups acknowledged that a lack of knowledge about adaptive technologies compromised their ability to use or deliver accessible formats.

Academics insisted that some types of graphic can only be described by an expert and students raised instances of poor support by non-experts. Accessible format producers acknowledged the difficulty of interpreting specialist diagrams but were reluctant to seek advice from the requesting university. One transcriber stated that not understanding content 'happens almost every job' for technical tertiary materials.

Tactile graphics production also requires considerable expertise in terms of understanding the principles of reading by touch, knowledge of the braille code and use of specialised software and hardware. Concerns were raised regarding the quality and clarity of some tactile graphics, particularly those produced within universities.

Clearly, expertise is required at a number of different levels in order to best ensure a vision-impaired student's access to university-level graphics. This expertise cannot be held by a single person, meaning that communication and referral are of vital importance.

5.4.4. Communication

DLO, student and academic interviewees all spoke about the importance of communication at the beginning of semester to set mutual expectations and understandings regarding needs. Most, but not all, of the students surveyed reported communicating directly with academic staff at the start of the semester (70%), if only in the form of an email. However, academics seemed to face difficulties in engaging and communicating with vision-impaired students. Only 8% of the survey respondents indicated that an academic had initiated contact with them.

A number of academics did establish and maintain strong communication links with students regarding their academic progress. Even in these cases, however, it was sometimes unclear to what extent they could ask the students more general questions about their study and coping mechanisms. For example, one academic said 'it was puzzling … I would love to know how [the student] does it but didn't want to ask directly'. This possibly highlights a need for a greater general awareness and understanding of students with disability and their learning practices.

When accessible graphics are created by an external producer, the communication chain is long and rarely allows for direct communication between the stakeholders. There can be up to four intermediaries between the student or academic and the accessible formats producer. As a result, the transcriber has little awareness of the student's preferences and cannot easily seek clarification regarding the subject matter when modifying or describing diagrams.

5.4.5. Responsibilities and independence

The interviews with the various stakeholder groups revealed several realms in which responsibilities were unclear or disputed. For example, several students complained that they did not get enough support from DLOs when dealing with academics who did not understand or respond to their needs. In contrast, the majority of DLOs defined their role as that of liaison and said that advocacy was the role of a different university service. Meanwhile, academic staff were often found to be unaware of their responsibility to incorporate universal design principles in their teaching practices, instead seeing it as

the role of the Disability Service Unit to provide modifications for individual students who cannot access their teaching materials.

Most DLOs hold the student as responsible for requesting the materials or services they need; however, in many cases the students are unsure what to ask for or are reluctant to ask due to some confronting element, such as an unwelcoming environment. This is particularly problematic for graphics because the resource constraints prevent every diagram from being produced and the student is unable to identify the most important diagrams themselves since they do not know what they contain. As one student stated:

> I can't know which diagrams are essential until I have seen them.

The issue of student independence is closely related to responsibility and, at times, there seems to be confusion between the two. Ideally, students should be enabled to learn independently in the manner, time and place that they prefer, but it remains the responsibility of the university to ensure that learning materials are accessible to students in a fair and equitable manner.

5.4.6. Resources

Limited resourcing compounds the many issues already raised. Similar to findings in the UK (Riddell, Tinklin, Wilson, 2005), lecturers reported that their willingness/ability to find out more about accessibility or provide extra support for disabled students was limited by a lack of time. DLOs focused on the need to increase resources in general in order to support what appeared to be an increasing number of students; not just those with vision impairments. One DLO even indicated that the numbers were approximately one DLO to provide support to 800 students with disability. This highlights a clear issue in resourcing, and possibly funding, of support processes for our tertiary students.

The high cost of accessible formats production was also mentioned as a limiting factor. One academic reported being told that specialist braille was too expensive so the student only received a sample of the materials provided to other students.

Adaptive technology and proficiency in their use are obvious tools to enhance independent access to materials for vision-impaired students. However, the equipment is expensive and many students must rely on charitable bursaries to purchase their own equipment. While most universities provide a library room with adaptive equipment and software for use on-campus, students complained of limited access.

6. Implications and recommendations

The survey and interview revealed that many, if not most, vision-impaired students are missing out on the information conveyed in graphics in their learning materials. This has significant implications for the students in question, universities and the broader HE sector.

Our results reveal a lack of equity. Many vision-impaired students are not receiving an equivalent educational experience to their peers. Whatever the reasons for not obtaining appropriate materials, these students are being placed at a severe disadvantage. As a consequence, many universities are most likely not meeting their obligations under the DDA.

While the number of examples is limited, similar circumstances are increasingly leading to litigations in other countries.

This limited access to graphical material also has consequence outside the immediate period of university study by reducing study and career options for vision-impaired students. We found that many students with vision impairment deliberately choose fields of study with fewer graphics, leading to poor representation across many disciplines, in particular STEM. The flow-on effects can be far reaching, as particular areas of employment may lose touch with the vision-impaired community and other disability groups. Ultimately, this may all contribute to negative perceptions about the capacity of people who are vision impaired or have other disabilities.

As demonstrated by the student participants in the survey and interviews, when afforded appropriate opportunities the students can be high achieving and vital members of the learning environment. A number of key recommendations to improve access and educational opportunities naturally emerged from our study: awareness and training, communication, feedback, universal design, technology and increased funding.

Many suggestions for improvement by survey students centred on awareness training for university staff. The AVCC Guidelines (2004) clearly state that it is expected 'the university has processes in place to ensure that teaching staff, including casual staff, receive training in inclusive teaching methods and course design' (p. 6). When academics were asked for suggestions for improvements, notions of training for academics were prevalent, with acknowledged needs for better understanding of processes, technology and support processes in general. Indeed, nearly all legal resolutions and settlements against universities in the US have resulted in requirements that institutions provide accessibility training to faculty and staff who develop or post content on any university website (University of Washington, 2015). There is international evidence to show that lecturers demonstrate greater sensitivity and inclusion after receiving training about the learning needs of disabled students (Murray, Lombardi, & Wren, 2011; Zhang et al., 2010).

Universal design guidelines are critical in the provision of quality accessible materials. Adherence to simple practices in document preparation, such as the use of clear print, labels for all graphics, pasting as text rather than an image and basic textual descriptions for graphics, can have major impact for students with vision impairment. Not only can this ensure that graphics are produced of an understood consistency, as well speed up the production of additional accessible versions if required, such guidelines can also result in the production of a better quality of learning material for all students.

Such guidelines, however, do not necessarily ensure that materials will meet the needs of all vision-impaired students. Given the diversity that exists among students with vision impairment, it is important to acknowledge that there is still a strong need to work closely with individuals to ensure that their particular vision impairment is catered for and that their specific learning needs are met.

Communication and clarification of responsibilities is in dire need of improvement, across the entire process of accessible graphic provision. Improved communication between students, academics, DLOs and transcribers is required not only in the graphics request and transcription process, but also in clearly defining expectations and responsibilities. Currently neglected, a feedback process is required whereby students with vision impairment are encouraged to provide feedback on the accessible materials provision

process and products. Such a feedback process should be formalised to ensure quality of provision and improved equity.

The use of technology for producing and engaging with accessible graphics also has significant scope for improvement. To make the most of emerging technologies, greater resources need to be provided for not only the acquisition of these technologies but also training all stakeholders in their appropriate use. Undoubtedly, this leads to the need for increased funding in the sector in general for the provision of a holistic support process.

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