# Something to Hold On To: Tactile Access to Graphics in Higher Education

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# Abstract

Tactile graphics have long been recognised as an important component of learning materials for blind and vision impaired students in primary and secondary school. However, at the higher education level in Australia there is an assumption that most graphics are not essential and students will self-advocate for access to any graphics they need. Do vision impaired university students get adequate access to graphics? What are the specific problems that limit the use of tactile graphics and 3-dimensional models in higher education? And what can be done to address these issues?

In this Australian study, we conducted an online survey of vision impaired university students and semi-structured interviews with key stakeholders: students, academics, disability services staff and accessible graphics providers. Here, we extract and examine our findings relating to the use of tactile graphics and 3-dimensional models by students with a severe vision impairment.

Information and strategies tailored to the higher education context are needed to ensure that vision impaired students are able to access information graphics in a clear and meaningful way. We developed a draft model for improved access to graphics and trialled the proposed strategies in a pilot study. We present the results of our attempts to improve and expand the provision of tactile and haptic solutions for access to graphics.

# Introduction

Graphics are increasingly being used as a core component of learning materials. In Australia, the importance of these graphics to vision impaired school students is well-recognised and tactile graphics are usually provided for touch readers, regardless of the high cost and lengthy processes involved. The provision of accessible graphics for Australia's 4,305 vision impaired tertiary students (Department of Education and Training, 2015), however, is not well documented.

Tactile strategies remain important for the representation of spatial concepts in higher education and are crucial to many STEM fields. It is well established that visual-spatial representations promote mathematical problem solving (Hegarty & Kozhevnikov, 1999; Kaufmann, 1990; Smith, 1964), with similar findings emerging for other STEM fields such as physics and chemistry (Hinojosa, 2015; Lopez & Hamed, 2004; Steiff, 2007). Are vision impaired students in higher education able to access graphics and, in particular, the spatial concepts and relationships which lie at the heart of some diagrams?

Australian legislation aims to eliminate, as far as possible, discrimination on the grounds of disability in education and other realms of life (The Disability Discrimination Act, 1992) and clarify the rights of students and expectations of education providers to achieve this (The Disability Standards for Education, 2005). Under the Disability Support Program, approximately $7 million per annum is allocated by the Australian government to support the cost of increasing disabled students' access to higher education. To receive part of this funding, higher education providers must submit detailed claims for costs relating to support of registered students with a disability. In any given year, universities receive reimbursement for 50-60% of their claimed costs, depending on the total claims made by all providers (KPMG, 2015). Universities are required to cover the remainder of the costs for local students and all costs for international students.

The majority of Australian universities follow a similar process whereby vision impaired students register with a disability services unit and meet with an advisor to discuss their needs. It is expected that a student will come to the university with the accessibility skills they need. The disability advisor and student liaise with academics to obtain learning materials, while disability services arrange any necessary accommodations for participation and assessment.

The Australian Vice Chancellor's Committee (AVCC) released guidelines on how to best accommodate students with disabilities in universities (AVCC, 2006) along with specific guidelines for students with a print disability (AVCC, 2004). However, the guidelines do not include decisive benchmarks and adherence to the guidelines is not regulated. As a result, universities diverge considerably in the manner in which needs are interpreted and accommodations are delivered. Some universities have established units for accessible materials production, some hire untrained independent transcribers, some send materials offshore (most frequently to India) or to Australian blindness agencies with expert production units, while the majority use a combination of these approaches. The overall level and quality of support for vision impaired university students' access to materials in Australia is poorly understood.

"Improving vision impaired students' access to graphics in higher education" is a two-year project aiming to quantify vision impaired university students' access to graphics in Australia, examine the reasons for this level and propose a model for best practice. Our team from Monash and Deakin Universities, with support from the Office for Learning and Teaching, conducted a survey of vision impaired university students in Australia and semi-structured interviews with stakeholders involved in accessible materials provision from a range of universities. Based on the findings from these exploratory studies, we then conducted a pilot study with a small number of students to implement and evaluate potential strategies for improved access to graphics.

Here, we focus on tactile strategies for access to graphics and restrict data analysis to those students who do not rely solely upon print to access their study materials. Tactile graphics are of particular interest due to their facility to convey spatial relationships. We hope to elucidate the underlying processes, attitudes, barriers and enablers for access to graphics and suggest some strategies for improved provision beyond the traditional production models.

# Methodology

## National online survey of students

An accessible online survey was created with 32 questions, mainly multiple choice. Questions focused on demographics, accessibility needs and graphics encountered at university. An invitation to complete the survey was circulated by university disability service providers to their registered students. The invitation was also promoted through Australian listservs and social media groups relating to blindness and accessibility.

A total of 35 responses were received from students who are not able to rely solely on enlarged print to access their study materials. All participants were currently undertaking studies in higher education or had done so in the last five years. Ages ranged from 18 to 69, with 69% of respondents over the age of 25. 40% of respondents were blind, with the remainder having low vision (54%) or a print disability (6%). Students were from 21 different universities in Victoria (n = 16), Queensland (n = 7), NSW (n = 6), South Australia (n = 3) and Western Australia (n = 3). There were no more than 5 students from the same university. The majority (66%) were undergraduate students but postgraduate students by coursework (20%) and research (11%) were also represented. The majority (69%) of students studied on campus, with the remainder studying online.

## Semi-structured interviews

A total of 41 semi-structured interviews of up to one hour in length were conducted in person or by phone with key stakeholders in the provision or use of accessible materials in Australian universities. Up to 29 questions were asked relating to the participant's background, university materials, accessibility of materials and evaluation of the current system.

Ten vision impaired students relying on braille and/or audio to access materials were recruited through disability services at Monash University (n = 5), Deakin University (n = 3), La Trobe University (n = 1) and the University of Adelaide (n = 1).

Twelve disability services staff were recruited through the austed-list administered by the Australian Tertiary Education Network on Disability (ATEND). They represented nine different universities and had an average of 8 years of experience in their roles as disability advisor, accessible formats producer or assistive technology officer.

Ten university academics with experience teaching a vision impaired student were recruited through their association with vision impaired student interviewees. The lecturers (n = 8) and tutors (n = 2) were all from Monash University and taught in the areas of information technology, mathematics and education.

A further nine staff involved in the production of accessible formats were recruited from Vision Australia, a leading provider of services for people who are blind or have low vision in Australia. These staff had an average of 18 years of experience in accessible formats provision.

Two of the disability services staff and three of the accessible formats producers were blind. In addition to talking about their current roles, they also gave insights into their own experiences as touch readers.

## Pilot study

Five students participated in a pilot study over two semesters, during which their access to graphics was observed and additional supports were provided. The students were recruited through disability services at Monash and Deakin Universities. A further 15 university and transcription staff involved in providing the students with educational support were observed and provided feedback and suggestions in an interview at the end of each semester. Interviews were up to 75 minutes in length.

The pilot study served the dual purposes of documenting current practices and trialling new or proposed best-practice strategies for increased access to graphics.

# Current practices

## Access to graphics

The use of graphics is widespread in university teaching materials. Even with a broad range of mainly non-technical study areas, 88% of surveyed students indicated that charts and tables were included in their print study materials.

Clear evidence was found that vision impaired students' access to graphics is inadequate in higher education, with the vast majority of surveyed students reporting that they skipped over inaccessible graphics and potentially missed out on important information either sometimes (49%) or often (43%). Almost all (97%) of surveyed students indicated that they could benefit from improved access to graphics.

As seen in Table 1, the surveyed students' use of tactile graphics was low compared with the more common methods of enlargement and description. This is in spite of the fact that almost half of the students had used a few (34%) or many (9%) tactile graphics outside of university. It is notable that while only 17% of surveyed students were provided with tactile graphics, a further 23% thought they would have been helpful.

**Table 1. Percentage of surveyed students who received or wanted access to graphics using various methods**

|  |  |  |
| --- | --- | --- |
| **method of access to graphics** | **method used** | **method not used but wanted** |
| verbal description provided by a university staff member | 49% | 29% |
| image for enlargement | 49% | 3% |
| written description (additional to the caption provided in print) | 43% | 23% |
| verbal description provided by a fellow student, friend or family | 40% | 3% |
| 3-dimensional model | 20% | 17% |
| tactile graphic  | 17% | 23% |
| graphics accessibility software, for example sonification | 14% | 20% |

Similarly, interviewees spoke of tactile graphics as an uncommon approach, used mainly for essential diagrams for blind students studying maths or science. Only one of the interview or pilot students reported that they had been provided with a map of the university campus, an item considered essential for all sighted students.

While 20% of surveyed students indicated they had used 3-dimensional models, interview responses suggest that each student is likely to use only one or two key models. These models were always ready-made, anatomy models being the most common.

## Barriers to use of tactile graphics and models

The semi-structured interviews and pilot study revealed a number of barriers underlying the limited provision of tactile graphics in Australian universities.

### Tactual literacy

Students and disability advisors in the interviews and pilot studies expressed concerns regarding tactual literacy. It is understood that students require considerable experience and skill to be able to make meaningful use of a tactile graphic. Further, it is thought that university students are not able to learn the required tactual skills and it is not considered to be the role of the university to provide tactile graphics for the sake of building or maintaining tactual literacy. There were several accounts of students being provided with tactile graphics for their end-of-unit examination materials without any prior exposure during semester. There were many more accounts of students being given limited or no tactile graphics due to concerns that they would not be able to understand them.

### Timeliness

Timeliness presents a major obstacle to the provision of accessible formats to students in higher education, where it is not unusual for lecture materials to be revised up until the day of their use. Of the 35 surveyed students, the majority indicated that they did not receive accessible formats on time either sometimes (51%) or often (14%). This issue is likely to be most salient for the time-consuming production of tactile graphics, particularly at those universities where production is completed off-site.

### Expense

While disability advisors were adamant that expense is not a barrier to the provision of accessible materials, they were certainly aware of the high cost of tactile graphics. The relative cost of tactile graphics production compared with other methods of conveying visual information does inform their decisions, with tactile graphics often only created in the absence of other options, and only for a selection of those considered most important.

### Specialist knowledge and expertise

For an effective transmission of information, print diagrams often need to be interpreted or simplified. The difficulty in simplifying graphics and making them tactually distinct was mentioned in interviews with students, disability advisors and accessible formats producers alike. However, the requisite knowledge and skills in both accessible formats and the diagram subject matter is rarely held by a single person in the university system.

With university disability funding awarded on the basis of materials provision, internal production staff are employed on a casual basis. Interviewees revealed that casual staff training, development and research are sorely needed but not covered in budgets for some university-based accessible production units. The advantage of in-house production, however, is that the staff can be recruited for their subject matter expertise. By contrast, external producers have much more expertise in accessibility formats but far understanding of the content of the specialist university materials they are transcribing.

### Difficulty in selecting graphics

Many graphics in university study materials are decorative or are not spatial in nature and can be adequately conveyed through description, which is relatively fast, easy and cost-effective. It is therefore unsurprising that most universities aim to produce only a small subset of diagrams as tactile graphics for those students who require them. However, the selection of diagrams for conversion to tactile format presents a difficulty in itself. Student and disability staff interviewees reported that graphics could be converted to accessible format if requested by the student, but both groups acknowledged the inherent difficulties of this model for a student who is unable to see the original print. As one student stated, "I can't know which diagrams are essential until I have seen them". When university staff are asked to identify the most important diagrams for conversion they often struggle because disability staff are not familiar with the requirements of the unit and teaching staff do not understand what vision impaired students are able to access.

### Integration with the text

Finally, a number of interviewed students and disability advisors objected to the use of tactile graphics on the basis of difficulties working with multiple formats. For one student, the solution was to request all text in hard copy braille when using tactile graphics. Others cited the logistical difficulties of dealing with bulky hard copy or using multiple formats as "the deciding factor" for foregoing tactile graphics altogether.

# Strategies for enhanced access

The pilot study served as an opportunity to implement and evaluate potential strategies to overcome some of the barriers to university students' access to tactile graphics. Some of these strategies are already practiced in a subset of universities, while others are new. Feedback was sought from stakeholders regarding the practicality and success of the proposed approaches.

## Ad-hoc tactile diagrams

Creation of ad-hoc tactile graphics in the classroom is rarely practiced in Australian universities and was not reported in any of the semi-structured interviews. Feedback from interview and pilot participants suggested attitudinal and expertise causes. University staff had little exposure to handmade tactile diagrams and believed that they were only useful for young children. Staff did not have the necessary information or experience to implement the strategy without prompting.

As part of the pilot study, a blind student's tutor was recruited to provide accessibility support, including the creation of handmade tactile graphics. Less than 30 minutes of training was provided, along with two short fact sheets and some basic tools. Around 10 tactile diagrams were produced for two units over a semester, these being identified as the most critical and reliant on spatial concepts. The student and tutor reported a high level of communication and the tutor also made direct contact with other faculty staff to inform decisions about the transcription; a highly valuable process that is generally absent when tactile graphics are produced off-site, as reported in the semi-structured interviews. The pilot study participants asserted that the diagrams would not have been provided in tactile format without the involvement of the tutor because of timeframe limitations in the production and identification of the print materials.

## Written descriptions to supplement tactile graphics

University students are expected to work much more independently than school students, with contact hours forming only a portion of their expected study time. They require accessible graphics solutions which are more self-contained, as the fall-back option to "ask your teacher for advice" is impractical when classes of 300 students are common.

Several students in the pilot study were provided with written descriptions to supplement tactile graphics. They reported that the descriptions were helpful in providing a quick overview and orientation to navigate the tactile diagram more effectively. For example, a highly proficient student reported that they would have skipped over a difficult tactile graphic if they did not have the accompanying written description. Such descriptions may be even more helpful for students who do not have a high level of experience or confidence with tactile graphics.

The relatively quick task of writing descriptions may also be helpful as a first step in selecting diagrams for further treatment. If a diagram is very difficult to describe, it is likely to be best conveyed as a tactile graphic or similar format with spatial layout.

## 3D printing

3D printing provides a potential new solution for the provision of 3-dimensional models for use by people with a vision impairment. It is recommended for anything that is too large, too small, too valuable/rare, or too dangerous to touch. It is also suitable for the representation of abstract concepts. At the higher education level, 3D printing holds particular promise for study areas such anatomy, geography, natural history, archaeology and mathematics. Where 3D printers are available, cost and delivery time may be reduced considerably compared with acquisition of ready-made models. For example, models of common 3-dimensional graphs are freely available through online repositories and can be printed with materials costing only a couple of dollars.

3D-printed models can be used by students with a less advance tactual literacy. Students in the pilot study, including those who did not normally use tactile graphics, responded positively to a 3-dimensional campus map with audio labels, stating that they could understand it more easily than a tactile graphic. The students were readily able to identify the buildings they already knew and make discoveries about parts of the campus they had not been oriented to.

## Haptic electronic diagrams

The GraVVITAS system for creating and reading audio haptic graphics on the iPad (Goncu, Marinai & Marriott, 2014) provides a potential method to convey spatial information tactually with reduced timeframes, cost and reliance on expertise. With a simple online interface for diagram production[[1]](#endnote-1), it is designed to provide a quicker and easier method for support workers to produce accessible graphics without the need for expertise in accessibility. Shapes are drawn with the facility to trace the original diagram as a guide. Each shape can be associated with a label and an overview description is also recommended. When the finished diagram is accessed on an ipad, touching each shape activates its spoken label and an audio tone. An optional haptic ring buzzes at different frequencies for each shape.

GraVVITAS diagrams produced for the pilot study were created more quickly than tactile graphics and without the need for specialist equipment. Pilot participants reported that the resultant diagrams were not as quick to use as tactile graphics, but were successful in conveying relative spatial information and advantageous for lengthy labels. The students were also enthusiastic about the ability to access a large number of diagrams on an ipad, which is much more portable than bulky tactile graphics. Further work is required to establish training requirements for accessibility novices and to explore technical options for improved identification of edges.

# Discussion

Our investigations revealed a low level of provision of tactile formats for vision impaired students in higher education. Once students enter university, tactile graphics are rarely considered a necessity and important information is potentially missed.

Strategies for improved access to graphics for vision impaired students in higher education must account for the unique barriers at this level of education, including a dispersal of expertise and emphasis on student independence.

Some strategies explored in the pilot provide hope. Recruitment of class tutors to create ad-hoc tactile diagrams improves communication and shared understanding, and allows materials to be created at much shorter notice. Provision of a written description alongside tactile diagrams supports greater independence and helps students less confident with the tactile medium to access spatial information. 3D objects are similarly advantageous for students with a lower level of tactual literacy and can be more readily obtained with the advent of 3D printing. Haptic electronic diagrams offer an easier way for class tutors to quickly create accessible diagrams, conveying simple spatial relationships with potentially lengthy audio labels. Just as new technologies offer opportunities for the usage of braille in the 21st century, so too can tactile graphics be modernised for easier and wider use.

A final pilot will be conducted in semester 1, 2016 with new students and at different universities. Where appropriate, we will apply these same strategies to confirm their worth across a wider context. In addition, we will explore strategies for improving communication between accessible formats producers, students and academics to address individual gaps in knowledge and strengthen the quality of outcomes.

# Acknowledgements

Support for this project has been provided by the Australian Government Office for Learning and Teaching. The views in this project do not necessarily reflect the views of the Australian Government Office for Learning and Teaching.

Our thanks are extended to all participants in the study.

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