Design/Tech

Powered by Augmented Reality

Lisa Wicks

Lisa Wicks teaches Design and Technology and Information Software Technologies in years 7-12 at at Kambala, a K-12 girls school, in NSW. Lisa has been teaching in this field for over 10 years, and in 2016 started a Masters of Education (Digital Learning) at Monash University. An increasing interest in emerging technologies and their potential for learning and education has lead Lisa to develop this Augmented Reality project, as part of her studies in the Master of Education program at Monash University.

Introduction

The purpose of this project was to explore the possibilities of augmented reality in a Design and Technology (DT) classroom and develop an instructional product that would be immediately useable in context, providing an authentic exploration of using this technology in the classroom. Augmented Reality (AR) uses technology to overlay data onto real-world views through devices eg tablets or smart phones, or headgear such as the Microsoft Hololens, or Google Glass. The most widely known, or commonly used example of AR is the game Pokemon Go, although, AR is also being used more frequently now for educational purposes, allowing students to access and interact with knowledge that may not be possible without this technology.

Initially, I analysed the context and specifications of the project, the proposed design brief, and a justification of the key project elements:

- Potential of augmented reality
- Need for reinforcement of learning
- Resource Content: Machine Safety and Operations, and
- The DT classroom context

Detailed Context and Specifications

Students (in year 7-12) in Design and Technology complete design projects that require the use of different machines in a workshop, including a scroll saw, drill press, buffing machine, sanding machines, and sewing machine. Students are instructed in the operations and safety requirements for each machine prior to its use, but often forget the details during a project and repeated instruction is required. A resource utilising augmented reality technology, such as a poster, could benefit students by enabling them to independently review the safety and operations of each machine. A further benefit would be to the teachers, enabling their time to be used to aid students in developing the complexity of their skills and quality of design projects, instead of restating basic preliminary knowledge. Based on these specifications, I developed the design brief following.

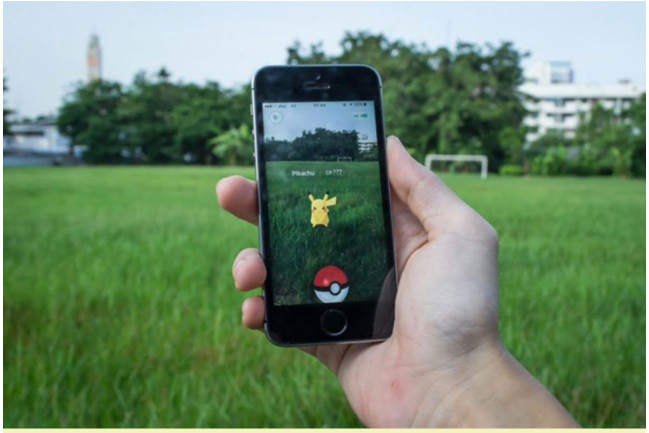
Analysis and Justification of the Design Brief

The Design Brief:

To design and create an instructional resource that utilises augmented reality to reinforce the learning of safety and operations of machines in the Design and Technology Classroom.

Augmented Reality (AR) Potential

AR is poised to become a widely-used technology, infiltrating our everyday lives, with greater impact and value to users than the initial novelty and hype of new technologies. Already, AR is being employed for advertising such as the Pepsi Max "Unbelievable Bus Shelter" Campaign (https://www.youtube.com/watch?v=Go9rf9GmYpM, PepsiMax, 2014), and for entertainment, for example, Disney's AR Colouring Book, and the game Pokemon Go which has brought AR into mainstream attention with its viral success (Gstoll, 2016).



A love letter from augmented reality to Pokémon Go (Gstoll, 2016)

Whilst these applications of AR will become more prevalent, the potential in education is immense. This is especially true with greater availability of mobile technology providing the capability of accessing and authoring AR content, AR will soon become inseparable from daily activities (Chi-Yin Yuen, Yaoyuneyong, & Johnson, 2011). Thus, exploration of the educational potential of AR is essential. Wu, Lee, Chang, & Liang (2013) state that "the educational values of AR are not solely based on the use of technologies but closely related to how AR is designed, implemented, and integrated into formal and informal learning settings" (p.41). Therefore, careful design and planning will be required to successfully support learning in the identified context.

Furthermore, educational research points towards increased engagement and efficacy of learning when AR is utilised compared with other computer-based technologies, and that students overall have an increased understanding of content, improved spatial understanding, improved physical task performance and increased motivation (Radu, 2014).

Whilst AR will be explored further, this brief introduction justifies AR as an appropriate medium to use in this project.

Reinforcing Learning - Current Issues

The purpose of the instructional resource was to reinforce safety and machine operations demonstrations provided by the teacher in the classroom.

Issues I have encountered include:

- Limited space for students to view details in demonstrations
  - Inhibits sensory input required for effective information processing.
  - Environmental and social distractions may contribute to poorly focussed attention and failed transfer of information to long-term memory (McInerney, 2014).
- Students forget demonstration content
  - Content has not been presented in a way to enable successful encoding of information and transference.
  - Lack of meaningfulness, complexity or length of content may contribute (McInerney, 2014).
- Limited time for repeating information
  - Lessons time could be used more effectively.

In my classroom, I had identified the need for an instructional resource that reinforces demonstrations.

Resource Content: Machine Safety and Operations

The importance of safety in the DT classroom is paramount as teachers have a responsibility for the safety of students in their classroom. This justified by legislative, and NSW Board of Studies (BOSTES) curriculum requirements. Proper instruction in machine operations will enable students to participate safely in classroom activities and develop skills towards producing high-quality designs (an essential component of learning within DT, as well as an assessable skill).

The Research section examines the specific details required by Work Health and Safety Legislation and relevant syllabus requirements that support the need for this content.

DT Classroom Context

Having been a DT teacher for over ten years, it is a context with which I am very familiar. Physical access to the space and pre-existing knowledge of machinery use and safety instruction provides the opportunity to develop an authentic product.

Research

In this section, four areas of research will be explored:

1. Analysis and discussion of the potential and challenges of AR in education,
2. Context investigation and analysis of staff survey,
3. Summary of Work, Health and Safety (WHS) legislative requirements, and
4. Summary of the NSW Board of Studies (BOSTES) curriculum requirements.

This research will direct decisions for content and structure of the resource.

AR: Potential Opportunities and Challenges

Defining AR is a critical in determining the best way to utilise this technology in the identified context. The clarification of this term will lead into a discussion of educational research and provide a sound basis for decision-making throughout this project.

AR has been defined in research in several ways. At its' core, as a computer generated, enhanced experience of real environments (Lee, 2012). Klopfer (2008, as cited by Wu et al., 2013) similarly suggests a broader definition as "any technology that blends real and virtual information in a meaningful way" (p. 42). Furthermore, Azuma (1997, as cited by Wu et al., 2013) introduces instantaneous interactivity and 3D synthesis of real and virtual components. The level of blending between real and virtual can be determined by the purpose of the educational resource and how the technology can best be used to meet the needs of the learner. Milgram, Takemura, Utsumi and Kishino (1994) explore the implications of the term AR, proposing a continuum of mixed reality displays from AR to Virtual Reality, relating to the proportion of the "real world" visible in the user's display. Examining this continuum was useful in determining how immersive my AR product should be.

Billinghurst, Grasset & Looser (2005) suggest that the close relationship between physical and virtual components allows an opportunity to design an AR interface providing familiarity for users. Ensuring the correct balance between real and virtual objects is essential to encourage connections between the learner and content. McInerney (2014) asserts that meaningful material is easier for learners to process, and from the perspective of Information Processing theory, encourages deeper retention of information. In this way, greater success will be achieved by creating lightly augmented resources for this project, as the environment will contain a higher proportion of real components, with greater familiarity to the user. This will directly relate to the design of the interface and, as Billinghurst et al., (2005) suggest, will need to consider the physical components, audio-visual elements, and the interactions that connect them.

Opportunities for AR in educational settings are rapidly emerging as technology becomes more accessible. Azuma, Billinghurst, & Klinker (2011) suggest that recent development of mobile technology provides educators with powerful AR hardware platforms; thus encouraging developers to create AR authoring tools such as Aurasma, Layar, Blippar and ZapWorks. I investigated these software platforms for their potential suitability for this project based on ease of use, functionality, and cost. Lee (2012) confirms that educational settings are ripe for using mobile technology for learning via AR integrated experiences and iterates AR projects in various science and mathematics subject areas. Possibilities exist to create valuable and engaging learning experiences in the DT subject area. Furthermore, the use of handheld devices increases experiential authenticity within the classroom environment as being less intrusive than head-mounted devices (Klopfer & Sheldon, 2010, as cited by Wu et al., 2013). The software identified above all enable access via mobile devices, and function across both Mac and PC operating systems, ensuring flexibility in the classroom.

AR operates via a markerless or marker-based operation to activate augmented components of a product. The software identified above use a variety of these in their platforms. Aurasma, Blippar and Layar operate as markerless AR, that is, they use image recognition, GPS or accelerometer data to engage interactive content.

Marker-based AR products are tagged with a unique target image that is recognised by the device's camera to activate the AR content (Albright, 2015). There are advantages and disadvantages to both types of AR for this project. Zapworks (2016) promote several advantages to a marker-based AR including:

- recognisable icons informing users of AR content
- simple, without reliance on potentially unsuccessful image recognition
- icons can be re-used on different product

Disadvantages of AR markers include:

- marker icons may not scan easily if they are too small or become damaged
- may not fit the design of the product, or visually disrupt product aesthetics
- different developer platforms use different markers and are not interchangeable
- rely on the use of a specific app to be downloaded onto the user's mobile device

("Markerless Augmented Reality - ARLab Blog", 2016)

Selecting a marker-based AR platform may be advantageous for this project as students will be able to clearly identify the AR components and similarly if AR is to be used in future educational resources, they will have developed that familiarity. The ability to re-use icons will be another advantage to choosing a marker-based style as the design of the page could change slightly in future, however, the AR component could remain the same, enabling future-proofing and saving time building subsequent resources.

There are many challenges of using AR in education and Wu et al., (2013) suggest three domains: Technological, Pedagogical, and Learning.

Technological issues include the bulky and expensive nature of head-mounted-display units, instability of AR between devices, and location dependency. These issues will be mitigated in this project by the use of mobile devices instead of head-mounted units as Wu et al., (2013) reason, including cost, but also the lack of accessible technology. A head-mounted unit would also present significant safety risks in a workshop, where an immersive device would impede students' physical awareness. The use of a multi-OS development app will help alleviate any issues arising from students having varied devices. Finally, the location dependency, while not relying on GPS data, the students will need to be close to the posters to initiate AR content. This will impact the poster placement within the classroom, to ensure they are close-by the relevant machine, however, not impacting on its' safe use.

Pedagogical issues discussed by Wu et al., (2013) refer to push-back from communities from using new technologies, content design and delivery, and inflexibility of content design in AR. As AR is becoming more commonplace, I believed that stakeholders will be excited by this project; already this is true from anecdotal evidence. Furthermore, a small-scale, low-risk introduction will ensure a greater likelihood of acceptance. Content design was carefully considered to ensure the correct balance of elements within the resource. Whilst inflexibility of content was a concern, the safety and operational requirements for the various machines will not change over the near future, therefore this is not significant.

Learning issues identified by Wu et al., (2013) include concerns of cognitive overload, and abilities requiring the need for scaffolding. This will guide content design and will be further examined through the Final Design development section.

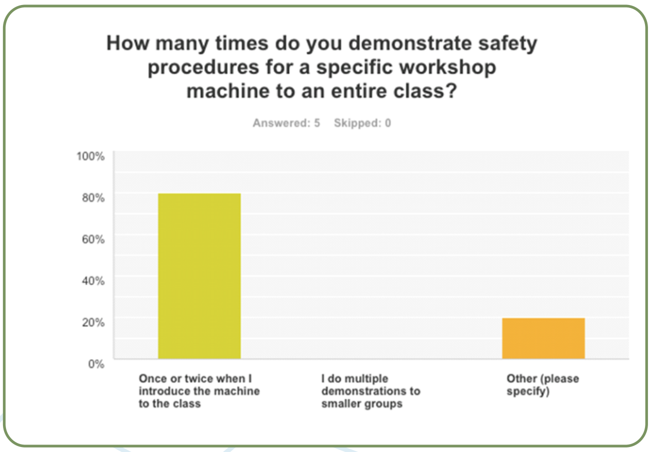
Context Investigation and Staff Survey

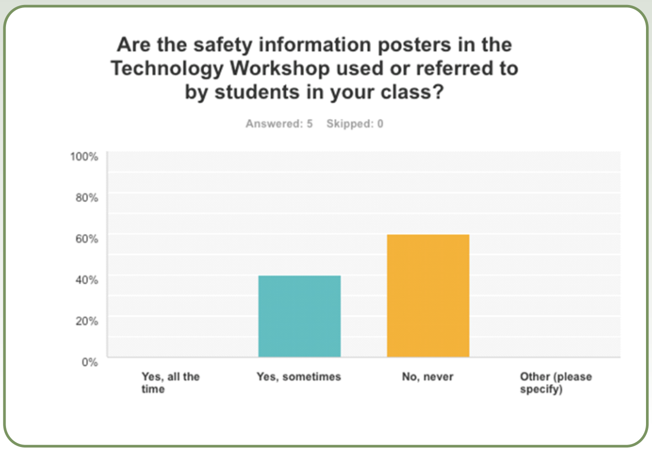
Data Collection

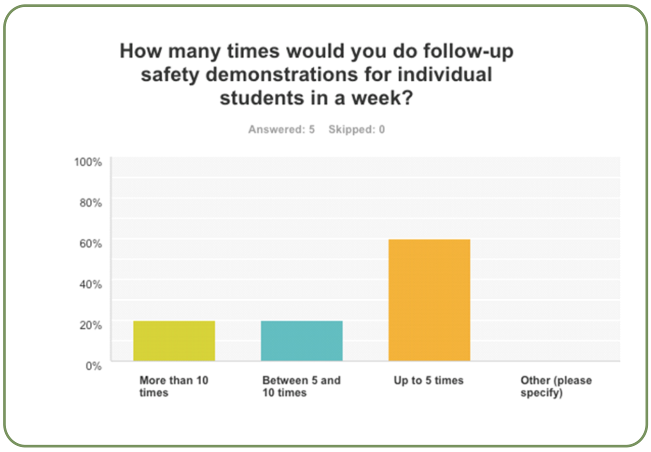
I had identified the need for this project based on personal experience and was interested if other teachers were having similar experiences. This would highlight a broader need and authenticity for this project. I conducted a short survey to ascertain this information and inquired on the following topics:

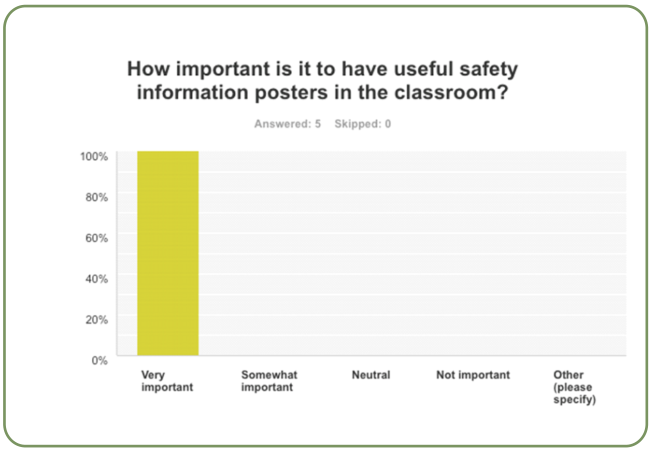
- usefulness of current safety posters
- mode of instruction for safety and operations
- level of repetition of instruction
- criteria of an interactive resource

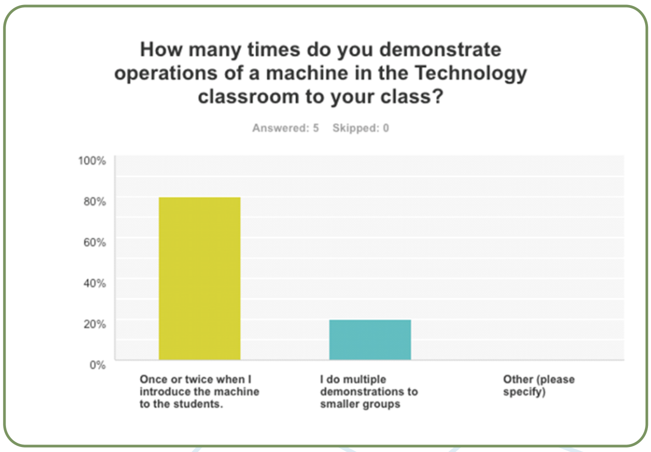
The survey consisted of ten multiple-choice questions, with optional comment areas for teachers, and was administered through Survey Monkey. There are 5 teachers in the faculty and each of them responded once. The questions and graphs of responses are shown below.

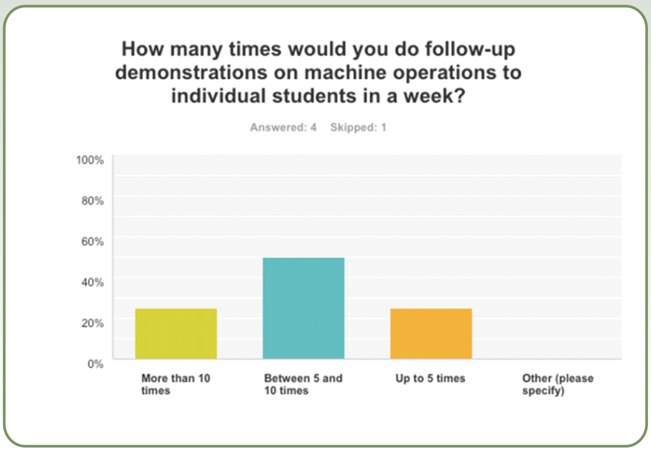


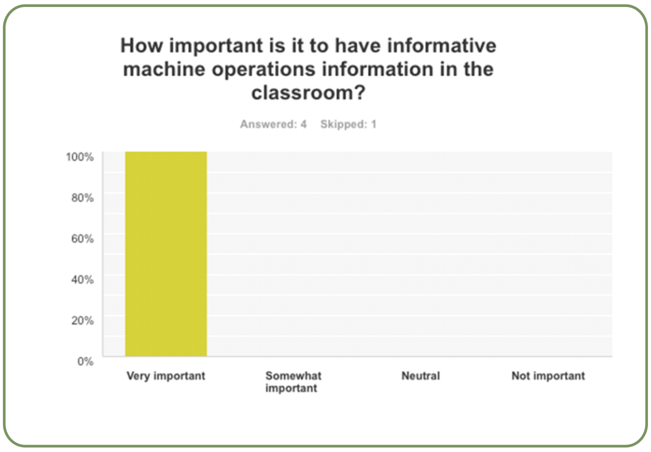


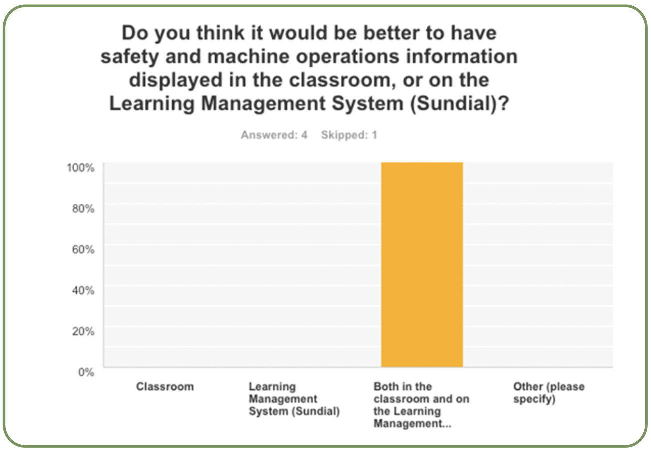


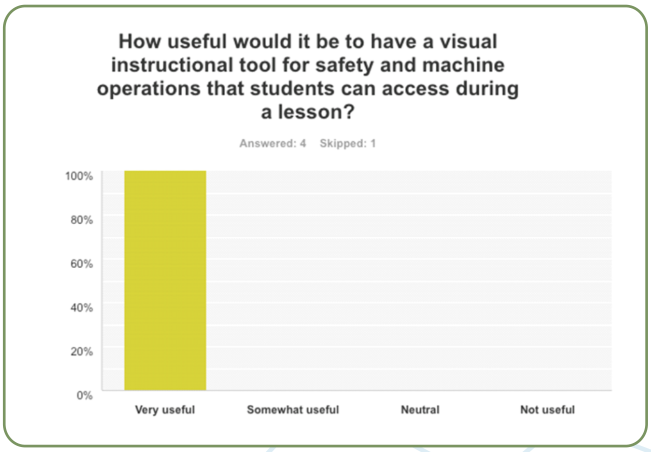


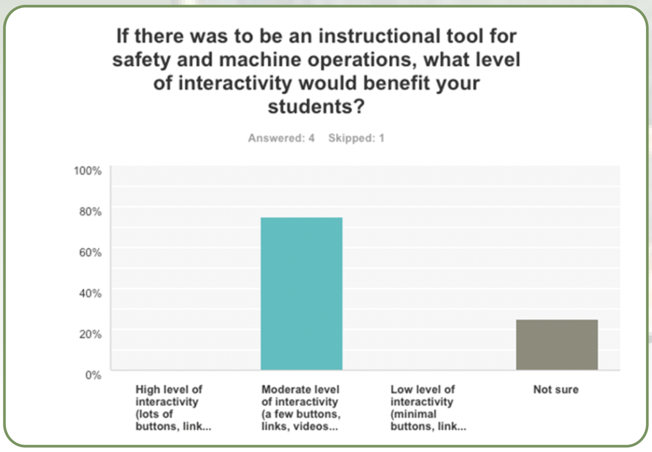












Data Analysis

I concluded that the other teachers had similar experiences regarding the safety and operation instruction. All teachers repeat demonstrations for both safety and operations with the majority instructing the entire class. One teacher commented that they present both small group and whole class instruction, though this included multiple repetitions. Similarly, follow-up instructions were repeated up to five times for both safety and instruction, however, the majority of teachers responded that they repeat operations more frequently, between five and ten times. Some teachers referred to the current posters, though more responded that they never refer to the safety posters. Unanimously, the teachers indicated the considerable importance of availability of safety/operations information in the classroom. Similarly, all teachers wanted to have the information on the current LMS platform. Finally, 100% of teachers felt that a resource of this kind would be very useful, and the preference was for a moderate level of activity. This confirms previous research stating the level of augmentation to be light.

Concluding Statements:

- Teachers are spending a large amount of time repeating instructions
- There is a greater need for operations content over safety content
- It is essential to have safety/operations information visible in the classroom
- Information must also be on the LMS platform, enabling students to access the resources when out of the classroom.

Work Health and Safety Legislation

A review of the Work, Health and Safety Act (WHS) 2011 (NSW) yielded the following essential conclusions:

Teachers must provide students with:

- physical demonstrations of safety requirements and machine operations

- training and instruction (can be in the form of supporting resources)
- safe working environment including access to Personal Protective Equipment (PPE)

Students are responsible for:

- taking reasonable care with their own safety and that their actions do not adversely affect the safety of others
- comply with instructions provided regarding safety

These points fall under the following sections of the WHS Act:

- Part 2, Division 2, Section 19: Primary Duty of Care
- Part 2, Division 4, Section 28: Duties of workers

Furthermore, Safe Work NSW provides guidance under the WHS Act 2011 (NSW) and the WHS Regulations 2011 (NSW) regarding the necessity for Personal Protective Equipment (PPE). This is one of the main safety considerations in the classroom, therefore, it was essential to include PPE content of this project.

Selecting safety content carefully was necessary to ensure that legal obligations were met under WHS legislation, though the primary source of safety instruction would be the teacher. Considering survey feedback from the teachers indicated safety instruction as a secondary purpose of the resource fitting well with the legal requirements of instruction and monitoring as prescribed above.

NSW Board of Studies (BOSTES) Requirements

To succinctly report the syllabus requirements, I focussed on the Year 7 and 8 Technology (Mandatory) course. The syllabi for years 9-12 follows a continuum with increasing sophistication of core concepts. Additionally, the machine requirements are consistent, and targeting the language towards the youngest users would ensure that terminology and information would be accessible to the majority of students using the posters.

Syllabus Objectives

Students develop:

- skills in the generation of creative design solutions
- understanding and skills for the safe use of tools

The table below identifies the key syllabus outcomes and course content that needed to be addressed by this project. The highlighted keywords indicate the main elements that were addressed in the resource developed. These keywords were selected based on relevance to WHS requirements, and analysis of staff survey.

Outcomes	Context
4.3.1 applies a broad range of contemporary and appropriate tools, materials and techniques with competence in the development of design projects	Students learn to: • select and **correctly use appropriate tools** and equipment for a design project • select and **use techniques** appropriate for the purposes of a design project (Technology (Mandatory) Years 7–8 Syllabus, 2003, p. 39)
4.3.2 demonstrates responsible and safe use of a range of tools, materials and techniques in each design project	Students learn to: • **manage risk** when developing design projects • **use tools**, materials and techniques in a responsible and safe **manner** in each design project. • **maintain tools** and equipment (Technology (Mandatory) Years 7–8 Syllabus, 2003, p. 24)
4.5.2 produces quality solutions that respond to identified needs and opportunities in each design project	Students learn to: • **identify** suitable materials, **tools and techniques** for each design project • practice and **refine skills** needed for design projects (Technology (Mandatory) Years 7–8 Syllabus, 2003, p. 25)

Ideation

This section communicates my ideas development based on research conducted previously regarding content and purpose of the resource, and incorporating research on content design.

I also explored the following:

- Design criteria - determining the elements required for a successful product
- Design constraints - identifying the restrictions or limitations for the project
- Ideas generation - demonstrating initial ideas and refinements to a final design concept

Design Criteria

Function:

- Effectively convey the required content using strategies like chunking, and scaffolding, as McInerney (2014) suggests, to provide more manageable pieces of information and build up levels of complexity
- Meaningful without added AR content so that students viewing the poster may increase their understanding of the machine prior to engaging with the AR content
- Use familiar terminology to activate prior knowledge, assisting in developing meaningful links between the student and content will increase learning potential (McInerney, 2014).
- Navigation structure should be consistent to promote ease of use. Predictable placement of features and elements across the posters will unify the collection, encouraging easier assimilation of knowledge.
- Manage cognitive load by providing multi-modal forms of instruction, but limiting competition between too many elements to avoid information processing failure.

Aesthetics:

- Prominence of features like buttons will ensure ease of use as these features will be correctly interpreted by the student (McInerney, 2014).
- Use familiar symbols to activate prior knowledge, similar to terminology above. An example might include standard PPE symbols as determined by the International Organization for Standardization (ISO) as these symbols are recognised worldwide.
- Design the content using the elements and principles of design and PARC principles will help create an aesthetically pleasing product.

Design Constraints

Time:

- Limited time to complete this project means the scope will need to be reasonable to be able to be achieved by the due date
- Due date: 10th October 2016 - updated to 17th October 2016 (26/9/16)

Finances:

- Minimal additional finances available meant development software either needed to be free to access or cost a minimal amount to create the product
  - Blippar has a free education account
  - ZapWorks has a personal account option that is initially free however an additional charge is required for continued use. Different software options allow varying degrees of sophistication in AR development.
  - Aurasma is free but has limited functionality appropriate to my needs
  - Layar is free to create but publishing incurs a hefty charge per page.

Practical Skills:

- I have strong graphics skills and have used the Adobe Creative Suite successfully (predominantly Photoshop and Illustrator) however, I have limited experience in 3D graphics, apart from SketchUp, and limited experience with advanced coding/scripting. Therefore, a solution will need to be developed where I can take advantage of existing skills.
- It will not be possible to produce a high-end, professional AR product that requires sophisticated 3D graphics skills or coding.

Ideas Generation

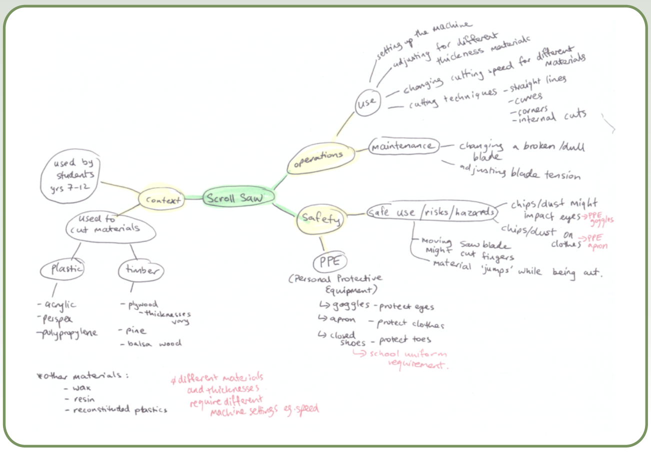
Brainstorming of Ideas

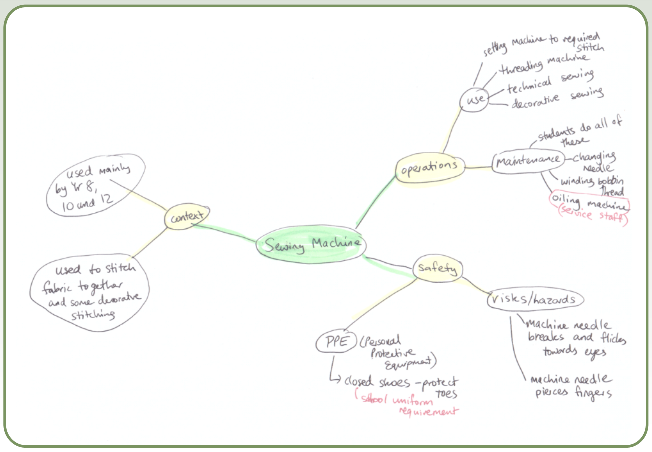
Initially, I identified five machines that might be addressed in this project. I completed a mind map for each machine, identifying its' context in the classroom, safety, and operations content. The points on each mind map were considered in response to research and survey data.

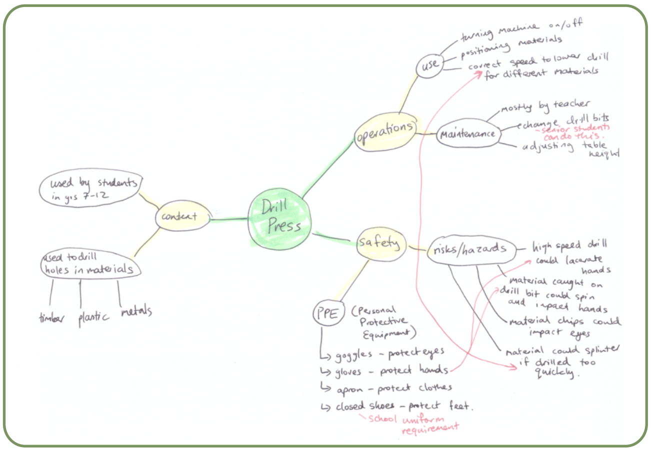
These maps highlighted key areas of content that needed to be addressed for the poster of each machine and I started formulating ideas for how each one might be approached in the product.

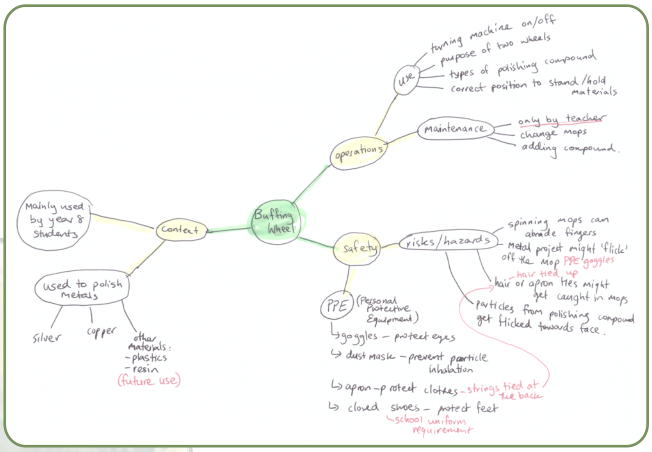
For each machine, I needed to address:

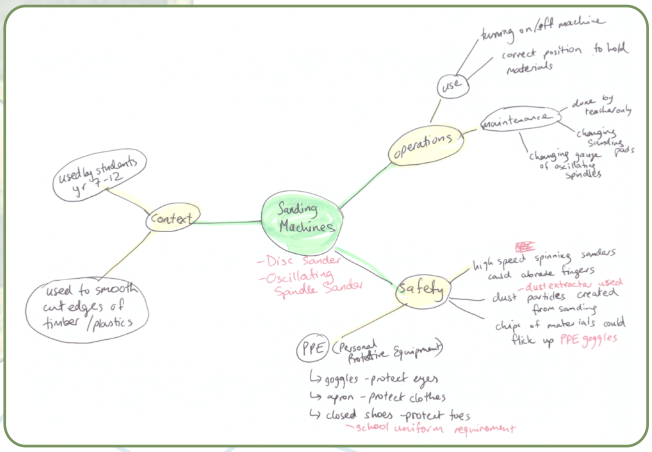
- how to set the machine to the correct settings
- how to operate the machine for different purposes
- maintenance skills required by the students
- PPE required





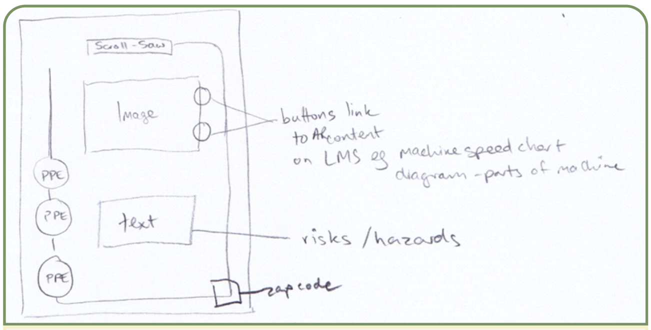




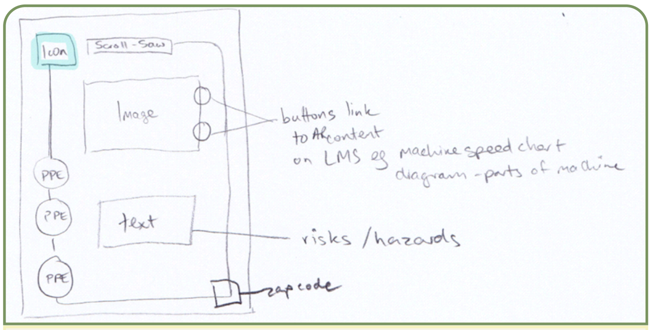


Design Sketching

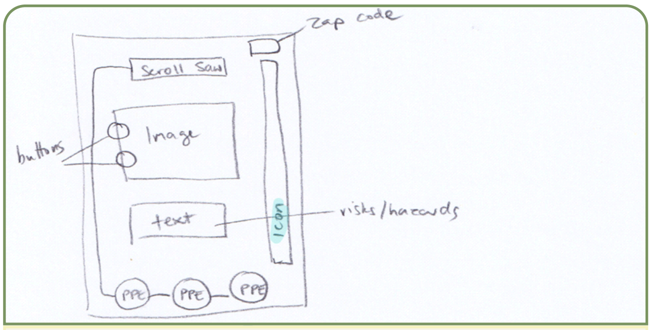
Initial idea sketches highlighted the need for machine-specific icons, which, in turn, dictated design decisions. Consideration of the elements and principles of design aided in the selection and placement of elements such as headings, buttons, images and text, as well as the AR specific identifiers (ZapCode).



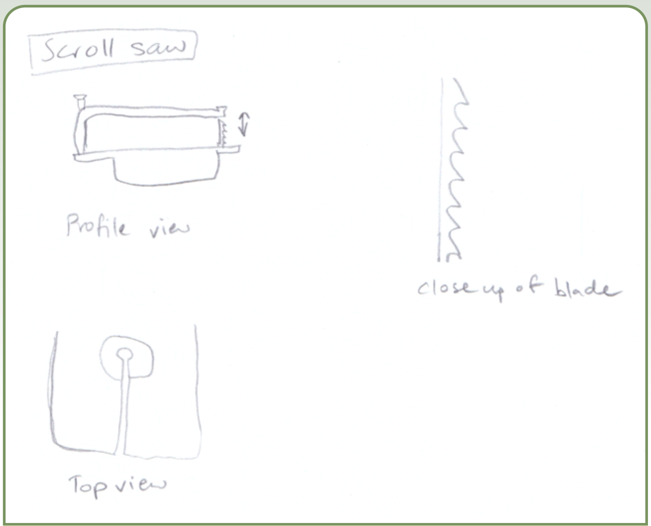
Design Idea 1



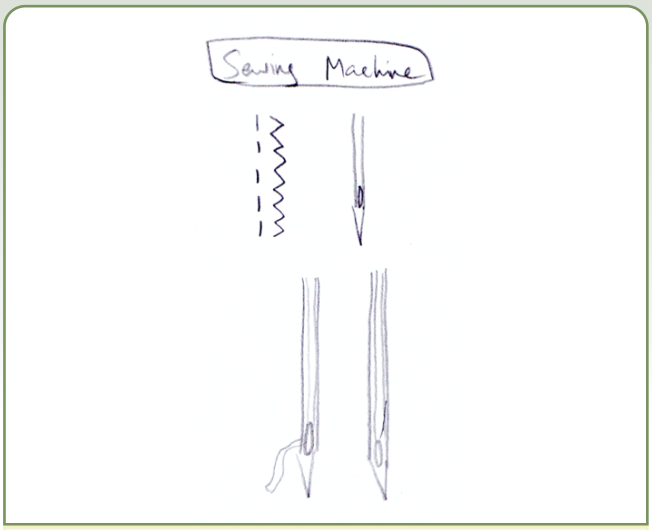
Design Idea 2: Added icon to the design to visually indicate the tool.



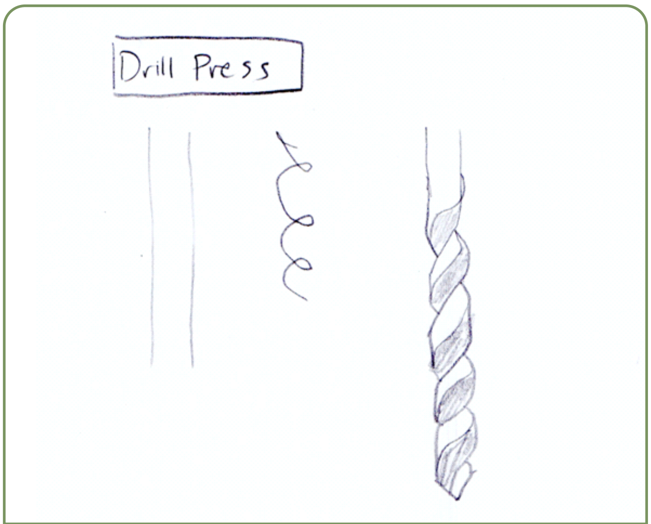
Design Idea 3: Icon location changed to a strip style incorporated into the border.



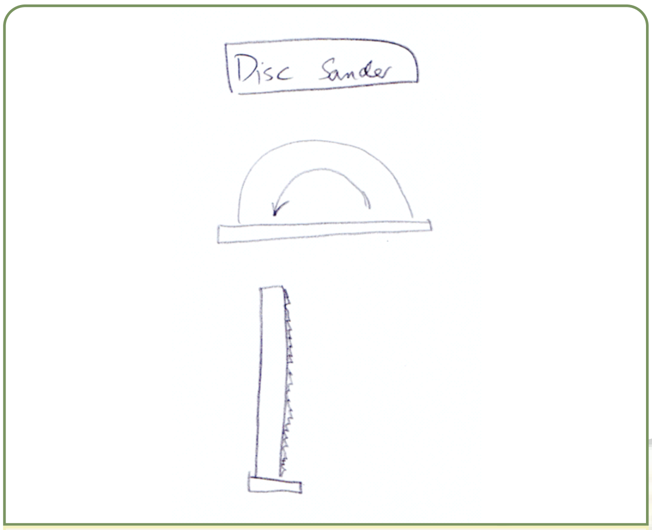
Icon Designs – Scroll Saw: Profile and top view are not as recognisable as the blade close-up. Acts as an immediate visual reminder of blade direction in machine.



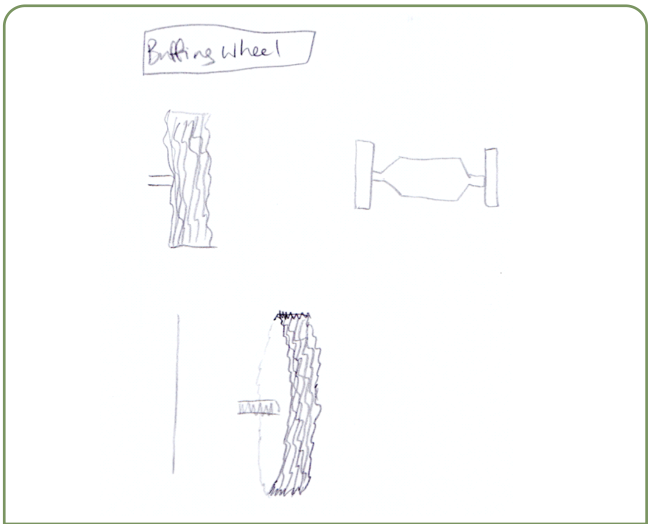
Icon Design – Sewing Machine: Stitch icons are recognisable, but add redundancy as they are pictured on the machine itself. The needle icon identifies a higher priority safety risk.



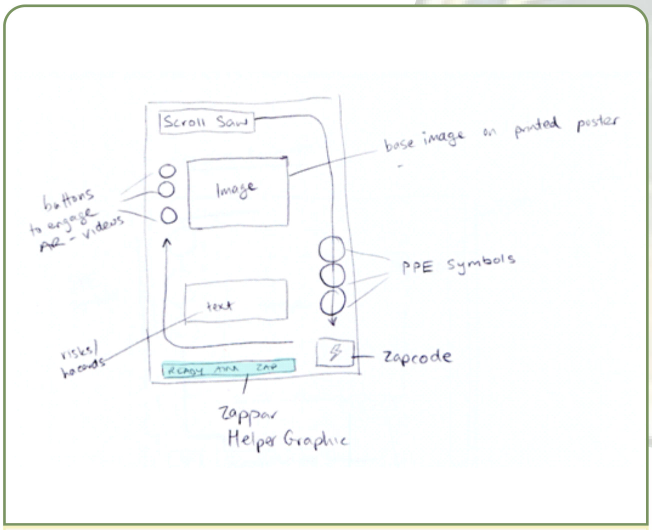
Icon Designs – Drill Press: Drill Bit icon as similar to Scroll Saw, using the "cutting implement" as an icon acts as a visual safety reminder.



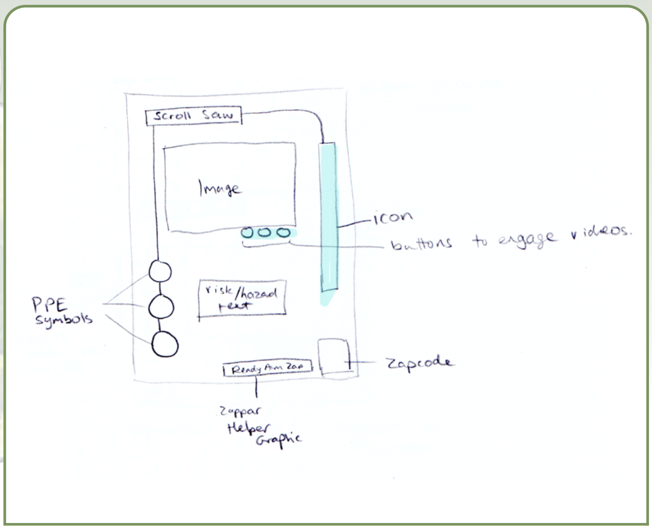
Icon Design – Disc Sander: Similar to other icon designs, the profile view acts as a safety reminder.



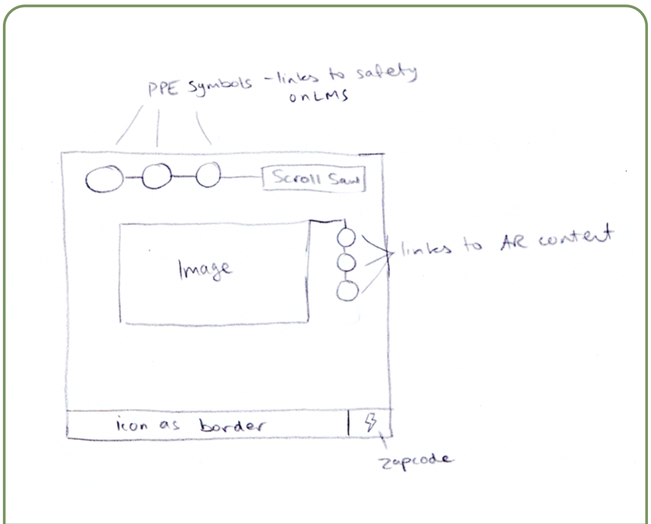
Icon Design – Buffing Wheel: Front view is more recognisable than profile view, however the profile highlights the abrasive surface as a safety reminder.



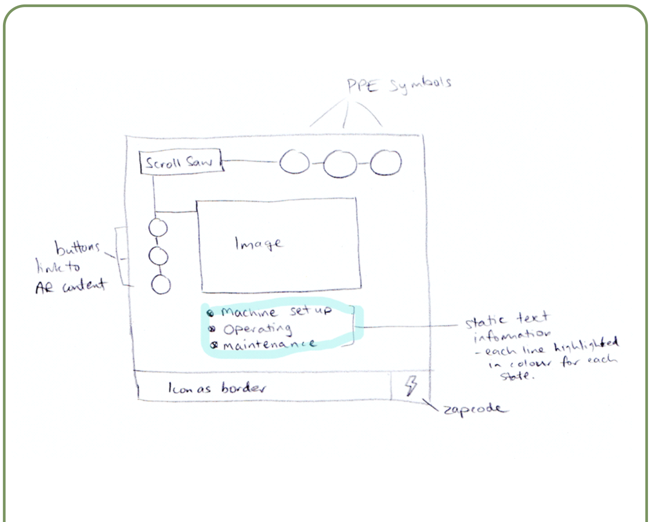
Design Idea 4: Added Zappar's "Helper Graphic" to assist users in activating AR content.



Design Idea 5: Added icon to the border and reduced size of helper graphic to minimise visual disruption.



Design Idea 6: Orientation of poster changed, icon at lower border and removed static text to reduce visual clutter.



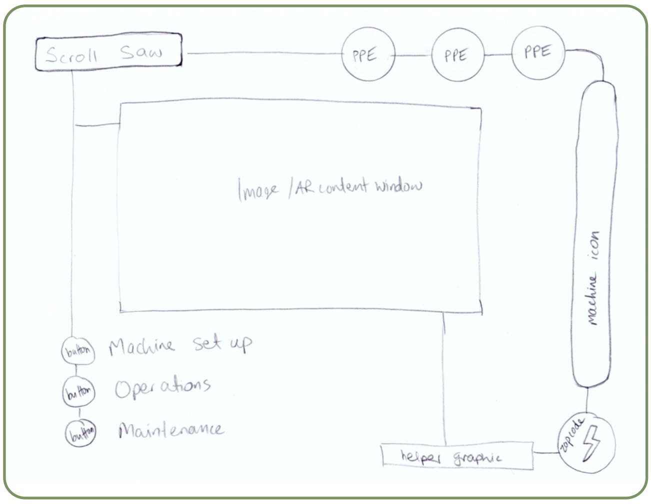
Design Idea 7: Static text revisited as headings for information that can be accessed in AR content.

Final Design

This section communicates the final design and some prototype development, justifying design decisions based on research of content design, colour theory, and cognitive load theory.

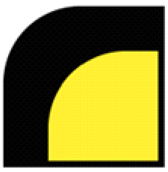
Final Design Sketch

The final layout of the poster is demonstrated for the Scroll Saw machine, however, all machine posters would follow the same format. This rough sketch was used to formulate the final product.

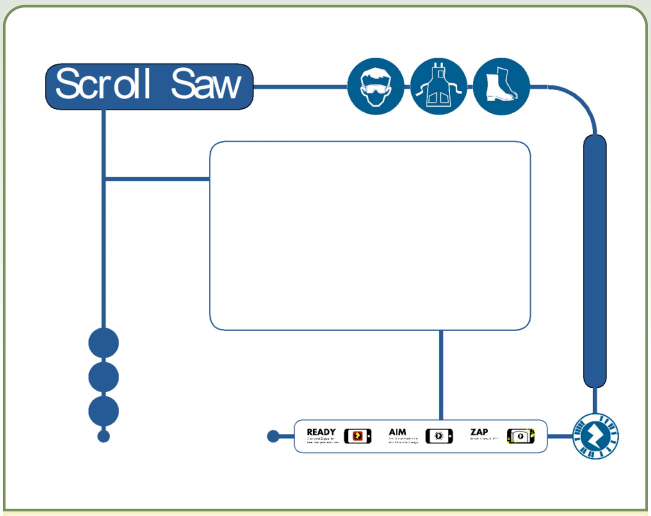


Colour Experimentation

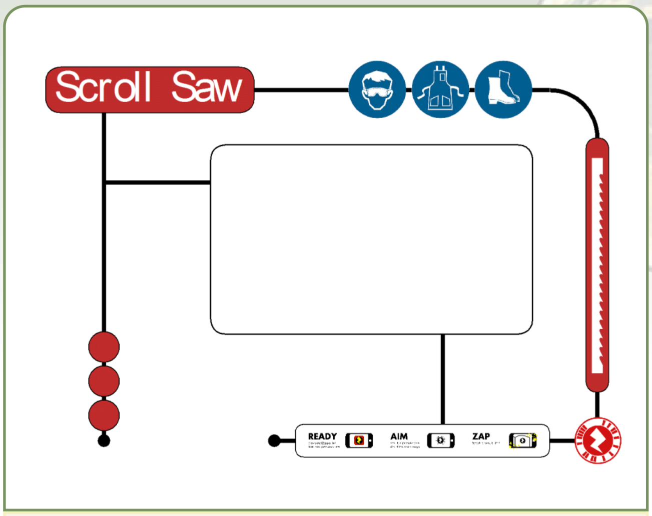
I used Adobe InDesign CC to create the layout for the poster and test colour combinations. Swatches are shown below with justifications of choices. A gallery of layout colour tests follows.

	Blue/White is consistent with mandatory PPE symbols and was selected to maintain consistency between elements, creating a cohesive design. Colour theory suggests blue to be a calming and non-threatening colour (Elrick, 2016) making it appropriate to encourage calm feelings in the workshop.
	Black/Yellow follows safety posters already used in workshops and WHS mandatory caution signs. Therefore, it is recognisable as a safety information source. Black promotes feelings of power and authority, whilst yellow, according to Linchpin SEO (2016) stimulates mental processes and activates memory ("Psychology of Color Guide For Designers [INFOGRAPHIC]", 2016).
	Red signifies danger (Elrick, 2016), and the Red/White combination is currently used in WHS mandatory warning signs. As such, it may provide confusion to the students as the purpose of the poster is for instruction, rather than alerting the user of impending danger.

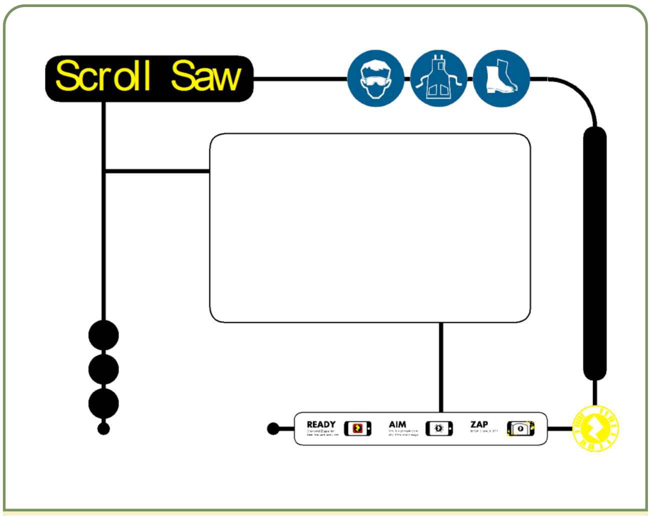
Colour Mockups



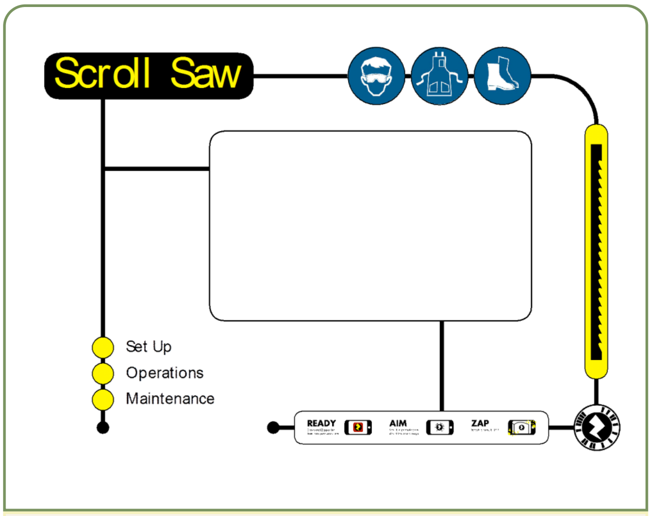
Blue Scheme: A consistent aesthetic but no contrast in colours. This makes it difficult to mentally organise groups of elements, restricting functionality of navigation.



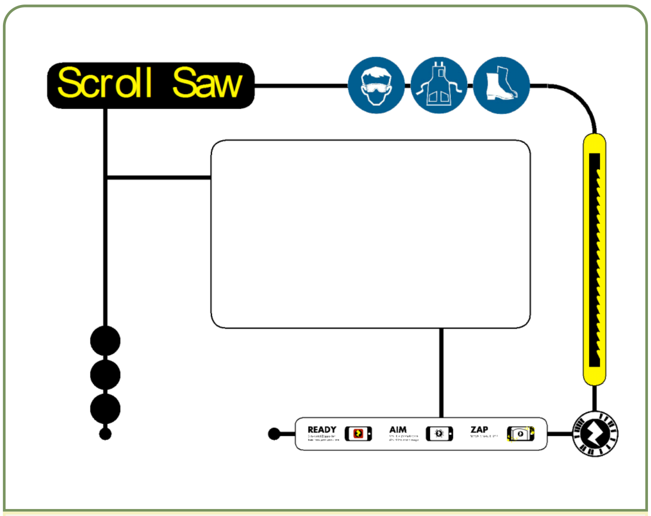
Red/White Scheme: Red stands out and attracts attention from the learner, but is perhaps too distracting. The combination of red, white and blue (PPE symbols) gives an undesired aesthetic.



Black/Yellow Scheme 1: Too much black in this version makes it heavy to view, and creates an imposing look. The yellow ZapCode does not have enough contrast to be functional. The title stands out and attracts attention.



Black/Yellow Scheme 3: Further modifications to the Black/Yellow design include yellow buttons, lightening the design and increasing contrast. Also, placement of left elements shifted further left increases white space and balance in the design.



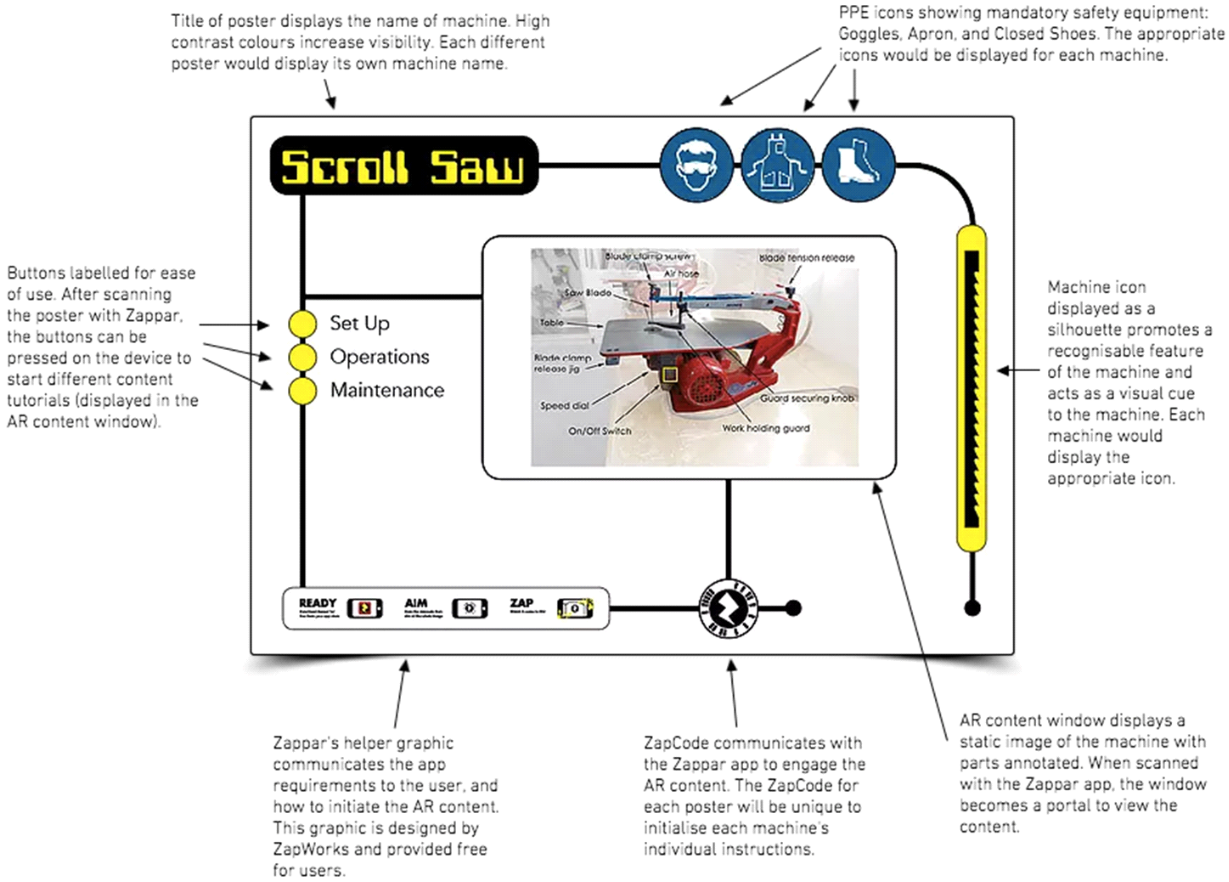
Black/Yellow Scheme 2: This modified version has a black Zapcode, increasing its functionality and this added black element is balanced by the modification of the icon element to yellow.

Final Design and Justification of Ideas

The final design is shown here, with annotations communicating an overview of design features and AR content.

Elements and Principles of Design

In design, the elements and principles assist designers in creating aesthetically pleasing and functional designs. The elements include Line, Shape, Colour, Texture, and Size. Graphic designers adhere to PARC (Proximity, Alignment, Repetition and Contrast) Principles to guide design decisions. Additionally, Balance and Space are principles adopted by many graphic designers ("The Principles of Design", 2016).



Elements

- Line
  - Lines have been used to create subtle connections. The border relates the title, across the top of the page, through the PPE icons and machine icon, highlighting safety aspects; similarly, the left line connects the operations with the AR content box, Zappar helper graphic and ZapCode.
- Shape
  - The circle shaped buttons were selected to mimic the PPE symbols and Zapcode (see Repetition below); furthermore, regular geometric shapes promote feelings of organisation and structure (Bradley, 2016) and are easily recognisable by learners as button shapes.
- Colour
  - A high-contrast, visually attracting aesthetic. Comparatively, it is the most visible, aiding in communicating the purpose of the poster, and ensuring prominence of important features (as required by established design criteria).
- Texture
  - A purposeful lack of texture limits distractions; McInerney (2014) suggests that sensory input will be hindered by poorly focussed attention.
- Size
  - The relative importance of elements has determined sizes. The large heading clearly identifies the poster topic. PPE symbols are a similar height to the heading, signifying their importance. The AR content window utilises the majority of the poster, for functionality. Similar elements are sized equally to create visual relationships.

Principles

- Proximity
  - Related features are located nearby each other, for example: the three PPE icons are grouped, as is the Zapper information and Zapcode, and the user buttons are located together, nearby the AR content box. This creates a visual relationship, reduces visual clutter and increases viewer comprehension ("The Principles of Design", 2016).

- Alignment
  - The PPE icons and buttons are aligned with each other in their groups, creating a visually predictable and cohesive poster. ("The Principles of Design", 2016). ZapWorks icons and ZapCode are closely aligned to ensure their association is clear to the user.
- Repetition
  - Repetition is used effectively through the circular motif, colours, and sizes of elements. The repeated circles assist in readability and comprehension (Schinkel, 2016); similarly, the yellow elements create a cohesive look that ties separate parts of the design together. Curved lines and borders further employ repetition to this end.
- Contrast
  - Contrast is mainly demonstrated by colour. The high contrast of yellow and black to the white background gives the user indications of what to focus on. The blue PPE symbols contrast to the rest of the design, creating a subtle chunk of information for learner encoding (McInerney, 2014).
- Balance
  - Balance refers to symmetry or asymmetry of elements in a design (Masters, 2016), and while my design is not symmetrical, it demonstrates asymmetrical balance in that the visual weight of elements is evenly distributed. This creates a pleasing aesthetic.
- Space
  - Positive and negative space have been used effectively. Elements are not too closely arranged, and allows for the separation of groups and individual elements ("The Principles of Design", 2016). This makes it easier for students to find information easily.

Managing Cognitive Load

When designing media-rich learning resources, consideration must be given to managing the cognitive load of the users to ensure that information gained is comprehended and retained. Greater levels of information increases strain on a student's mental resources, increasing cognitive load (Feinberg & Murphy, 2000) and consequently affect their ability to process content. Taking advantage of students' prior knowledge increases their ability to process the content provided by this resource, as schemas have been established and information is easily retrievable, reducing cognitive load (Valcke, 2002, as cited by Cook, 2006). Braune & Foshay (1983, as cited by Cook, 2006) suggest that interpretations of visual stimulus will be affected by prior knowledge. Students will have developed a prior understanding of the machine safety and operations and as such will have greater success interpreting the content on the poster.

Cook (2006) proposes instructional design considerations for managing cognitive load including dual-mode presentations, split-attention effect, redundancy, interactivity and instructional guidance.

Dual-Mode Presentations

Cook (2006) suggests that employing both visual and verbal stimulus has greater learning impact than using either independently and that greater quantities of information may be processed successfully this way.

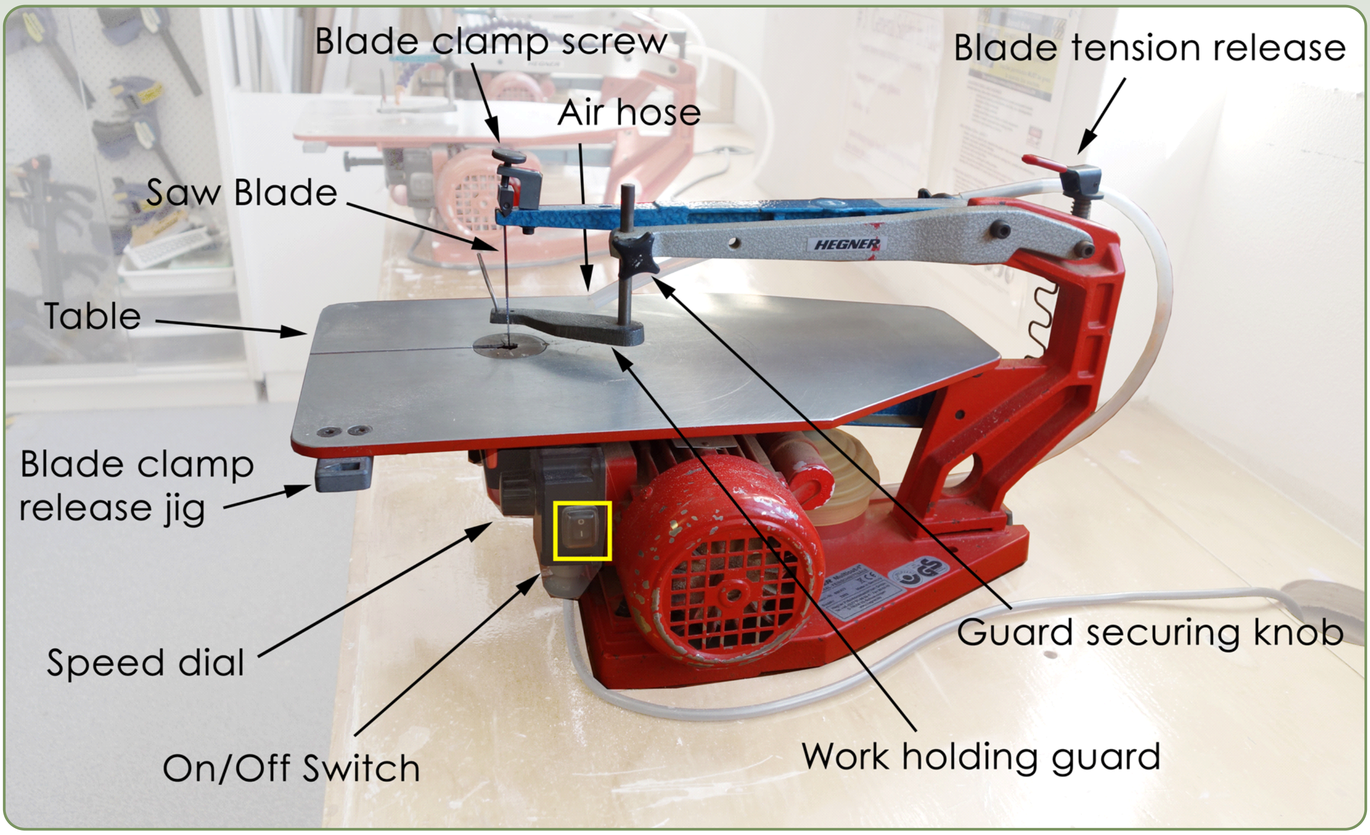
Paivio's dual coding theory concurs that these modes are processed independently in a learner's working memory (Paivio, 1986, as cited by Cook, 2006). Thus the decision was made to ensure that all videos included visual graphics, with a voice-over soundtrack. The introduction sequence of each video includes music, with on-screen text, another example of successful visual/auditory combination. All videos were produced consistently, demonstrating the application of dual-mode presentations.

Split-Attention Effects

Feinberg & Murphy (2000) assert that skill acquisition can be hindered through strain on working memory resulting from competition between text and graphics, however they do not clarify if text in this case is written or verbal. Cook (2006) suggests additionally that integration of complementary verbal text and graphics facilitates processing. Chandler and Sweller (1992, as cited by Cook, 2006) suggest that contiguous association of graphical and verbal information mitigates the cognitive load imposed by split-attention as learners can more easily form associations. Narration was used in my content videos to accompany the visual component to alleviate split-attention effects.

Redundancy

Redundant information creates cognitive load by requiring learners to process the same information twice (Cook, 2006). Despite the preference of teachers to have information repeated on the LMS (identified in Survey analysis), this would create redundancy of information, decreasing learning. Students transfer learning more successfully with narration accompanied visuals, than those with on-screen text (Mayer et al., 200, as cited by Cook, 2006). Feinberg & Murphy (2000) state that "Redundant sources of information place increased demand on cognition that can be freed for intrinsic load" (p. 3), suggesting maps as a fully featured graphic not requiring accompanying text. The labelled diagram of the scroll saw, shown below, similarly represents information that requires no



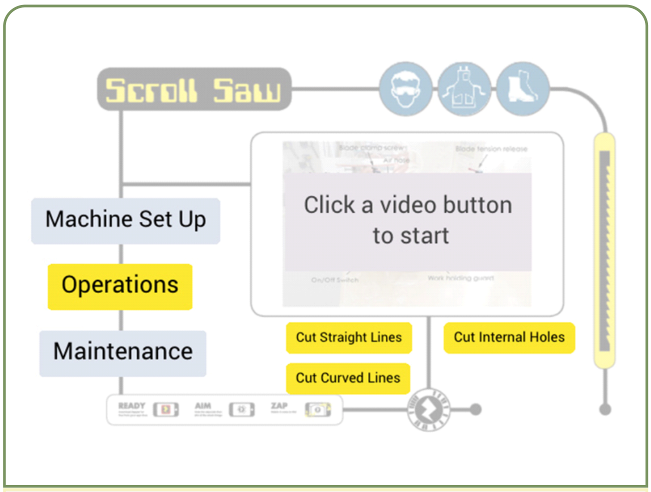
Interactivity

High levels of simultaneous interactivity places immense load on cognitive processing. Cook (2006) states that "if the number of interacting elements exceeds what can be processed by working memory simultaneously, it is unlikely that learning will occur" (p. 11), therefore, isolating interactive elements will enable learners to access the content more successfully. Functionally, it would not be possible to play multiple videos simultaneously.

Instructional Guidance

Students will need some level of guidance to contextualise learning from this resource. Cook (2006) suggests a balance of guidance to maintain quality of learning. The use of the Zappar helper graphic, shown below, on the poster provides guidance to students who have never used the app previously. As a new product in class, this was necessary for students to know how to access the app to view the AR content.

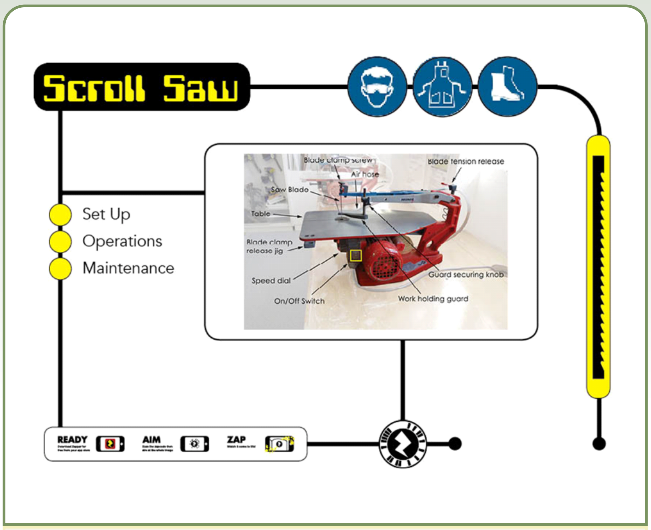
Further guidance is provided when the AR content is viewed, instructions are given on some screens to guide students to select a video to watch.



Zapworks designer view, showing instructional guidance buttons.

Evaluation

I evaluated the final product based on the success of the design and prototype, as well as commenting on the successful achievement of the design criteria set out previously.



Final Poster, To test the poster, please download and scan with the Zappar app.

Evaluation

Overall, I believed I had successfully met the objectives of the project. I set out to design and create an instructional resource that utilises augmented reality to reinforce the learning of safety and operations of machines in the Design and Technology Classroom.

Unexpected functionality provided by the ZapWorks Designer software enabled their "Grab n Go" feature, whereby once the AR content is initialised in the device, the student can move away from the poster to view the content. This allowed for added safety in the classroom, and multiple students could use the poster simultaneously.

Aesthetically, the software did not allow for ultimate design control and as such, some of the buttons did not appear as I had designed. The desired function still enables for effective engagement with the content despite the visual modifications.

Design Criteria Evaluation

Function:

- Effectively convey the required content using strategies like chunking, and scaffolding, as McInerney (2014) suggests, to provide more manageable pieces of information and build up levels of complexity
    - Chunking strategies were used effectively to manage content. Each video is less than 60 seconds in length providing manageable segments of information and aiding with information processing.
- Meaningful without added AR content so that students viewing the poster may increase their understanding of the machine prior to engaging with the AR content
    - The poster clearly conveyed static information on the parts of the scroll saw, useful information to aid students in better understanding this workshop tool.
- Use familiar terminology to activate prior knowledge, assisting in developing meaningful links between the student and content will increase learning potential (McInerney, 2014).
    - Throughout the videos, terminology was consistent and linked with terms on the static poster (eg parts of the machine). This developed product knowledge and helped students assimilate this learning effectively.
- Navigation structure should be consistent to promote ease of use. Predictable placement of features and elements across the posters will unify the collection, encouraging easier assimilation of knowledge.
    - Consistent navigation between "scenes" of AR content promoted easy use. ZapWorks Designer software was not as refined as preferred and consequently the final layout differed slightly from design, however, still consistent.
- Manage cognitive load by providing multi-modal forms of instruction, but limiting competition between too many elements to avoid information processing failure.
    - Cognitive load was managed effectively through content design. All videos demonstrate contiguous integration of verbal and visual elements, enabling successful processing by the learners.

Aesthetics:

- Prominence of features like buttons will ensure ease of use as these features will be correctly interpreted by the student (McInerney, 2014).
    - Colour choice of buttons and other elements aids the interpretation of their function.
- Use familiar symbols to activate prior knowledge, similar to terminology above. An example might include standard PPE symbols as determined by the International Organization for Standardization (ISO) as these symbols are recognised worldwide.
    - Familiar symbols and terms are used throughout to create a cohesive and easily accessed product.
- Design the content using the elements and principles of design and PARC principles will help create an aesthetically pleasing product.
    - As justified previously, the elements and principles of design have been successfully used in the design of the product. The final prototype did not match the design as preferred. This was a result of the limitations of the software. With more time, more sophisticated software could be used to create a preferred look.

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